Biota Environmental Sciences

MAC Phase 4 Marillana Creek Targeted MNES Fauna Survey

Prepared for BHP WAIO

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Biota Environmental Sciences

ABN 49 092 687 119
Level 1, 228 Carr Place
Leederville Western Australia 6007
Ph: (08) 9328 1900 Fax: (08) 9328 6138

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Prepared by: S. Schmidt, J. Graff, J. King, R. De Vos, J. Alexander, D. Kamien, N. Beerkens

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MAC Phase 4 Marillana Creek MNES Fauna Survey

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1.0 Summary

1.1 Background

Biota Environmental Sciences (Biota) was commissioned by BHP Western Australia Iron Ore (BHP WAIO) to undertake a two-phase survey targeting fauna species listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) as Matters of National Environmental Significance (MNES) within the MAC Phase 4 Marillana Creek Area (hereafter referred to as the 'study area'). The study area was 23,424 ha in extent and located approximately 110 km northeast of Newman.

The purpose of this assessment is to present zoological information on MNES species and habitats in the study area through desktop study and field survey, to enhance knowledge at the locality scale and place this into regional context. This will inform future environmental impact assessment in relation to the study area.

1.2 Methodology

As part of the desktop study, a review of relevant database records and past surveys from the locality was undertaken to identify significant fauna known from, or potentially occurring within, the study area and to inform survey design and preliminary habitat mapping.

The field survey was conducted from November 17 to 24, 2020 (Phase 1) and March 25 to 31, 2021 (Phase 2) with a site visit conducted from January 18 to 20, 2021 in accordance with Environmental Protection Authority (EPA) and EPBC Act guidance.

Sampling effort within the study area comprised:

- targeted searches conducted at 23 sites, with over 121 km walked and a total search effort of over 94 hours;
- nocturnal searches conducted at ten sites, with over 39 km walked and a total search effort of over 25 hours;
- long-term deployment of remote infrared motion cameras to target ground-dwelling mammals at nine sites for a total of 645 nights;
- deployment of SongMeter echolocation call recorders targeting the bat assemblage at 13 locations for a total of 165 recording nights;
- deployment of SongMeter acoustic call recorders targeting Night Parrots at six locations for a total of 87 nights;
- fauna landscape mapping and habitat assessment; and
- non-systematic survey activities including night-spotting, ground foraging, identification of secondary signs and opportunistic records.

1.3 Results

1.3.1 Vertebrate Species

Based on the desktop study, a total of 332 vertebrate species, comprising 23 native and ten introduced non-volant mammal species, 14 bat species, eight amphibian species, 119 reptile species and 158 bird species, were identified as potentially occurring in the study area locality. Of these, 21 are MNES species, including one species listed as Critically Endangered, three as Endangered, five as Vulnerable, and 13 as Migratory (one species listed as both Critically Endangered and Migratory). All MNES species identified are also State listed significant species, with another eight species listed at State-level only also potentially occurring.

A total of 93 vertebrate species were recorded during the survey, all of which are known from the study area locality.

One MNES species was recorded within the study area during the current survey, the Pilbara Olive Python, *Liasis olivaceus barroni* (Vulnerable). A further four species have also been recorded from the study area during previous surveys. Three MNES species identified from the desktop study are also considered likely to occur, and two may occur within the study area:

Recorded (current survey):

- Pilbara Olive Python, *Liasis olivaceus barroni* (Vulnerable under both the EPBC Act and the State *Biodiversity Conservation Act 2016* (BC Act)).

Recorded (previous surveys):

- Northern Quoll, *Dasyurus hallucatus* (Endangered under both the EPBC Act and the BC Act);
- Pilbara Leaf-nosed Bat, *Rhinonicteris aurantia* (Pilbara form) (Vulnerable under both the EPBC Act and the BC Act);
- Ghost Bat, *Macroderma gigas* (Vulnerable under both the EPBC Act and the BC Act); and
- Common Greenshank, *Tringa nebularia* (Migratory under both the EPBC Act and the BC Act).

Likely to occur:

- Pacific Swift, *Apus pacificus* (Migratory under both the EPBC Act and the BC Act);
- Wood Sandpiper, *Tringa glareola* (Migratory under both the EPBC Act and the BC Act); and
- Grey Falcon, *Falco hypoleucos* (Vulnerable under both the EPBC Act and the BC Act).

May occur:

- Greater Bilby, *Macrotis lagotis* (Vulnerable under both the EPBC Act and the BC Act); and
- Common Sandpiper, *Actitis hypoleucos* (Migratory under both the EPBC Act and the BC Act).

While these significant species utilise or are likely to utilise the study area, none are restricted to the study area, and some may only occur as transient visitors.

1.3.2 Fauna Habitats

Six fauna landscapes (broad fauna habitats) were identified and mapped:

1. Low open eucalypt woodland floodplains with patches of mulga (BHP fauna habitat type 'Drainage Area/ Floodplain);
2. Undulating low ironstone hills and footslopes supporting soft and hard spinifex (BHP fauna habitat type 'Undulating Low Hills');
3. Undulating low calcrete hills and stony plains supporting (shrubby) hard spinifex grasslands (BHP fauna habitat type 'Stony Plain');
4. Ironstone mountains, gorges and gullies supporting hard spinifex grasslands (BHP fauna habitat type 'Gorge/ Gully' and 'Hillcrest/ Hillslope');
5. Vegetated drainage systems with ephemeral pools (BHP fauna habitat type 'Major Drainage Line'); and
6. 'Flat rocks' drainage system with permanent pools (BHP fauna habitat type 'Waterhole').

Four of the six identified fauna landscapes (1, 4, 5, 6) within the study area are considered to represent potentially suitable habitat for MNES species. Critical habitat for MNES species including Pilbara Olive Python, Northern Quoll, Pilbara Leaf-nosed Bat, Ghost Bat and Grey Falcon is present within fauna landscapes 4, 5 and 6; thus, these habitats are likely to be of most importance with respect to MNES species.

All habitats identified as utilised or having the potential to be utilised by MNES species within the study area are not restricted to the locality and occur contiguously beyond the study area.

2.0 Introduction

2.1 Project Background and Purpose

BHP Western Australia Iron Ore (BHP WAIO) required assessment of the MAC Phase 4 Marillana Creek study area, a 23,424 ha area located approximately 110 km northeast of Newman, hereafter referred to as the 'study area' (Figure 2.1). The study area encompasses part of Marillana Creek and surrounds upstream and west of BHP's Yandi Operations, and is located off BHP tenure but overlaps third party active and non-active (exploration) tenure, and is intersected by a sealed road and an active railway.

Biota Environmental Sciences (Biota) was commissioned by BHP WAIO to undertake a two-phase survey within the study area targeting fauna species listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) as Matters of National Environmental Significance (MNES).

The purpose of this report is to present zoological information on MNES species in the study area through desktop study and field survey, to enhance the level of knowledge at the locality scale and place this into regional context. This will inform future environmental impact assessment in relation to the study area. However, this report does not consider any specific development proposed by BHP WAIO.

2.2 Scope and Objectives

The scope of this study was to undertake a two-phase targeted MNES fauna survey of the study area consistent with Environmental Protection Authority (EPA) and EPBC Act guidance. The key elements of the scope comprised:

1. preparation of a desktop study including database and literature searches, in order to consolidate all available and relevant existing data for contextual comparison;
2. assessment and description of fauna habitats, including those deemed significant for supporting known or potential populations of MNES fauna; and
3. identification and assessment of the likelihood of occurrence of MNES fauna, or their preferred habitat, within the study area.

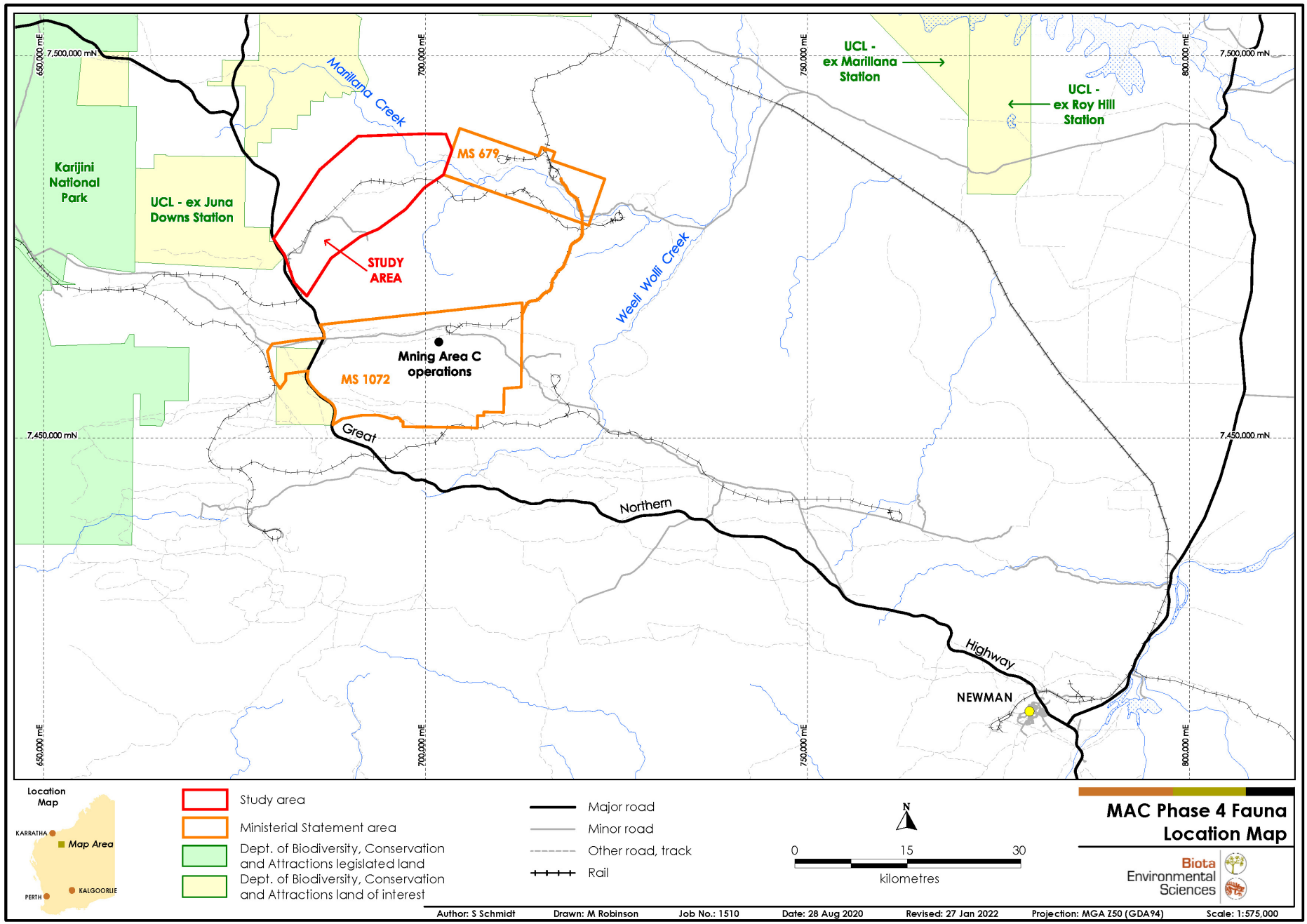

Figure 2.1: Study area location map.

3.0 Methodology

3.1 Desktop Study

The aim of the desktop study was to review information relevant to the study area to identify target species previously recorded or with the potential to occur. This review considered regional information and previous biological surveys completed in the locality (Section 3.1.1) and the results of database searches (Section 3.1.2).

3.1.1 Literature Review

The literature review comprised:

- regional information, including bioregion and subregion data (Kendrick 2003), land systems mapping (van Vreeswyk et al. 2004), vegetation descriptions and mapping by Beard (1975a, 1975b), and surface geology (Department of Minerals Energy 1996).
- relevant biological surveys previously completed in the locality within 10 years prior to this study.

The results of the literature review and database searches are summarised in Section 4.2 and detailed results are provided in Appendix 1.

3.1.2 Database Searches

The following databases were searched as part of the desktop study:

1. Federal Department of Agriculture, Water and the Environment (DAWE) Protected Matters Search Tool (to identify fauna species listed under the EPBC Act potentially occurring within the study area);
2. NatureMap, a joint project of the Department of Biodiversity, Conservation and Attractions (DBCA) and the Western Australian Museum (WAM), was searched to obtain a list of all fauna species recorded within or adjacent to the study area, primarily to identify records of significant fauna known from the locality. This database represents the most comprehensive source of information on the distribution of Western Australia's fauna, comprising records from:
    a. DBCA Threatened Fauna database (to identify species listed under the WA *Biodiversity Conservation Act 2016* (BC Act), or those species listed as Priority by DBCA, that have previously been recorded within or adjacent to the study area);
    b. Fauna Survey Returns Database (managed by the DBCA);
    c. WAM Specimen Database; and
    d. BirdLife Australia Atlas of Australian Birds;
3. International Union for Conservation of Nature and Natural Resources (IUCN) Red List (to identify species listed by the IUCN as Critically Endangered, Endangered, Vulnerable or Near Threatened that potentially occur within the study area); and
4. The Atlas of Living Australia on-line database (to identify species previously recorded within or adjacent to the study area).

All searches were centred on the coordinate 22.4510° S, 118.5121° E, with search results requested from a 40 km radius, except for IUCN, which returns a 25 km radius.

3.1.3 Assessment of Likelihood of Occurrence in the Study area

Results from the literature review and database searches were used to compile a list of terrestrial fauna species of significance that had previously been recorded from the locality. The likelihood that each taxon would occur in the study area was assessed taking into account habitat ground-

truthing/assessments and fauna sampling conducted during the survey using the rankings and criteria provided in Table 3.1, based on consideration of:

- the documented distribution of the species;
- the proximity of the study area to existing records; and
- preferred habitats.

Habitats were defined for this purpose according to vegetation units, landforms apparent on aerial imagery, and taking into account existing information regarding the environment. The term 'close proximity' was defined as being within 20 km of the study area, while the broader 'locality' comprised the area up to 40 km from the study area.

Table 3.1: Criteria used to assign the likelihood of occurrence of a species within the study area.

Rank	Criteria
Recorded*	1. The species has been previously recorded in the study area.
Likely to occur	1. There are existing records of the species in close proximity to the study area (within 20 km); and • the species is strongly linked to a specific habitat, which is present in the study area; or • the species has more general habitat preferences, and suitable habitat is present.
May occur	1. There are existing records of the species from the locality (within 40 km), however • the species is strongly linked to a specific habitat, of which only a small amount is present in the study area; or • the species has more general habitat preferences, but only some suitable habitat is present. 2. There is suitable habitat in the study area, but the species is recorded infrequently in the locality.
Unlikely to occur	1. The species is linked to a specific habitat, which is absent from the study area; or 2. Suitable habitat is present, however there are no existing records of the species from the locality despite reasonable previous search effort in suitable habitat; or 3. There is some suitable habitat in the study area, however the species is very infrequently recorded in the locality or the only records are historic (>40 years ago).
Would not occur	1. The species is strongly linked to a specific habitat, which is absent from the study area; or 2. The species' range is very restricted and does not include the study area; or 3. The species is not considered extant in the locality.

* previously or during current survey

3.1.4 Nomenclature

Consistent with the EPA (2016a) Technical Guidance, species nomenclature for herpetofauna and mammals follows the WAM fauna taxonomic checklist, which is revised and released every six months or as necessary[1]. Nomenclature for avifauna follows Gill et al. (2021). Where nomenclature differs from species list provided by BHP WAIO, this is indicated (Appendix 1)[2].

3.1.5 Threatened Fauna Statutory Framework

Native fauna species that are rare, threatened with extinction, or have high conservation value, are specially protected by law under either or both the State BC Act and the Federal EPBC Act. Migratory and Marine species are also protected under the EPBC Act as MNES.

In addition, DBCA maintains a list of Priority fauna species that have not been assigned statutory protection under the BC Act, but are still considered to be of conservation priority or are rare but

[1] Current checklist released June 2021 (http://museum.wa.gov.au/research/departments/terrestrial-zoology/checklist-terrestrial-vertebrate-fauna-western-australia)
[2] Data supplied matching BHP species list as requested with report nomenclature provided in addition (comments).

not threatened and are in need of monitoring. Appendix 2 details the categories of significance recognised under these three frameworks.

For the purposes of this report, Marine-listed species have not been considered, as there are no marine environments within or in proximity to the study area, so almost all Marine-listed species identified as potentially occurring are bird species listed that do not use marine environments and are listed erroneously.

3.2 Survey Timing and Weather

3.2.1 Survey Team

The field survey was conducted by a team of Biota zoologists from November 17 to 24, 2020 (Phase 1) and March 25 to 31, 2021 (Phase 2) with a site visit conducted from January 18 to 20, 2021 (Table 3.2). The survey was completed under "Fauna Taking (Biological Assessment)" Licence No. BA27000325 and "Authorisation to take or disturb threatened species' FRA 2020-0125 issued to Dr. Sylvie Schmidt (Appendix 3).

Table 3.2: Summary of personnel involved in the fauna survey.

Name	Position at Biota	Qualification	Years of Experience	Survey Role
Garth Humphreys	Director / Principal Ecologist	BSc. Hons	33	Project Director, Final report review
Sylvie Schmidt	Senior Biologist	BSc. Hons, PhD, MBA	16	Project Manager Survey design/Desktop study Field Team Leader (all phases) Data analysis and reporting
Michael Greenham	Senior Zoologist	BSc.	21	Field survey (all phases)
Joshua Keen	Zoologist	BSc. Hons	4	Field survey (phase 2)
Nathan Beerkens	Zoologist	BSc. Hons	4	Desktop study Field survey (phase 2)
Dan Kamien	Principal Zoologist	BSc. Hons	23	Bat call analysis
John Graff	Zoologist	BSc. Hons	11	Desktop study Bird call analysis
Jacinta King	Zoologist	BSc. Hons	3	Desktop study
Jason Alexander	Principal Zoologist	BSc. Hons	15	Desktop study, Peer review
Roxanne de Vos	Graduate Zoologist	BSc.	2	Desktop study, Camera data analysis

3.2.2 Weather

Weather data were obtained from the Bureau of Meteorology weather station at Newman Airport (No. 001767), located approximately 120 km southeast of the southern end of the study area. Weather conditions were hot and dry during all phases of the survey, with temperatures ranging from a minimum of 18.4°C to a maximum of 42.2°C and no rainfall recorded (Table 3.3). While conditions were very dry during Phase 1 with only one fresh water pool detected in the far north east of the study area (Flat Rocks), several large ephemeral pools were present in the main drainage within the study area during the site visit and during Phase 2 of the survey (see site pictures provided in Appendix 4 and comparison with long-term observations in Section 3.2.3).

Table 3.3: Weather at Newman Aero during the survey periods.

Phase 1	17/11	18/11	19/11	20/11	21/11	22/11	23/11	24/11	Mean/Total
Maximum temperature (°C)	41.6	39.9	40.5	38.0	41.0	42.2	38.1	36.7	**39.8** ± 0.69
Minimum temperature (°C)	21.7	20.9	23.5	27.2	22.9	28.1	21.9	25.3	**23.9** ± 0.94
Rainfall (mm)	0	0	0	0	0	0	0	0	**0**

Site visit	18/01	19/01	20/01						Mean/Total
Maximum temperature (°C)	37.4	39.6	40.8						**39.3** ± 1.00
Minimum temperature (°C)	25.3	29.3	23.2						**25.9** ± 1.7
Rainfall (mm)	0	0	0						**0**
Phase 2	**25/03**	**26/03**	**27/03**	**28/03**	**29/03**	**30/03**	**31/03**		**Mean/Total**
Maximum temperature (°C)	37.2	37.5	37.9	38.6	37.7	37.2	35.1		**37.3** ± 0.41
Minimum temperature (°C)	20.8	20.8	21.5	24.2	24.2	23.8	18.4		**22.0** ± 0.83
Rainfall (mm)	0	0	0	0	0	0	0		**0**

3.2.3 Climate

Long-term climate data were obtained from the Newman Airport weather station (Figure 3.1). Maximum and minimum temperatures in the twelve months preceding the survey were consistent with long-term averages. However, Phase 1 of the survey was conducted during a period with higher than average long-term minimum (21.2°C) and maximum (37.6°C) November temperatures, and Phase 2 was conducted during a period with lower than average long-term maximum March (40.9°C) temperatures.

Conditions for Phase 1 of the survey were drier than average with a total of 27 mm of rainfall received from May to November compared to a long-term average of 77 mm. Conditions for the site visit were consistent with long-term January conditions. Conditions for Phase 2 of the survey were wetter than average, with total rainfall for February, the month preceding the survey being far above average with a total of 169 mm of rainfall over a period of less than 3 weeks, which is over twice the long-term mean February rainfall.

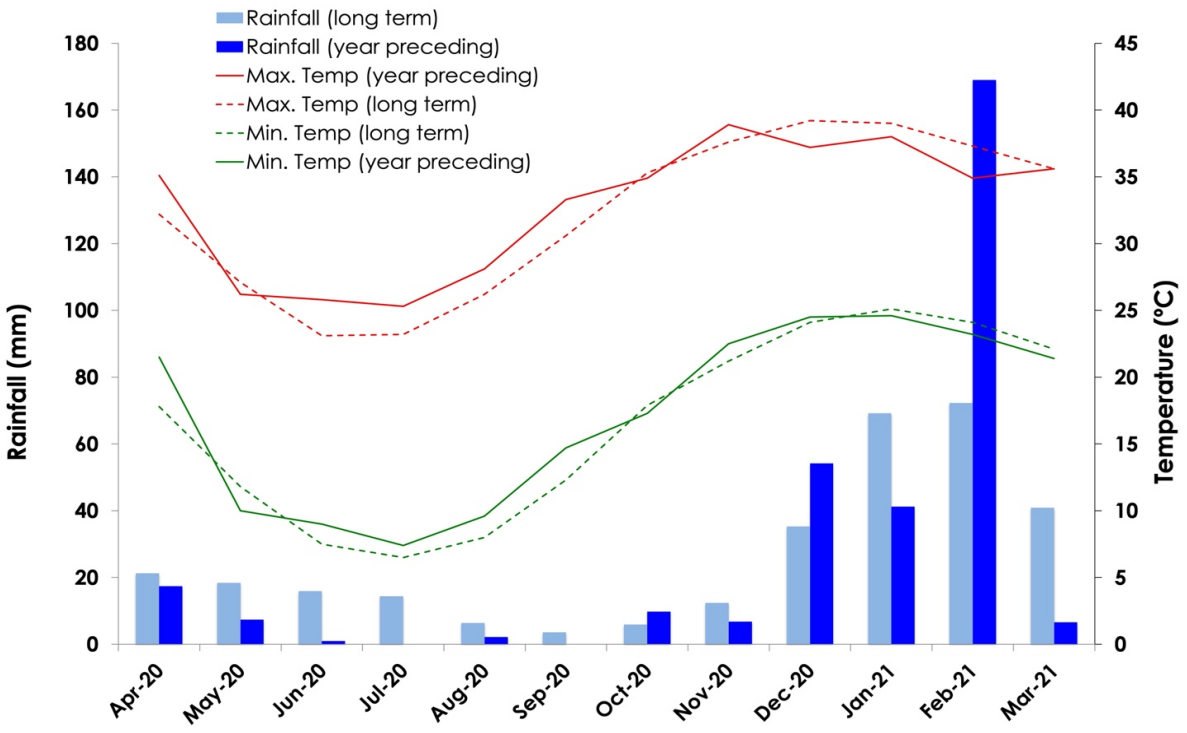

Figure 3.1: **Climate and weather graph depicting long-term averages and the twelve months preceding the survey (April 2020 – March 2021).**
(Long-term data rainfall 1971-2021, temperatures 1996 – 2021).

3.3 Survey Design

3.3.1 Survey Methods

The methodology was developed with reference to the following guidance documents:

Commonwealth

- Survey Guidelines for Australia's Threatened Birds (DEWHA 2010a);
- Survey Guidelines for Australia's Threatened Mammals (DSEWPaC 2011a);
- Survey Guidelines for Australia's Threatened Bats (DSEWPaC 2010);
- Survey Guidelines for Australia's Threatened Reptiles (DSEWPaC 2011b);
- Survey Guidelines for Australia's Threatened Frogs (DEWHA 2010b);
- EPBC Act Referral Guideline for the Endangered Northern Quoll *Dasyurus hallucatus* (DotE 2016); and
- Significant Impact Guidelines 1.1 – Matters of National Environmental Significance (DotE 2013);

State

- Technical Guidance – Sampling Methods for Terrestrial Vertebrate Fauna (EPA 2016a);
- Technical Guidance – Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment (EPA 2020);
- Environmental Factor Guidelines – Terrestrial Fauna (EPA 2016b);
- Statement of Environmental Principles, Factors and Objectives (EPA 2015);
- Guidelines for surveys to detect the presence of bilbies, and asses the importance of habitat in Western Australia (DBCA 2017a); and
- Interim Guideline for Preliminary Surveys of Night Parrot (*Pezoporus occidentalis*) in Western Australia (DBCA 2017b).

Client

- BHP WAIO's Guidance for Vertebrate Fauna Surveys in the Pilbara (SPR-IEN-EMS-015).

The vertebrate fauna survey consisted of a combination of systematic and non-systematic opportunistic sampling and targeted searching (Section 3.3.3).

Preliminary site selection was determined through assessment of aerial photography and thematic layers including land systems, geology and Beard's vegetation mapping (see Section 4.1). Preliminary site selection was revised in the field based on microhabitat and access limitation.

3.3.2 Target Species

Through the desktop study (see Section 4.2), 29 significant vertebrate species, including 21 MNES species, were identified as having the potential to occur within the study area, either due to previous records from the locality or due to the likely presence of suitable habitat (see Table 4.4 and Table 4.6). Table 3.4 summarises the 21 MNES species and the sampling methods used to target them during the survey (detailed descriptions of sampling methods and sites are provided in Sections 3.3.3.2 to 3.3.3.7).

While the survey was targeted specifically at these MNES species, any opportunistic sightings or signs of other vertebrate fauna detected were also recorded, including significant and introduced fauna.

Table 3.4: Summary of target MNES species and sampling methods.

Family	Species Name	Common Name	Commonwealth Conservation Status	Sampling Methods
Non-volant mammals				
Dasyuridae	*Dasyurus hallucatus*	Northern Quoll	Endangered	Motion cameras, Targeted searches, Nocturnal searches, Habitat assessment. Hair traps (if active burrows detected)
Thylacomyidae	*Macrotis lagotis*	Greater Bilby[1]	Vulnerable	
Bats				
Rhinonycteridae	*Rhinonicteris aurantia*	Pilbara Leaf-nosed Bat	Vulnerable	Echolocation call recorders, Targeted searches, Nocturnal searches, Habitat assessment.
Megadermatidae	*Macroderma gigas*	Ghost Bat	Vulnerable	
Herpetofauna				
Pythonidae	*Liasis olivaceus barroni*	Pilbara Olive Python	Vulnerable	Targeted searches, Nocturnal searches, Habitat assessment.
Avifauna				
Psittacidae	*Pezoporus occidentalis*	Night Parrot	Endangered[2]	Acoustic recorders, Targeted searches, Nocturnal searches, Habitat assessment.
Apodidae	*Apus pacificus*	Pacific Swift	Migratory	Opportunistic observations, Targeted searches, Nocturnal searches, Habitat assessment.
Charadriidae	*Charadrius veredus*	Oriental Plover	Migratory	
Rostratulidae	*Rostratula australis*	Australian Painted-snipe	Endangered	
Scolopacidae	*Calidris acuminata*	Sharp-tailed Sandpiper	Migratory	
	Calidris ferruginea	Curlew Sandpiper	Critically Endangered; Migratory	
	Calidris melanotos	Pectoral Sandpiper	Migratory	
	Actitis hypoleucos	Common Sandpiper	Migratory	
	Tringa glareola	Wood Sandpiper	Migratory	
	Tringa nebularia	Common Greenshank	Migratory	
Laridae	*Gelochelidon nilotica*	Australian [Gull-billed] Tern	Migratory	
	Onychoprion anaethetus	Bridled Tern	Migratory	
Falconidae	*Falco hypoleucos*	Grey Falcon	Vulnerable	
Hirundinidae	*Hirundo rustica*	Barn Swallow	Migratory	
Motacillidae	*Motacilla tschutschensis*	Eastern Yellow Wagtail	Migratory	
	Motacilla cinerea	Grey Wagtail	Migratory	

[1] Referred to as Greater Bilby in this report for consistency with EPBC Act listing in line with purpose of report, contra usage of Bilby in current WA Museum taxonomy
[2] Listed as Critically Endangered at State level

3.3.3 Fauna Sampling

In addition to sampling using bat (echolocation) call recorders, bird call recorders and motion cameras, the following fauna observation techniques were used to investigate fauna habitats identified from the desktop study and microhabitats identified during the course of the survey:

- habitat-specific targeted searches for evidence of significant fauna (including nocturnal searches) and opportunistic observations of reptiles, frogs, small mammals and birds;
- identification of secondary signs (where possible) including tracks, scats, skins, mounds, hollows, nests and diggings; and
- identification of road-kill and other animal remains (where encountered).

3.3.3.1 Sampling Locations

Table 3.5, Figure 3.2 (point sampling) and Figure 3.3 (searches) provide an overview of all sampling locations and methods used across the study area. The following sections provide additional information for each sampling method employed, including dates and survey effort.

3.3.3.2 Targeted Searches

Targeted searches were conducted at 23 sites with a total search effort of over 121 km walked (94.75 hours). Table 3.6 details each targeted search conducted, and Figure 3.3 shows individual zoologist's tracks walked for each targeted and nocturnal search.

Table 3.5: Summary of sampling sites and methods.

Site ID	Latitude (°S)	Longitude (°E)	Land System	Dominant Landform	Fauna Landscape	Sampling Methods
MAC-01	-22.761638	118.833989	Boolgeeda	Drainage Area/Floodplain	Landscape 1: Floodplains	Acoustic (bird call) recording unit
MAC-02	-22.748162	118.834726	Boolgeeda	Major Drainage Line	Landscape 5: Vegetated drainage systems	Bat (echolocation) call recorder
						Nocturnal search
MAC-03	-22.711136	118.977405	Robe	Major Drainage Line	Landscape 2: Low undulating ironstone hills	Targeted search
						Nocturnal search
MAC-04	-22.759047	118.833658	Calcrete	Undulating Low Hills	Landscape 3: Low undulating calcrete hills and plains	Nocturnal road spotting (north of rail)
MAC-05	-22.756987	118.860887	Boolgeeda	Sandy/Stony Plain	Landscape 1: Floodplains	Acoustic (bird call) recording unit
MAC-06	-22.722042	118.973757	McKay	Major Drainage Line	Landscape 6: 'Flat Rocks' drainage system	Bat (echolocation) call recorder
						Targeted search
						Nocturnal search
MAC-07	-22.834696	118.799253	Newman	Undulating Low Hills	Landscape 4: Ironstone mountains, gorges and gullies	Targeted search
MAC-08	-22.812047	118.78386	Boolgeeda	Drainage Area/Floodplain	Landscape 5: Vegetated drainage systems	Acoustic (bird call) recording unit
MAC-09	-22.838609	118.807422	Newman	Breakaway	Landscape 4: Ironstone mountains, gorges and gullies	Bat (echolocation) call recorder
MAC-10	-22.720987	118.9732	McKay	Breakaway	Landscape 2: Low undulating ironstone hills	Motion camera
						Targeted search
MAC-11	-22.869663	118.792142	Newman	Breakaway	Landscape 4: Ironstone mountains, gorges and gullies	Bat (echolocation) call recorder
						Targeted search
MAC-12	-22.693803	118.873108	Calcrete	Drainage Area/Floodplain	Landscape 3: Low undulating calcrete hills and plains	Nocturnal search
MAC-13	-22.869623	118.792181	Newman	Gully	Landscape 4: Ironstone mountains, gorges and gullies	Nocturnal search
MAC-14	-22.803711	118.856312	Boolgeeda	Sandy/Stony Plain	Landscape 1: Floodplains	Nocturnal road spotting (south of rail)
MAC-15	-22.834966	118.784892	Newman	Hillcrest/Hillslope	Landscape 4: Ironstone mountains, gorges and gullies	Camera signal repeater
						Targeted search
MAC-16	-22.806798	118.820221	Newman	Hillcrest/Hillslope	Landscape 4: Ironstone mountains, gorges and gullies	Camera signal repeater
						Targeted search
MAC-17	-22.838094	118.807319	Newman	Breakaway	Landscape 4: Ironstone mountains, gorges and gullies	Motion camera
MAC-18	-22.720102	118.94867	Robe	Major Drainage Line	Landscape 5: Vegetated drainage systems	Motion camera
						Targeted search

Site ID	Latitude (°S)	Longitude (°E)	Land System	Dominant Landform	Fauna Landscape	Sampling Methods
MAC-19	-22.756314	118.893889	McKay	Hillcrest/Upper Hillslope	Landscape 2: Low undulating ironstone hills	Camera system cellbase
MAC-20	-22.852510	118.787678	Newman	Breakaway	Landscape 4: Ironstone mountains, gorges and gullies	Motion camera
						Bat (echolocation) call recorder
						Targeted search
MAC-21	-22.815282	118.842433	Newman	Breakaway	Landscape 4: Ironstone mountains, gorges and gullies	Motion camera
MAC-22	-22.815459	118.842089	Newman	Breakaway	Landscape 4: Ironstone mountains, gorges and gullies	Targeted search
MAC-23	-22.716492	118.968133	Oakover	Undulating Low Hills	Landscape 3: Low undulating calcrete hills and plains	Habitat assessment
MAC-24	-22.715065	118.858070	Boolgeeda	Drainage Area/Floodplain	Landscape 1: Floodplains	Acoustic (bird call) recording unit
MAC-25	-22.787853	118.782391	Boolgeeda	Drainage Area/Floodplain	Landscape 5: Vegetated drainage systems	Acoustic (bird call) recording unit
MAC-26	-22.776285	118.922756	Platform	Undulating Low Hills	Landscape 2: Low undulating ironstone hills	Habitat assessment
MAC-27	-22.720812	118.958217	Platform	Major Drainage Line	Landscape 5: Vegetated drainage systems	Bat (echolocation) call recorder
						Targeted search
MAC-28	-22.693594	118.920837	Boolgeeda	Major Drainage Line	Landscape 5: Vegetated drainage systems	Bat (echolocation) call recorder
						Targeted search
						Nocturnal search
MAC-29	-22.727971	118.849085	Boolgeeda	Drainage Area/Floodplain	Landscape 1: Floodplains	Habitat assessment
MAC-30	-22.863133	118.796407	Newman	Gully	Landscape 4: Ironstone mountains, gorges and gullies	Targeted search
MAC-31	-22.865838	118.791731	Newman	Breakaway	Landscape 4: Ironstone mountains, gorges and gullies	Bat (echolocation) call recorder
						Targeted search
MAC-32	-22.870131	118.792080	Newman	Breakaway	Landscape 4: Ironstone mountains, gorges and gullies	Bat (echolocation) call recorder
						Targeted search
MAC-33	-22.786476	118.827742	Boolgeeda	Drainage Area/Floodplain	Landscape 1: Floodplains	Acoustic (bird call) recording unit
MAC-34	-22.862753	118.793339	Newman	Gully	Landscape 4: Ironstone mountains, gorges and gullies	Targeted search
MAC-35	-22.707678	118.924708	Calcrete	Major Drainage Line	Landscape 5: Vegetated drainage systems	Bat (echolocation) call recorder
						Targeted search
MAC-36	-22.720876	118.971515	Oakover	Major Drainage Line	Landscape 3: Low undulating calcrete hills and plains	Targeted search
						Nocturnal search

Site ID	Latitude (°S)	Longitude (°E)	Land System	Dominant Landform	Fauna Landscape	Sampling Methods
MAC-37	-22.714425	118.876690	Oakover	Undulating Low Hills	Landscape 3: Low undulating calcrete hills and plains	Habitat assessment
MAC-38	-22.733441	118.869266	Boolgeeda	Major Drainage Line	Landscape 5: Vegetated drainage systems	Motion camera
MAC-39	-22.718600	118.933688	Platform	Major Drainage Line	Landscape 5: Vegetated drainage systems	Targeted search
MAC-40	-22.720892	118.972055	McKay	Major Drainage Line	Landscape 6: 'Flat Rocks' drainage system	Motion camera
MAC-41	-22.794806	118.805226	Boolgeeda	Drainage Area/Floodplain	Landscape 1: Floodplains	Habitat assessment
MAC-42	-22.701521	118.859154	Pindering	Drainage Area/Floodplain	Landscape 1: Floodplains	Habitat assessment
MAC-43	-22.735835	118.867953	Boolgeeda	Drainage Area/Floodplain	Landscape 5: Vegetated drainage systems	Habitat assessment
MAC-44	-22.689907	118.956001	Robe	Undulating Low Hills	Landscape 2: Low undulating ironstone hills	Habitat assessment
MAC-45	-22.812464	118.830623	Newman	Gully	Landscape 4: Ironstone mountains, gorges and gullies	Targeted search
						Nocturnal search
MAC-46	-22.813080	118.833951	Newman	Gully	Landscape 4: Ironstone mountains, gorges and gullies	Motion camera
						Targeted search
MAC-47	-22.815996	118.834014	Newman	Breakaway	Landscape 4: Ironstone mountains, gorges and gullies	Bat (echolocation) call recorder
						Targeted search
MAC-48	-22.819704	118.835441	Newman	Gorge	Landscape 4: Ironstone mountains, gorges and gullies	Bat (echolocation) call recorder
						Targeted search
MAC-49	-22.864819	118.791154	Newman	Breakaway	Landscape 4: Ironstone mountains, gorges and gullies	Motion camera
						Nocturnal search

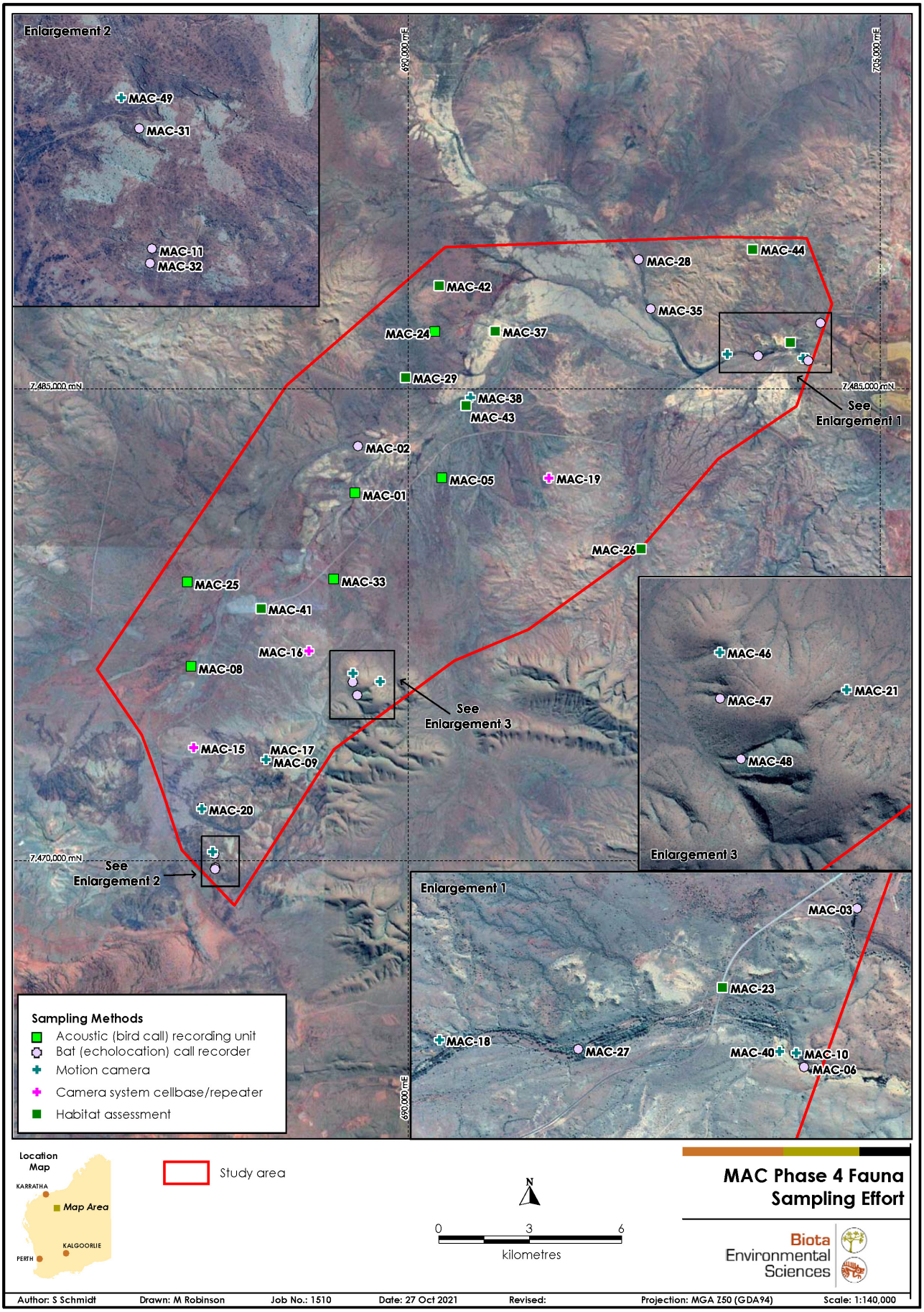

Figure 3.2: Vertebrate fauna point sampling sites in the study area.

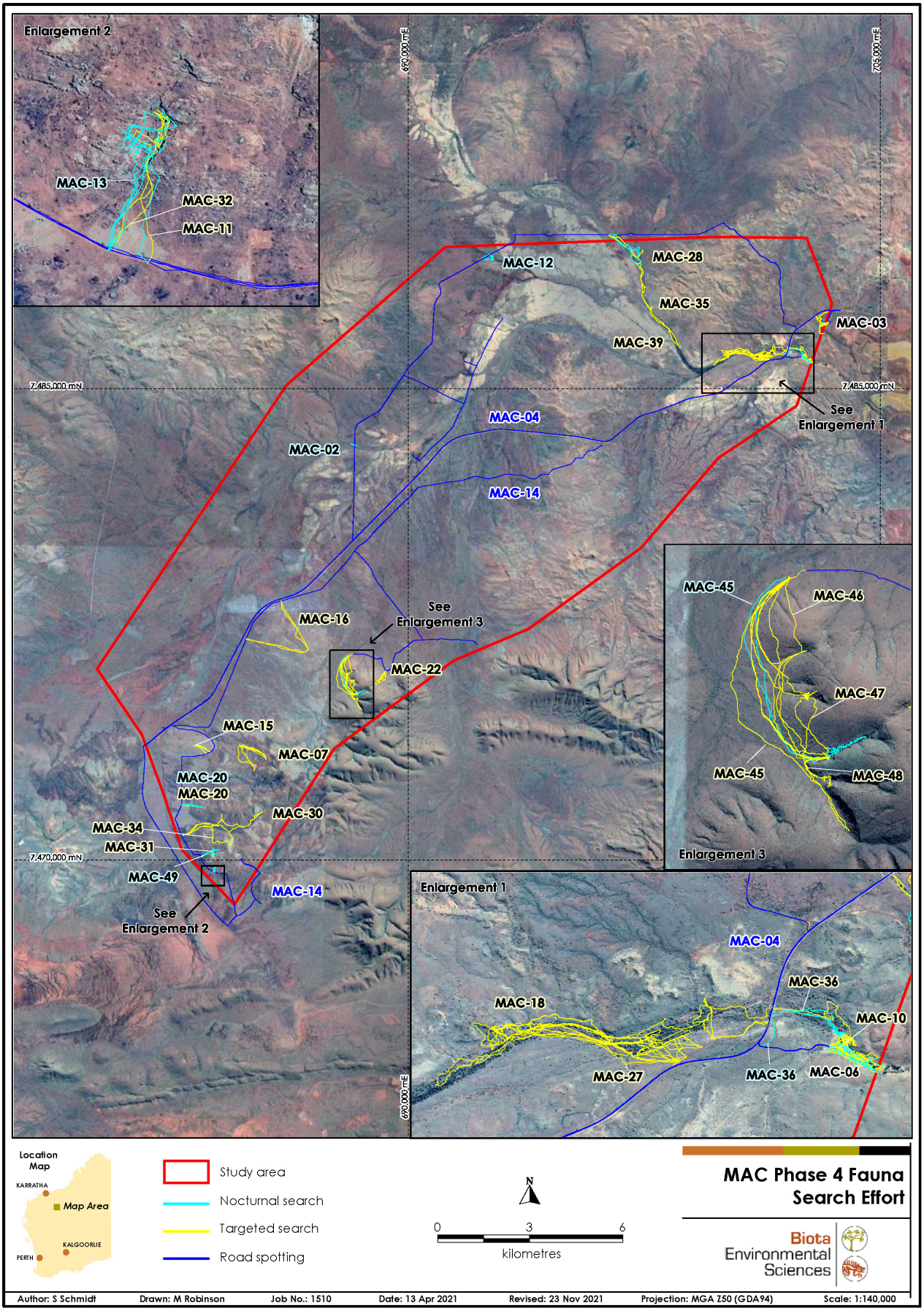

Figure 3.3: Vertebrate fauna targeted and nocturnal searches in the study area.

Table 3.6: Targeted search sites and effort.

Site	Landform(s) Searched	Date	Number of Zoologists	Distance (km)*
MAC-03	Drainage Area/Floodplain, Medium Drainage Line, Ephemeral Pools	18/11/20	2	1.1
		30/03/21	2	3.6
MAC-06	Major Drainage Line, Rock Pools, Breakaway	19/11/20	1	2.8
		21/11/20	1	1.3
		24/11/20	1	1.0
		26/03/21	1	0.8
		28/03/21	1	1.5
MAC-07	Undulating Low Hills	19/11/20	1	2.1
		22/11/20	1	4.1
		19/01/21	1	2.2
		27/03/21	2	4.6
MAC-10	Major Drainage Line, Breakaway, Hillslope	20/11/20	1	0.4
		19/01/20	1	1.4
MAC-11	Breakaway	19/11/20	1	0.6
MAC-15	Hillslope, Hillcrest/Upper Hillslope	21/11/20	1	1.3
		22/11/20	1	1.1
		19/01/21	1	1.1
MAC-16	Hillslope, Hillcrest/Upper Hillslope	21/11/20	1	4.3
		20/01/21	1	3.7
MAC-18	Major Drainage Line, Gully, Boulders/Rockpiles	22/11/20	1	1.9
		23/11/20	1	1.5
		23/11/20	1	1.3
		18/01/21	2	2.2
MAC-20	Breakaway, Footslope	23/11/20	1	1.3
		19/01/21	1	1.6
MAC-22	Breakaway, Footslope	21/11/20	1	0.9
		22/11/20	1	0.7
		23/11/20	1	1.9
		19/01/21	1	0.7
MAC-27	Major Drainage Line, Drainage Area/Floodplain, Ephemeral Pools	18/11/20	2	3.4
		22/11/20	1	3.2
		23/11/20	1	4.7
		24/11/20	1	2.3
		18/01/21	2	4.9
		19/01/21	1	3.5
		28/03/21	2	8.2
MAC-28	Major Drainage Line, Drainage Area/Floodplain, Ephemeral Pools	29/03/21	2	5.7
MAC-30	Gorge, Gully, Breakaway, Footslope, Boulders/Rockpiles	28/03/21	2	10.2
MAC-31	Gully, Footslope	19/01/21	1	1.7
MAC-32	Gully, Footslope	19/01/21	1	0.4
MAC-34	Gorge, Gully, Breakaway, Footslope, Boulders/Rockpiles	28/03/21	1	1.5
MAC-35	Major Drainage Line, Drainage Area/Floodplain, Ephemeral Pools	27/03/21	1	5.8
MAC-36	Major Drainage Line, Drainage Area/Floodplain, Ephemeral Pools, Breakaway, Hillslope	24/11/20	1	3.2
MAC-39	Major Drainage Line, Drainage Area/Floodplain, Ephemeral Pools	27/03/21	1	4.0

Site	Landform(s) Searched	Date	Number of Zoologists	Distance (km)*
MAC-45	Gorge, Gully, Breakaway, Footslope, Boulders/Rockpiles	27/03/21	2	3.0
		30/03/21	2	4.5
MAC-46	Gorge, Gully, Breakaway, Footslope, Boulders/Rockpiles	27/03/21	1	1.1
		30/03/21	2	1.6
MAC-47	Gorge, Gully, Breakaway, Footslope, Boulders/Rockpiles	27/03/21	2	3.5
		30/03/21	2	1.8
MAC-48	Gorge, Gully, Breakaway, Footslope, Boulders/Rockpiles	27/03/21	1	0.5
		30/03/21	2	1.4
* combined effort where two zoologists involved			**Total**	**133.1**

3.3.3.3 Nocturnal Searches

Nocturnal searches were conducted on foot at 10 sites with a total search effort of over 39 km walked (25.75 hours). Nocturnal searching was focused on three main areas – Marillana Creek, Flat Rocks and the rocky area in the south of the study area as these were the most prospective habitats to encounter the target species. The remaining area was mainly searched by road spotting to allow a larger area to be sampled. Road-spotting was conducted both north (MAC-04) and south (MAC-14) of the railway/road with a total of over 224 km.

Table 3.7 details each targeted search conducted and Figure 3.3 shows individual zoologist's tracks walked, and roads/tracks used for road spotting for each targeted and nocturnal search.

Table 3.7: Nocturnal search sites and effort.

Site	Landform	Date	Number of Zoologists	Distance (km)*
Foot traverses			**Total**	**39.1**
MAC-02	Medium Drainage Line	18/11/20	2	0.5
MAC-03	Drainage Area/Floodplain, Medium Drainage Line, Ephemeral Pools	26/03/21	2	2.5
MAC-06	Major Drainage Line, Rock Pools, Breakaway, HIllslope	18/11/20	2	1.9
		26/03/21	2	1.4
		27/03/21	2	2.2
		28/03/21	3	4.2
MAC-12	Drainage Area/Floodplain	20/11/20	2	3.0
MAC-13	Breakaway, Gully, Footslope	19/11/20	1	0.2
		26/03/21	2	1.3
MAC-20	Breakaway, Footslope	26/03/21	2	2.8
MAC-28	Major Drainage Line, Drainage Area/Floodplain, Ephemeral Pools	27/03/21	2	6.9
MAC-36	Major Drainage Line, Drainage Area/Floodplain, Ephemeral Pools, Breakaway, Hillslope	28/03/21	2	4.1
MAC-45	Gorge, Gully, Breakaway, Footslope, Boulders/Rockpiles	27/03/21	1	5.1
MAC-49	Breakaway, Gully, Footslope	26/03/21	2	3.0
Road Spotting			**Total**	**224.7**
MAC-04	Drainage Area/Floodplain, Undulating Low Hills, Minor Drainage Line, Sandy/Stony Plain	18/11/20	2	15.6
		19/11/20	1	54.8
		20/11/20	2	5.1
		26/03/21	2	64.5
		27/03/21	2	29.7
MAC-14	Drainage Area/Floodplain, Undulating Low Hills, Minor Drainage Line, Sandy/Stony Plain	19/11/20	1	2.7
		27/03/21	2	52.3

* combined effort where two people involved, roadspotting distance excludes travel where road outside study area boundary

3.3.3.4 Habitat Assessments

In addition to habitat assessments conducted at each sampling site, eight habitat assessments were conducted at additional locations throughout the study area (MAC-23, MAC-26, MAC-29, MAC-37, MAC-41-44), see Table 3.5, Figure 3.2, and Appendix 4.

3.3.3.5 Motion Cameras

Infrared motion cameras were deployed primarily to target ground-dwelling mammals, especially Northern Quoll. Cameras were set up at nine sites within the study area, mainly in gorges/gullies, and near water along breakaways and major drainage habitat (Table 3.8). A container of universal bait was placed on the ground in the camera's field of view to attract animals. Five cameras were deployed for two long-term sampling rounds, i.e. set up and baited during Phase 1 of the survey in late November 2020, and rebaited in January 2021. As no evidence of target species had been recorded, three long-term cameras were rebaited again in late March during Phase 2 of the survey (short, 3rd sampling round), and four additional cameras were deployed in the most prospective habitat for three to four additional nights. In total, nine motion cameras were deployed for a total of 645 nights over four months (Table 3.8).

Table 3.8: Remote camera sites and effort.

Site	Landform	Sampling Round	(Re)baited Date	Sampling Nights
MAC-10	Breakaway	1	21/11/20	59
		2	19/01/21	66
		3	26/03/21	2
MAC-17	Breakaway	1	22/11/20	58
		2	19/01/21	67
		3	27/03/21	2
MAC-18	Major Drainage Line	1	22/11/20	57
		2	18/01/21	69
MAC-20	Breakaway	1	23/11/20	57
		2	19/01/21	66
		3	26/03/21	2
MAC-21	Breakaway	1	23/11/20	57
		2	19/01/21	69
MAC-38	Major Drainage Line	1	26/03/21	4
MAC-40	Major Drainage Line	1	26/03/21	4
MAC-46	Gully	1	27/03/21	3
MAC-49	Breakaway	1	26/03/21	3
			Total	**645**

3.3.3.6 Bat Echolocation Call Recorders

Sampling was conducted within the study area to target potentially occurring MNES bat species (Ghost Bat and Pilbara Leaf-nosed Bat). Echolocation calls were recorded using SM4 FS BAT SongMeters, and SM4mini SongMeters, which detect and record ultrasonic echolocation calls emitted during bat flight. The selectable filters and triggers, jumper and audio settings used followed the manufacturer's recommendations for bat detection (Wildlife Acoustics 2010, 2019).

Sampling was undertaken at 13 locations, with SongMeters recording for a total of 165 sampling nights from twelve locations (no data from MAC-09, see Table 3.9). Data from eight locations, totaling 65 sampling nights, were obtained using SM4mini units. Data subsequently indicate that these are less effective at detecting the high frequency calls of Pilbara Leaf-nosed Bats than SM4 FS Bat units (B. Bullen, pers. comm., Biota's own research; see also Section 3.4 and Section 5.2.2).

The SongMeters were placed in locations considered likely to provide records of target species, including fresh water, potential flyways through drainage lines and along breakaways and gorges or gullies, and at cave entrances (Table 3.9).

Bat echolocation call analysis was conducted by Dan Kamien of Biota using Kaleidoscope Pro software (version 5.0.3), and following methods recommended by the Australasian Bat Society (2006) in conjunction with available reference data (Churchill 2008, McKenzie and Bullen 2009). Only sequences containing good quality search phase calls were considered for identification.

Table 3.9: Bat sampling sites and effort.

Site	Landform	Water/ Cave	Sampling Round	Recording Unit	Date Deployed	Sampling Nights
MAC-02	Major Drainage Line	Water	1	SM4Bat FS	18/11/20	32
MAC-03	Major Drainage Line	Water	1	SM4mini	26/03/21	2
MAC-06	Major Drainage Line	Water	1	SM4mini	26/03/21	4
MAC-09	Breakaway	-	1	SM4mini	19/11/20	-*
MAC-11	Breakaway	Cave	1	SM4mini	19/11/20	18
MAC-20	Breakaway	-	1	SM4mini	26/03/21	3
MAC-27	Major Drainage Line	Water	1	SM4Bat FS	24/11/20	13
			2	SM4Bat FS	19/01/21	25
MAC-28	Major Drainage Line	Water	1	SM4Bat FS	27/03/21	2
MAC-31	Breakaway	Cave	1	SM4mini	19/01/21	17
MAC-32	Breakaway	Cave	1	SM4mini	19/01/21	15
MAC-35	Major Drainage Line	Water	1	SM4Bat FS	20/01/21	28
MAC-47	Breakaway	Cave	1	SM4mini	27/03/21	3
MAC-48	Gorge	Cave	1	SM4mini	27/03/21	3
					Total	**165**

* SD card corrupted, data could not be read after collection.

3.3.3.7 Acoustic Recording Units

The Interim Guideline for Preliminary Surveys of the Night Parrot (*Pezoporus occidentalis*) (DBCA 2017b) recommends passive acoustic surveys as an effective low impact survey method. SM4 Mini SongMeter Acoustic Recording Units were deployed in the most prospective areas within the study area (predominantly *Triodia* grassland with large hummocks), and set to record from dusk until dawn, to detect Night Parrot calls. Sampling was undertaken at six locations with SongMeters recording for a total of 87 sampling nights (Table 3.10). Recorders deployed in November 2020 and January 2021 were left deployed until batteries were depleted. At two sites (MAC-05 and MAC-08), batteries were depleted before six consecutive nights were recorded.

Audio files were analysed by John Graff of Biota using SongScope software (version 4.1.5), with a recogniser built using Night Parrot calls recorded in Western Australia (calls sourced from https://nightparrot.com.au/index.php/resources/night-parrot-calls). Potential matches were then assessed manually by visually inspecting the spectra and listening to the recordings.

Table 3.10: Night Parrot sampling sites and effort.

Site	Landform	Sampling Round	Date Deployed	Sampling Nights
MAC-01	Drainage Area/Floodplain	1	18/11/20	10
MAC-05	Sandy/Stony Plain	1	19/11/20	5
MAC-08	Drainage Area/Floodplain	1	20/11/20	4
		2	19/01/21	43
MAC-24	Drainage Area/Floodplain	1	25/03/21	6
MAC-25	Drainage Area/Floodplain	1	25/03/21	6
MAC-33	Drainage Area/Floodplain	1	20/01/21	13
			Total	**87**

3.3.4 Habitat Mapping

Vertebrate fauna habitats of the study area were identified and mapped based on Biota's fauna landscape approach (Biota 2013), which characterises habitats based on functional landforms within a broader landscape. Preliminary fauna habitat descriptions were based on land systems,

as the main framework, as these are mapped more widely at regional scale, and additionally considered available digital aerial imagery, contour mapping, regional vegetation mapping and surface geology in order to validate and inform the extent of identified habitats.

Fauna landscapes, while not necessarily equating to the distribution of any single species, offer a parallel grouping of landforms and substrates comprising a suite of ecological niches distinct from those in other landscapes.

Preliminary desktop-based habitat mapping was ground-truthed in the field and revised after the survey. This included identification and classification of potential critical habitat for MNES species, adopting criteria aligned with the broad criteria used by DAWE (DotE 2013, 2016), and as inferred from previous controlled action decisions for Pilbara mining projects (see Section 5.2.3.

During the survey, habitat assessment data were collected at each vertebrate fauna sampling site (41sites), and at eight additional (habitat assessment-only) locations throughout the study area in accordance with BHP WAIO's data requirements (SPR-IEN-EMS-015), including dominant fauna habitat type at the location, selected from prescribed values (see Appendix 4). Additional information collected included dominant vegetation, site pictures and other relevant data, in accordance with BHP WAIO's vertebrate fauna survey guidance (SPR-IEN-EMS-012 section 3.7).

All sampling sites were then assigned to a land system and fauna landscape to place these into broader context within the study area and locality, and the more detailed attributes documented for each sampling site provided for finer scale habitat assessment and fauna landscape mapping. Fauna landscapes are presented alongside BHP fauna habitat types for cross-reference in the relevant sections, as well as Figure 5.1, Table 5.1 and Appendix 4).

3.4 Study Limitations

In accordance with the EPA Technical Guidance 'Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment' (EPA 2020) potential constraints and limitations of the survey are addressed in Table 3.1.

Table 3.11: Potential constraints and limitations of the fauna survey.

Potential Constraint	Statement of Limitations
1. Availability of contextual information	• There is abundant contextual information available on a regional level and there has been adequate recent vertebrate fauna survey effort in the study area locality, including five recent surveys multi-phase systematic surveys and three single-phase targeted and Level 1 surveys. • These previous surveys were conducted in the north, south, east and west of the study area in similar habitats or overlapping with the study area. • Local level contextual information was not a limiting factor for this study.
2. Competency and experience of survey team	• The field survey team consisted of two senior zoologists with over 15 years of experience each and two zoologists (Phase 2 only) with multiple years of experience each, including numerous similar surveys in the Pilbara bioregion. • Required resources were available. • There were therefore no limitations due to resourcing or experience.
3. Proportion of fauna recorded and any identification issues	• A two-phase MNES targeted vertebrate fauna survey of the study area was required and this was adequately completed in accordance with relevant guidance documents, with passive recording units (cameras, bird/bat call recorders) deployed for longer than the minimum requirements. • Data from one bat recorder was not retrievable due to card corruption. • Use of SM4minis to record bats during 65 of 165 sampling nights may have resulted in lower than expected detection probability for Pilbara Leaf-nosed Bats at some sites (reduced sensitivity to high-frequency calls in SM4minis compared to SM4Bat FS bat call recorders, detailed discussion of results, see Section 5.2.2). • identification of fauna considered to be a minor limitation due to potential bat recorder equipment issues.

Potential Constraint	Statement of Limitations
4. Appropriate area fully surveyed	• The study area was surveyed thoroughly with 41 sampling sites assessed, some more than once, in addition to eight habitat assessment sites, and extensive foot traverses completed both during the day (over 121 km) and at night (over 39 km) with important areas searched on multiple occasions. • Sampling techniques and effort were adequate to inform future environmental impact assessment. • Survey techniques and effort were in accordance with or exceeding those outlined in relevant guidance documents (Section 3.3.1). • Survey effort and extent is not considered to be a limitation.
5. Access constraints	• The majority of the study area was not accessible by vehicle as usable tracks were limited and access to some areas was limited/prohibited due to construction/drilling. • Due to limited vehicle track access, in the majority of the study area only areas accessible on foot from vehicle tracks could be searched, sampled, assessed. • The railway dividing the study area was only able to be crossed during certain times (Phase 1 and site visit) during the day and not at all during Phase 2, impacted efficient use of survey time/sampling at times. • Major construction (powerline) limited access within the northern part of the study area. • Only male team members could access an area in the southeast of the study area due to Heritage restrictions (male-only access). • Access to the entire study area is considered to be a minor limitation due to the extent of area having to be covered on foot.
6. Survey timing, rainfall and season	• Historical climate data were not available for the study area, and had to be taken from the closest weather station located approximately 120 km to the southeast. • Seasonal survey timing and conditions including rainfall prior to survey were optimal and not considered to be a limitation.
7. Disturbance that may have affected the survey results	• Most of the study area was undisturbed with only a small proportion cleared. • Disturbance was not considered to be a limitation.

4.0 Desktop Study

4.1 Regional Context of the Study area

4.1.1 IBRA Bioregion and Subregion

The study area lies within the Pilbara bioregion, one of 89 bioregions defined by the Interim Biogeographic Regionalisation for Australia (IBRA) (DSEWPaC 2012). The Pilbara bioregion is divided into four subregions. The study area lies within the Hamersley subregion (PIL3), more specifically in the northeast of the subregion, near the border of the adjacent Fortescue Plains subregion. The Hamersley subregion is described by Kendrick (2001) as follows:

> "PIL3 is the Southern section of the Pilbara Craton. Mountainous area of Proterozoic sedimentary ranges and plateau, dissected by gorges (basalt, shale and dolerite). Mulga low woodland over bunch grasses on fine textured soils in valley floors, and *Eucalyptus leucophloia* over *Triodia brizoides* on skeletal soils of the ranges. The climate is Semi-desert tropical, average 300mm rainfall, usually in summer cyclonic or thunderstorm events. Winter rain is not uncommon. Drainage into either the Fortescue (to the north), the Ashburton to the south, or the Rove to the west. Subregional area is 6,215,092 ha."

4.1.2 Land Systems

A total of 105 land systems have been identified and mapped in the Pilbara bioregion[3]. Land systems mapping covering the study area has been prepared by Payne et al. (1988). The study area is dominated by the Boolgeeda land system, covering almost 50%, however it intersects seven additional land systems (Platform, McKay, Newman, Calcrete, Oakover, Robe, and Pindering), as summarised in Table 4.1 and shown in Figure 4.1.

All of these land systems are widespread and well-represented in the Pilbara bioregion with the land system with the smallest extent in the Pilbara, Pindering, comprising over 35 km^2. The study area contains only a very small proportion of the regional extents of the land systems it intersects, with extents ranging from 0.2 % (Newman) to 2.2 % (Platform) of the total Pilbara extent (Table 4.1).

Table 4.1: Land systems intersected by the study area.
(Data from Payne et al. 1988, and van Vreeswyk et al. 2004.)

Land System	Description	Total Area of Land System in the Pilbara Bioregion (ha)	Extent within Study Area (ha) & Proportion of Study Area	Proportion of Total Land System that occurs in the Study Area
Boolgeeda (RGEBGD)	Stony lower slopes and plains below hill systems supporting hard and soft spinifex grasslands or mulga shrublands.	777,800	10,687 (45.6%)	1.4%
Platform (RGEPLA)	Dissected slopes and raised plains supporting hard spinifex grasslands.	157,000	3,386 (14.5%)	2.2%
McKay (RGEMCK)	Hills, ridges, plateaux remnants and breakaways of meta sedimentary and sedimentary rocks supporting hard spinifex grasslands.	420,200	2,982 (12.7%)	0.7%

[3] This information was obtained by merging the Ashburton land system mapping (Payne et al. 1988) and Pilbara land system mapping (van Vreeswyk et al. 2004) and intersecting this with the Pilbara bioregion (Environment Australia 2000).

Land System	Description	Total Area of Land System in the Pilbara Bioregion (ha)	Extent within Study Area (ha) & Proportion of Study Area	Proportion of Total Land System that occurs in the Study Area
Newman (RGENEW)	Rugged jaspallite plateaux, ridges and mountains supporting hard spinifex grasslands.	1,458,000	2,239 (9.6%)	0.2%
Calcrete (RGECAL)	Low calcrete platforms and plains supporting shrubby hard spinifex grasslands.	144,400	1,655 (7.1%)	1.1%
Oakover (RGEOAK)	Breakaways, mesas, plateaux and stony plains of calcrete supporting hard spinifex grasslands.	152,900	1,317 (5.6%)	0.9%
Robe (RGEROB)	Low plateaux, mesas and buttes of limonites supporting soft spinifex (and occasionally hard spinifex) grasslands.	86,500	719 (3.1%)	0.8%
Pindering (REGPDG)	Gravelly hardpan plains supporting groved mulga shrublands with hard and soft spinifex.	35,100	438 (1.9%)	1.2%

4.1.3 Surface Geology

Nine surface geology units occur within the study area (Geological Survey of Western Australia 1996) (Figure 4.2 and Table 4.2). The majority of the study area (>66%) is dominated by alluvial and colluvial sediment (Czc, Qw, Qa, Qc). The remaining extent is dominated by, and roughly equally divided between banded iron-formations (>18%; PLHj, PLHb) in the southern part of the study area and calcrete-sheet carbonate (14.7%; Czk) in the north. The surface geology of the study area is broadly typical of this area of the Pilbara bioregion (Thorne and Trendall 2001).

Table 4.2: Geological units of the study area.

Code	Geological Description	Extent within Study Area (ha) & Proportion of Study Area
Czc	Colluvium – partly consolidated quartz and rock fragments in silt and sand matrix; old valley-fill deposits.	8,996.9 (38.4%)
Qw	Alluvium and colluvium – red-brown sandy and clayey soil; on low slopes and sheetwash areas.	4,164.2 (17.8%)
Czk	Calcrete-sheet carbonate; found along major drainage lines.	3,436.3 (14.7%)
PLHj	WEELI WOLLI FORMATION: banded iron formation (commonly jaspilitic), pelite, and numerous metadolerite sills.	2,423.8 (10.3%)
Qa	Alluvium – unconsolidated silt, sand, and gravel; in drainage channels and on adjacent floodplains.	2,269.0 (9.7%)
PLHb	BROCKMAN IRON FORMATION: banded iron-formation, chert, and pelite.	1,899.6 (8.1%)
Czp	ROBE PISOLITE: pisolitic limonite deposits developed along river channels.	131.7 (0.6%)
Qc	Colluvium – unconsolidated quartz and rock fragments in soil; locally derived soil, and scree, and talus deposits.	101.0 (0.4%)
Czl	Lateritic deposits – massive and pisolitic ferruginous duricrust.	0.9 (<0.01%)

4.1.4 Vegetation

Beard (1975b, 1975a) described and mapped the vegetation of the Pilbara at a scale of 1:1,000,000. The study area lies within the Fortescue Botanical District (generally characterised by tree and shrub steppes) of the Eremaean Botanical Province as defined by Beard (1975b, 1975a). The vegetation of this province is typically open, and frequently dominated by spinifex, wattles and occasional eucalypts.

The study area intersects two Beard vegetation units (Table 4.3 and Figure 4.3). Both vegetation units are widespread in the Hamersley subregion and have been subject to limited clearing.

Table 4.3: Beard's vegetation units in the study area.

Vegetation Unit	Description	Extent within Study Area (ha) & Proportion of Study Area
Hammersley 18	Low woodland, open low woodland or sparse woodland; Mulga *Acacia aneura*	518,255.5 (77.9%)
Hammersley 82	Low tree-steppe; Hummock grassland with scattered bloodwoods and snappy gum, *Triodia* spp., *Corymbia dichromophloia*, *Eucalyptus leucophloia*.	5,168.0 (22.1%)

The study area is dominated by low/open low mulga (*Acacia aneura*) woodland (Hamersley 18), with associated species being mainly acacias. This is the most widespread vegetation type in Western Australia (vegetation type 8, (Beard et al. 2013). The extent of the second vegetation unit, low tree-steppe of scattered bloodwood and snappy gum over *Triodia* spp. hummock grassland (Hamersley 82), is approximately aligned with Newman and MacKay land system areas within the study area. This vegetation type (vegetation type 35) is the third most extensive vegetation type in Western Australia and dominates the Pilbara Bioregion (Beard et al. 2013).

4.1.5 Conservation Reserves in the Locality

The closest DBCA managed land is Karijini National Park, approximately 20 km to the west of the study area.

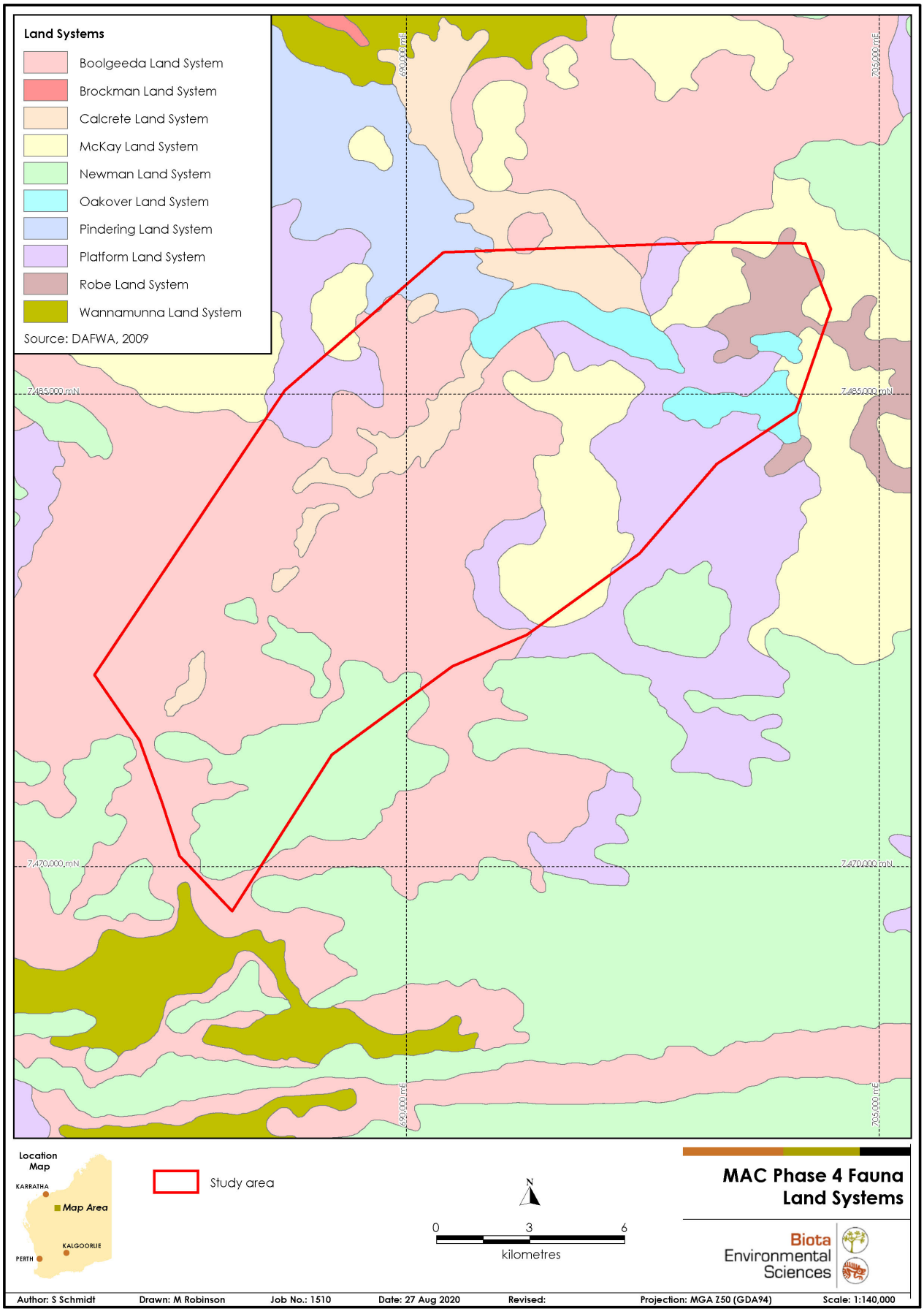

Figure 4.1: Land systems of the study area.

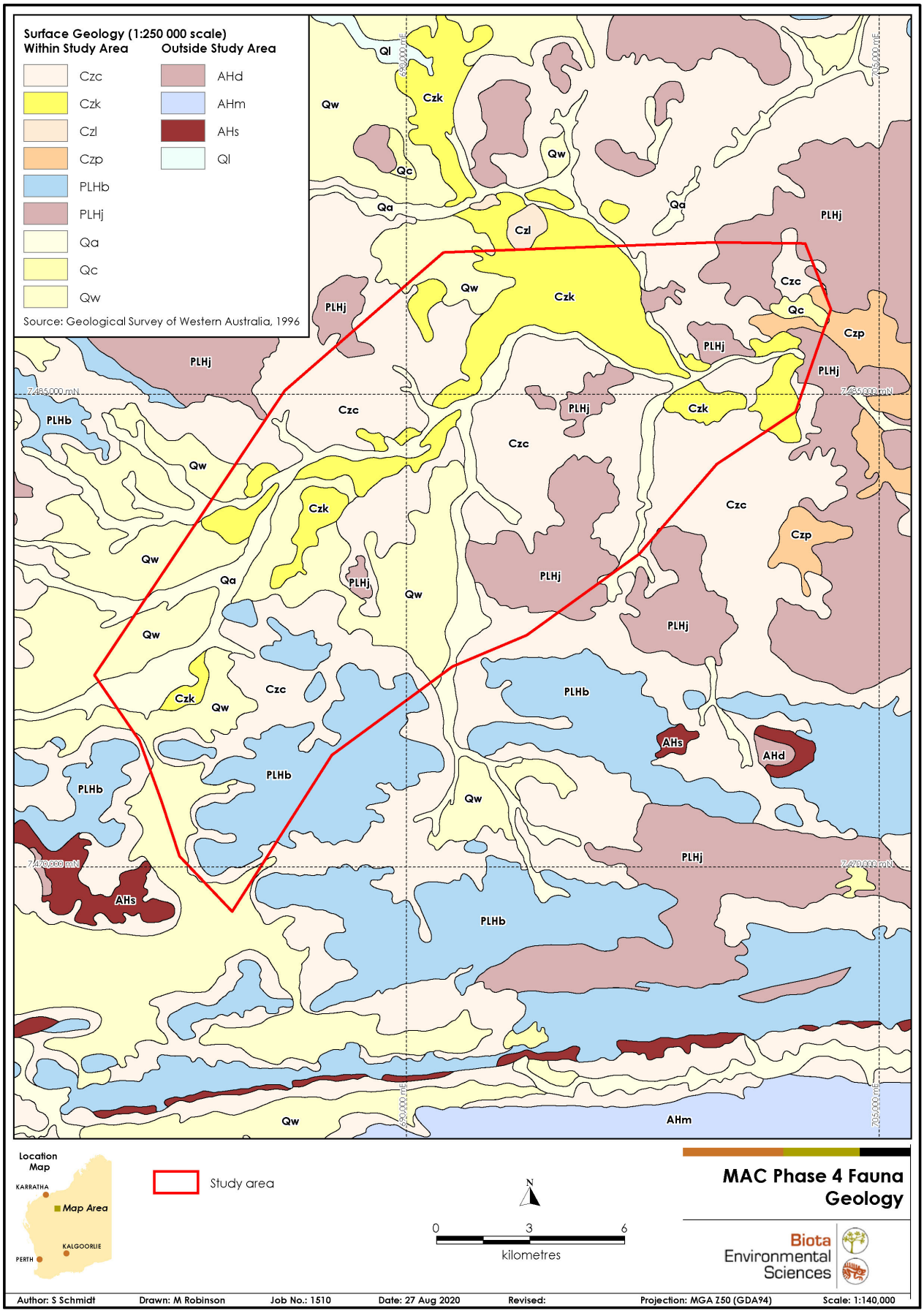

Figure 4.2: Surface geology of the study area.

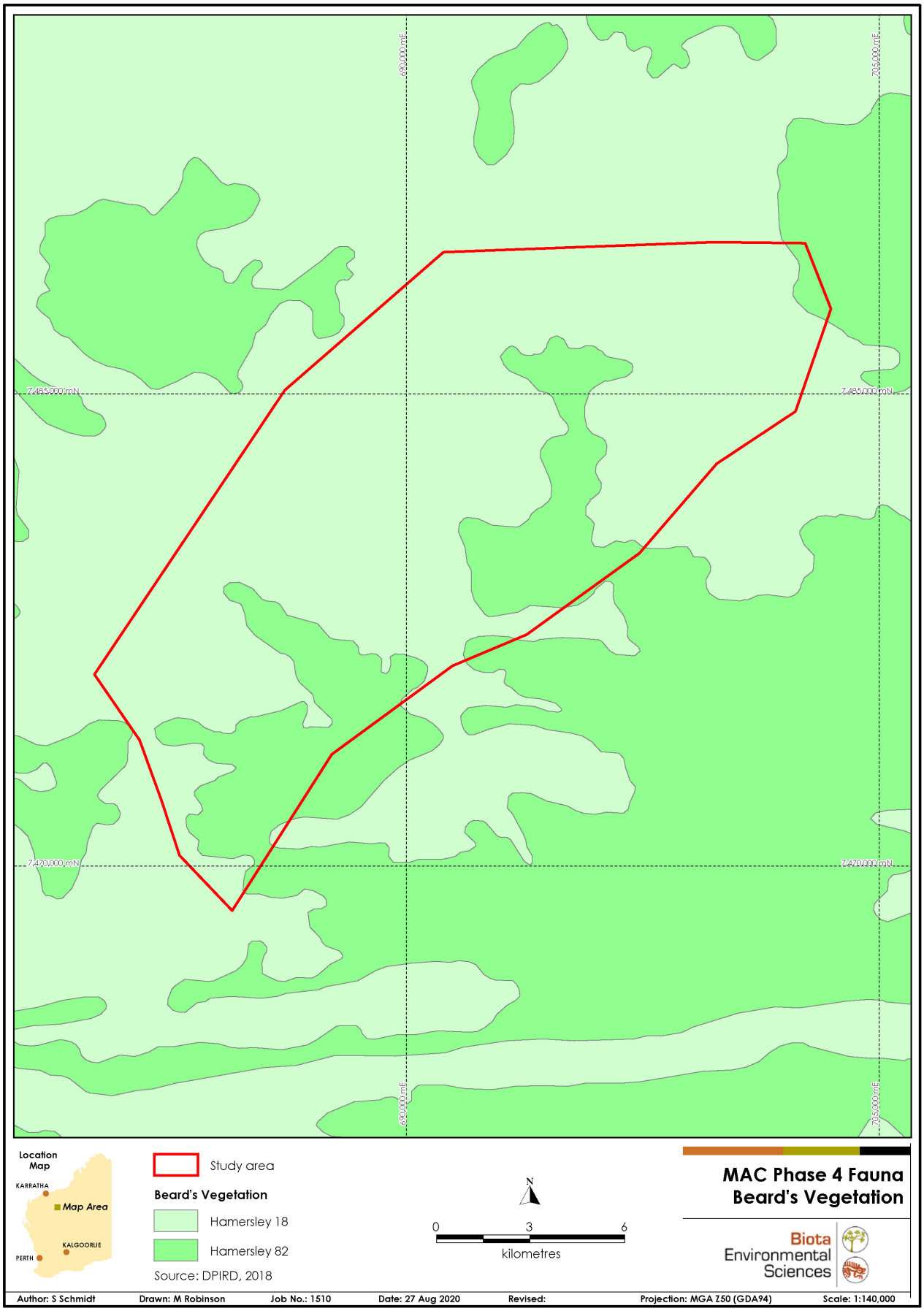

Figure 4.3: Beard's vegetation units of the study area.

4.2 Database Searches and Previous Fauna Surveys

Previous surveys conducted in the locality (within 40 km of the study area) are summarised in Table 4.4, Table 4.5, and Figure 4.4, with detailed results of the literature review and database searches are provided in Appendix 1 (including taxonomic and nomenclature changes).

Table 4.4: Vertebrate species identified from the desktop study.

Vertebrate Fauna Group	Number of Species	Number of Significant Species
Ground mammals	33	5
Bats	14	2
Amphibians	8	0
Reptiles	119	4
Birds	158	18
Total	**332**	**29**

A total of 332 vertebrate species were identified as potentially occurring in the locality of the study area, based on the results of the desktop study (Table 4.4, Appendix 1). Of these, 21 are MNES fauna species which are also listed at State level, and eight species are only listed at State level and thus were not targeted by this survey (Table 4.6). As there are no marine environs present within or in the locality of the study area, and many Marine-listed bird species are listed erroneously, these are excluded from further discussion in this report. Where conservation status changes have occurred for species recorded during previous surveys since the time of those studies, details are included in Table 4.5 (see also Appendix 1).

The likelihood of occurrence of significant taxa in the study area was assessed after the survey, taking into account the results (see Table 5.3).

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Table 4.5: Summary of previous relevant surveys conducted in the locality of the study area.

Survey (Reference)	Survey Timing & Type	Seasonal Conditions	Fauna Survey Techniques & Effort	Summary of Species Richness	Significant Species Recorded (based on current listings; MNES species in bold)	Limitations
Koodaideri Iron Ore Project Vertebrate Fauna Integration Report (Biota 2012a)	August 2010 – May 2012 Series of eight vertebrate fauna surveys	Various	Pit & funnel trap lines, Elliott traps, Nocturnal searches & road spotting, Active foraging, Targeted searches, Ultrasonic recorders, Harp traps, Infrared motion cameras, Systematic avifauna census, Opportunistic records, Identification of secondary trace signs (incl. tracks, scats, diggings etc.) and roadkill/other remains	223 vertebrate taxa: 22 non-volant mammal, 14 bat, 3 amphibian, 89 reptile and 95 bird species.	• **Endangered Northern Quoll**, *Dasyurus hallucatus* • **Vulnerable Pilbara Olive Python** *Liasis olivaceus barroni* • **Vulnerable Pilbara Leaf-nosed Bat**, *Rhinonicteris aurantia* (Endangered/Priority 1 at time of survey) • **Vulnerable Ghost Bat**, *Macroderma gigas* (Priority 4 at time of survey) • **Vulnerable Grey Falcon**, *Falco hypoleucos* (Priority 4 at time of survey) • **Migratory Pacific Swift**, *Apus pacificus*[1] • Other specially protected Peregrine Falcon, *Falco peregrinus* (Schedule 4 at time of survey) • Priority 4 Western Pebble-mound mouse *Pseudomys chapmani* • Priority 1 *Anilios ganei*[2]	Not every section of the study area was ground-truthed or systematically sampled. Parts of the study area were inaccessible by vehicle or helicopter.
Yandi Terrestrial Fauna Integration Report (Biota 2015)	March 1994, August 2003 – September 2014 Review of 14 vertebrate fauna surveys	Various	Pit & funnel trap lines, Elliott traps, Nocturnal searches & road spotting, Active foraging, Targeted searches, Ultrasonic recorders, Harp traps, Infrared motion cameras, Systematic avifauna census, Opportunistic records, Identification of secondary trace signs (incl. tracks, scats, diggings etc.) and roadkill/other remains	206 vertebrate taxa: 21 non-volant mammal, 10 bat, 3 amphibian, 69 reptile and 103 bird species.	• **Vulnerable Pilbara Olive Python** *Liasis olivaceus barroni* • **Migratory Pacific Swift**, *Apus pacificus*[1] • Other specially protected Peregrine Falcon, *Falco peregrinus* (Schedule 4 at time of survey) • Priority 4 Brush-tailed Mulgara, *Dasycercus blythi* • Priority 4 Western Pebble-mound mouse *Pseudomys chapmani*	Not every section of the study area was ground-truthed or systematically sampled. Parts of the study area were inaccessible by vehicle.
Area C West to Yandi Level 2 Vertebrate Fauna Survey (Biota 2013b)	May/June 2011 September 2011 February 2012 Three-phase Level 2 systematic survey	Phase 1& 3 wetter, Phase 2 drier than average conditions	Pit & funnel trap lines, Elliott traps, Nocturnal searches & road spotting, Active foraging, Targeted searches, Ultrasonic recorders, Harp traps, Systematic avifauna census, Opportunistic records, Identification of secondary trace signs (incl. tracks, scats, diggings etc.) and roadkill/other remains	172 vertebrate taxa: 14 non-volant mammal, 14 bat, 3 amphibian, 57 reptile and 84 bird species.	• **Vulnerable Pilbara Leaf-nosed Bat**, *Rhinonicteris aurantia* (Endangered/Priority 1 at time of survey) • **Migratory Common Greenshank,** *Tringa nebularia* • Other specially protected Peregrine Falcon, *Falco peregrinus* (Schedule 4 at time of survey) • Priority 4 Western Pebble-mound mouse *Pseudomys chapmani*	Not every section of the study area was ground-truthed or systematically sampled. Parts of the study area were inaccessible by vehicle.
South Flank to Jinidi Level 2 Vertebrate Fauna Survey (Biota 2012b)	April 2011 November 2011 February 2012 Three-phase Level 2 systematic survey	Above-average rainfall, average temperature	Pit & funnel trap lines, Elliott traps, Nocturnal searches & road spotting, Active foraging, Targeted searches, Ultrasonic recorders, Harp traps, Systematic avifauna census, Opportunistic records, Identification of secondary trace signs (incl. tracks, scats, diggings etc.) and roadkill/other remains	173 vertebrate taxa: 14 non-volant mammal, 12 bat, 5 amphibian, 63 reptile and 79 bird species.	• **Vulnerable Ghost Bat**, *Macroderma gigas* (Priority 4 at time of survey) • Priority 2 Pilbara Barking Gecko *Underwoodisaurus seorsus* (not significant at time of survey) • Priority 4 Western Pebble-mound mouse *Pseudomys chapmani*	Not every section of the study area was ground-truthed or systematically sampled. Parts of the study area were inaccessible by vehicle, incl. Oakover land system, therefore, a systematic sampling site was placed just outside the South Flank to Jinidi study area, as a proxy for this habitat type within the study area
Koodaideri Mining Lease Additional Areas Targeted Fauna Survey (Biota 2013c)	May 2013 Single-phase targeted fauna survey	Consistent with long-term conditions	Elliott traps, Nocturnal searches Active foraging, Targeted searches, Ultrasonic recorders, Harp traps, Infrared motion cameras, Opportunistic records, Identification of secondary trace signs (incl. tracks, scats, diggings etc.) and roadkill/other remains	32 vertebrate taxa: 7 non-volant mammal, 9 bat, 1 amphibian, 8 reptile and 7 bird species.	• **Endangered Northern Quoll**, *Dasyurus hallucatus* • **Vulnerable Pilbara Leaf-nosed Bat**, *Rhinonicteris aurantia* (Endangered/Priority 1 at time of survey) • **Vulnerable Ghost Bat**, *Macroderma gigas* (Priority 4 at time of survey) • Priority 4 Western Pebble-mound mouse *Pseudomys chapmani*	Terrestrial vertebrate and invertebrate sampling was targeted at a small number of significant taxa and specific groups. Collection of other taxa was largely opportunistic. Additional effort would have likely resulted in additional species

Survey (Reference)	Survey Timing & Type	Seasonal Conditions	Fauna Survey Techniques & Effort	Summary of Species Richness	Significant Species Recorded (based on current listings; MNES species in bold)	Limitations
Area C West Vertebrate Survey (Biologic 2013)	April/May 2011 September/ October 2011 January 2012 Two phase Level 2 systematic survey, with additional spotlighting survey	Above average summer rainfall, below average winter rainfall, average temperatures	Pitfall & funnel trap lines, Elliott & cage traps, Nocturnal searches & road spotting, Active foraging. Targeted searches. Ultrasonic recorders, Systematic avifauna census, Infrared motion cameras, Opportunistic records Identification of secondary trace signs (incl. tracks, scats, diggings etc.) and roadkill/other remains	213 vertebrate taxa; 31 mammal, 3 amphibian, 79 reptile and 100 bird.	• **Endangered Northern Quoll**, *Dasyurus hallucatus* • **Vulnerable Ghost Bat**, *Macroderma gigas* (Priority 4 at time of survey) • **Vulnerable Pilbara Olive Python** *Liasis olivaceus barroni* • **Migratory Wood Sandpiper**, *Tringa glareola* • Priority 4 Western Pebble-mound mouse *Pseudomys chapmani* • Priority 4 Short-tailed Mouse *Leggadina lakedownensis* • Other specially protected Peregrine Falcon, *Falco peregrinus*	Prevailing dry conditions may have reduced capture rates.
MAC4 Pipeline Level 1 Vertebrate Fauna Assessment (Biologic 2019)	November 2018 Single phase Level 1 fauna survey	Below-average rainfall in preceding four months, average temperature.	Targeted searches, Opportunistic records Identification of secondary trace signs (incl. tracks, scats, diggings etc.) and roadkill/other remains	11 vertebrate taxa; 1 mammal, 2 reptile and 8 bird.	• Priority 4 Western Pebble-mound mouse *Pseudomys chapmani*	None relevant
Upper Marillana and Munjina Flora, Vegetation and Fauna Assessment (ENV 2011)	August/ September 2010 Single phase opportunistic survey	Below-average rainfall, average temperature	Opportunistic records Identification of secondary trace signs (incl. tracks, scats, diggings etc.) and roadkill/other remains	3 vertebrate taxa; 1 mammal, 2 bird.	• Priority 4 Western Pebble-mound mouse *Pseudomys chapmani*	Only fauna of significance recorded. Both bird species recorded are no longer of significance.
Yandi Vertebrate Fauna Review (Biologic 2011)	December 2010 Single phase Level 1 survey	Average temperature, rainfall during survey	Active foraging, Targeted searches, Ultrasonic recorders, Infrared motion cameras, Opportunistic records, Identification of secondary trace signs (incl. tracks, scats, diggings etc.) and roadkill/other remains	75 vertebrate taxa; 5 non-volant mammal, 3 bat, 2 amphibian, 12 reptile and 53 bird.	• **Vulnerable Pilbara Olive Python** *Liasis olivaceus barroni* • **Migratory Pacific Swift**, *Apus pacificus*[1] • Priority 4 Western Pebble-mound mouse *Pseudomys chapmani*	Access to areas deemed to have significant heritage value was denied. The north eastern corner of the study area was inaccessible for this reason. Nocturnal work did not occur.

[1] Listed as Fork-tailed Swift *Apus pacificus* at time of survey

[2] Listed as *Ramphotyphlops ganei* at time of survey

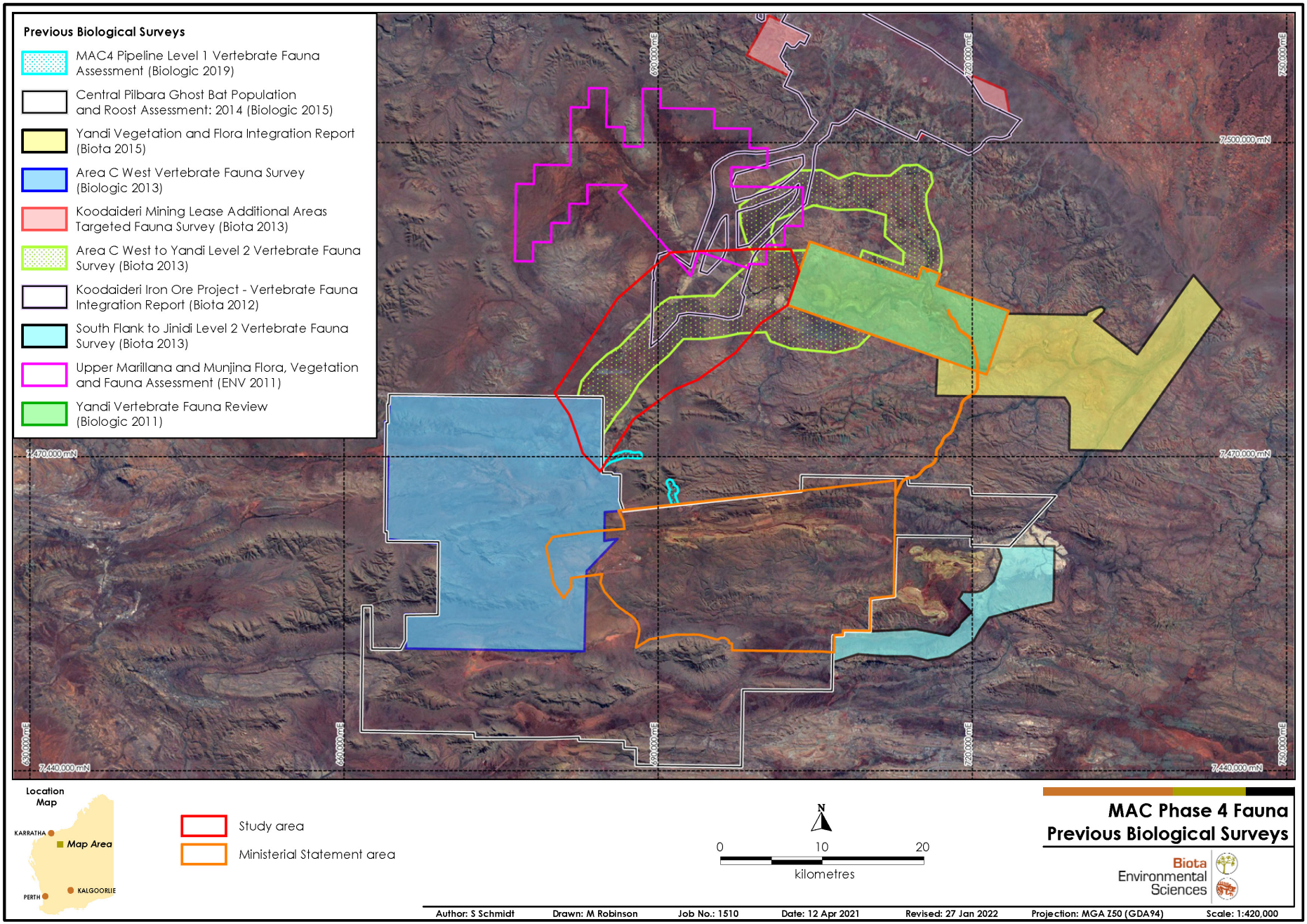

Figure 4.4: Previous relevant surveys conducted in the locality of the study area.

Table 4.6: MNES vertebrate species identified through the desktop study.

Family	Species Name	Common Name	Conservation Status	
			State	Commonwealth
Non-volant mammals				
Dasyuridae	*Dasyurus hallucatus*	Northern Quoll	Endangered	Endangered
Thylacomyidae	*Macrotis lagotis*	Bilby	Vulnerable	Vulnerable
Bats				
Rhinonycteridae	*Rhinonicteris aurantia*	Pilbara Leaf-nosed Bat	Vulnerable	Vulnerable
Megadermatidae	*Macroderma gigas*	Ghost Bat	Vulnerable	Vulnerable
Herpetofauna				
Pythonidae	*Liasis olivaceus barroni*	Pilbara Olive Python	Vulnerable	Vulnerable
Avifauna				
Apodidae	*Apus pacificus*	Pacific Swift	Migratory	Migratory
Charadriidae	*Charadrius veredus*	Oriental Plover	Migratory	Migratory
Rostratulidae	*Rostratula australis*	Australian Painted-snipe	Endangered	Endangered
Scolopacidae	*Calidris acuminata*	Sharp-tailed Sandpiper	Migratory	Migratory
	Calidris ferruginea	Curlew Sandpiper	Critically Endangered, Migratory	Critically Endangered, Migratory
	Calidris melanotos	Pectoral Sandpiper	Migratory	Migratory
	Actitis hypoleucos	Common Sandpiper	Migratory	Migratory
	Tringa glareola	Wood Sandpiper	Migratory	Migratory
	Tringa nebularia	Common Greenshank	Migratory	Migratory
Laridae	*Gelochelidon macrotarsa*	Australian (Gull-billed) Tern	Migratory	Migratory
	Onychoprion anaethetus	Bridled Tern	Migratory	Migratory
Accipitridae	*Elanus scriptus*	Letter-winged Kite	Priority 4	
Falconidae	*Falco hypoleucos*	Grey Falcon	Vulnerable	Vulnerable
	Falco peregrinus	Peregrine Falcon	Other Specially Protected Fauna	
Psittacidae	*Pezoporus occidentalis*	Night Parrot	Critically Endangered	Endangered
Hirundinidae	*Hirundo rustica*	Barn Swallow	Migratory	Migratory
Motacillidae	*Motacilla tschutschensis (flava)*	Eastern Yellow Wagtail	Migratory	Migratory
	Motacilla cinerea	Grey Wagtail	Migratory	Migratory

Table 4.7: State-listed vertebrate species identified through the desktop study.

Family	Species Name	Common Name	Conservation Status
			State
Non-volant mammals			
Dasyuridae	*Dasycercus blythi*	Brush-tailed Mulgara	Priority 4
Muridae	*Leggadina lakedownensis*	Short-tailed Mouse	Priority 4
	Pseudomys chapmani	Western Pebble-mound Mouse	Priority 4
Herpetofauna			
Carphodactylidae	*Underwoodisaurus seorsus*	Pilbara Barking Gecko	Priority 2
Scincidae	*Ctenotus uber johnstonei*	Spotted Ctenotus	Priority 2
Typhlopidae	*Anilios ganei*	Gane's Blind Snake	Priority 1
Avifauna			
Accipitridae	*Elanus scriptus*	Letter-winged Kite	Priority 4
Falconidae	*Falco peregrinus*	Peregrine Falcon	Other Specially Protected Fauna

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5.0 Results and Discussion

5.1 Fauna Habitats

Six fauna landscapes fauna landscapes (broad fauna habitats) were determined on the basis of the approach outlined in Section 3.3.4, in combination with on-ground habitat assessment and consideration of the ecological niches relevant to fauna. These are mapped inFigure 5.1 (with fauna landscape 7 comprising cleared/disturbed areas), and Table 5.1 presents detailed information for each fauna landscape, including dominant vegetation, a representative site picture and BHP WAIO – prescribed fauna habitat types.

The 41 sampling sites, and an additional eight habitat assessment sites, were selected to represent all habitats and the habitats present within the study area as far as accessible (see Section 3.4). Habitat assessment data and a photo for each sampling and habitat assessment site as required by BHP WAIO's spatial data requirements (SPR-IEN-EMS-015) are presented in Appendix 4, including fauna landscapes for cross-reference.

Based on reviews of aerial imagery and land systems, vegetation, and surface geology mapping, the fauna landscapes identified during the fauna survey are not confined to the study area and most are common and widespread within the Hamersley subregion (van Vreeswyk et al. 2004). The limited 'Flat Rocks' fauna landscape within the study area reflects the limited extent of such habitats within the subregion.

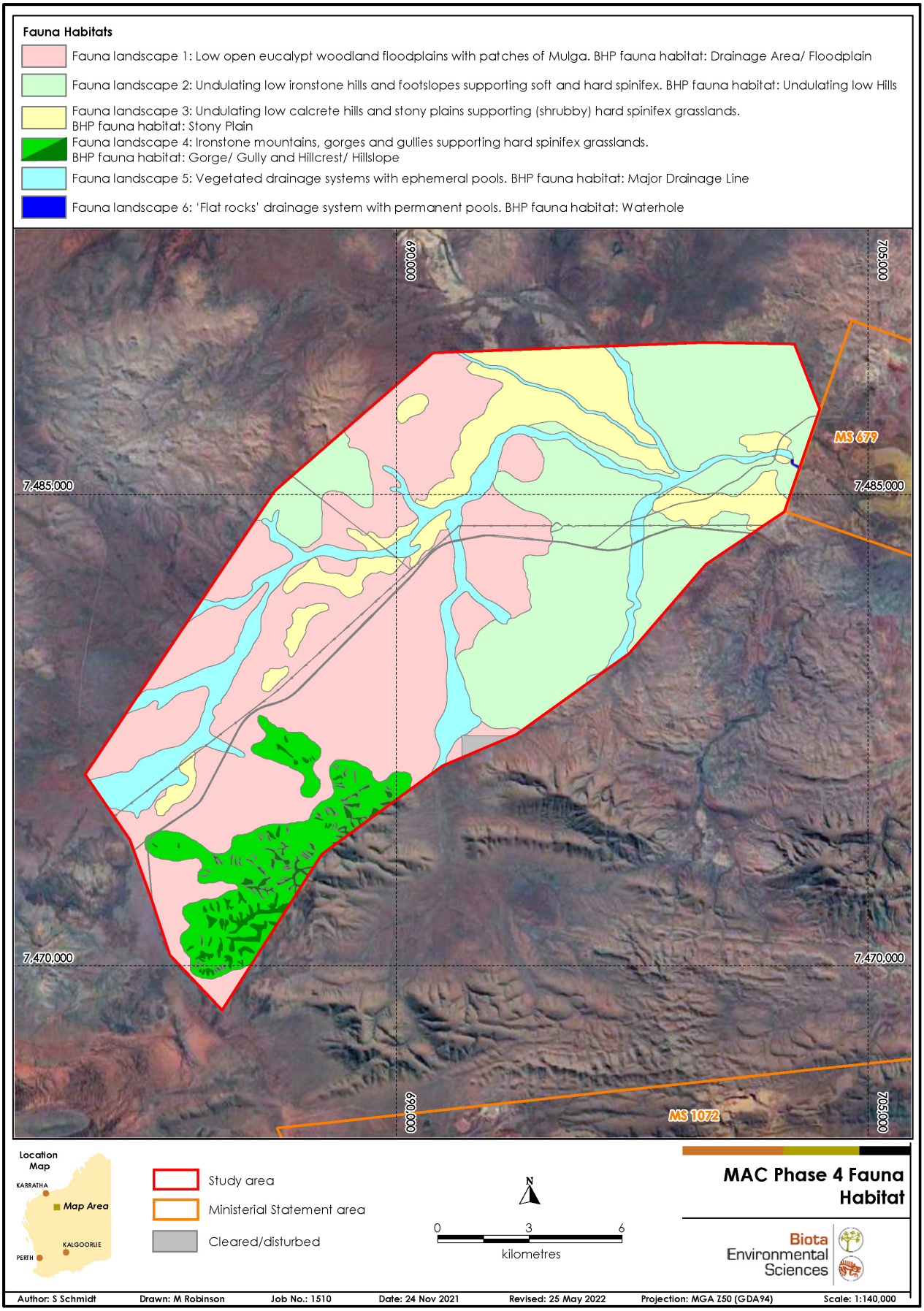

Figure 5.1: Fauna habitats within the study area.

Table 5.1: Fauna habitats identified within the study area including area and dominant characteristics.

Fauna Habitat	Extent (proportion)	Representative photo
Fauna Landscape 1: **Low open eucalypt woodland floodplains with patches of Mulga** Dominant BHP Fauna habitat type: Drainage Area/ Floodplain. Land systems: Boolgeeda, Pindering, Newman. Landforms: Drainage area/floodplain, sandy/stony plain. Fauna habitats: Drainage area/floodplain, Eucalypt woodland, Mulga woodland, sandy/stony plain, vegetation grove. Substrate: Gravelly sandy or silty clay loam. Surface geology: predominantly alluvium and colluvium (red-brown sandy and clayey soil), and colluvium (partly consolidated quartz and rock fragments in silt and sand matrix). Vegetation: Low open eucalypt/*Corymbia* woodland over mixed *Acacia* tall shrubland/low mixed shrubland over open *Triodia* hummock grassland, tussock grasses and herbs, with patches of Mulga (*Acacia aneura*).	9,388.7 ha (40.08%)	
Fauna Landscape 2: **Undulating low ironstone hills and footslopes supporting soft and hard spinifex** Dominant BHP Fauna habitat type: Undulating Low Hills. Land systems: McKay, Platform, Robe. Landforms: Undulating low hills, footslope, hillslope, hillcrest/upper hillslope, ironstone outcrops. Fauna habitats: Undulating low hills, hillcrest/hillslope, ironstone outcrops. Substrate: Gravelly silty or sandy clay loam. Surface geology: predominantly colluvium (partly consolidated quartz and rock fragments in silt and sand matrix), and Weeli Wolli (banded) iron formation, some Robe pisolite. Vegetation: Scattered eucalypts over open *Acacia* shrubland over *Triodia* hummock grassland.	6,638.9 ha (28.3%)	

Fauna Habitat	Extent (proportion)	Representative photo
Fauna Landscape 3: Undulating low calcrete hills and stony plains supporting (shrubby) hard spinifex grasslands Dominant BHP Fauna habitat type: Stony Plain Land systems: Calcrete, Oakover. Landforms: Undulating low hills, calcrete outcrops, calcrete plain. Fauna habitats: Undulating low hills, hillcrest/hillslope, calcrete outcrops, calcrete plain, stony plain. Substrate: Gravelly/sandy clay loam. Surface geology: predominantly calcrete-sheet carbonate found along major drainage lines. Vegetation: Low open eucalypt/*Corymbia* woodland over mixed *Acacia* low open shrubland/over open (hard) *Triodia* hummock grassland.	2,707.9 ha (11.6%)	
Fauna Landscape 4: Ironstone mountains, gorges and gullies supporting hard spinifex grasslands. Dominant BHP Fauna habitat type: Gorge/ Gully and Hillcrest/ Hillslope. Land systems: Newman. Landforms: Boulders/rockpiles, breakaway, cliff, gorge, gully, hillcrest/upper hillslope, ironstone outcrops, footslope. Fauna habitats: Boulders/rockpiles, breakaway/cliff, cave, gorge/gully, hillcrest/hillslope, ironstone outcrops. Substrate: stony loams or exposed rock. Surface geology: Brockman (banded) iron formation. Vegetation: Scattered eucalypts over low very open *Acacia* shrubland over (hard) *Triodia* hummock grassland.	2,176.3 ha (9.3%)	

Fauna Habitat	Extent (proportion)	Representative photo
Fauna Landscape 5: **Vegetated drainage systems with ephemeral pools** Dominant BHP Fauna habitat type: Major Drainage Line Land systems: Boolgeeda, Oakover, Platform, Calcrete. Landforms: Major/medium drainage lines (including river/creek bed and banks, ephemeral pools and flood out). Fauna habitats: Major/medium drainage line, waterhole (ephemeral pools). Substrate: Sandy/silty clay loam or alluvial rocks. Surface geology: predominantly alluvium - unconsolidated silt, sand, and gravel. Vegetation: Tall open eucalyptus woodland over *Acacia/Melaleuca*, over low shrubs, grasses, sedges and herbs.	2,329.9 ha (10%)	
Fauna Landscape 6: **'Flat rocks' drainage system with permanent pools** Dominant BHP Fauna habitat type: Waterhole Land systems: McKay. Landforms: Major drainage line, waterhole (ephemeral pools). Fauna habitats: Major drainage line, waterhole (ephemeral rock pools with one assumed to be permanent), cliff/breakaway. Substrate: exposed rock. Surface geology: pisolitic limonite deposits developed along river channel. Vegetation: Scattered eucalypts and low shrubs over sedges, herbs and tussock grasses around edges of pools, hard spinifex on banks.	3.6 ha (<0.1%)	
Fauna Landscape 7: Cleared exploration and construction areas, tracks, roads, train line BHP Fauna habitat type: Cleared/disturbed.	178.3 ha (<1%)	-

5.2 MNES Vertebrate Fauna

Table 5.3 provides an overview of the 21 MNES species that were identified in the desktop study (see Section 4.2) with the likelihood of occurrence of each species determined based on existing information and taking into account the habitat assessment and sampling conducted during the field survey. Twelve species were considered 'unlikely to occur' or 'would not occur' in the study area (Table 5.3). These species were all birds, mostly migratory, for which no or only limited habitat is present within the study area and that have not been recorded in the locality.

The MNES species confirmed as occurring (one species) or that have the potential to occur (eight species likely to occur or may occur) are discussed below (Section 5.2.1). While these species utilise or are likely to utilise the study area (Section 5.1), none are expected to be restricted to the study area.

5.2.1 MNES Vertebrate Species Recorded in the Study Area

One MNES vertebrate species was recorded from the study area during the current survey (Figure 5.2), and a further four species have previously been recorded within the study area:

Pilbara Olive Python, *Liasis olivaceus barroni*
Vulnerable under the EPBC Act and the BC Act.

Distribution: The Pilbara Olive Python has a known distribution that coincides roughly with the Pilbara bioregion (DSEWPaC 2012). It is known from 17 localities in the Pilbara and apparently stable populations occur in four areas: Pannawonica, Millstream, Tom Price and the Burrup Peninsula. At some of these sites, the species occurs in sizeable numbers (DAWE 2020).

Ecology: Preferred habitat for the Pilbara Olive Python includes gorges, escarpments, rocky outcrops and water holes where it may find suitable prey. It seeks shelter in caves, beneath boulders, in pools of water and occasionally in trees overhanging water (Bush and Maryan 2011). It is often associated with ephemeral or permanent water, but may also be recorded in rocky habitats some distance from these features (Biota 2009), demonstrating that the species can have a large range (estimated between 88 ha and 449 ha) (DAWE 2020).

Likelihood of occurrence: Occurs within the study area. One adult individual was observed during a nocturnal search in a rock pool at site MAC-06 (see Figure 3.2, Plate 5.1, Appendix 4) on 18/11/2020. In addition, at least 14 records have been documented both north and east of the survey boundary approximately 18 and 8 km respectively, primarily from the Koodaideri area to the north (DBCA 2021).

Plate 5.1: Pilbara Olive Python at 'Flat Rocks'.

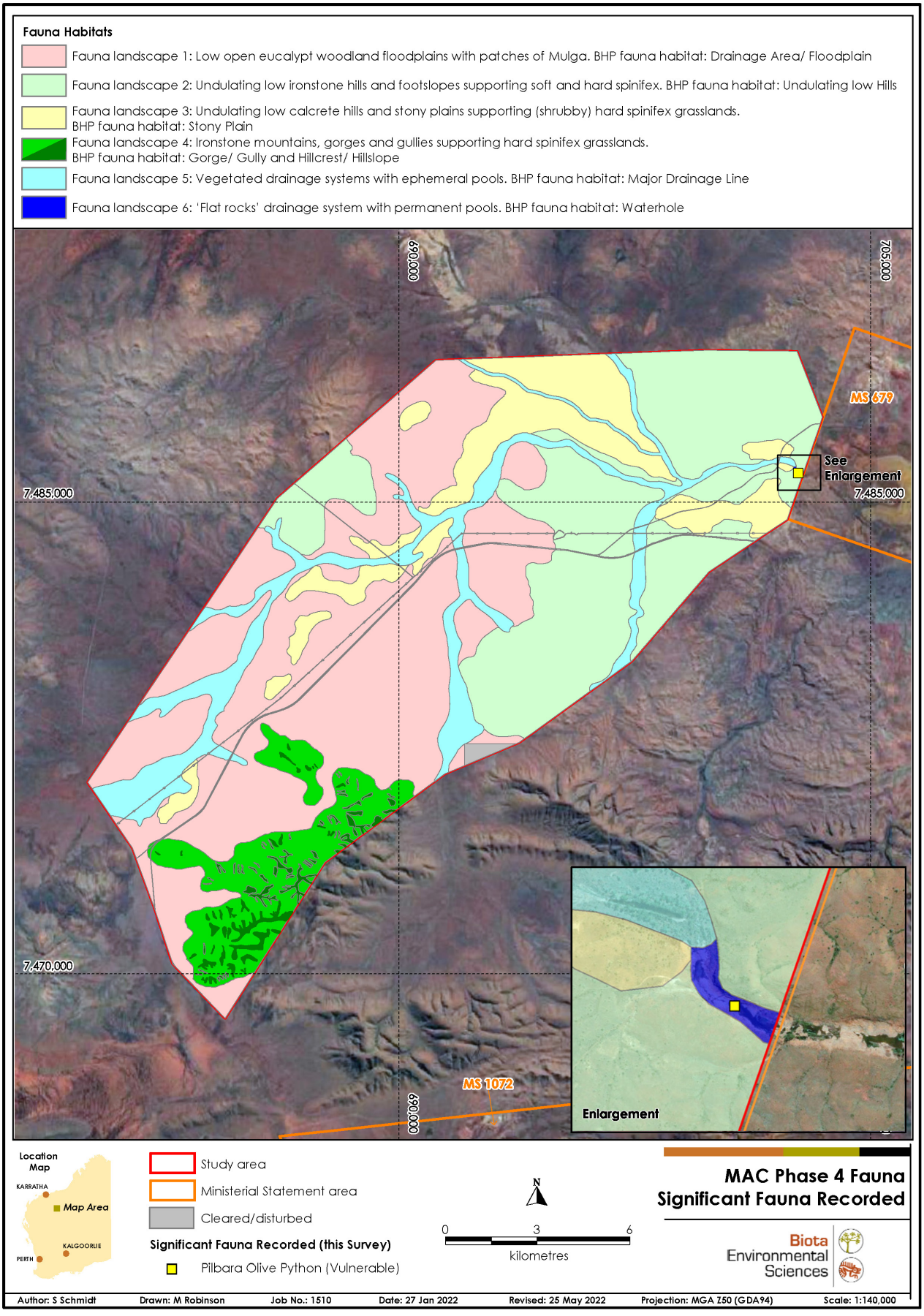

Figure 5.2: Significant fauna records from current survey.

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Table 5.2: MNES species from the desktop study and their likelihood of occurrence.
(confirmed species, and species likely to occur or may occur highlighted in grey)

Family	Species Name	Common Name	Conservation Status		Preferred habitat	Habitat Available in Study Area	Occurrence in Locality	Likelihood of Occurrence
			State	Commonwealth				
Non-volant mammals								
Dasyuridae	*Dasyurus hallucatus*	Northern Quoll	Endangered	Endangered	Critical: gorges, gullies, free faces, breakaways, boulder piles and incised hills. Supporting: permanent and semi-permanent water, drainage systems	✓	Numerous records within the locality, all records within 20 km are located to the North. Biologic (2013) reports one scat was found in the southwest corner of the study area on a 2011 survey by Biologic/Onshore).	Recorded
Thylacomyidae	*Macrotis lagotis*	Greater Bilby	Vulnerable	Vulnerable	Open tussock grassland on uplands and hills, mulga woodland/shrubland growing on ridges and rises, and hummock grassland in plains and alluvial areas.	✓	Three records within the locality (30-40 km north and southwest).	May occur
Bats								
Rhinonycteridae	*Rhinonicteris aurantia*	Pilbara Leaf-nosed Bat	Vulnerable	Vulnerable	Semi-desert adapted, caves or mine adits with stable, very hot and very humid microclimates. Foraging habitat includes *Triodia* hummock grassland, sparse tree and shrub savannah and riparian vegetation along drainage lines.	✓	A well surveyed roost is located approximately 18 km to the north. One call	Recorded
Megadermatidae	*Macroderma gigas*	Ghost Bat	Vulnerable	Vulnerable	Broad range of habitats, with their distribution being influenced by the availability of suitable caves and mines for roost sites.	✓	Previous records within the study area, as well as approximately 18 km north and 13 km south of the study area.	Likely to occur
Herpetofauna								
Pythonidae	*Liasis olivaceus barroni*	Pilbara Olive Python	Vulnerable	Vulnerable	Gorges, escarpments, rocky outcrops and water holes, shelters in caves, beneath boulders, in pools of water and occasionally in trees overhanging water. Associated with ephemeral or permanent water but may also be recorded in rocky habitats some distance from these features.	✓	One individual recorded inside the study area during the current survey, and numerous records both north and east of the study area boundary approximately (18 and 8 km).	Recorded
Avifauna								
Apodidae	*Apus pacificus*	Pacific Swift	Migratory	Migratory	Entirely aerial when in Australia.	n/a	Numerous records within 40 km.	Likely to occur
Charadriidae	*Charadrius veredus*	Oriental Plover	Migratory	Migratory	Estuarine mudflats, sandbanks, beaches or reefs, and grasslands immediately after migration. Thereafter- flat, open, semi-arid or arid grasslands interspersed with hard, bare ground (claypans, paddocks, lawns, recently burnt areas), lightly wooded grasslands.	✓	Closest record over 80 km away to the North-east (NatureMap)	Unlikely to occur
Rostratulidae	*Rostratula australis*	Australian Painted-snipe	Endangered	Endangered	Shallow, terrestrial freshwater wetlands (temporary and permanent lakes, swamps, claypans), inundated grassland or saltmarsh and dams. Often include tussocks of grass, sedges, rushes or reeds, or samphire. Breeding: shallow wetlands with areas of bare wet mud and both upper and canopy cover.	✓	Closest record over 70 km away to the East (NatureMap)	Unlikely to occur
Scolopacidae	*Calidris acuminata*	Sharp-tailed Sandpiper	Migratory	Migratory	Muddy edges of shallow fresh or brackish wetlands with inundated or emergent low vegetation including sedges, saltmarsh or grass. Includes swamps, lakes, dams, saltpans, hypersaline saltlakes, saltworks, sewage dams, and flooded paddocks.	✓	Closest record over 250 km away to the North-east (NatureMap)	Unlikely to occur
	Calidris ferruginea	Curlew Sandpiper	Critically Endangered, Migratory	Critically Endangered, Migratory	Intertidal mudflats in sheltered coastal areas (estuaries, bays, inlets and lagoons), non-tidal swamps, lakes and lagoons near the coast, inland around ephemeral and permanent lakes, dams, waterholes and bore drains with bare edges of mud or sand. Fresh or brackish waters.	✓	Closest record over 100 km away to the South-east (NatureMap)	Unlikely to occur
	Calidris melanotos	Pectoral Sandpiper	Migratory	Migratory	Shallow fresh to saline wetlands. Coastal lagoons, estuaries, bays, swamps, lakes, inundated grasslands, saltmarshes, river pools, creeks, floodplains and artificial wetlands. When found inland, generally in wetlands that have open fringing mudflats and low, emergent or fringing vegetation.	✓	Closest record 250 km away to the North (NatureMap)	Unlikely to occur

Family	Species Name	Common Name	Conservation Status		Preferred habitat	Habitat Available in Study Area	Occurrence in Locality	Likelihood of Occurrence
			State	Commonwealth				
Scolopacidae (cont.)	*Actitis hypoleucos*	Common Sandpiper	Migratory	Migratory	Wide range of coastal and inland wetlands mostly found around muddy margins (narrow, steep) or rocky shores (rarely mudflats). Often associated with mangroves.	✓	Closest record 90 km away to the North-east (NatureMap)	May occur
	Tringa glareola	Wood Sandpiper	Migratory	Migratory	Well-vegetated, shallow, freshwater wetlands such as swamps, dominated by taller fringing vegetation, especially *Melaleuca and* Red River Gums. Inundated grasslands and wooded floodplains where floodwaters are temporary or receding, drying wetlands.	✓	Closest recorded observation was 2.5 km South (Biologic 2013)	Likely to occur
	Tringa nebularia	Common Greenshank	Migratory	Migratory	Edges of wetlands, mudflats, channels, shallow edges around water, shallow pools, puddles, slightly elevated rocks, sandbanks and muddy islets.	✓	Recorded twice within the study area (NatureMap)	Recorded
Laridae	*Gelochelidon macrotarsa*	Australian (Gull-billed) Tern	Migratory	Migratory	Sparsely vegetated islands, banks, flats, dunes, saltmarshes, saltpans, freshwater lagoons, estuaries, inland lakes, rivers, swamps, grasslands and semi-desert regions.	✓	One record approx. 14 km South-east (DBCA TF).	Unlikely to occur
	Onychoprion anaethetus	Bridled Tern	Migratory	Migratory	Foraging offshore (mid- and outer continental shelf waters), roost on branches of shrubs or low trees, on rocks, sandbanks or beaches, less often on ground among vegetation, rubble, or shoreline.	-	One record 13 km East (ALA), all other records (North) are coastal.	Unlikely to occur
Falconidae	*Falco hypoleucos*	Grey Falcon	Vulnerable	Vulnerable	Lightly wooded plains, major watercourses with taller trees or isolated man-made structures such as communications towers.	✓	Four records within 20 km.	Likely to occur
Psittacidae	*Pezoporus occidentalis*	Night Parrot	Critically Endangered	Endangered	Arid or semi-arid spinifex grasslands with large, established and unburnt hummocks. Foraging habitat includes areas of samphire, bluebush and saltbush. Remote arid and semi-arid areas. Roosting and nesting in clumps of dense vegetation (primarily old and large spinifex clumps) that is naturally fragmented and therefore protected from fire. Grasslands, shrublands, scattered trees and shrubs, Mulga woodland.	✓	Closest record 50 km to the North-east (NatureMap)	Unlikely to occur
Hirundinidae	*Hirundo rustica*	Barn Swallow	Migratory	Migratory	Open country in coastal lowlands, often near water, towns and cities. Seen on overhead wires, freshwater wetlands, *Melaleuca* wetlands, mesophyll shrub thickets and tussock grassland.	✓	Closest Record 300 km North (NatureMap)	Unlikely to occur
Motacillidae	*Motacilla tschutschensis (flava)*	Eastern Yellow Wagtail	Migratory	Migratory	Wet meadows, marshland, grassy and muddy lakeshores, fields, often near livestock, shrubland, grassland, and wetlands.	✓	260 km North (ALA)	Unlikely to occur
	Motacilla cinerea	Grey Wagtail	Migratory	Migratory	Flowing water, rocky or surrogate rocky habitat, mountain streams, weirs, inland wetlands, grassland, forested areas, and lowland water courses.	✓	closest Record 45 km North (NatureMap)	Unlikely to occur

Northern Quoll, *Dasyurus hallucatus*
Endangered under the EPBC Act and the BC Act.

Distribution: On mainland Australia, the Northern Quolls distribution restricted to six main areas: the north and western top end of the Northern Territory, north of Cape York, the Atherton-Cairns area, the Carnarvon Range-Bowen area of Queensland (Menkhorst and Knight 2011), and the northwest Kimberley and Pilbara regions of Western Australia (Braithwaite and Griffiths 1994). Within the Pilbara, the distributional boundaries are defined in the north, east and south by the Great Sandy Desert, Gibson Desert and Little Sandy Deserts.

Ecology: The critical habitat of the Northern Quoll includes gorges, gullies, free faces, breakaways, boulder piles and incised hills, with supporting habitats including permanent and semi-permanent water, and drainage systems (Hill and Ward 2010). It is considered a partially arboreal and aggressive carnivore, preying on a varied diet of small invertebrates and vertebrates, including lizards, birds, snakes, small mammals and frogs (Oakwood 2000).

Likelihood of occurrence: Numerous records exist within the locality, all records within 20 km are located to the north of the study area. In addition, Biologic (2013) report one scat was found in the southwest corner of the study area on a 2011 survey by Biologic/Onshore. Given the proximity of previous records, and the presence of extensive denning and foraging habitat (Table 5.3; over 4,500 ha – see Table 5.1) within the study area, the Northern Quoll is considered to occur within the study area. However, despite significant targeted/nocturnal search and motion camera effort, with baited cameras continuously deployed for four months (645 camera nights) to increase detection probability of itinerant individuals and outweigh potential effects of seasonality on detection (as the survey was undertaken after the mating period when most males die off (e.g. Hernandez-Santin et al. 2019)), no detections were obtained during this survey. This suggests that Northern Quoll may only be present in low density, or occur as transitory dispersing individuals, consistent with the location of the study area near the edge of the species' known distribution (Department of the Environment 2017).

Pilbara Leaf-nosed Bat, *Rhinonicteris aurantia* (Pilbara form)
Vulnerable under the EPBC Act and the BC Act.

Distribution: The Pilbara Leaf-nosed Bat is a sub-population of the Orange Leaf-nosed Bat and is endemic to the Pilbara and Ashburton regions of Western Australia. The Pilbara population is isolated from the main population in the Kimberley, Northern Territory and Queensland by 400 km of unsuitable habitat.

Ecology: The Pilbara Leaf-nosed Bat is semi-desert adapted and has specific roosting requirements, requiring roost sites in caves or mine adits with stable, very hot (28 – 32°C) and very humid (96 – 100 %) microclimates (Churchill 2008). Caves deep enough to create this environment are relatively uncommon in the Pilbara (van Dyck and Strahan 2008), which limits the availability of diurnal roosts for this species. Observed foraging habitat includes *Triodia* hummock grassland, sparse tree and shrub savannah and riparian vegetation along drainage lines (Duncan et al. 1999). The Pilbara Leaf-nosed Bat has a cryptic, high frequency call that has previously imparted low detectability of this species, and as such has potentially resulted in an underestimate of population size. However, McKenzie and Bullen (2009) found that this species is more common than previously recognised (Hancock and Timms 2002).

Likelihood of occurrence: A well surveyed roost is located approximately 18 km to the north of, and extensive foraging and dispersal habitat, as well as habitat suitable for short-term refuges and likely suitable for roosting (Table 5.3; over 4,500 ha – see Table 5.1) is present within the study area. In addition, BHP WAIO data include a single call reported from a location in the southwest of the study area by Biologic in 2011 reported in (Biologic 2013). Given the Pilbara Leaf-nosed Bat is a highly mobile species, the presence of extensive foraging and dispersal, in addition to denning and potential roosting habitat (e.g. caves with confirmed previous records of Ghost Bat), the known roost nearby, and a previous record from the study area, it is considered to occur within the study area. That no detections were made during the current survey, despite 165 bat call recorder sampling nights, and that only one call and no other evidence has previously been detected despite multiple surveys, suggests the species may only be present in low densities, or as a transient visitor to the study area. While it is possible that detectability may have been reduced

at sites where SM4mini recording units were used (as we have only subsequently been made aware that there is some evidence that these units are less effective at detecting high frequency Pilbara Leaf-nosed Bat calls, see Section 3.4), it is unlikely that the lack of records was entirely a function of this because 100 of the165 sample nights were conducted with SM4Bat FS unit, only 65 with SM4minis, and previous studies also failed to record the species despite considerable effort without using SM4minis with only a single call previously recorded within the study area (see Section 4.2). Detectability would also have been affected by extensive amounts of water present during parts of the survey period along the river system, giving potentially present foraging individuals a choice of multiple pools/large areas. This may have contributed to the SM4s deployed in the river system also failing to record this species.

Ghost Bat, *Macroderma gigas*
Vulnerable under the EPBC Act and the BC Act.

Distribution: The Ghost Bat occurs in a broad range of habitats, with their distribution being influenced by the availability of suitable caves and mines for roost sites (Churchill 1998). The distribution of the Ghost Bat is fragmented, with each population showing some genetic differentiation (Armstrong and Wilmer 2004, Biota 2004). Populations in the Pilbara bioregion appear to be isolated from those in the Kimberley and Northern Territory. A study by McKenzie and Bullen (2009) found that the Ghost Bat is more common than previously thought.

Ecology: Ghost Bats are efficient predators of small birds, mammals, reptiles and large insects, and they have highly developed echolocation, visual and hearing systems (Churchill 1998). Vocalisations audible to humans are used in their complex social interactions (Churchill 1998). Bats forage over large distances (ranges of ~ 60 ha; (Churchill 1998)), and the size of their foraging area is probably inversely related to the productivity of their landscape. Bats are known to have overlapping ranges (Churchill 1998).

Likelihood of occurrence: Previous records from one location in the southwest of the study area exist (NatureMap and observation by Biologic in 2013 supplied by BHP WAIO), and this species has also been recorded previously approximately 18 km north and 13 km south of the study area. In addition, BHP WAIO data include locations of multiple additional records, however details were not provided, and these records do not exist in NatureMap, and thus could not be verified. Given this species can be highly mobile (e.g. seasonal dispersal of up to 50 km recorded by Toop (1985)), the presence of extensive foraging/dispersal habitat and habitat suitable for roosting including caves with confirmed previous records (Table 5.3; over 4,500 ha – see Table 5.1), in addition to previous records from the study area, the Ghost Bat is considered to occur in the study area.

Common Greenshank, *Tringa nebularia*
Migratory under the EPBC Act and the BC Act.

Distribution: The Common Greenshank does not breed in Australia. In Western Australia, it occurs around most of the coast from Cape Arid to Carnarvon, and throughout the south-west and north-east of the Kimberley. It is the most widely distributed shorebird in Australia, inhabiting inland wetlands and sheltered coastal areas including mudflats, saltmarshes, river estuaries, deltas and lagoons (Department of Agriculture, Water and the Environment n.d.).

Ecology: A migratory species often found near edges of wetlands, seen singularly or in large flocks. Foraging occurs at the edges of wetlands or on mudflats, channels, or shallow edges around water. The Common Greenshank will roost around wetlands, in shallow pools and puddles, or on slightly elevated rocks, sandbanks and muddy islets (Department of Agriculture, Water and the Environment n.d.). Roebuck Bay may be an important roost site during non-breeding season.

Likelihood of occurrence: This species has twice been recorded within the study area. It occurs in a range of habitats where surface water is present, including those present in the study area (Table 5.3). Therefore, this species is considered to occur in the study area, though likely only as a foraging visitor, particularly from September to April.

5.2.2 MNES Vertebrate Species Potentially Occurring in the Study area

Four MNES vertebrate species were not recorded during the survey and have not previously been recorded within the study area but have the potential to occur within the study area:

Greater Bilby[4], *Macrotis lagotis*
Vulnerable under the EPBC Act and the BC Act.

Distribution: The distribution of the Bilby is discontinuous with the species occurring in a number of desert locations between south-west Queensland and the Pilbara.

Ecology: The Greater Bilby is a solitary nocturnal omnivorous species inhabiting deep, often complex burrows. Remaining subpopulations occupy three major vegetation types: open tussock grassland on uplands and hills, mulga woodland/shrubland growing on ridges and rises, and hummock grassland in plains and alluvial areas.

Likelihood of occurrence: Three records exist near the boundary of the study area locality, to the north and southwest of the study area. Some suitable habitat is also present within the study area (fauna landscape 1). No evidence of the species was recorded during the current survey. However, based on these records and availability of some suitable habitat, it is possible this species may occur in the study area periodically, most likely as a transient visitor.

Pacific Swift, *Apus pacificus*
Migratory under the EPBC Act and the BC Act.

Distribution: The Pacific Swift occurs across much of Australia from September to April, particularly in the northern half of the continent. The species is most common closer to the coast but occurs over much of the Pilbara.

Ecology: The species is a non-breeding migrant to Australia and is generally present from September to April. In Australia, the species is considered entirely aerial in habits, foraging for flying insects and even sleeping on the wing. The species is highly mobile, often occurring in association with unsettled weather and low pressure systems (Johnstone and Storr 1998).

Likelihood of occurrence: Numerous records have been documented within 40 km of the study area. Given the broad distribution and high mobility of the species, the Pacific Swift is likely to occur over all fauna landscapes within the study area erratically from September to April. It is most likely to occur in association with unsettled weather, including thunderstorms and low pressure systems, but may occur in any weather conditions.

Common Sandpiper, *Actitis hypoleucos*
Migratory under the EPBC Act and the BC Act.

Distribution: The Common Sandpiper is a widespread migrant to Australia, occurring across most of the country where suitable habitat is present.

Ecology: This species is migratory, occurring in Australia during the non-breeding season, typically from late July until the end of March (Menkhorst et al. 2017). They typically occur along sheltered coasts and in a variety of wetland habitats, often with narrow or steep shorelines, or rocky outcropping (Menkhorst et al. 2017).

Likelihood of occurrence: The closest record identified during the desktop study was 90 km to the north-east of the survey boundary (DBCA 2021). However, the species is mobile, and suitable habitat is present in the study area when surface water is present in drainage lines (fauna landscapes 4 and 5), so it may occur as an occasional visitor.

[4] Referred to as Greater Bilby in this report for consistency with EPBC Act listing in line with purpose of report, contra usage of Bilby in current WA Museum taxonomy.

Wood Sandpiper, *Tringa glareola*
Migratory under the EPBC Act and the BC Act.

Distribution: The Wood Sandpiper has its largest numbers recorded in north-west Australia, with all areas of national importance being located in Western Australia. Western Australian distribution is widespread but scattered (Department of Agriculture, Water and the Environment n.d.)

Ecology: This species is migratory, occurring in Australia during the non-breeding season. They are typically associated with well-vegetated, shallow, freshwater wetlands such as swamps, dominated by taller fringing vegetation, especially *Melaleuca and* Red River Gums as well as inundated grasslands and wooded floodplains where floodwaters are temporary or receding, drying wetlands (Department of Agriculture, Water and the Environment n.d.)

Likelihood of occurrence: The closest recorded observation was 2.5 km south of the survey boundary in (Biologic 2013). Given the mobility and wide distribution of this species, it is likely to occur in the study area as an occasional visitor to the study area where surface water is present in drainage lines (fauna landscapes 4 and 5).

Grey Falcon, *Falco hypoleucos*
Vulnerable under the EPBC Act and the BC Act.

Distribution: The species is sparsely distributed across much of arid inland Australia, including the Pilbara, occurring mainly on lightly wooded plains and along major watercourses (Johnstone et al. 2013).

Ecology: Breeding usually takes place in taller trees such as river red gums, or on isolated man-made structures such as communications towers.

Likelihood of occurrence: Given four previous records within 20 km of the study area (three to the south and one to the north), and the presence of suitable habitat, the Grey Falcon is likely to occur in the study area, at least as a foraging visitor. It may also use the study area for roosting and nesting, as suitable nesting habitat does occur along the major drainage lines in the study area (Table 5.3 and 5.1).

5.2.3 MNES Vertebrate Fauna Habitat

When assessing the value of habitat in the study area, it is informative to consider the critical habitat for individual species of significance. For each MNES species, fauna habitats may be classified (DotE 2013) as:

1. "critical" – this comprises habitat considered to potentially contain roosting, denning or breeding sites, primary foraging areas, or refugia during drought, fire or other stress; or
2. "supporting" – these comprise the remaining habitats of the study area, which may be used on a transitory, dispersing or occasional basis, but do not represent critical habitat.

It is assumed that some proportion of critical habitat must be maintained across the species' range to ensure the persistence of the species in the region. Supporting habitats may be used for less regular foraging or on a transitory, dispersing, or occasional basis, but do not represent critical habitat.

Eight MNES species were confirmed as recorded or likely to occur in the study area (Table 5.3). Based on desktop and field survey results, these species may utilise the identified fauna landscapes (Section 5.1, Figure 5.1), as summarised in Table 5.3.

Table 5.3: Probable MNES species habitat utilisation.

MNES Species	Habitat		
Mammals & Reptiles	**Fauna Landscape 4: Mountains, gorges, gullies (BHP: Gorge/ Gully & Hillcrest/ Hillslope)**	**Fauna Landscape 5: Vegetated drainage systems (BHP: Major Drainage Line**	**Fauna Landscape 6: 'Flat Rocks' drainage system (BHP: Waterhole)**
Northern Quoll	Denning and foraging	Foraging and dispersal	Foraging and dispersal
Pilbara Leaf-nosed Bat	Roosting and foraging	Foraging and dispersal	Foraging and dispersal#
Ghost Bat	Roosting and foraging	Foraging and dispersal	Foraging and dispersal
Pilbara Olive Python	Sheltering and foraging	Foraging and dispersal	Sheltering and foraging#
Birds	**Fauna Landscape 1: Eucalypt/Mulga Floodplains (BHP: Drainage Area/ Floodplain)**	**Fauna Landscape 5: Vegetated drainage systems (BHP: Major Drainage Line)**	**Fauna Landscape 6: 'Flat Rocks' drainage system (BHP: Waterhole)**
Pacific Swift	Foraging*		
Wood Sandpiper	Foraging^	Foraging^	–
Common Greenshank	–	Foraging^	Foraging^
Grey Falcon	Foraging	Nesting and foraging	Nesting and foraging

Orange cells indicate critical habitat; yellow cells indicate supporting habitat.

Critical habitat as only known permanent pool

* Almost entirely aerial in habits when in Australia

^ After flooding events when pools are present in drainages and floodplain vegetation is seeding.

All fauna landscapes identified as being utilised or having the potential to be utilised by MNES species within the study area are not restricted to the locality and occur contiguously beyond the study area.

5.3 Other Vertebrate Fauna

5.3.1 Overview

A total of 93 vertebrate species were recorded during the survey. Table 5.4 provides a summary of the number of species recorded from each major vertebrate group. The fauna recorded during the survey represent 28% of the total of 332 species identified from the locality of the study area (Appendix 1).

Table 5.4: Vertebrate fauna recorded during the survey and known from the locality (potentially occurring in the study area) based on desktop study.

	Number of Species	
Vertebrate Fauna Group	**This Survey**	**Desktop Study**
Non-volant Mammals	6	33
Bats	10	14
Birds	55	158
Reptiles[5]	20	119
Amphibians	2	8
Total	**93**	**332**

[5] This represents the minimum number of species recorded, as *Gehyra* spp. in the Pilbara have recently undergone extensive taxonomic revision (see Appendix 1)

5.3.2 Non-volant Mammals

Six ground-dwelling mammal species were recorded from the study area, representing 18% of all ground-dwelling mammal species known from the locality (n=33 based on database records and previous surveys; Appendix 1).

The recorded species comprised two kangaroo species (Macropodidae), one rodent species (Muridae), Dingo, Dog and Cattle.

No ground-dwelling mammal MNES species were recorded during the survey. One State-level listed species was detected, the Western Pebble-mound Mouse*, Pseudomys chapmani* (Priority 4).

5.3.3 Bats

Ten bat species from three families were recorded from the study area, representing 71% of the species known from the locality (n=14 based on database records and previous surveys; Appendix 1).

No bat species of significance were recorded during the survey.

5.3.4 Birds

Fifty-five bird species from 30 families were recorded from the study area representing nearly 35% of the 158 species known from the locality based on database records and previous surveys.

No bird species of significance were recorded during the survey.

5.3.5 Reptiles

Twenty reptile species were recorded from the study area. These include species from seven of the 11 families known from the locality based on database records and previous surveys (Appendix 1). The recorded species comprised six geckos, two dragons, six skinks, one goanna, three pythons and two elapid snake species.

One reptile species of significance was recorded during the survey, the Pilbara Olive Python, *Liasis olivaceus barroni* (Vulnerable).

5.3.6 Amphibians

Two amphibian species were recorded from the study area, representing one quarter of all amphibian species known from the locality (n=8 based on database records and previous surveys; Appendix 1).

No amphibian species of significance were recorded during the survey.

6.0 Conclusions

Based on the desktop study, 21 MNES species were identified as potentially occurring with the study area, including one species listed as Critically Endangered, three as Endangered, five as Vulnerable, and 13 as Migratory (one species listed as both Critically Endangered and Migratory). All MNES species identified are also State listed significant species, with another eight species listed at State-level only also potentially occurring.

One MNES species was recorded within the study area during the current survey, the Pilbara Olive Python, *Liasis olivaceus barroni* (Vulnerable). A further four species have also been recorded from the study area during previous surveys. Three MNES species identified from the desktop study are also considered likely to occur, and two may occur within the study area:

Recorded (current survey):

- Pilbara Olive Python, *Liasis olivaceus barroni* (Vulnerable under both the EPBC Act and the State *Biodiversity Conservation Act 2016* (BC Act)).

Recorded (previous surveys):

- Northern Quoll, *Dasyurus hallucatus* (Endangered under both the EPBC Act and the BC Act);
- Pilbara Leaf-nosed Bat, *Rhinonicteris aurantia* (Pilbara form) (Vulnerable under both the EPBC Act and the BC Act);
- Ghost Bat, *Macroderma gigas* (Vulnerable under both the EPBC Act and the BC Act); and
- Common Greenshank, *Tringa nebularia* (Migratory under both the EPBC Act and the BC Act).

Likely to occur:

- Pacific Swift, *Apus pacificus* (Migratory under both the EPBC Act and the BC Act);
- Wood Sandpiper, *Tringa glareola* (Migratory under both the EPBC Act and the BC Act); and
- Grey Falcon, *Falco hypoleucos* (Vulnerable under both the EPBC Act and the BC Act).

May occur:

- Greater Bilby, *Macrotis lagotis* (Vulnerable under both the EPBC Act and the BC Act); and
- Common Sandpiper, *Actitis hypoleucos* (Migratory under both the EPBC Act and the BC Act).

While these significant species utilise or are likely to utilise the study area, none are restricted to the study area.

6.1 Fauna Habitats

Six fauna landscapes were identified:

1. Low open eucalypt woodland floodplains with patches of mulga (BHP fauna habitat type 'Drainage Area/ Floodplain);
2. Undulating low ironstone hills and footslopes supporting soft and hard spinifex (BHP fauna habitat type 'Undulating low Hills');
3. Undulating low calcrete hills and stony plains supporting (shrubby) hard spinifex grasslands (BHP fauna habitat type 'Stony Plain');
4. Ironstone mountains, gorges and gullies supporting hard spinifex grasslands (BHP fauna habitat type 'Gorge/ Gully' and Hillcrest/ Hillslope');
5. Vegetated drainage systems with ephemeral pools (BHP fauna habitat type 'Major Drainage Line'); and
6. 'Flat rocks' drainage system with permanent pools (BHP fauna habitat type 'Waterhole').

Four of the six identified fauna landscapes (1, 4, 5, 6) within the study area are considered to represent potentially suitable habitat for MNES species. Critical habitat for MNES species including Pilbara Olive Python, Northern Quoll, Pilbara Leaf-nosed Bat, Ghost Bat and Grey Falcon is present within fauna landscapes 4, 5 and 6; thus these habitats are likely to be of most importance with respect to MNES species. Habitats identified as utilised or having the potential to be utilised by MNES species within the study area are not restricted to the locality and occur contiguously beyond the study area.

7.0 Glossary

BC Act	State *Biodiversity Conservation Act 2016*.
Biota	Biota Environmental Sciences.
Significant	A species listed under the BC Act and/or the Federal EPBC Act and/or as a DBCA Priority species.
DBCA	Department of Biodiversity, Conservation and Attractions formerly Department of Parks and Wildlife, Department of Environment and Conservation (DEC), and Department of Conservation and Land Management (CALM).
EPA	Environmental Protection Authority of Western Australia.
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.
IBRA	Interim Biogeographic Regionalisation for Australia.
Landform	A geomorphological unit that is largely defined by its surface form and location in the landscape.
MNES species	Species that are listed as Matters of National Environmental Significance under the EPBC Act.
Opportunistic record	Recorded by non-systematic sampling methods.
SM4Bat FS	SongMeter 4 ultrasonic bat call recorder.
SM4Mini	SongMeter 4 mini ultrasonic or acoustic recording unit.
sp. (plural: spp.)	Abbreviation of "species".
Study area	MAC Phase 4 Marillana Creek study area boundary
Locality	Area included in the desktop study, i.e. 40 km radius of study area
WAM	Western Australian Museum.

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8.0 References

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Appendix 1

Vertebrate Database Search Results and Previous Surveys in the Locality, Including Current Survey Records

Non-volant Mammals

			Conservation status		Databases					Previous surveys								
Family/Species	Common Name	This survey	BC Act	EPBC Act	NatureMap	EPBC	ALA	IUCN	DBCF TF	Biota (2012)	Biota (2015)	Biota (2013)	Biota (2012)	Biota (2013)	Biologic (2013)	Biologic (2019)	Biologic (2011)	ENV (2011)
Tachyglossidae																		
Tachyglossus aculeatus	Short-beaked Echidna				•					•					•			
Dasyuridae																		
Dasycercus blythi	Brush-tailed Mulgara, Ampurta		P4		•				•		•							
Dasykaluta rosamondae	Kaluta				•		•			•	•	•	•		•			
GartDasyurus hallucatus	Northern Quoll		EN	EN	•	•		•	•	•				•	•			
Ningaui ridei	Wongai Ningaui				•						•							
Ningaui timealeyi	Pilbara Ningaui				•		•			•	•	•	•		•			
Planigale sp. (ex. *ingrami*) (1)					•					•		•	•		•			
Planigale sp. (ex. *maculata*) (1)					•					•								
Pseudantechinus woolleyae	Woolley's Pseudantechinus				•		•							•	•			
Sminthopsis macroura	Stripe-faced Dunnart				•		•			•	•	•	•		•			
Sminthopsis ooldea	Ooldea Dunnart				•		•			•								
Sminthopsis youngsoni	Lesser Hairy-footed Dunnart				•		•			•	•		•		•			
Thylacomyidae																		
Macrotis lagotis	Bilby, Dalgyte		VU	VU	•	•			•									
Macropodidae																		
Osphranter robustus (2)	Euro, Biggada	•			•					•	•	•	•		•		•	
Osphranter rufus (2)	Red Kangaroo, Marlu				•					•	•				•			•
Petrogale rothschildi	Rothschild's Rock-wallaby	•			•						•	•	•		•		•	
Muridae																		
Leggadina lakedownensis	Short-tailed Mouse		P4		•		•		•						•			
Mus musculus	House Mouse				•		•			•	•		•		•			
Notomys alexis	Spinifex Hopping-mouse										•							
Pseudomys chapmani	Western Pebble-mound Mouse	•	P4		•		•		•	•	•	•	•	•	•	•	•	•
Pseudomys delicatulus	Delicate Mouse				•		•											
Pseudomys desertor	Desert Mouse				•		•			•	•	•	•		•			
Pseudomys hermannsburgensis	Sandy Inland Mouse				•		•			•	•	•	•		•			
Zyzomys argurus	Common Rock-rat				•		•			•	•	•	•	•	•			
Leporidae																		
Oryctolagus cuniculus	Rabbit				•	•												
Canidae																		
Canis familiaris dingo (3)	Dingo	•								•					•		•	•
Canis familiaris familiaris (3)	Dog	•									•	•	•					
Vulpes vulpes	Red Fox					•												
Felidae																		
Felis catus	Cat				•		•			•	•				•			•
Equidae																		
Equus asinus	Donkey									•	•							
Equus caballus	Horse				•	•				•	•	•			•			•
Camelidae																		
Camelus dromedarius	Dromedary, Camel				•	•	•				•	•						
Bovidae																		
Bos taurus	European Cattle	•			•						•	•	•		•			•

(1) Planigales in Pilbara currently considered to comprise two undescribed species, previously listed as *P. ingrami* and *P. maculata.*
(2) Previously included within genus Macropus.
(3) Previously included within *C. lupus* as *C. lupus dingo* and *C. lupus familiaris*, some previous records listed as such.
Single record each of Water Buffalo *Bubalus bubalis, Zyzomys woodwardi* and *Z. pedunculatus* returned from NatureMap search are erroneous (data entry errors) and have not been included.

Bats

Family/Species	Common Name	This survey	Conservation status		Databases					Previous surveys								
			State	Commonwealth	NatureMap	EPBC	ALA	IUCN	DBCF TF	Biota (2012)	Biota (2015)	Biota (2013)	Biota (2012)	Biota (2013)	Biologic (2013)	Biologic (2019)	Biologic (2011)	ENV (2011)
Rhinonycteridae																		
Rhinonicteris aurantia (Pilbara) (1)	Pilbara Leaf-nosed Bat		VU	VU	•	•	•		•	•		•		•				
Megadermatidae																		
Macroderma gigas	Ghost Bat		VU	VU	•	•	•	•	•	•			•	•	•			
Emballonuridae																		
Saccolaimus flaviventris	Yellow-bellied Sheath-tailed Bat				•		•			•		•	•	•	•		•	
Taphozous georgianus	Common Sheath-tailed Bat	•			•		•			•		•	•	•	•			
Taphozous hilli	Hill's Sheath-tailed Bat				•		•			•		•						
Molossidae																		
Austronomus australis (2)	White-striped Free-tailed Bat	•			•		•			•		•	•	•	•			
Chaerephon jobensis	Greater Northern Free-tailed Bat	•			•		•			•		•	•	•	•			
Ozimops lumsdenae (3)	Northern Free-tailed Bat	•			•		•			•		•	•		•			
Vespertilionidae																		
Chalinolobus gouldii	Gould's Wattled Bat	•			•		•			•		•	•	•	•		•	
Chalinolobus morio	Chocolate Wattled Bat	•			•		•			•		•	•					
Nyctophilus daedalus (4)	Pallid Long-eared Bat	•			•		•					•	•					
Nyctophilus geoffroyi	Lesser Long-eared Bat	•			•		•			•		•	•		•			
Scotorepens greyii	Little Broad-nosed Bat	•			•		•			•		•	•	•	•		•	
Vespadelus finlaysoni	Finlayson's Cave-bat	•			•		•			•		•	•	•	•			

(1) Distinctive form of Orange Leaf-nosed Bat, some previous records still listed under Orange Leaf-nosed Bat.
(2) Some records of *Austronomus australis* included as *Tadarida australis.*
(3) *O. lumsdenae* has recent synonyms of *Mormopterus beccarii* (historical) and *M. lumsdenae* (after a recent reclassification - Reardon et al. (2014)), some previous records listed as such.
(4) Previously included as subspecies of *N. bifax,* some previous records listed as such.

Amphibians

Family/Species	Common Name	This survey	Conservation status		Databases					Previous surveys								
			State	Commonwealth	NatureMap	EPBC	ALA	IUCN	DBCF TF	Biota (2012)	Biota (2015)	Biota (2013)	Biota (2012)	Biota (2013)	Biologic (2013)	Biologic (2019)	Biologic (2011)	ENV (2011)
Pelodryadidae																		
Cyclorana australis	Giant Frog						•											
Cyclorana maini	Sheep Frog	•			•		•			•	•	•	•		•		•	
Cyclorana occidentalis (1)	Western Water-holding Frog												•					
Litoria rubella	Little Red Tree Frog	•			•		•			•	•	•	•		•		•	
Limnodynastidae																		
Neobatrachus aquilonius	Northern Burrowing Frog				•		•											
Neobatrachus sutor	Shoemaker Frog				•		•						•		•			
Myobatrachidae																		
Pseudophryne douglasi	Gorge Toadlet				•		•											
Uperoleia saxatilis (2)	Pilbara Toadlet				•		•			•	•	•	•					

(1) Formerly included within *C. platycephala* (revised in 2016), previous records listed as such.
(2) Formerly included within *U. russelli*, some previous records listed as such (Catullo et al. 2011)
One record of *Crinia bilingua* returned from ALA database not included here as species not known to range south of the Kimberley and photo accompanying record suggests misidentification.

Reptiles

Family/Species	Common Name	This survey	Conservation status		Databases					Previous surveys								
			State	Commonwealth	NatureMap	EPBC	ALA	IUCN	DBCF TF	Biota (2012)	Biota (2015)	Biota (2013)	Biota (2012)	Biota (2013)	Biologic (2013)	Biologic (2019)	Biologic (2011)	ENV (2011)
Cheluidae																		
Chelodina steindachneri	Flat-shelled Turtle												•		•			
Carphodactylidae																		
Nephrurus cinctus (1)	Northern Banded Knob-tailed				•		•			•	•	•	•		•			
Underwoodisaurus seorsus (2)	Pilbara Barking Gecko		P2		•		•		•				•		•			
Diplodactylidae																		
Crenadactylus ocellatus^	South-western Clawless Gecko				•		•						•		•			
Crenadactylus pilbarensis (3)	Pilbara Clawless Gecko				•		•						•		•			
Diplodactylus conspicillatus (4)	Variable Fat-tailed Gecko				•		•			•	•							
Diplodactylus laevis	Desert Fat-tailed Gecko						•											
Diplodactylus pulcher					•		•			•			•		•			
Diplodactylus savagei	Southern Pilbara Beak-faced				•		•			•		•	•		•			
Lucasium wombeyi					•		•			•		•	•		•			
Lucasium woodwardi (5)					•		•			•	•	•	•		•			
Oedura fimbria (6)	Western Marbled Velvet Gecko	•			•		•			•	•	•		•	•		•	
Rhynchoedura ornata	Western Beaked Gecko				•		•			•	•	•	•	•	•			
Strophurus elderi					•		•			•			•		•			
Strophurus jeanae					•		•			•	•				•			
Strophurus wellingtonae		•			•		•			•	•		•		•			
Gekkonidae																		
Gehyra crypta^	Western Cryptic Gehyra						•											
Gehyra micra	Small Pilbara Spotted Rock Gehyra						•											
Gehyra montium					•													
Gehyra pilbara					•		•			•	•	•						
Gehyra punctata (7)		•			•		•			•	•	•	•		•			•
Gehyra purpurascens					•					•								
Gehyra variegata (8)		•			•		•			•	•	•	•		•		•	•
Heteronotia binoei	Bynoe's Gecko	•			•		•			•	•	•	•		•			
Heteronotia spelea	Pilbara Cave Gecko	•			•		•					•	•		•			
Pygopodidae																		
Delma butleri (9)					•		•			•	•				•			
Delma elegans					•		•											
Delma nasuta					•		•			•	•	•	•		•			
Delma pax					•		•			•	•	•	•		•			
Delma tincta					•		•			•	•	•	•		•			
Lialis burtonis					•		•			•	•	•	•		•			
Pygopus nigriceps					•		•			•	•		•					
Agamidae																		
Ctenophorus caudicinctus	Ring-tailed Dragon	•			•		•			•	•	•	•		•		•	•
Ctenophorus isolepis	Military Dragon				•		•			•	•	•	•		•	•	•	
Ctenophorus nuchalis	Central Netted Dragon				•		•				•							
Ctenophorus reticulatus	Western Netted Dragon				•		•			•	•				•			
Ctenophorus scutulatus										•								
Diporiphora amphiboluroides (10)	Mulga Dragon						•			•		•	•		•			
Diporiphora valens	Southern Pilbara Tree Dragon				•		•			•		•			•			•

Family/Species	Common Name	This survey	Conservation status		Databases					Previous surveys								
			State	Commonwealth	NatureMap	EPBC	ALA	IUCN	DBCF TF	Biota (2012)	Biota (2015)	Biota (2013)	Biota (2012)	Biota (2013)	Biologic (2013)	Biologic (2019)	Biologic (2011)	ENV (2011)
Gowidon longirostris (11)	Long-nosed Dragon	•			•		•			•	•	•	•		•		•	
Pogona minor					•		•			•	•	•	•		•			•
Tympanocryptis diabolicus (12)	Hamersley Pebble-mimic Dragon				•		•								•			
Scincidae																		
Carlia munda		•			•		•			•	•	•	•		•			
Carlia triacantha					•		•			•	•	•	•		•			
Cryptoblepharus buchananii (13)					•						•				•			
Cryptoblepharus ustulatus					•		•			•	•	•	•		•		•	
Ctenotus ariadnae					•		•			•	•							
Ctenotus duricola					•		•			•	•	•	•		•			
Ctenotus grandis					•					•	•		•					
Ctenotus hanloni		•			•					•	•							
Ctenotus helenae (14)					•		•			•	•	•	•		•	•		
Ctenotus leonhardii					•						•				•			
Ctenotus pantherinus^	Leopard Ctenotus	•			•		•			•	•	•	•		•			
Ctenotus quattuordecimlineatus					•					•								
Ctenotus robustus					•													
Ctenotus rubicundus					•		•			•	•	•	•		•			
Ctenotus rutilans					•		•			•		•	•					
Ctenotus saxatilis	Rock Ctenotus	•			•					•	•	•	•		•		•	
Ctenotus schomburgkii					•		•			•	•	•	•		•			
Ctenotus serventyi					•		•				•				•			
Ctenotus uber			P2		•					•					•			
Cyclodomorphus melanops	Slender Blue-tongue				•		•			•	•	•	•		•			
Egernia cygnitos (15)	Western Pilbara Spiny-tailed Skink				•		•								•			
Egernia formosa					•		•			•	•	•	•		•		•	
Egernia pilbarensis	Pilbara Skink										•							
Eremiascincus isolepis					•		•											
Eremiascincus pallidus (16)	Western Narrow-banded Skink				•		•					•	•		•			
Eremiascincus richardsonii	Broad-banded Sand Swimmer	•			•		•			•					•			
Eremiascincus rubiginosus (16)	Rusty Skink						•											
Lerista bipes					•					•	•							
Lerista jacksoni					•					•								
Lerista labialis					•		•				•							
Lerista muelleri					•		•			•	•	•	•		•			
Lerista neander					•		•						•					
Lerista timida					•					•								
Lerista verhmens					•					•								
Lerista zietzi					•		•			•		•		•	•			
Menetia greyii					•		•			•	•	•	•		•			
Menetia surda					•		•			•			•		•			
Morethia ruficauda					•		•			•	•	•	•		•			
Notoscincus ornatus					•		•			•	•							
Proablepharus reginae					•		•			•	•				•			
Tiliqua multifasciata	Central Blue-tongue	•			•		•			•	•	•	•		•			
Varanidae																		

Family/Species	Common Name	This survey	Conservation status		Databases					Previous surveys								
			State	Commonwealth	NatureMap	EPBC	ALA	IUCN	DBCF TF	Biota (2012)	Biota (2015)	Biota (2013)	Biota (2012)	Biota (2013)	Biologic (2013)	Biologic (2019)	Biologic (2011)	ENV (2011)
Varanus acanthurus	Spiny-tailed Goanna				•		•			•	•	•	•		•			
Varanus brevicauda	Short-tailed Pygmy Goanna				•		•			•	•	•	•		•			
Varanus bushi	Pilbara Mulga Goanna				•		•			•	•		•		•		•	
Varanus caudolineatus					•					•					•			
Varanus eremius	Pygmy Desert Goanna				•		•			•	•							
Varanus giganteus	Perentie				•										•			
Varanus gilleni	Pygmy Mulga Goanna									•								
Varanus gouldii	Bungarra or Sand Goanna				•		•			•	•	•			•			
Varanus hamersleyensis (17)	Southern Pilbara Rock Goanna																	
Varanus panoptes	Yellow-spotted Goanna	•			•		•			•	•	•	•		•			
Varanus pilbarensis	Northern Pilbara Rock Goanna				•						•	•	•		•			
Varanus tristis	Racehorse Goanna				•		•			•	•	•	•		•		•	
Typhlopidae*																		
Anilios ammodytes							•			•	•	•						
Anilios ganei			P1		•		•		•	•								
Anilios grypus					•		•			•	•	•	•		•			
Anilios hamatus					•		•			•			•					
Anilios pilbarensis										•								
Anilios waitii										•								
Pythonidae																		
Antaresia perthensis	Pygmy Python	•			•		•			•	•	•	•	•	•			
Antaresia children (18)	Children's Python	•			•		•			•		•	•		•			
Aspidites melanocephalus	Black-headed Python				•							•			•			
Liasis olivaceus barroni	Pilbara Olive Python	•	VU	VU	•	•	•		•	•	•				•		•	
Elapidae																		
Acanthophis wellsi	Pilbara Death Adder				•		•			•	•				•			
Brachyurophis approximans					•		•			•	•		•		•			
Brachyurophis fasciolatus^							•											
Demansia psammophis	Yellow-faced Whipsnake				•		•			•	•	•			•			
Demansia rufescens	Rufous Whipsnake	•			•		•			•	•	•	•		•			
Furina ornata	Moon Snake				•		•			•		•	•		•			
Pseudechis australis	Mulga Snake	•			•		•			•	•	•	•		•		•	
Pseudonaja mengdeni (19)	Western Brown Snake				•		•					•	•		•			
Pseudonaja modesta	Ringed Brown Snake				•		•			•		•	•		•			
Simoselaps bertholdi	Jan's Banded Snake						•											
Suta fasciata	Rosen's Snake				•		•						•		•			
Suta gaikhorstorum (20)					•		•			•		•	•		•			
Suta punctata	Spotted Snake				•					•								
Vermicella snelli					•					•								

(1) Formerly included within *N. wheeleri*, some previous records listed as such. Split in paper by Kealley et al. 2020.
(2) Previously included within *U. milii*, some previous records listed as such (Doughty & Oliver 2011).
(3) Previously included within *C. ocellatus*, some previous records listed as such.
(4) Close to range of *D. bilybara* (Oliver et al. 2014).
(5) Previously included within *L. stenodactylus [L. stenodactylum]*, previous records listed as such.
(6) Previously included within *O. marmorata*, some previous records listed as such.
(7) *Gehyra punctata* split into several species in 2018, specimens recorded from the locality of the study area as *G. punctata* may be *G. punctata*, *G. fenestrula* or *G. micra* (Doughty et al. 2018); This includes *Gehyra* specimens observed during the current survey as species cannot be readily identified morphologically in the field Doughty et al. 2018).
(8) *Gehyra variegata* split into several species in 2018, specimens recorded from the locality of the study area as *G. variegata* may be *G. variegata*, *G. crypta, G. montium* or *G. incognita*. This includes *Gehyra* specimens observed during the current survey as species cannot be readily identified morphologically in the field (Kealley et al. 2018).

(9) Synonymous with *D. haroldi*, some previous records listed as such.
(10) Previously listed in monotypic genus Caimanops, some previous records listed as such.
(11) Previously included within the genera Amphibolurus and Lophognathus, some previous records listed as such.
(12) Previously included within *T. cephalus*, previous records of *T. cephalus* most likely attributable to *T. diabolicus* based on range, but some chance *T. fortescuensis* or *T. pseudosephos*.
(13) Previously included within *C. plagiocephalus*, some previous records listed as such.
(14) At times included within *C. inornatus*, some previous records listed as such.
(15) Previously included within *E. depressa*, some previous records listed as such.
(16) Both *E. pallidus* and *E. rubiginosus* have previously been included within *E. fasciolatus*.
(17) Previously included within *V. pilbarensis*, previous records listed as such.
(18) Previously *A. stimsoni*, previous records listed as such
(19) Previously included within *P. nuchalis*, some previous records listed as such.
(20) Previously included within *P. monachus*, some previous records listed as such (Maryan et al. 2020).
* Note Anilios genus replaces Ramphotyphlops.
^ Indicates species for which BHP WAIO internal nomenclature currently differs/species not currently included in BHP WAIO internal species list.

Avifauna

Family/Species	Common Name	This survey	Conservation status		Databases						Previous surveys								
			State	Commonwealth	NatureMap	EPBC	ALA	IUCN	DBCF TF	Biota (2012)	Biota (2015)	Biota (2013)	Biota (2012)	Biota (2013)	Biologic (2013)	Biologic (2019)	Biologic (2011)	ENV (2011)	NatureMap
Casuariidae																			
Dromaius novaehollandiae	Emu				•		•			•	•	•	•	•		•			
Phasianidae																			
Coturnix pectoralis	Stubble Quail			MA						•	•	•							
*Coturnix ypsilophora^*	Brown Quail	•			•		•			•	•					•			
Anatidae																			
Dendrocygna eytoni	Plumed Whistling Duck				•		•			•						•			
Chenonetta jubata	Maned Duck															•			
Anas superciliosa	Pacific Black Duck	•			•		•			•		•	•			•		•	
Anas gracilis	Grey Teal	•					•					•				•			
Podargidae																			
Podargus strigoides	Tawny Frogmouth	•			•		•			•			•	•		•			
Caprimulgidae																			
Eurostopodus argus	Spotted Nightjar	•		MA	•		•			•	•	•	•	•		•		•	
Aegothelidae																			
Aegotheles cristatus	Australian Owlet-nightjar	•			•		•			•	•	•	•	•	•	•		•	
Apodidae																			
Apus pacificus	Pacific Swift (1)		MI	MI/MA	•	•	•		•	•	•	•						•	
Otididae																			
Ardeotis australis	Australian Bustard	•			•		•			•	•	•	•	•		•		•	•
Cuculidae																			
Centropus phasianinus	Pheasant Coucal				•		•			•		•							
Chrysococcyx basalis	Horsfield's Bronze Cuckoo (2)	•			•		•			•	•	•	•	•		•			
Chrysococcyx osculans	Black-eared Cuckoo (2)	•		MA	•	•	•			•	•	•							
Cacomantis pallidus	Pallid Cuckoo	•		MA	•		•			•	•	•		•		•			
Columbidae																			
Phaps chalcoptera	Common Bronzewing	•			•		•			•	•	•	•	•		•		•	•
Ocyphaps lophotes	Crested Pigeon	•			•		•			•	•	•	•	•		•		•	•
*Geophaps plumifera^*	Spinifex Pigeon	•			•		•			•	•	•	•	•		•		•	
Geopelia cuneata	Diamond Dove	•			•		•			•	•	•	•	•		•			
*Geopelia placida^*	Peaceful Dove	•			•		•			•	•	•		•				•	•
Rallidae																			
Porzana tabuensis	Spotless Crake			MA	•							•							
Fulica atra	Eurasian Coot						•					•							
Podicipedidae																			
Tachybaptus novaehollandiae	Australasian Grebe						•												
Turnicidae																			
Turnix velox	Little Buttonquail	•			•		•			•	•	•	•	•		•			
Burhinidae																			
Burhinus grallarius	Bush Stone-curlew				•		•			•						•			
Recurvirostridae																			
Himantopus leucocephalus	Pied Stilt			MA	•		•			•						•			
Charadriidae																			
Erythrogonys cinctus	Red-kneed Dotterel											•							
Charadrius veredus	Oriental Plover		MI	MI/MA		•													

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Elseyornis melanops	Black-fronted Dotterel	•			•		•			•		•	•			•		•	
Rostratulidae																			
Rostratula australis	Australian Painted-snipe		EN	EN		•													
Scolopacidae																			
Calidris acuminata	Sharp-tailed Sandpiper		MI	MI/MA		•													
Calidris ferruginea	Curlew Sandpiper		CR; MI	CR/MI/MA		•													
Calidris melanotos	Pectoral Sandpiper		MI	MI/MA		•													
Actitis hypoleucos	Common Sandpiper		MI	MI/MA		•													
Tringa glareola	Wood Sandpiper		MI	MI/MA			•									•			
Tringa nebularia	Common Greenshank		MI	MI/MA	•				•				•						
Laridae																			
*Gelochelidon macrotarsa^*	Australian [Gull-billed] Tern (3)		MI	MI/MA					•										
*Onychoprion anaethetus^*	Bridled Tern		MI	MI			•												
Ciconiidae																			
Ephippiorhynchus asiaticus	Black-necked Stork							•											
Phalacrocoracidae																			
*Microcarbo melanoleucos^*	Little Pied Cormorant						•			•		•						•	
Phalacrocorax sulcirostris	Little Black Cormorant									•								•	
Phalacrocorax varius	Australian Pied Cormorant				•					•			•						
Anhingidae																			
Anhinga novaehollandiae	Australasian Darter											•	•	•		•			
Threskiornithidae																			
Threskiornis spinicollis	Straw-necked Ibis			MA	•		•			•		•							
Ardeidae																			
Ixobrychus flavicollis	Black Bittern				•														
Nycticorax caledonicus	Nankeen Night Heron			MA									•						
*Bubulcus coromandus^*	Eastern Cattle Egret (4)			MA		•													
Ardea pacifica	White-necked Heron				•		•			•		•							
*Ardea alba^*	Great Egret (5)			MA		•						•							
*Egretta novaehollandiae^*	White-faced Heron	•			•		•			•		•	•					•	
*Egretta garzetta^*	Little Egret			MA			•												
Pelecanidae																			
Pelecanus conspicillatus	Australian Pelican			MA	•								•						
Accipitridae																			
Elanus axillaris	Black-shouldered Kite				•					•	•								
Elanus scriptus	Letter-winged Kite		P4		•				•										
*Lophoictinia isura^*	Square-tailed Kite				•		•												
Hamirostra melanosternon	Black-breasted Buzzard				•		•			•	•	•				•			
Hieraaetus morphnoides	Little Eagle				•		•			•	•	•				•			
Aquila audax	Wedge-tailed Eagle	•			•		•			•	•		•		•	•			
Accipiter fasciatus	Brown Goshawk	•		MA	•		•			•		•	•			•		•	
Accipiter cirrocephalus	Collared Sparrowhawk				•		•			•	•	•		•		•			
Circus approximans	Swamp Harrier			MA	•						•								
Circus assimilis	Spotted Harrier	•			•		•			•	•	•	•	•	•	•			
Milvus migrans	Black Kite	•			•		•			•	•	•	•	•				•	

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Haliastur sphenurus	Whistling Kite	•		MA	•		•			•	•	•	•	•		•		•	•
Tytonidae																			
Tyto javanica	Eastern Barn Owl (6)	•			•		•			•					•				
Strigidae																			
Ninox connivens	Barking Owl	•			•		•					•	•						
Ninox boobook	Australian Boobook (7)	•		MA			•			•	•	•	•	•		•		•	
Alcedinidae																			
Dacelo leachii occidentalis	Blue-winged Kookaburra	•			•		•			•	•	•	•			•		•	
Todiramphus sanctus	Sacred Kingfisher	•		MA	•		•			•	•	•	•	•		•		•	•
Todiramphus pyrrhopygius	Red-backed Kingfisher	•			•		•			•	•	•	•	•		•		•	
Meropidae																			
Merops ornatus	Rainbow Bee-eater	•		MA	•	•	•			•	•	•	•	•	•	•		•	•
Falconidae																			
Falco cenchroides	Nankeen Kestrel			MA	•		•			•	•	•	•	•		•			
Falco longipennis	Australian Hobby				•		•			•	•	•	•	•		•			
Falco berigora	Brown Falcon	•			•		•			•	•	•	•	•		•		•	
Falco hypoleucos	Grey Falcon		VU	VU	•	•		•	•		•								
Falco peregrinus	Peregrine Falcon		OS		•		•		•	•	•	•	•			•			
Cacatuidae																			
Nymphicus hollandicus	Cockatiel	•			•		•			•	•	•	•	•		•			
*Eolophus roseicapilla^*	Galah	•			•		•			•	•	•	•	•		•			•
Cacatua sanguinea	Little Corella	•			•		•			•	•	•	•	•		•		•	•
Psittaculidae																			
*Psephotellus varius^*	Mulga Parrot				•		•			•	•	•							
*Barnardius zonarius^*	Australian Ringneck	•			•		•			•	•	•	•	•		•	•	•	•
Pezoporus occidentalis	Night Parrot		CR	EN		•		•											
Neopsephotus bourkii	Bourke's Parrot				•		•			•						•			
Melopsittacus undulatus	Budgerigar	•			•		•			•	•	•	•	•		•			
Ptilonorhynchidae																			
*Chlamydera guttata^*	Western Bowerbird	•			•		•			•	•		•	•	•	•		•	
Climacteridae																			
Climacteris melanurus	Black-tailed Treecreeper						•					•							
Maluridae																			
*Malurus assimilis^*	Purple-backed Fairywren (8)	•			•		•			•	•	•	•	•		•	•	•	•
Malurus splendens	Splendid Fairywren				•		•			•						•			
Malurus leucopterus leuconotus	White-winged Fairywren	•			•		•			•	•	•	•	•		•			
Stipiturus ruficeps	Rufous-crowned Emu-wren				•		•			•	•					•			
Amytornis striatus	Striated Grasswren				•		•			•	•					•		•	
Meliphagidae																			
Epthianura tricolor	Crimson Chat				•		•			•	•	•	•	•		•			
Conopophila whitei	Grey Honeyeater				•		•			•		•		•		•			
Certhionyx variegatus	Pied Honeyeater				•		•			•	•					•			
Sugomel niger	Black Honeyeater						•			•	•	•	•	•		•			
Lichmera indistincta	Brown Honeyeater	•			•		•			•	•	•	•	•		•			•
Melithreptus gularis laetior	Black-chinned Honeyeater	•			•		•			•	•	•	•	•		•		•	
Purnella albifrons	White-fronted Honeyeater						•				•	•							

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Gavicalis virescens	Singing Honeyeater (9)	•			•		•			•	•	•	•	•		•	•	•	•
Ptilotula keartlandi	Grey-headed Honeyeater (9)	•			•		•			•	•	•	•	•		•		•	
Ptilotula penicillata	White-plumed Honeyeater (9)	•			•		•			•	•	•	•	•		•		•	•
Acanthagenys rufogularis	Spiny-cheeked Honeyeater	•			•		•			•	•	•	•	•		•			•
Manorina flavigula	Yellow-throated Miner	•			•		•			•	•	•	•	•		•		•	•
Pardalotidae																			
Pardalotus rubricatus	Red-browed Pardalote				•		•			•	•	•	•	•		•			
Pardalotus striatus	Striated Pardalote				•		•			•	•	•	•	•		•			•
Acanthizidae																			
Smicrornis brevirostris	Weebill	•			•		•			•	•	•	•	•		•	•	•	•
Pyrrholaemus brunneus	Redthroat				•		•			•									
Gerygone fusca	Western Gerygone	•			•		•			•	•	•	•	•		•		•	•
Acanthiza apicalis	Inland Thornbill	•			•		•			•	•	•	•	•		•			
Acanthiza uropygialis	Chestnut-rumped Thornbill				•		•			•	•	•		•		•			
Acanthiza chrysorrhoa	Yellow-rumped Thornbill				•		•			•	•			•		•			
Acanthiza robustirostris	Slaty-backed Thornbill				•		•			•	•	•				•			
Aphelocephala leucopsis	Southern Whiteface									•									
Pomatostomidae																			
Pomatostomus temporalis	Grey-crowned Babbler	•			•		•			•	•	•	•	•		•		•	•
Pomatostomus superciliosus	White-browed Babbler				•		•			•	•			•		•			
Psophodidae																			
Psophodes occidentalis	Chiming Wedgebill				•					•						•			
Cinclosomatidae																			
*Cinclosoma marginatum^*	Western Quail-thrush (10)						•												
Artamidae																			
Artamus leucorynchus	White-breasted Woodswallow				•						•								
Artamus personatus	Masked Woodswallow	•			•		•			•	•	•	•	•		•			•
Artamus cinereus	Black-faced Woodswallow	•			•		•			•	•	•	•	•		•		•	•
Artamus cyanopterus	Dusky Woodswallow (11)				•														
Artamus minor	Little Woodswallow	•			•		•			•	•	•	•	•		•		•	
*Gymnorhina tibicen^*	Australian Magpie (12)	•			•		•			•	•	•	•	•		•		•	•
Cracticus torquatus	Grey Butcherbird	•			•		•			•	•	•		•		•			
Cracticus nigrogularis	Pied Butcherbird				•		•			•	•	•	•	•		•		•	•
Campephagidae																			
Coracina maxima	Ground Cuckooshrike				•		•			•			•			•			
Coracina novaehollandiae	Black-faced Cuckooshrike	•		MA	•		•			•	•	•	•	•		•		•	•
Lalage tricolor	White-winged Triller (13)	•			•		•			•	•	•	•	•		•		•	
Neosittidae																			
Daphoenositta chrysoptera	Varied Sittella				•		•			•		•							
Oreoicidae																			
Oreoica gutturalis	Crested Bellbird	•			•		•			•	•	•	•	•		•		•	•
Pachycephalidae																			
Pachycephala rufiventris	Rufous Whistler	•			•		•			•	•	•	•	•		•	•	•	•
Colluricincla harmonica	Grey Shrikethrush	•			•		•			•	•	•	•	•		•	•	•	
Rhipiduridae																			
Rhipidura leucophrys	Willie Wagtail	•			•		•			•	•	•	•	•		•	•	•	•

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Rhipidura albiscapa	Grey Fantail				•		•			•			•	•		•			
Monarchidae																			
Grallina cyanoleuca	Magpie-lark	•		MA	•		•			•	•	•	•	•		•		•	•
Corvidae																			
Corvus orru	Torresian Crow	•			•		•			•	•	•	•	•		•		•	•
Corvus bennetti	Little Crow	•			•		•			•	•	•		•					
Corvus coronoides^	Australian Raven				•														
Petroicidae																			
Melanodryas cucullata	Hooded Robin				•		•			•	•	•	•	•		•		•	•
Petroica goodenovii	Red-capped Robin				•		•			•	•	•	•	•		•			•
Alaudidae																			
Mirafra javanica	Horsfield's Bush Lark				•		•			•	•		•			•			
Hirundinidae																			
Cheramoeca leucosterna	White-backed Swallow									•		•							
Hirundo rustica	Barn Swallow		MI	MI		•													
Hirundo neoxena	Welcome Swallow			MA						•									
Petrochelidon ariel	Fairy Martin				•		•			•		•	•	•		•			
Petrochelidon nigricans	Tree Martin			MA	•		•			•		•	•	•		•			
Acrocephalidae																			
Acrocephalus australis	Australian Reed Warbler				•					•		•	•					•	
Locustellidae																			
Poodytes carteri^	Spinifexbird (14)	•			•		•			•	•	•	•	•		•			
Cincloramphus cruralis	Brown Songlark						•			•	•		•	•		•			
Cincloramphus mathewsi	Rufous Songlark	•					•			•	•	•	•	•		•		•	
Dicaeidae																			
Dicaeum hirundinaceum	Mistletoebird	•			•		•			•	•	•		•		•			
Estrildidae																			
Emblema pictum	Painted Finch	•			•		•			•	•	•	•	•		•		•	
Neochmia ruficauda	Star Finch				•		•			•	•	•						•	
Taeniopygia guttata^	Zebra Finch	•			•		•			•	•	•	•	•		•	•	•	•
Motacillidae																			
Motacilla tschutschensis^	Eastern Yellow Wagtail		MI	MI/MA		•													
Motacilla cinerea	Grey Wagtail		MI	MI/MA		•													
Anthus australis	Australian Pipit (15)			MA	•		•			•	•	•	•						

(1) Formerly included within Fork-tailed Swift, previous records listed as such. Has retained the specific name *A. pacificus* in the taxonomic revision but common name changed.
(2) Formerly genus *Chalcites*, some previous records listed as such.
(3) Formerly included within Gull-billed Tern *G. nilotica,* previous records listed as such. In this region, past records of *G. nilotica* all likely referrable to *G. macrotarsa.*
(4) Formerly included within Cattle Egret *B. ibis* or *Ardea ibis*, some previous records listed as such.
(5) Sometimes considered a separate species Eastern Great Egret *A. modesta*, some previous records listed as such.
(6) Formerly included within Barn Owl *T. alba*, some previous records listed as such.
(7) Formerly included within Southern Boobook *N. novaeseelandiae* or *N. boobook*, some previous records listed as such. Has retained specific name *N. boobook* in most recent taxonomic revision.
(8) Formerly included within Variegated Fairywren *M. lamberti*, some previous records listed as such.
(9) Until 2011 genus *Lichenostomus*, some previous records listed as such.
(10) Formerly included within Chestnut-breasted Quail-thrush *C. castaneothorax*, previous records listed as such.
(11) Records of Dusky Woodswallow likely to be data errors or misidentification of Little Woodswallow.
(12) Formerly included in genus *Cracticus*, some previous records listed as such.
(13) Formerly included within White-shouldered triller *L. sueurii*, some previous records listed as such.
(14) Formerly genus *Eremiornis*, some previous records listed as such.
(15) Sometimes included within Australasian Pipit *A. novaeseelandiae*, some previous records listed as such.
Single record of Great Bowerbird, two records of Painted Honeyeater, and multiple records of House Crow returned by NatureMap search are erroneous (data errors) and have not been included.
Occurrence of Grey-fronted Honeyeater (except as a potential vagrant) in the Pilbara has not been well-demonstrated, so has not been included here.

* None of the Marine listed species are true marine species and are considered to be listed erroneously as none rely upon marine environments for survival, and all are relatively common and widespread. These species are excluded from the discussion of species of significance.
^ Indicates species for which BHP WAIO internal nomenclature currently differs/species not currently included in BHP WAIO internal species list.

Appendix 2

Threatened Fauna Statutory Framework – Western Australia

Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*

Fauna species of national environmental significance are listed under the Commonwealth EPBC Act, and may be classified as 'critically endangered', 'endangered', 'vulnerable' or 'lower risk', which are consistent with IUCN categories.

Critically Endangered (CR): a taxon is Critically Endangered when it is facing an extremely high risk of extinction in the wild in the immediate future.

Endangered (EN): a taxon is Endangered when it is not Critically Endangered but is facing a very high risk of extinction in the wild in the near future.

Vulnerable (VU): a taxon is Vulnerable when it is not Critically Endangered or Endangered but is facing a high risk of extinction in the wild in the medium-term future.

Lower Risk (LR): a taxon is Lower Risk when it has been evaluated, does not satisfy the criteria for any of the categories Critically Endangered, Endangered or Vulnerable. Taxa included in the Lower Risk category can be separated into three subcategories:

1. **Conservation Dependent (CD).** Taxa which are the focus of a continuing taxon-specific or habitat-specific conservation program targeted towards the taxon in question, the cessation of which would result in the taxon qualifying for one of the threatened categories above within a period of five years.
2. **Near Threatened (NT).** Taxa which do not qualify for Conservation Dependent, but which are close to qualifying for Vulnerable.
3. **Least Concern (LC).** Taxa which do not qualify for Conservation Dependent or Near Threatened.

Migratory species (MI) are also protected under the *EPBC Act* as species of national environmental significance. Migratory species are those animals that migrate to Australia and its external territories, or pass through or over Australian waters during their annual migrations. The list of migratory species consists of those species listed under the following international conventions:

1. Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention);
2. China-Australia Migratory Bird Agreement (CAMBA);
3. Japan-Australia Migratory Bird Agreement (JAMBA); and,
4. Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA).

Marine species (MA) are also protected under the *EPBC Act*, and are listed to ensure the long-term conservation of the species. Marine species include all Australian sea snakes, seals, crocodiles, dugongs, marine turtles, seahorses and seabirds that naturally occur in the Commonwealth marine area.

Western Australian *Biodiversity Conservation Act 2016*

The Wildlife Conservation (Specially Protected Fauna) Notice 2018 has 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:

Threatened Species

- **Critically Endangered (CR):** 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.
- **Endangered (EN):** 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".
- **Vulnerable (VU):** 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".

Extinct Species

- **Extinct Species (EX):** Species where "there is no reasonable doubt that the last member of the species has died"
- **Extinct in the wild (EW):** 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"

Specially Protected Species

- **Migratory (MI):** 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. 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
- **Species of special conservation interest (conservation dependent fauna) (CD):** Fauna of special conservation need being species dependent on ongoing conservation intervention to prevent it becoming eligible for listing as threatened.
- **Other specially protected fauna (OS):** Fauna otherwise in need of special protection to ensure their conservation

Department of Biodiversity, Conservation and Attractions Priority Listing

The DBCA maintains a list of Priority species that have not been assigned statutory protection under the *Biodiversity Conservation Act 2016*. Species on this list are considered to be of conservation priority because there is insufficient information to make an assessment of their conservation status or they are considered to be rare but not threatened and are in need of monitoring. Under this list, species are classified according to four Priority categories:

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.

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.

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.

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 3

Fauna Licence

Department of **Biodiversity, Conservation and Attractions**

GOVERNMENT OF WESTERN AUSTRALIA

FAUNA TAKING (BIOLOGICAL ASSESSMENT) LICENCE

Regulation 27, Biodiversity Conservation Regulations 2018

Licence Number: BA27000325

Licence Holder: Dr Sylvie Schmidt
Biota Environmental Sciences
Level 1 / 228 Carr Place
Leederville WA 6007

Date of Issue: 01/10/2020

Date Valid From: 01/10/2020
Date of Expiry: 31/03/2021

LICENSED ACTIVITIES

Subject to the terms and conditions on this licence, the licence holder may –

1. Take and disturb fauna for fauna survey for BHP Iron Ore (BHP WAIO) using remote sensing cameras, ultrasonic bat detectors, and visual observations (spotlighting / secondary signs / habitat assessment) to inform future environmental approvals.

LOCATIONS

1. MAC Phase 4 Marillana Creek Area 90km north-west Newman (Pilbara Region).

AUTHORISED PERSONS

The following persons or persons of the specified class may assist in carrying out the licensed activities:

1. Michael Greenham

CONDITIONS

1. Fauna must not be taken on CALM land, (as defined in the Conservation and Land Management Regulations 2002*),* unless authorised by a written notice of a lawful authority issued under regulations 4 and 8 of the Conservation and Land Management Regulations 2002.
2. If persons, other than the licence holder, are authorised to carry out/assist in carrying out the activities under the licence, the licence holder must ensure those persons have read and understand the licence terms and conditions.
3. The written authorisation of the person in possession or occupation of the land accessed and upon which fauna is taken, as required under regulation 101(2) and referred to in “Additional information” below, must:
   a) state location details (including lot or location number, street/road, suburb and local government authority);
   b) state land owner or occupier name, and contact phone number;
   c) specify the time period that the authorisation is valid for;
   d) be signed and dated; and
   e) be attached to this licence at all times.

4. This licence, and any written authorisation or lawful authority which authorises the take of fauna on specified locations must be carried at all times while conducting licensed activities and be produced on demand by a wildlife officer.
5. If a species of fauna listed as a threatened species under Section 19 of the *Biodiversity Conservation Act 2016* is inadvertently captured, that species is to be released immediately at the point of capture. If the fauna is injured or deceased, the licence holder shall contact the DBCA Wildlife Licensing Section (wildlifelicensing@dbca.wa.gov.au) for advice on treatment or disposal. Details of any capture of threatened fauna must be included in the "Return of Fauna Taken."
6. The licence holder must not:
   a) release any fauna in any area where it does not naturally occur;
   b) transfer fauna to any other person or authority (other than the Western Australian Museum) unless approved in writing by the CEO; or
   c) dispose of the remains of fauna in any manner likely to interfere the natural or present day distribution of the species.
7. The licence holder must not take and remove more than ten specimens of any one protected species of fauna from any location less than 20km apart. Where exceptional circumstances make it necessary to take a larger number of specimens from a particular location in order to obtain adequate statistical data, the collector must proceed with circumspection and justify their actions to the Director General in advance.
8. All holotypes and syntypes and a half share of paratypes of species or subspecies permitted to be permanently taken under this licence must be donated to the Western Australian Museum. Duplicates (one pair in each case) of any species collected, which represents a significant extension of geographic range must be offered to the Western Australian Museum.
9. All specimens and material retained under the authority of this licence must be offered to the Western Australian Museum for loan, for inclusion in its collection, or on request be made available to other persons involved in relevant scientific studies.
10. The licence holder must create, compile and maintain records and information as required in a DBCA approved "Return of Fauna Taken" of all fauna taking activities as they occur.
11. A DBCA approved "Return of Fauna Taken" must be completed in full (including nil taking details) and submitted to DBCA Wildlife Licensing Section (wildlifelicensing@dbca.wa.gov.au) prior to the end of each annual period of the licence (from the valid from date) (refer to "Additional Information" section below).

Danny Stefoni
LICENSING OFFICER
WILDLIFE PROTECTION BRANCH

Delegate of CEO

ADDITIONAL INFORMATION

1. It is an offence to take any species of fauna listed as a threatened species under Section 19 of the *Biodiversity Conservation Act 2016* unless the person is authorised under Section 40. The penalty ranges between $300 000 and $500 000; Section 150 Biodiversity Conservation Act 2016.
2. Regulation 82 empowers the CEO to add, substitute or delete a term or condition of a licence or to correct errors. Such power may be exercised on application of a licence holder or by the CEO's own initiative. If an amendment to a licence term or condition is required, please contact the CEO or the Licensing Section on wildlifelicensing@dbca.wa.gov.au in the first instance. The licence holder, if adversely affected by a condition imposed in this licence, may apply to the State Administrative Tribunal for review of the decision of the CEO to impose that condition on a licence: regulation 89(2) Biodiversity Conservation Regulations 2018.
3. A person must not contravene a condition of a licence. The penalty for an offence involving the contravention of a condition of a licence is a fine of $10 000: regulation 84 of the Biodiversity Conservation Regulations 2018.
4. It is an offence for persons authorised by this licence to enter land that is not in their possession or under their control without first having the *prior* written authorisation of the current owner or occupier of the land to:

   a) enter the land; and

   b) carry out the activity authorised by this licence.

   The penalty for this offence is a fine of $5 000: regulation 101(2) of the Biodiversity Conservation Regulations 2018.
5. The licence holder must be able to produce for inspection upon request any information or records required by regulation 85(2) of the Biodiversity Conservation Regulations 2018 Penalty $10 000. It is an offence to knowingly include false or misleading information or make statements in records: regulation 85(3) of the Biodiversity Conservation Regulations 2018 Penalty $10 000. It is an offence to include any information or make any statement in a return that the licence holder knows to be false or misleading in a material particular: regulation 86 (2) of the Biodiversity Conservation Regulations 2018 Penalty $10 000.
6. The approved DBCA "Return of Fauna Taken" data file can be downloaded from the DBCA webpage (https://www.dpaw.wa.gov.au/plants-and-animals/licences-and-authorities).
7. The issuing of a licence under the Biodiversity Conservation Regulations 2018 does not constitute an animal ethics approval or a licence to use animals for scientific purposes as required under the *Animal Welfare Act 2002,* Animal Welfare (Scientific Purposes) Regulations 2003. It is the responsibility of a licence applicant / licence holder to ensure that they comply with the requirements of all applicable legislation. Enquiries relating to the Animal Welfare Act licences and animal ethics approvals are to be directed to the Department of Primary Industries and Regional Development (https://www.agric.wa.gov.au/animalwelfare).
8. Threatened fauna can only be taken under a *Biodiversity Conservation Act 2016* Section 40 authorisation, Occurrences of threatened species must be reported to the CEO. For more information please see https://www.dpaw.wa.gov.au/plants-and-animals/threatened-species-and-communities/threatened-animals.
9. Any interaction involving Nationally Listed Threatened Fauna that may be invasive and/or harmful to the fauna may require approval from the Commonwealth Department of the Environment and Energy http://www.environment.gov.au/about-us/business-us/permits-assessments-licences. Interaction with such species is controlled by the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* and Environment Protection and Biodiversity Conservation Regulations 2000 as well as the *Biodiversity Conservation Act 2016* and Biodiversity Conservation Regulations 2018.

GOVERNMENT OF WESTERN AUSTRALIA

Department of **Biodiversity, Conservation and Attractions**

AUTHORISATION TO TAKE OR DISTURB THREATENED SPECIES

Section 40 of the Biodiversity Conservation Act 2016

AUTHORISATION DETAILS

Authorisation type: Fauna

Authorisation number: TFA 2020-0125

Authorisation duration: From date signed by Minister's delegate, below, until 31 March 2021.

AUTHORISATION HOLDER

Sylvie Schmidt

Biota Environmental Sciences

Level 1/228 Carr Place

Leederville WA 6007

AREA TO WHICH THIS AUTHORISATION APPLIES

Marillana Creek area, 90km north-west Newman (Pilbara Region).

AUTHORISED ACTIVITY

Purpose of taking/disturbance:

Two-phase targeted, matter of national environmental significance, fauna survey to inform future environmental approvals.

Threatened species authorised to be taken/disturbed (including conservation status):

Northern quoll, *Dasyurus hallucatus* (Endangered)

Bilby, *Macrotis lagotis* (Vulnerable)

Quantity of threatened species authorised to be taken/disturbed:

Any number of individual animals of the above listed threatened fauna species may potentially be observed and/or disturbed by the survey activities.

Authorised taking/disturbance methodology:

Deploy five, permanently set, lured motion-detecting cameras (minimum distance of 100 m apart). Cameras will be baited with a mixture of peanut butter, rolled oats, bacon and truffle oil for scent. Bait will be inaccessible, except a small amount during baiting/rebaiting (initial set up and 2 months later).

ADDITIONAL AUTHORISED PERSONS

Michael Greenham

Additional personnel who are suitably qualified and experienced in the authorised activities working under the direction of the authorisation holder.

..... (Delegate's initials)

Field assistants assisting with the authorised activities working under the direct supervision of the authorisation holder or suitably qualified and experienced named additional authorised person.

CONDITIONS

1. The written authorisation of the person in possession or occupation of the land accessed and upon which threatened fauna is taken or disturbed must:
   a) state location details (including lot or location number, street/road, suburb and local government authority);
   b) state land owner or occupier name, and contact phone number;
   c) specify the time period that the authorisation is valid for;
   d) be signed and dated; and
   e) be attached to this Authorisation to take or disturb threatened species at all times.
2. This Authorisation to take or disturb threatened species, and any other written authorisation or lawful authority which authorises the take or disturbance of fauna on specified locations for the authorised activities must be carried at all times while conducting authorised activities and be produced on demand by a wildlife officer.
3. Named additional authorised persons who are not suitably qualified and experienced in the authorised activities, and volunteer field assistants assisting with the authorised activities, must be working under direct supervision of experienced and competent named authorised persons.
4. Any inadvertently captured species of non-target threatened fauna or non-threatened fauna (threatened fauna as defined in *Biodiversity Conservation Act 2016* Section 19) is to be released immediately at the point of capture. Details of such fauna must be included in the fauna taking return as required under this authorisation.
5. The authorisation holder, unless specified in the authorised activities, must not:
   a) release any threatened fauna in any area where it does not naturally occur;
   b) transfer threatened fauna to any other person or authority (other than the Western Australian Museum) unless the fauna is injured or abandoned fauna (condition 5); or
   c) dispose of the remains of threatened fauna in any manner likely to confuse the natural or present-day distribution of the species.
6. All threatened fauna injuries, unexpected deaths, unplanned euthanasia, and abandoned young or eggs, must be reported by the authorisation holder to the DBCA Wildlife Licensing Section (wildlifelicensing@dbca.wa.gov.au) to notify of the incident and for advice on treatment or disposal. All deceased threatened fauna must be offered to the Western Australian Museum.
7. All holotypes and syntypes and a half share of paratypes of species or subspecies permitted to be permanently taken under this authorisation must be donated to the Western Australian Museum. Duplicates (one pair in each case) of any species collected, which represents a significant extension of geographic range must be offered to the Western Australian Museum.
8. To prevent any unnecessary collecting in this State, all specimens and material taken and retained under this authorisation, that remain at the conclusion of the activities, must be offered to the Western Australian Museum for loan, for inclusion in its collection, or made available to other persons involved in relevant scientific studies if so required.
9. The authorisation holder must create, compile and maintain records and information as required in a DBCA approved "Return of Fauna Taken/Disturbed" of all fauna taking activities as they occur.
10. A DBCA approved "Return of Fauna Taken/Disturbed" must be completed in full (including nil taking details) and submitted to DBCA Wildlife Licensing Section (wildlifelicensing@dbca.wa.gov.au) prior to the end of the authorisation duration and, if the

..... (Delegate's initials)

authorisation duration is greater than 12 months, prior to the end of each annual period of the authorisation (from the date signed by the Minister's delegate) (refer to "Additional Information" section below). Where a licence to take or disturb fauna is issued in conjunction with this Authorisation to take or disturb threatened species, a combined "Return of Fauna Taken/Disturbed" may be completed and submitted.

11. A written report detailing the undertaken authorised activities, outcome, unintended incidents, injuries and mortalities of threatened fauna, implemented monitoring, mitigation and management, and explaining the records and information as required in a DBCA approved "Return of Fauna Taken/Disturbed" must be submitted, in addition to a "Return of Fauna Taken/Disturbed" to DBCA Wildlife Licensing Section (wildlifelicensing@dbca.wa.gov.au).

ADDITIONAL INFORMATION

1. Before undertaking the Authorised Activity, permission must be obtained from: (a) the owner or occupier of private land; or (b) the Department or Authority controlling Crown land, on which the Threatened Fauna occur. This includes obtaining the written endorsement from Department of Biodiversity, Conservation and Attractions (DBCA) if the authorised activity is proposed for land managed by DBCA.
2. This Authorisation to take or disturb threatened species does not constitute lawful authority issued under regulations 4 and 8 of the *Conservation and Land Management Regulations 2002*. Contact the applicable Department District Officer for further information.
3. The approved DBCA "Return of Fauna Taken/Disturbed" data file can be downloaded from the DBCA webpage (https://www.dpaw.wa.gov.au/plants-and-animals/licences-and-authorities).
4. Any interaction involving nationally listed threatened fauna that may be harmful to the fauna and/or invasive may require approval from the Commonwealth Department of the Environment and Energy (http://www.environment.gov.au/biodiversity/threatened/permits). Interaction with such species is controlled by the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* and *Environment Protection and Biodiversity Conservation Regulations 2000*.
5. It is the responsibility of the authorisation holder to ensure that they comply with the requirements of all applicable legislation.
6. An Authorisation to take or disturb threatened species does not constitute an animal ethics approval or a licence to use animals for scientific purposes as required under the *Animal Welfare Act 2002, Animal Welfare (Scientific Purposes) Regulations 2003*. Enquiries relating to the Animal Welfare Act licences and animal ethics approvals are to be directed to the Western Australian Department of Primary Industries and Regional Development (https://www.agric.wa.gov.au/animalwelfare).

.....Margaret Byrne.....

Dr Margaret Byrne

Executive Director of Biodiversity and Conservation Science

AS DELEGATE OF THE MINISTER

DATE: ...25.../...9...../2020

Appendix 4

Habitat Assessment

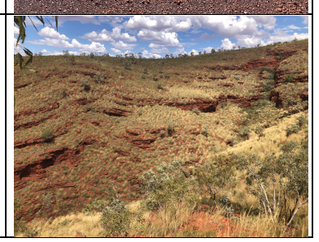
Habitat Assessment

Site ID	Longitude (°E)	Latitude (°S)	(Dominant) BHP Fauna Habitat Type	(Dominant) Landform	Aspect	Slope	Soil Type	Soil Availability	Amount of Outcropping	Outcropping Rock Type	Rock Size	Vegetation Litter Cover	Hollow Bearing Trees	Time Since Last Fire	Disturbances	Mapped Fauna Habitat	Picture
MAC-01	118.833989	-22.761638	Sandy/Stony Plain	Drainage Area/ Floodplain	Flat	Flat	Silty Clay Loam	Many Large Patches	Negligible	Other	Gravel (1-4cm)	Few Small Patches	-	Old (6+ yr)	Road/ Access Track	Fauna landscape 1: Floodplains	
MAC-02	118.834726	-22.748162	Drainage Area/ Floodplain	Major Drainage Line	East	Flat	Silty Clay Loam	Many Small Patches	Negligible	Other	Gravel (1-4cm)	Many Small Patches	-	Old (6+ yr)	None discernible	Fauna landscape 5: Vegetated drainage systems	
MAC-03	118.977405	-22.711136	Medium Drainage Line	Major Drainage Line	North/ East	Low	Clay Loam	Many Large Patches	Negligible	Other	Gravel (1-4cm)	Few Small Patches	-	Old (6+ yr)	Road/ Access Track	Fauna landscape 2: Low undulating ironstone hills	
MAC-04	118.833658	-22.759047	Sandy/Stony Plain	Undulating Low Hills	Flat	Flat	Silty Clay Loam	Few Large Patches	Limited Outcropping	Calcrete	Gravel (1-4cm)	Many Small Patches	-	Old (6+ yr)	Road/ Access Track	Fauna landscape 3: Low undulating calcrete hills and plains	
MAC-05	118.860887	-22.756987	Sandy/ Stony Plain	Sandy/ Stony Plain	Flat	Flat	Clay Loam	Few Large Patches	Negligible	Other	Pebbles (5-10cm)	Many Small Patches	-	Old (6+ yr)	Road/ Access Track	Fauna landscape 1: Floodplains	
MAC-06	118.973757	-22.722042	Major Drainage Line	Major Drainage Line	South/ East	Low	Silty Clay Loam	Many Small Patches	Minor Outcropping	Other	Pebbles (5-10cm)	Many Small Patches	-	Old (6+ yr)	Cattle grazing	Fauna landscape 6: 'Flat Rocks' drainage system	

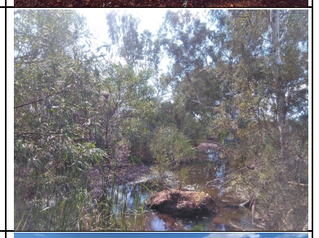
Site ID	Longitude (°E)	Latitude (°S)	(Dominant) BHP Fauna Habitat Type	(Dominant) Landform	Aspect	Slope	Soil Type	Soil Availability	Amount of Outcropping	Outcropping Rock Type	Rock Size	Vegetation Litter Cover	Hollow Bearing Trees	Time Since Last Fire	Disturbances	Mapped Fauna Habitat	Picture
MAC-07	118.799253	-22.834696	Undulating Low Hills	Undulating Low Hills	North/ West	Low	Clay Loam	Many Small Patches	Extensive Outcropping	Other	Pebbles (5-10cm)	Few Small Patches	-	Moderate (3-5 yr)	Road/ Access Track	Fauna landscape 4: Ironstone mountains, gorges and gullies	
MAC-08	118.783860	-22.812047	Drainage Area/ Floodplain	Drainage Area/ Floodplain	Flat	Flat	Silty Clay Loam	Few Large Patches	Negligible	Other	Gravel (1-4cm)	Few Small Patches	-	Old (6+ yr)	Road/ Access Track	Fauna landscape 5: Vegetated drainage systems	
MAC-09	118.807422	-22.838609	Breakaway/ Cliff	Breakaway	North/ East	Moderate	Clay Loam	Few Small Patches	Extensive Outcropping	BIF	Large Rocks (21-60 cm)	Few Small Patches	-	Old (6+ yr)	None discernible	Fauna landscape 4: Ironstone mountains, gorges and gullies	
MAC-10	118.973200	-22.720987	Major Drainage Line	Breakaway	South	Low	Clay Loam Sandy	Few Large Patches	Moderate Outropping	Other	Gravel (1-4cm)	Few Small Patches	-	Old (6+ yr)	Road/ Access Track	Fauna landscape 2: Low undulating ironstone hills	
MAC-11	118.792142	-22.869663	Gorge/Gully	Breakaway	South/ East	Steep	Clay Loam	Few Small Patches	Extensive Outcropping	BIF	Large Rocks (21-60 cm)	Few Small Patches	-	Old (6+ yr)	None discernible	Fauna landscape 4: Ironstone mountains, gorges and gullies	
MAC-12	118.873108	-22.693803	Drainage Area/ Floodplain	Drainage Area/ Floodplain	West	Flat	Silty Clay Loam	Many Large Patches	Negligible	Other	Gravel (1-4cm)	Many Large Patches	-	Old (6+ yr)	Road/ Access Track	Fauna landscape 3: Low undulating calcrete hills and plains	

Site ID	Longitude (°E)	Latitude (°S)	(Dominant) BHP Fauna Habitat Type	(Dominant) Landform	Aspect	Slope	Soil Type	Soil Availability	Amount of Outcropping	Outcropping Rock Type	Rock Size	Vegetation Litter Cover	Hollow Bearing Trees	Time Since Last Fire	Disturbances	Mapped Fauna Habitat	Picture
MAC-13	118.792181	-22.869623	Undulating Gorge/Gully	Gully	South	Low	Clay Loam	Many Small Patches	Minor Outcropping	BIF	Pebbles (5-10cm)	Few Small Patches	-	Moderate (3-5 yr)	Cattle grazing	Fauna landscape 4: Ironstone mountains, gorges and gullies	
MAC-14	118.856312	-22.803711	Sandy/Stony Plain	Sandy/ Stony Plain	Flat	Flat	Clay Loam	Many Large Patches	Negligible	Other	Negligible	Many Small Patches	-	Moderate (3-5 yr)	Cattle grazing	Fauna landscape 1: Floodplains	
MAC-15	118.784892	-22.834966	Hillcrest/ Hillslope	Hillcrest/ Hillslope	North	Moderate	Clay Loam	Many Small Patches	Moderate Outcropping	Other	Pebbles (5-10cm)	Scarce	-	Moderate (3-5 yr)	None discernible	Fauna landscape 4: Ironstone mountains, gorges and gullies	
MAC-16	118.820221	-22.806798	Hillcrest/ Hillslope	Hillcrest/ Hillslope	North	Moderate	Clay Loam	Many Small Patches	Moderate Outcropping	Other	Pebbles (5-10cm)	Few Small Patches	-	Recent (0-2 yr)	None discernible	Fauna landscape 4: Ironstone mountains, gorges and gullies	
MAC-17	118.807319	-22.838094	Breakaway/ Cliff	Breakaway	West	Moderate	Clay Loam	Few Small Patches	Extensive Outcropping	BIF	Small Rocks (11-20cm)	Few Small Patches	-	Moderate (3-5 yr)	None discernible	Fauna landscape 4: Ironstone mountains, gorges and gullies	
MAC-18	118.948670	-22.720102	Major Drainage Line	Major Drainage Line	South	Steep	Sandy Clay Loam	Few Small Patches	Minor Outcropping	Other	Pebbles (5-10cm)	Few Small Patches	-	Old (6+ yr)	Cattle grazing	Fauna landscape 5: Vegetated drainage systems	

Site ID	Longitude (°E)	Latitude (°S)	(Dominant) BHP Fauna Habitat Type	(Dominant) Landform	Aspect	Slope	Soil Type	Soil Availability	Amount of Outcropping	Outcropping Rock Type	Rock Size	Vegetation Litter Cover	Hollow Bearing Trees	Time Since Last Fire	Disturbances	Mapped Fauna Habitat	Picture
MAC-19	118.893889	-22.756314	Hillcrest/ Hillslope	Hillcrest/ Upper Hillslope	North/ West	Low	Clay Loam	Many Small Patches	Negligible	Other	Gravel (1-4cm)	Few Small Patches	-	Old (6+ yr)	Road/ Access Track	Fauna landscape 2: Low undulating ironstone hills	
MAC-20	118.787678	-22.852510	Breakaway/ Cliff	Breakaway	South	Moderate	Clay Loam	Few Small Patches	Major Outcropping	BIF	Large Rocks (21-60 cm)	Few Small Patches	-	Old (6+ yr)	None discernible	Fauna landscape 4: Ironstone mountains, gorges and gullies	
MAC-21	118.842433	-22.815282	Breakaway/ Cliff	Breakaway	East	Steep	Clay Loam	Scarce	Extensive Outcropping	BIF	Small Rocks (11-20cm)	Scarce	-	Old (6+ yr)	None discernible	Fauna landscape 4: Ironstone mountains, gorges and gullies	
MAC-22	118.842089	-22.815459	Breakaway/ Cliff	Breakaway	East	Very steep	Clay Loam	Scarce	Extensive Outcropping	BIF	Small Rocks (11-20cm)	Scarce	-	Old (6+ yr)	None discernible	Fauna landscape 4: Ironstone mountains, gorges and gullies	
MAC-23	118.968133	-22.716492	Calcrete Outcrops	Undulating Low Hills	East	Low	Sandy Clay Loam	Many Small Patches	Limited Outcropping	Calcrete	Gravel (1-4cm)	Few Small Patches	-	Old (6+ yr)	Mining Exploration	Fauna landscape 3: Low undulating calcrete hills and plains	
MAC-24	118.858070	-22.715065	Drainage Area/ Floodplain	Drainage Area/ Floodplain	Flat	Flat	Silty Clay Loam	Few Large Patches	Negligible	Other	Gravel (1-4cm)	Few Small Patches	-	Old (6+ yr)	Road/ Access Track	Fauna landscape 1: Floodplains	

Site ID	Longitude (°E)	Latitude (°S)	(Dominant) BHP Fauna Habitat Type	(Dominant) Landform	Aspect	Slope	Soil Type	Soil Availability	Amount of Outcropping	Outcropping Rock Type	Rock Size	Vegetation Litter Cover	Hollow Bearing Trees	Time Since Last Fire	Disturbances	Mapped Fauna Habitat	Picture
MAC-25	118.782391	-22.787853	Drainage Area/ Floodplain	Drainage Area/ Floodplain	Flat	Flat	Silty Clay Loam	Few Small Patches	Negligible	Other	Negligible	Few Small Patches	-	Old (6+ yr)	Road/ Access Track	Fauna landscape 5: Vegetated drainage systems	
MAC-26	118.922756	-22.776285	Undulating Low Hills	Undulating Low Hills	North	Low	Silty Clay Loam	Few Large Patches	Minor Outcropping	Other	Gravel (1-4cm)	Few Small Patches	-	Recent (0-2 yr)	Road/ Access Track	Fauna landscape 2: Low undulating ironstone hills	
MAC-27	118.958217	-22.720812	Major Drainage Line	Major Drainage Line	East	Low	Clay Loam	Many Small Patches	Limited	Other	Small Rocks (11-20cm)	Many Large Patches	-	Old (6+ yr)	None discernible	Fauna landscape 5: Vegetated drainage systems	
MAC-28	118.920837	-22.693594	Major Drainage Line	Major Drainage Line	South/ East	Low	Silty Loam	Many Large Patches	Negligible	Other	Pebbles (5-10cm)	Few Small Patches	-	Old (6+ yr)	Cattle grazing	Fauna landscape 5: Vegetated drainage systems	
MAC-29	118.849085	-22.727971	Eucalypt Woodland	Drainage Area/ Floodplain	East	Flat	Silty Clay Loam	Many Large Patches	Negligible	Other	Gravel (1-4cm)	Scarce	-	Recent (0-2 yr)	Road/ Access Track	Fauna landscape 1: Floodplains	
MAC-30	118.796407	-22.863133	Breakaway/ Cliff	Gully	North	Steep	Sandy Clay Loam	Scarce	Major Outcropping	BIF	Small Rocks (11-20cm)	Few Small Patches	0	Old (6+ yr)	None discernible	Fauna landscape 4: Ironstone mountains, gorges and gullies	

Site ID	Longitude (°E)	Latitude (°S)	(Dominant) BHP Fauna Habitat Type	(Dominant) Landform	Aspect	Slope	Soil Type	Soil Availability	Amount of Outcropping	Outcropping Rock Type	Rock Size	Vegetation Litter Cover	Hollow Bearing Trees	Time Since Last Fire	Disturbances	Mapped Fauna Habitat	Picture
MAC-31	118.791731	-22.865838	Gorge/Gully	Breakaway	East	Steep	Clay Loam	Few Small Patches	Extensive Outcropping	BIF	Small Rocks (11-20cm)	Few Small Patches	-	Moderate (3-5 yr)	None discernible	Fauna landscape 4: Ironstone mountains, gorges and gullies	
MAC-32	118.792080	-22.870131	Gorge/Gully	Breakaway	West	Moderate	Clay Loam	Few Small Patches	Extensive Outcropping	BIF	Small Rocks (11-20cm)	Few Small Patches	-	Old (6+ yr)	None discernible	Fauna landscape 4: Ironstone mountains, gorges and gullies	
MAC-33	118.827742	-22.786476	Drainage Area/ Floodplain	Drainage Area/ Floodplain	Flat	Flat	Clay Loam	Few Large Patches	Negligible	Other	Pebbles (5-10cm)	Many Small Patches	-	Old (6+ yr)	None discernible	Fauna landscape 1: Floodplains	
MAC-34	118.793339	-22.862753	Breakaway/ Cliff	Gully	South	Steep	Sandy Clay Loam	Scarce	Major Outcropping	Other	Small Rocks (11-20cm)	Few Small Patches	-	Old (6+ yr)	None discernible	Fauna landscape 4: Ironstone mountains, gorges and gullies	
MAC-35	118.924708	-22.707678	Major Drainage Line	Major Drainage Line	South/ East	Low	Sandy Loam	Few Small Patches	Negligible	Other	Gravel (1-4cm)	Few Small Patches	-	Old (6+ yr)	Road/ Access Track	Fauna landscape 5: Vegetated drainage systems	
MAC - 36	118.971515	-22.720876	Major Drainage Line	Major Drainage Line	East	Low	Silty Clay Loam	Few Large Patches	Limited Outcropping	Calcrete	Pebbles (5-10cm)	Few large Patches	-	Old (6+ yr)	Road/ Access Track	Fauna landscape 3: Low undulating calcrete hills and plains	

Site ID	Longitude (°E)	Latitude (°S)	(Dominant) BHP Fauna Habitat Type	(Dominant) Landform	Aspect	Slope	Soil Type	Soil Availability	Amount of Outcropping	Outcropping Rock Type	Rock Size	Vegetation Litter Cover	Hollow Bearing Trees	Time Since Last Fire	Disturbances	Mapped Fauna Habitat	Picture
MAC-37	118.876690	-22.714425	Undulating Low Hills	Undulating Low Hills	South	Low	Clay Loam	Many Small Patches	Limited Outcropping	Calcrete	Pebbles (5-10cm)	Few Small Patches	-	Moderate (3-5 yr)	Road/ Access Track	Fauna landscape 3: Low undulating calcrete hills and plains	
MAC-38	118.869266	-22.733441	Major Drainage Line	Major Drainage Line	North/ East	Flat	Silty Clay Loam	Evenly Spread	Negligible	Other	Pebbles (5-10cm)	Few Small Patches	-	Old (6+ yr)	Cattle grazing	Fauna landscape 5: Vegetated drainage systems	
MAC-39	118.933688	-22.718600	Major Drainage Line	Major Drainage Line	East	Low	Sandy Loam	Few Small Patches	Negligible	Calcrete	Gravel (1-4cm)	Many Small Patches	-	Old (6+ yr)	None discernible	Fauna landscape 5: Vegetated drainage systems	
MAC-40	118.972055	-22.720892	Major Drainage Line	Major Drainage Line	South	Low	Clay Loam Sandy	Few Large Patches	Moderate Outcropping	Other	Gravel (1-4cm)	Few Small Patches	-	Old (6+ yr)	Road/ Access Track	Fauna landscape 6: 'Flat Rocks' drainage system	
MAC-41	118.805226	-22.794806	Eucalypt Woodland	Drainage Area/ Floodplain	East	Low	Silty Clay Loam	Few Small Patches	Negligible	Other	Gravel (1-4cm)	Many Small Patches	-	Old (6+ yr)	Road/ Access Track	Fauna landscape 1: Floodplains	
MAC-42	118.859154	-22.701521	Eucalypt Woodland	Drainage Area/ Floodplain	East	Flat	Silty Clay Loam	Many Large Patches	Negligible	Other	Gravel (1-4cm)	Scarce	-	Recent (0-2 yr)	Road/ Access Track	Fauna landscape 1: Floodplains	

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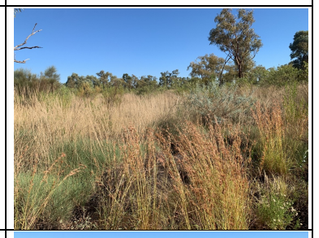
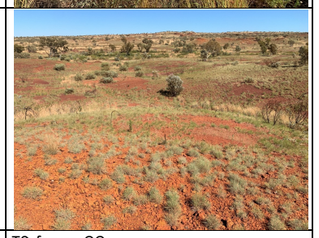
MAC-43	118.867953	-22.735835	Eucalypt Woodland	Drainage Area/ Floodplain	East	Low	Silty Clay Loam	Scarce	Negligible	Other	Gravel (1-4cm)	Many Small Patches	-	Old (6+ yr)	Road/ Access Track	Fauna landscape 5: Vegetated drainage systems	
MAC-44	118.956001	-22.689907	Undulating Low Hills	Undulating Low Hills	South/ East	Low	Clay Loam	Many Small Patches	Limited Outcropping	Other	Gravel (1-4cm)	Few Small Patches	-	Moderate (3-5 yr)	Road/ Access Track	Fauna landscape 2: Low undulating ironstone hills	
MAC-45	118.830623	-22.812464	Breakaway/ Cliff	Gully	West	Steep	Clay Loam	Few Small Patches	Extensive Outcropping	BIF	Large Rocks (21-60 cm)	Few Small Patches	-	Moderate (3-5 yr)	None discernible	Fauna landscape 4: Ironstone mountains, gorges and gullies	TS from 22 
MAC-46	118.833951	-22.813080	Breakaway/ Cliff	Gully	South/ West	Moderate	Clay Loam	Few Small Patches	Extensive Outcropping	BIF	Large Rocks (21-60 cm)	Many Small Patches	-	Moderate (3-5 yr)	None discernible	Fauna landscape 4: Ironstone mountains, gorges and gullies	
MAC-47	118.834014	-22.815996	Gorge/Gully	Breakaway	West	Moderate	Clay Loam	Few Small Patches	Major Outcropping	BIF	Large Rocks (21-60 cm)	Many Small Patches	-	Moderate (3-5 yr)	None discernible	Fauna landscape 4: Ironstone mountains, gorges and gullies	
MAC-48	118.835441	-22.819704	Gorge/Gully	Gorge	South/ West	Moderate	Clay Loam	Few Small Patches	Extensive Outcropping	BIF	Small Rocks (11-20cm)	Few Small Patches	-	Moderate (3-5 yr)	None discernible	Fauna landscape 4: Ironstone mountains, gorges and gullies	

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MAC-49	118.791154	-22.864819	Gorge/Gully	Breakaway	South	Steep	Clay Loam	Few Small Patches	Extensive Outcropping	BIF	Small Rocks (11-20cm)	Few Small Patches	-	Moderate (3-5 yr)	None discernible	Fauna landscape 4: Ironstone mountains, gorges and gullies	

Note: As per BHP data requirements each site characteristic can only have one value, therefore all values here reflect the characteristic at the location given, however the range of values would differ for the area searched/covered by sampling techniques used; Hollow bearing trees not counted as not relevant for target species.