APPENDIX E: TERRESTRIAL FAUNA

E.1: West Angelas Beyond 2020 Infrastructure Corridors Reconnaissance and Targeted Survey

Biologic Environmental Survey Pty Ltd
PO Box 179
Floreat, WA, 6014

15 December 2022

Attn: Elizabeth Mason and Carolyn Ellis

Rio Tinto Iron Ore

Dear Elizabeth and Carolyn,

Please find below a memo summarising the basic and targeted vertebrate fauna survey completed by Biologic Environmental Survey Pty Ltd (Biologic) within unsurveyed areas for the Western Hill, Deposit H and Deposit F Infrastructure areas for the West Angelas Project Envelope.

Yours sincerely,

Ryan Ellis
Principal Zoologist
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(08) 6365 5066 | 0448 808 796

Reviewed by C. Knuckey 15th December 2022.

1. INTRODUCTION AND OBJECTIVES

Biologic were commissioned to undertake a basic and targeted vertebrate fauna survey of historically surveyed and unsurveyed proposed infrastructure areas for Western Hill, Deposit H and Deposit F within the West Angelas Project Envelope (herein collectively referred to as the Study Area) (Figure 1.1). The Study Area is located within the West Angelas Revised Proposed Development Envelope and comprises three survey areas covering a total of 1,036.86 hectares (ha) (Figure 1.1), comprising:

- Western Hill Infrastructure (WHI) area – 118.89 ha;
- Deposit H Infrastructure (DHI) area – 858.25 ha; and
- Deposit F Infrastructure (DFI) area – 59.72 ha.

The overarching objective of this assessment was to undertake a single season basic and targeted vertebrate fauna survey to identify the occurrence of vertebrate fauna species within the Study Area, with a particular focus on significant species (as per EPA (2020)), to inform future development and environmental approvals within the West Angelas Development Envelope. Significant species that were the focus of this survey are based on species identified in a previous desktop assessment completed for the broader West Angelas Revised Proposal Development Envelope, which encompasses the Study Area (Biologic, 2021a).

1.1. Conformance and Licensing

This assessment, particularly where suitable habitat for significant species was present, was carried out in a manner consistent with the following guidelines and recommendations from the Department of Climate Change, Energy, the Environment and Water (DCCEEW; formerly DAWE, DEHWA, DSEWPaC, DoE), the Environmental Protection Authority (EPA), relevant survey-specific license conditions and, where relevant, Rio Tinto guidelines and standards:

- DoE (2016) Environment Protection and Biodiversity Conservation (EPBC) Act referral guideline for the endangered northern quoll *Dasyurus hallucatus*;
- DEWHA (2010a) Survey guidelines for Australia's threatened bats;
- DEWHA (2010b) Survey guidelines for Australia's threatened birds;
- DoE (2013) Matters of National Environmental Significance: Significant impact guidelines 1.1;
- DSEWPaC (2011b) Survey guidelines for Australia's threatened mammals;
- DSEWPaC (2011a) Survey guidelines for Australia's threatened reptiles;
- EPA (2020) Technical Guidance: Terrestrial vertebrate fauna surveys for environmental impact assessment; and
- Rio Tinto (2021b) RTIO fauna habitat guidelines and definitions.

Fauna sampling was conducted under a DBCA Regulation 27 "Fauna Taking (Biological Assessment) License" (BA27000578) issued to C. Knuckey. In accordance with Section 40 of the Biodiversity Conservation (BC) Act, threatened species sampling was completed under a DBCA "Authorisation to Take or Disturbed Threatened Species" (authorisation number TFA 2019-0183-4) issued to C. Knuckey.

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7434000

Western Hill Infrastructure

Western Hill Infrastructure

Deposit H Infrastructure

West Angelas

Deposit F Infrastructure

Legend

- Study Area
- Pilbara Region
- Operating Mine

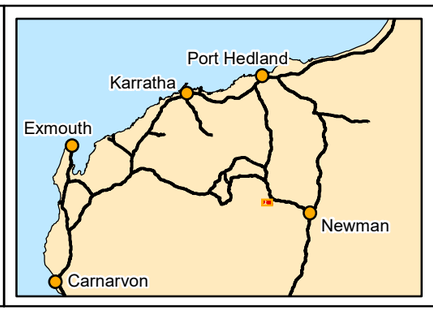
N

biologic Environmental Survey

Scale: 1:62,000

0 1 2 3 Km

Coordinate System: GDA2020 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA2020 Created 10/06/2022



RIO TINTO IRON ORE

Mt Ella, Depsit J and Deposit G Flora and Fauna Survey

Figure 1.1: Study Area and regional context

1.2. Background to Protection of Vertebrate Fauna

Terrestrial fauna may be considered significant species for a range of reasons (EPA, 2016), including:

- being identified as a threatened or priority species;
- being a species with restricted distribution;
- enduring a degree of historical impact from threatening processes; or
- providing an important function required to maintain the ecological integrity of a significant ecosystem.

All native fauna in Western Australia (WA) are protected at a state level under the BC Act and at a national level under the EPBC Act. Any action that has the potential to impact native fauna needs to be approved by relevant state and/or federal departments in accordance with the WA *Environmental Protection Act 1986* (EP Act) and the federal EPBC Act. While all native fauna are protected under these Acts, some species are afforded extra protection. These include species that are considered Threatened under the EPBC Act and/or BC Act, or; migratory bird species that are protected under international agreements and subsequently listed as Migratory under the EPBC Act and/or BC Act (Table 1.1). Furthermore, any species that may be threatened but for which there is insufficient information available to allocate a threatened status under the EBPC Act and/or BC Act, can also be listed as Priority species by DBCA (Table 1.1).

For the purposes of this assessment, significant species are those that are afforded protection under the EPBC Act, BC Act and/or listed as Priority by DBCA (Table 1.1). A summary of applicable legislation and status' is provided in Table 1.1.

Table 1.1: Definitions and terms for significant species

Act, Agreement or List	Status Codes
Federal	
EPBC Act In Australia, native fauna are protected under the EPBC Act. This Act makes provisions for an independent committee (the Threatened Species Scientific Committee [TSSC]), which is charged with maintaining a list of threatened species. Threatened species are listed under one of six categories, depending on their specific conservation status. Migratory bird species are those listed under international agreements and protected under the EPBC Act as a MNES. Relevant international agreements include the Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention), China-Australia Migratory Bird Agreement (CAMBA), Japan-Australia Migratory Bird Agreement (JAMBA), and Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA).	*Extinct:* • EX – Extinct • EW – Extinct in the Wild *Threatened:* • CR – Critically Endangered • EN – Endangered • VU – Vulnerable • CD – Conservation Dependent *Other:* • MI – Migratory
State	
BC Act In WA, native fauna are protected under the BC Act. Species in special need of protection are listed as being Extinct, Threatened or Specially Protected. Within these groups, species are listed under one of eight categories, depending on their specific conservation status. Migratory bird species are those listed under the Bonn Convention and/or CAMBA, JAMBA and ROKAMBA agreements.	*Extinct:* • EX – Extinct *Threatened:* • CR – Critically Endangered • EN – Endangered • VU – Vulnerable *Specially Protected:* • MI – Migratory • CD – Conservation Dependent • OS – Other specially protected fauna
DBCA Priority List The DBCA maintains a list of Priority species that are considered to be possibly threatened but have not been assigned statutory protection under the BC Act, as not enough information is available for an accurate determination of conservation status. These species are generally in urgent need of survey to determine their distribution and abundance.	*Poorly Known:* • P1 – Priority 1 • P2 – Priority 2 • P3 – Priority 3 *Rare, Near Threatened and other* • P4 – Priority

2. METHODS

2.1. Taxonomy and Nomenclature

The latest checklist of mammal, reptile and amphibian names published by the WAM (2022) was used as a guide to the current taxonomy and nomenclature of these groups. For birds, the current checklist of Australian birds maintained by Birdlife Australia (based on Christidis & Boles, 2008) was used in conjunction with the ABRS (2021) species list. While compiling a list of fauna potentially occurring in the Study Area, all records were checked to ensure the latest taxonomy, using recent papers and lists, was used.

2.2. Desktop Assessment

A desktop assessment was undertaken utilising information from a previous desktop assessment conducted by Biologic (2021a) for the broader West Angelas Beyond 2020 Development Envelope, which encompasses the Study Area. Additionally, any significant species records from the Biologic (2021a) field surveys were also considered for this assessment. The desktop assessment was used to further refine sampling methods to ensure appropriate sampling was undertaken for all target species and to allow an accurate assessment of their occurrence or likelihood of occurrence within the Study Area.

2.3. Field Survey

2.3.1. Survey Timing and Personnel

The field survey was undertaken over two days between the 21st and 28th of February 2022 by Principal Zoologist Ryan Ellis and Senior Zoologist Phil Runham, whom collectively have over 25 years of experience undertaking fauna surveys within the Pilbara region, including targeted surveys for the significant species that were the focus of this assessment (Table2.1).

Table2.1: Project Team and experience

Personnel	Position and Role	Qualification	Experience
Ryan Ellis	Principal Zoologist • project management • field survey • reporting	BESc Wildlife and Conservation Biology Dip Conservation and Land Management	12 years' EIA (consulting) 16 years' field survey 16 years' vertebrate zoology/ ecology
Phil Runham	Senior Zoologist • field survey	PhD Zoology Post Grad Dip Zoology BSc Zoology	16 years' EIA (consulting) 22 years' field survey 22 years' vertebrate zoology/ ecology

2.3.2. Climate and Weather

Observed weather conditions prior to and during the survey are shown in Figure 2.1, alongside long-term climatic data for Newman Airport (station #007176). In the 12 months prior to the survey (March 2021–February 2022), mean minimum and maximum temperatures recorded at Newman Airport were similar to the long-term averages for most months (Figure 2.1). Rainfall in the 12 months preceding the survey was variable, with below long-term averages recorded through most months, except for April 2021, which recorded well above the annual long-term average (56 mm v 21 mm), November 2021 (14 mm v 12 mm) and February 2022 (73 mm v 72 mm), which had rainfall consistent with long-term averages Figure 2.1. In total, the rainfall received in the 12 months prior to the survey (March 2021 to February 2022; 191.60 mm) was well below the annual long-term average (324.4 mm) (BoM, 2022).

Observed minimum temperatures during the survey were similar to the long-term average, while maximum temperatures were slightly higher (Table 2.2) (BoM, 2022). No rainfall was recorded during the survey (Table 2.2); however, a total of 73.0 mm was recorded in the two weeks prior (BoM, 2022).

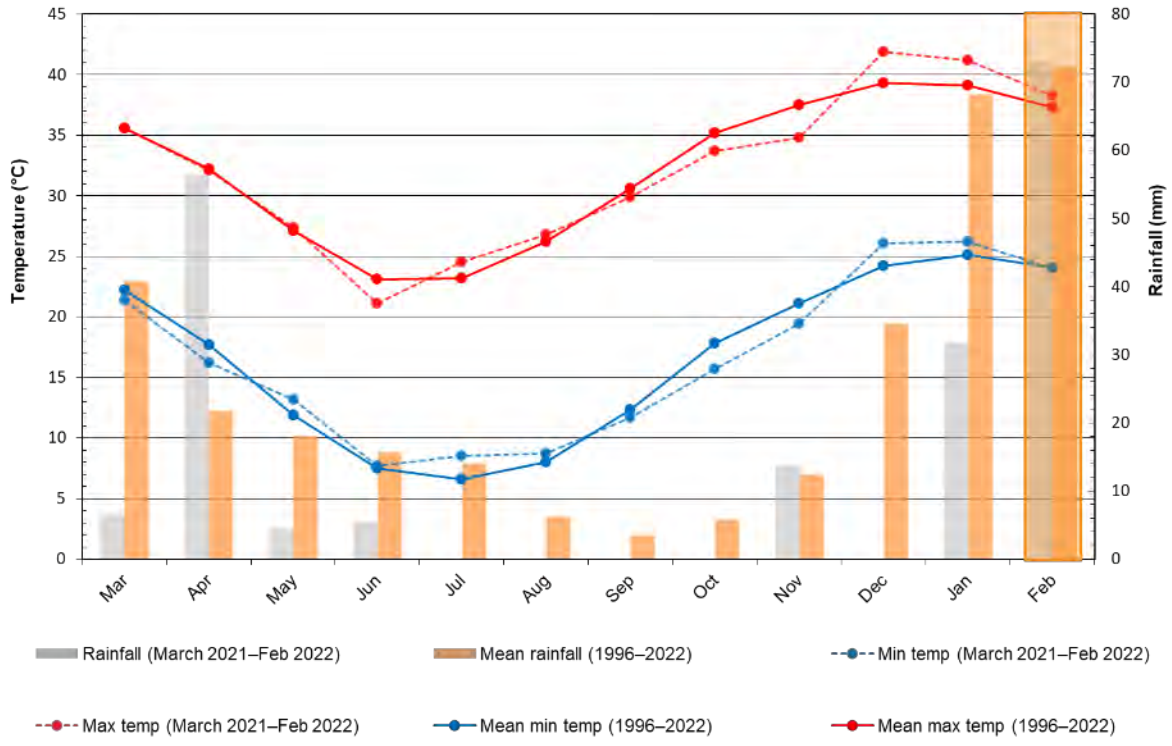


Figure 2.1: Monthly rainfall and long-term average rainfall for Newman Aero (Station ID 007176) with approximate survey timing shown in shaded box

Table 2.2: Climatic conditions recorded for Newman Airport during the field survey

Date	Min. temp (°C)	Max. temp (°C)	Rainfall (mm)
21/02/2022	19.6	39.6	0
22/02/2022	20.1	40.7	0
23/02/2022	22.8	42.1	0
24/02/2022	24.2	42.2	0
25/02/2022	25.9	41.1	0
26/02/2022	22.3	41.4	0
27/02/2022	22.5	42.8	0
28/02/2022	28.8	42.3	0
Average/ total	**23.3**	**41.5**	**0**

2.3.3. Sampling and Survey Methods

Habitat Assessments and Mapping

Broad fauna habitats were previously defined and delineated for the West Angelas Development Envelope by Biologic (2021b), which encompasses the Study Area. During the field survey, Biologic (2021b) habitat mapping was ground truthed to verify fauna habitats previously mapped and their likelihood of supporting significant species. Habitat assessments were undertaken at a total of 57 locations within the Study Area during the field survey to define and delineate fauna habitats (Table 2.3; Figure 2.2; Appendix A). Following the field survey, broad fauna habitat mapping completed by Biologic (2021b) was reviewed with consideration of results of the field survey and, where deemed necessary, amended and refined to reflect field observations. Habitat assessments were conducted using methodology and terminology modified from the *Australian Soil and Land Survey Field Handbook* (National Committee on Soil and Terrain, 2009). The characteristics recorded during the habitat assessments were:

- site information: location and photo;
- habitat: broad habitat type, landform, aspect, slope, soil type and availability, rocky outcropping presence and type;
- ground cover: rock size, vegetation litter and woody debris;
- vegetation: broad vegetation type, structure and dominant species;
- condition: time since fire, disturbance and overall habitat condition; and
- microhabitat: rocky cracks/ crevices, burrowing suitability, hollow presence and abundance, water presence.

Table 2.3: Fauna sampling effort

Site ID	Latitude	Longitude	Habitat assessment	Active searches (person hrs)	Bird census (min)	Targeted search[1] (person hrs)	Ultrasonic recording (nights)
Western Hill Infrastructure Area							
VWH-001	-23.1402	118.6416	•	1	20		3
VWH-002	-23.1420	118.6415	•	1	20		
VWH-003	-23.1425	118.6421	•				
VWH-004	-23.1390	118.6560	•	1	20		
VWH-005	-23.1402	118.6608	•		20		
VWH-006	-23.1424	118.6657	•	1	20		
VWH-007	-23.1421	118.6622	•		20		3
VWH-008	-23.1429	118.6591	•		20		
VWH-009	-23.1447	118.6637	•	1	20		
Total (WHI)			**9**	**5**	**160**		**6**
Deposit H Infrastructure Area							
VDHI-001	-23.1143	118.7736	•	1	20		
VDHI-002	-23.1141	118.7776	•	1	20	1 (NQ, PLNB, GB, POP)	
VDHI-003	-23.1136	118.7840	•	1	20		
VDHI-004	-23.1130	118.8030	•		20		
VDHI-005	-23.1156	118.8112	•				
VDHI-006	-23.1272	118.8229	•	1			
VDHI-007	-23.1594	118.8068	•	1	20		
VDHI-008	-23.1440	118.8183	•	1	20		3
VDHI-009	-23.1316	118.8157	•				
VDHI-010	-23.1536	118.8180	•				3
VDHI-011	-23.1202	118.8210	•	1	20	2 (NQ, PLNB, GB, POP)	
VDHI-012	-23.1175	118.8186	•	1	20	4.5 (NQ, PLNB, GB, POP)	
VDHI-013	-23.1578	118.7767	•	1	20		
VDHI-014	-23.1548	118.7791	•	1	20		
VDHI-015	-23.1343	118.8064	•		20		
VDHI-016	-23.1358	118.8057	•				
VDHI-017	-23.1305	118.8114	•		20		
VDHI-018	-23.1555	118.8126	•				
VDHI-019	-23.1555	118.8167	•		20		
VDHI-020	-23.1476	118.8220	•				
VDHI-021	-23.1519	118.8219	•		20		
VDHI-022	-23.1409	118.8153	•	1	20		
VDHI-023	-23.1399	118.8151	•	1	20		
VDHI-024	-23.1366	118.8115	•				

Site ID	Latitude	Longitude	Habitat assessment	Active searches (person hrs)	Bird census (min)	Targeted search[1] (person hrs)	Ultrasonic recording (nights)
VDHI-025	-23.1335	118.8220	•		20		
VDHI-026	-23.1136	118.8218	•				
VDHI-027	-23.1278	118.8190	•		20		
VDHI-028	-23.1240	118.8201	•	1	20	3 (NQ, PLNB, GB, POP)	
VDHI-029	-23.1235	118.8216	•	1	20	1 (NQ, PLNB, GB, POP)	
VDHI-030	-23.1214	118.8246	•		20		
VDHI-031	-23.1218	118.8222	•				
VDHI-032	-23.1142	118.8188	•	1	20	3 (NQ, PLNB, GB, POP)	
VDHI-033	-23.1128	118.8243	•	1	20	3 (NQ, PLNB, GB, POP)	
VDHI-034	-23.1597	118.7987	•				
VDHI-035	-23.1572	118.7882	•				
VDHI-036	-23.1137	118.7875	•	1	20	2 (NQ, PLNB, GB, POP)	
VDHI-037	-23.1120	118.7883	•	1	20	2 (NQ, PLNB, GB, POP)	
Total (DHI)			**37**	**18**	**500**	**21.5** (NQ, PLNB, GB, POP)	**6**
Deposit F Infrastructure Area							
VDFI-001	-23.1802	118.8502	•	1	20		3
VDFI-002	-23.1784	118.8424	•		20		
VDFI-003	-23.1808	118.8480	•				
VDFI-004	-23.1853	118.8564	•	1	20		
VDFI-005	-23.1837	118.8551	•	1	20	2 (NQ, PLNB, GB, POP)	
VDFI-006	-23.1797	118.8455	•		20		
VDFI-007	-23.1785	118.8515	•		20		
VDFI-008	-23.1793	118.8545	•				
VDFI-009	-23.1818	118.8525	•		20		
VDFI-010	-23.1879	118.8580	•	1	20	1.5 (NQ, PLNB, GB, POP)	
Total (DFI)			**11**	**4**	**160**	**3.5** (NQ, PLNB, GB, POP)	**3**
Total (Study Area)			**57**	**27**	**820**	**25 (NQ, PLNB, GB, POP)**	**15**

[1] NQ = northern quoll, PLNB = Pilbara leaf-nosed bat, GB = ghost bat, POP = Pilbara olive python.

Water Feature Assessments

During the survey, searches were undertaken for any water features occurring within the Study Area, particularly those that had the potential to support significant species (i.e. critical habitat for Pilbara olive python or water sources for Pilbara leaf-nosed bat). Each water feature was assessed to characterise key features and identify the likelihood of target species utilising them. The characteristics recorded during water feature assessments include:

- dimensions: length, width, depth;
- water presence: above the surface, in the intermediate zone;
- location and photograph;
- vegetation: obligate phreatophytes, emergent macrophytes; and
- presence of fauna.

Cave Assessments

During the current survey, cave assessments were conducted for any accessible caves recorded within the Study Area (*n* = 3; Appendix B). Due to access limitations (heritage areas with restricted access) cave assessments could not be undertaken at three caves or overhangs within DHI. The cave assessments were designed to characterise the physical features of each structure and to identify the potential importance to the ghost bat and the Pilbara leaf-nosed bat. Each cave assessment recorded the following characteristics:

- entrance location and photograph;
- entrance type, position, aspect, exposure, width, and height;
- cave depth and internal floor slope;
- chambers: main chamber height, and number of total chambers;
- water presence;
- indicative roost type; and
- presence of target species: no. individuals, and/or secondary evidence.

Each cave was categorised based on data from the cave assessments, including the presence of any target bat species via primary or secondary evidence (i.e. calls, scats and individual remains). The categories of cave significance for Pilbara leaf-nosed bats followed the classifications defined by Bat Call WA (2021b):

- **Category 1** (permanent diurnal/ maternity roost): Maternity roosts where seasonal presence of young is proven. Often supporting presence of a large colony. Critical habitat for the daily and long-term survival of the species.
- **Category 2** (permanent diurnal roost): Diurnal roosts occupied year-round, often by smaller colonies to Category 1 roosts, without confirmed maternity usage (presence of young). Critical habitat for the daily and long-term survival of the species.

- **Category 3** (semi-permanent diurnal roost): Diurnal roost with occasional/ intermittent occupancy, not occupied year-round. May be used during the breeding cycle and may also facilitate long distant distance dispersal, particularly around autumn. Often occurring as a 'satellite' roost associated with nearby Category 1 and/or Category 2 roosts. Critical habitat for the long-term survival of the species.
- **Category 4** (nocturnal refuge): Roosts occupied or entered at night for resting, feeding or other purposes, with perching not a requirement. Not considered critical habitat for the species; however, important for persistence in a local area.

For ghost bat, cave significance followed the classifications defined by Bat Call WA (2021a):

- **Category 1** (maternity/ diurnal roost with permanent occupancy): Permanently occupied roost tending to have large fluctuating populations. Due to permanent presence maternity usage is assumed. Structurally, caves are often deep and dark with one or more elevated roosting chambers that provide a stable microhabitat. Critical for the ongoing presence of ghost bat in the area.
- **Category 2** (maternity/ diurnal roost with regular occupancy): Ghost bat presence regular, but not permanent/ continuous over long periods. Pregnant or pup-carrying individuals may be present. Similar to Category 1 caves, but often less complex, with only a single inner chamber and are often in less productive areas only used by the species periodically. Bats present for 25% to 75% but may be abandoned for weeks or months. Typically have several other caves, shelters and overhangs within a few hundred meters, which together make up an 'apartment block' grouping that supports the ongoing presence of the species. Critical for the ongoing presence of the species in the area.
- **Category 3** (diurnal roost with occasional occupancy): Diurnal roosts where the species roosts occasionally, or rarely. Structurally, less well-developed and often used as feeding sites (as evidenced y middens with food scraps) or temporary refuges. Scats and/or small food middens present but may be no evidence of roosting bats or observations of roosting not consistent. May facilitate long-distance movements of individuals more broadly across the landscape. When adjacent to Category 2 roosts, considered part of an 'apartment block' and therefore critical habitat for the ongoing presence of the species in the area. Where occurring in isolation, not considered critical habitat essentially for the long-term viability of a local population.
- **Category 4** (nocturnal roost with opportunistic usage): Roosts used in at least an opportunistic manner by itinerant individuals and may comprise single visitations to longer periods including periods of rest or feeding during foraging. Includes majority of shallow caves, shelters and deep overhangs in the Pilbara. Not considered critical habitat.

Active Searches

Active searching was undertaken opportunistically throughout the Study Area, including at all locations habitat assessments were completed (Table 2.3; Figure 2.2). Sampling sites were selected to represent all broad fauna habitats and habitat features or microhabitats occurring within the Study Area. Active searching was undertaken for approximately 27 person hours through the Study Area during the field survey.

Bird Census

A 20-minute bird census was undertaken at 41 locations within the Study Area, equating to approximately 13.7 person hours in total (Table 2.3). Each census was completed over an area of approximately 2 ha and, where possible, confined to the habitat type represented by the site's habitat assessment. During each census, birds were identified by visual appearance, their characteristic calls and flight behaviour. Additionally, any birds opportunistically observed throughout the Study Area were also recorded.

Targeted Searches

Where suitable habitat considered to potentially support significant species was identified, targeted searches were undertaken. Targeted searches comprised traverse searching for occurrence of target species from direct observation, secondary evidence (i.e. tracks, scats, sloughs and foraging evidence) and/or habitat features (i.e. dens, roost caves and water features) likely to be utilised by target species. A total of 25 person hours of targeted searches was undertaken at 11 sites during the field survey, targeting northern quoll, ghost bat, Pilbara leaf-nosed bat and Pilbara olive python (Table 2.3). Additionally, western pebble-mound mouse was opportunistically targeted while traversing suitable habitat (i.e. Hillcrest and Hillslope and some instances of Footslopes and Plain habitat).

Ultrasonic Recorders for Pilbara Leaf-nosed Bat and Ghost Bat

SongMeter (SM; Wildlife Acoustics Inc.) ultrasonic bat recorders were deployed at five locations during the field survey (Table 2.3; Figure 2.2). At each location, recorders were placed in, or in the vicinity of, areas of prospective roosting or foraging and dispersal habitats most likely to be utilised by bats. Each recorder was deployed for three consecutive nights, in accordance with EPA (2020), equating to a total of 15 recording nights during the field survey. Audio settings, selectable filters and triggers were set to detect all species known to occur within the region, including echolocation and social calls of the ghost bat and Pilbara leaf-nosed bat (McKenzie & Bullen, 2009). Bat calls were analysed by Robert Bullen of Bat Call WA.

Opportunistic Records

At all times while surveying, all records pertaining to species not previously recorded during the survey, particularly significant species, were documented. These records include those from primary (i.e. direct observation of species) or secondary (e.g. burrows, scratchings, diggings and scats) evidence.

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700000
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7452000
7440000
7428000

VWHI-001
VWHI-002
VWHI-003
VWHI-004
VWHI-005
VWHI-006
VWHI-007
VWHI-008
VWHI-009

Great Northern Hwy

Deposit H Infrastructure

Western Hill Infrastructure

Western Hill Infrastructure

Deposit F Infrastructure

West Angelas

VDFI-026
VDFI-007
VDFI-006
VDFI-008
VDEF-001
VDFI-003
VDFI-009
VDFI-005
VDFI-004
VDFI-010

VDHI-037
VDHI-002
VDHI-001
VDHI-003
VDHI-036
VDHI-004
VDHI-026
VDHI-033
VDHI-032
VDHI-005
VDHI-012
VDHI-011
VDHI-030
VDHI-031
VDHI-028
VDHI-029
VDHI-006
VDHI-027
VDHI-017
VDHI-009
VDHI-015
VDHI-025
VDHI-016
VDHI-024
VDHI-023
VDHI-022
VDHI-008
VDHI-020
VDHI-014
VDHI-021
VDHI-018
VDHI-010
VDHI-035
VDHI-019
VDHI-013
VDHI-034
VDHI-007

Legend

- Operating Mine
- Study Area
- Local Road
- State Road

Sampling Type

- Acoustic recording
- Habitat assessment

Traverse

- Opportunistic and Driving
- Targeted - northern quoll, Pilbara leaf-nosed bat, ghost bat, Pilbara olive python

N

biologic Environmental Survey

Scale: 1:150,000

0 2 4 6 8 Km

Coordinate System: GDA2020 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA2020 Created 15/12/2022

Port Hedland
Karratha
Exmouth
Newman
Carnarvon

RIO TINTO IRON ORE

Mt Ella, Deposit J and Deposit G Flora and Fauna Survey

Figure 2.2: Sample sites and traverses

2.3.4. Likelihood of Vertebrate Fauna Occurrence

Following completion of the field survey, significant species identified by the Biologic (2021a) desktop assessment were assessed for their likelihood of occurring within the Study Area using a decision matrix (Table 2.4). This decision matrix, each species was assigned to one of six categories of likelihood: Confirmed, Highly Likely, Likely, Possible, Unlikely, or Highly Unlikely.

The decision matrix is intended to be an indicative guide only, and the way in which it is interpreted may vary between species, depending on a given species' habitat preferences and ability to disperse, as well as the reliability and availability of contextual information. For example, a species with a limited dispersal capability will have a reduced likelihood of occurring in the Study Area compared with a species with greater dispersal capability. It is also recognised that a lack of records in the vicinity of the Study Area may indicate limited sampling effort rather than species' absence, and that previous records may include historic or presumed erroneous information which may misrepresent a species' current distribution.

Where the determination of a species' likelihood of occurrence within the Study Area deviates from the decision matrix, detailed justification for any variation is provided.

Table 2.4: Species likelihood of occurrence decision matrix

		Habitat suitability of Study Area			
		Breeding habitat present	**Foraging and dispersal habitat present**	**Marginally suitable habitat[2] present**	**No suitable habitat present**
Species Records[1]	**Recorded in Study Area**	Confirmed	Confirmed	Confirmed	Confirmed
	Recorded within 10 km of Study Area	Highly Likely	Likely	Possible	Possible
	Recorded within 10–50km of Study Area	Likely	Possible	Possible	Unlikely
	Recorded within 50–100 km of Study Area	Possible	Possible	Unlikely	Unlikely
	Recorded >100 km of Study Area	Possible	Unlikely	Unlikely	Highly Unlikely
	Species considered locally/regionally extinct	Unlikely	Unlikely	Highly Unlikely	Highly Unlikely

[1] Only records within the previous 50 years are considered.

[2] Marginally suitable habitat is habitat which is possibly used by a species but is unlikely to be depended upon; for example, it may be used only when in proximity to core breeding, foraging or dispersal habitat.

2.3.5. Limitations

The survey was not restricted by any material limitations that significantly impacted the results of the survey and/or the determined likelihood of occurrence assessments for significant species, as outlined by EPA (2020). Three caves within DHI were not accessible during the field survey due to access limitations (heritage areas with restricted access) and were therefore not subject to a detailed cave assessment or targeted searches for evidence of significant bat species (ghost bat and Pilbara leaf-nosed bat). Although some caves could not be inspected directly, targeted sampling for the species included deployment of an ultrasonic recorder within the gully the caves occurred. No evidence of either bat species was detected from the ultrasonic recorder deployed within the gully or searches of accessible caves and overhangs within the gully.

Although the current surveys comprised only basic and targeted sampling, a significant amount of survey work has been undertaken in the wider local area and surrounding region leading to a good understanding of the faunal assemblage in the greater West Angelas area and within the Study Area. These previous survey results were available for review and utilised in the desktop assessment and fauna habitat mapping. Due to the previous survey effort and limited occurrence of critical habitat or habitat features for significant species, the basic and targeted fauna survey effort completed for the current survey is considered adequate.

3. RESULTS AND DISCUSSION

3.1. Desktop Assessment

A total of 24 species of significance were identified as potentially occurring within the Study Area from the desktop assessment completed for the West Angelas Beyond 2020 detailed fauna assessment (Biologic, 2021a) (Table 3.1).Two species have previously been recorded within the Study Area:

- ghost bat (*Macroderma gigas* – Vulnerable EPBC Act and BC Act) – recorded on multiple occasions from secondary evidence (scats) (1998, 2000, 2002–3003, 2012–2021), twice from ultrasonic call recordings (2012, 2013) and once from direct observation (1978–79) within a cave (cave L3) subject to long-term monitoring within the DHI area (Figure 3.1) (Biologic, 2022b; Rio Tinto, 2021a); and
- western pebble-mound mouse (*Pseudomys chapmani* – Priority 4 DBCA) – recorded twice from secondary evidence (pebble-mound) within the WHI area and DFI areas (Figure 3.1) (Rio Tinto, 2021a).

Additionally, both species have also previously been recorded on multiple occasions within 5 km of the Study Area, including ghost bat on 21 occasions and western pebble-mound mouse on 202 occasions (Biologic, 2021a; DBCA, 2021c; Rio Tinto, 2021a).

A further seven significant species have previously been recorded within 5 km of the Study Area, including (Biologic, 2021a; DBCA, 2021c; Rio Tinto, 2021a):

- northern quoll (*Dasyurus hallucatus* – Endangered EPBC Act and BC Act) – one record (scat) ~2.8 km north-west of WHI;
- Pilbara leaf-nosed bat (*Rhinonicteris aurantia* (Pilbara form) – Vulnerable EPBC Act and BC Act) – eight records (ultrasonic call recording), nearest ~300 m south WHI;
- grey falcon (*Falco* hypoleucos – Vulnerable EPBC Act and BC Act) – one record (direct observation) ~4.3 km north-east WHI;
- Pilbara olive python (*Liasis olivaceus barroni* – Vulnerable EPBC Act and BC Act) – two records (camera trap and scat), nearest ~2.8 km north-west WHI;
- fork-tailed swift (*Apus pacificus* – Migratory EPBC Act and BC Act) – 13 records (direct observation), nearest ~150 m south DFI;
- Pilbara barking gecko (*Underwoodisaurus seorsus* – Priority 2 DBCA) – four records (direct observation), nearest ~2.6 km west DFI; and
- northern short-tailed mouse (*Leggadina lakedownensis* – Priority 4 DBCA) – six records (direct observation), nearest ~3.4 km south-west DHI.

Table 3.1: Significant species identified as potentially occurring in the Biologic (2021a) desktop assessment

Scientific Name	Common Name	Conservation Status		
		EPBC Act	BC Act	DBCA
Mammals				
Dasyuridae				
Dasycercus blythi	brush-tailed mulgara			P4
Dasyurus hallucatus	northern quoll	EN	EN	
Hipposideridae				
Rhinonicteris aurantia Pilbara form	Pilbara leaf-nosed bat	VU	VU	
Megadermatidae				
Macroderma gigas	ghost bat	VU	VU	
Muridae				
Leggadina lakedownensis	northern short-tailed mouse			P4
Pseudomys chapmani	western pebble-mound mouse			P4
Thylacomyidae				
Macrotis lagotis	greater bilby	VU	VU	
Aves				
Apodidae				
Apus pacificus	fork-tailed swift	MI	MI	
Charadriidae				
Charadrius veredus	oriental plover	MI	MI	
Falconidae				
Falco peregrinus	peregrine falcon		OS	
Falco hypoleucos	grey falcon	VU	VU	
Hirundinidae				
Hirundo rustica	barn swallow	MI	MI	
Motacillidae				
Motacilla cinerea	grey wagtail	MI	MI	
Motacilla flava	yellow wagtail	MI	MI	
Psittacidae				
Pezoporus occidentalis	night parrot	EN	CR	
Rostratulidae				
Rostratula benghalensis australis	Australian painted snipe	EN	EN	
Scolopacidae				
Calidris acuminata	sharp-tailed sandpiper	MI	MI	
Calidris ferruginea	curlew sandpiper	CR/ MI	CR/ MI	
Calidris melanotos	pectoral sandpiper	MI	MI	
Tringa hypoleucos	common sandpiper	MI	MI	
Reptiles				
Carphodactylidae				
Underwoodisaurus seorsus	Pilbara barking gecko			P2

Scientific Name	Common Name	Conservation Status		
		EPBC Act	BC Act	DBCA
Pythonidae				
Liasis olivaceus barroni	Pilbara olive python	VU	VU	
Scincidae				
Notoscincus butleri	lined soil-crevice skink			P4
Typhlopidae				
Anilios ganei	Pilbara flat-headed blind-snake			P1

640000 680000 720000

7440000 7400000

Packsaddle Rd
West Angelas Rd
Great Northern Hwy
Eagle Pool Rd
Turee Creek Rd

DBCA Database

Bird
- VU - grey falcon
- IA - fork-tailed swift
- OS- peregrine falcon

Mammal
- EN - northern quoll
- VU - ghost bat
- VU- greater bilby
- VU - Pilbara leaf-nosed bat
- P4 - brush-tailed mulgara
- P4 - northern short-tailed mouse
- P4 - western pebble-mound mouse

Reptile
- VU - Pilbara olive python
- P1- Pilbara flat-headed blind-snake
- P2 - unpatterned robust slider
- P2 - Pilbara barking gecko

RTIO Database

Bird
- P4 - letter-winged kite
- IA - fork-tailed swift

Mammal
- VU - ghost bat
- VU - Pilbara leaf-nosed bat
- P4 - western pebble-mound mouse, ngadji

Reptile
- P2- Pilbara barking gecko

Legend

Study Area
Local Road
State Road

Biologic (2021a)

Bird
- IA - fork-tailed swift

Mammal
- EN - northern quoll
- P4 - western pebble-mound mouse
- VU - ghost bat
- VU - Pilbara leaf-nosed bat

Reptile
- VU - Pilbara olive python

N

biologic Environmental Survey

Scale: 1:349,000

0 10 20 Km

Coordinate System: GDA2020 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA2020 Created 15/12/2022

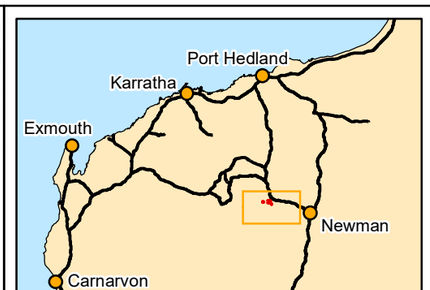

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Figure 3.1: Significant fauna recorded in the desktop assessment

3.2. Broad Fauna Habitats

Following completion of the field survey, broad fauna habitat mapping that overlaps the Study Area Biologic (2021a) was revised to reflect observed habitats more accurately as a result of ground truthing during the field survey. Changes to the Biologic (2021a) fauna habitat mapping primarily comprised reclassification of broad habitats (i.e. areas Hillcrest and Hillslope changed to Footslopes and Plain) and further delineation of habitats not clearly visible from aerial imagery (i.e. new areas of Gorge/Gully within Hillcrest and Hillslope or PEC Cracking Clay within Footslopes and Plain habitat). It should be noted, the PEC Cracking Clay fauna habitat mapped within the Study Area is representative of the West Angelas Cracking Clays Priority 1 Priority Ecological Community (PEC) (DBCA, 2021b) (P15 vegetation unit of Biologic (2022a)). Although this habitats occurrence extended beyond the boundary of the Study Area, its broad extent was subject to delineation during the subsequent flora and vegetation survey and will be reported on in greater detail in the relevant survey memo for the area (Biologic, in prep.-b).

A total of six broad fauna habitat types are mapped across the Study Area (Table 3.2; Table 3.3; Figure 3.2), comprising, in decreasing order of extent: Footslopes and Plain (56.98%), Hillcrest and Hillslope (32.82%), Gorge/Gully (1.62%), Drainage Line (0.77%), PEC Cracking Clay (0.69%), and Mixed Acacia Woodland (0.14%) (Table 3.2; Table 3.3). The remaining 6.96% of the Study Area comprised Disturbed areas, including land that has been cleared of vegetation for access tracks, topsoil stockpiles and/or exploration activities (i.e. drill pads).

Table 3.2: Extent of broad fauna habitats within the Study Area

Fauna Habitat	Extent Within Study Area							
	WHI		DHI		DFI		Total (all areas)	
	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%
Footslopes and Plain	101.21	85.14%	473.82	55.22%	15.79	26.44%	590.82	56.98%
Hillcrest and Hillslope	-	-	299.48	34.89%	40.86	68.42%	340.34	32.82%
Gorge/Gully	-	-	16.75	1.95%	0.02	0.04%	16.77	1.62%
Drainage Line	4.36	3.66%	3.29	0.38%	0.38	0.63%	8.03	0.77%
PEC Cracking Clay	-	-	7.20	0.84%	-	-	7.20	0.69%
Mixed Acacia Woodland	-	-	1.50	0.17%	-	-	1.50	0.14%
Disturbed	13.32	11.20%	56.21	6.55%	2.66	4.46%	72.19	6.96%
Total	**118.89**	**100.00%**	**858.25**	**100.00%**	**59.72**	**100.00%**	**1036.86**	**100.00%**

Of the six broad fauna habitat types identified within the Study Area, two (Gorge/Gully and Hillcrest and Hillslope) were deemed to be of high significance for vertebrate fauna, as it is likely to provide critical (primary breeding, foraging and dispersal) habitat for multiple significant species, including northern quoll, ghost bat, Pilbara leaf-nosed bat and Pilbara olive python (Table 3.3). Of the remaining five habitats, one (Drainage Line) was deemed to be of moderate value, as it may provide secondary or supporting habitat (foraging and/or dispersal) for multiple significant species; however, do not represent critical habitat for any target MNES species (Table 3.3). The occurrence of the three remaining habitats (Footslopes and Plain, PEC Cracking Clay and Mixed Acacia Woodland) within the Study Area was deemed to be of low value to vertebrate fauna (Table 3.3).Habitats deemed to be of moderate or low significance are relatively common and widespread in the broader vicinity of the Study Area, and significant species occurrence within them is often dependent on the occurrence of critical or high value habitat (i.e. primary breeding, nesting and/or roosting habitat) proximal to the Study Area. Except for PEC Cracking Clays, all broad fauna habitats mapped within the Study Area are relatively common and widespread within the broader vicinity of the Study Area and throughout the Pilbara region.

3.2.1. Habitat Features

Caves

Caves can be important features within a landscape, particularly in arid zone systems, often providing stable microclimates, shelter and protection (Medellin *et al.*, 2017). Three caves have been recorded within the Study Area, including one previously known (i.e. recorded prior to the current survey; L3) and two recorded for the first time during the current survey (CDHI-001 and CDHI-002; Appendix B). Cave L3 is known to be utilised by ghost bat and is part of a long-term ghost bat monitoring program for West Angelas mine operations (Biologic, 2022b). All three caves within the Study Area occurred within Gorge/Gully or Hillcrest and Hillslope habitat (Appendix B; Figure 3.2). No evidence of ghost bat or Pilbara leaf-nosed bat was recorded at any new caves (CDHI-001 and CDHI-002) recorded during the survey; however, based on cave assessments and previous records, cave L3 is considered a Category 3 for ghost bat and Category 4 for Pilbara leaf-nosed bat, as defined by Bat Call WA (2021a, 2021b). The current classification of L3 as a Category 3 roost has been determined from the results of long-term ghost bat monitoring at the site between 2014 to present (Biologic, 2022b); however, based on the presence of a large historic scat pile, it is likely that this cave was previously used as a Category 2 prior to increased disturbance from mining activities. The remaining two caves (CDHI-001 and CDHI-002) were classified as Category 4 caves for both ghost bats and Pilbara leaf-nosed bat (Appendix B).

Water Features

No water features likely to support significant species were recorded within the Study Area during the field survey. Temporary ephemeral pools may occur within Gorge/ Gully habitat following rainfall events; however, are not likely to persist for prolonged periods outside the wet season.

Table 3.3: Fauna habitat descriptions

Habitat Type	Description	Extent within the Study Area	Habitat for Significant Species	Representative Photo
Footslopes and Plain **Extent in Study Area:** 590.82 ha (56.96%) **Vertebrate Fauna Significance:** Low	Footslopes and Plain habitat comprise low-lying open plains and the low rolling hills below upland areas. Vegetation is dominated by scattered *Eucalyptus* trees mixed *Acacia* and *Grevillea* shrubs over open *Triodia* hummock grassland on stony and/or clay loam substrates.	Footslopes and Plain habitat occurs throughout the majority of the Study Area (Figure 3.2). The habitat is common and widespread both within the Study Area and in the broader vicinity of the Study Area.	• **Pilbara leaf-nosed bat –** secondary foraging and/or dispersal (if proximal to primary roosting and breeding habitat, otherwise secondary foraging and/or dispersal) • **ghost bat –** secondary foraging and/or dispersal (if proximal to primary roosting and breeding habitat) • **grey falcon –** secondary foraging (if proximal to primary nesting and breeding habitat) • **peregrine falcon –** secondary foraging and/or dispersal (if proximal to primary nesting and breeding habitat) • **fork-tailed swift –** secondary foraging and/or dispersal • **brush-tailed mulgara –** reeding, foraging and dispersal habitat • **northern short-tailed mouse** – breeding, foraging and dispersal habitat • **western pebble-mound mouse –** breeding, foraging and dispersal habitat	
Hillcrest and Hillslope **Extent in Study Area:** 340.34 ha (32.82%) **Vertebrate Fauna Significance:** High	Hillcrest and Hillslope habitat comprises hills and undulating stony plains of higher elevation, supporting hard spinifex with a mantle of gravel and larger rocks with occasional minor outcropping. Vegetation is dominated by scattered *Eucalyptus* trees and *Acacia* and/or *Grevillea* shrubs over open *Triodia* hummock grassland with. This habitat also includes minor instances of outcropping and breakaway within its occurrence.	Hillcrest and Hillslope habitat occupies a large portion of DHI and DFI, often forming part of a larger occurrence of the habitat that extends beyond the Study Area (Figure 3.2). No occurrence within WHI. This habitat is a common and widespread habitat throughout the surrounding region.	• **Pilbara leaf-nosed bat** – secondary foraging and/or dispersal (if proximal to primary roosting and breeding habitat, otherwise secondary foraging and/or dispersal) • **Pilbara olive python** – secondary foraging and/or dispersal (if proximal to primary habitat) • **fork-tailed swift** – secondary foraging and/or dispersal • **western pebble-mound mouse –** breeding, foraging and dispersal habitat • **Pilabra barking gecko –** breeding, foraging and dispersal habitat	
PEC Cracking Clay **Extent in Study Area:** 7.20 ha (0.69%) **Vertebrate Fauna Significance:** Low	Characterised by low-lying cracking-clay loam depressions and flow lines supporting spars vegetation cover. Vegetation often comprises open tussock grasslands comprising isolated *Sida* shrubs over mixed *Astrebla* and *Aristida* grasses. Confirms with the description of the West Angelas Cracking-Clays Priority 1 PEC.	Occurs in a small low-lying area of DHI, with extent of occurrence extending beyond the Study Area (Figure 3.2). Occurs in small sparsely scattered areas in the vicinity of the Study Area. No occurrence within WHI and DFI.	• **northern short-tailed mouse –** breeding, foraging and dispersal habitat	

Habitat Type	Description	Extent within the Study Area	Habitat for Significant Species	Representative Photo
Gorge/Gully **Extent in Study Area:** 16.77 ha (1.62%) **Vertebrate Fauna Significance:** High	Often surrounded by Hillcrest and Hillslope habitat. This habitat often contains exposed rock outcropping and breakaway. Usually dominated by open *Eucalyptus* woodlands, *Acacia* and *Grevillea* shrublands and *Triodia* low hummock grasslands vegetation.	Within the Study Area Gorge/Gully habitat occurs in few instances amongst Hillcrest and Hillslope habitat within DHI (Figure 3.2). No occurrence of this habitat within WHI and DFI. This habitat is a common habitat throughout the surrounding region.	• **northern quoll –** primary denning/ shelter, foraging and/or dispersal habitat • **Pilbara leaf-nosed bat –** primary roosting, foraging and/or dispersal (secondary foraging/ dispersal if roosting not proximal) • **ghost bat** – primary roosting, foraging and/or dispersal (secodary foraging/ dispersal if roosting not proximal) • **Pilbara olive python** – secondary breeding, foraging and dispersal habitat • **peregrine falcon –** primary breeding (where rocky areas of high elevation occur) • **Pilbara flat-headed blind-snake** – breeding, foraging and dispersal habitat	
Drainage Line **Extent in Study Area:** 8.03 ha (0.77%) **Vertebrate Fauna Significance:** Moderate	Drainage Line habitat often occurs as an intersecting habitat within lower-lying areas of Footslopes and Plain habitat. Presence and persistence of water within Drainage Line habitat variable, often influenced by rainfall. Vegetation within the habitat is variable depending on presence of water, often comprising fringing vegetation dominated scattered *Eucalypts* and *Acacia* species over mixed shrub and tussock grassland understory.	Drainage Line habitat intersects the Study Area at multiple locations; however, only occupies a small portion overall (Figure 3.2). The habitat is a commonly occurring habitat in the broader vicinity of the Study Area.	• **Pilbara leaf-nosed bat –** secondary foraging and/or dispersal (if proximal to primary roosting and breeding habitat) • **Pilbara olive python –** secondary foraging and/or dispersal (particularly if proximal to instances of primary habitat) • **fork-tailed swift –** secondary foraging and/or dispersal	
Mixed Acacia Woodland **Extent in Study Area:** 1.50 ha (0.14%) **Vertebrate Fauna Significance:** Low	Mixed Acacia Woodland habitat comprises *Acacia* shrubland of varying density, often dominated by varying mulga (*Acacia aneura*), over open understory comprising scattered small shrubs and/or tussock and hummock grasses on stony and/or clay loam substrates. The habitat is often associated with plains subject to sheet flow following rainfall.	Within the Study Area, the occurrence of Mixed Acacia Woodland is limited to a small extent in the northern extent of DHI (Figure 3.2). No occurrence of this habitat within WHI and DFI; however, Footslopes and Plain habitat throughout the Study Area can also comprises small instances of this habitat. This habitat is a common and widespread habitat throughout the surrounding region.	• **Pilbara leaf-nosed bat –** secondary foraging and/or dispersal (if proximal to primary roosting and breeding habitat) • **ghost bat –** secondary foraging and/or dispersal (if proximal to primary roosting and breeding habitat) • **fork-tailed swift –** secondary foraging and/or dispersal • **brush-tailed mulgara –** breeding, foraging and dispersal habitat • **northern short-tailed mouse –** breeding, foraging and dispersal habitat	

Habitat Type	Description	Extent within the Study Area	Habitat for Significant Species	Representative Photo
Disturbed **Extent in Study Area:** 72.19 ha (6.96%) **Vertebrate Fauna Significance:** Negligible	Disturbed and/or cleared areas (i.e. roads and access tracks, mine pits and infrastructure, drill pads and other clearing)	Variable extents of disturbance occur throughout parts of the Study Area, primarily associated with existing operations (pits, stockpiles and mine access roads), explorations activities (drill pads and associated tracks) and numerous small access tracks (Figure 3.2).	• **fork-tailed swift –** secondary foraging and/or dispersal	

670000
676000
682000
688000
7440000
7434000

A2
CDHI-001
A1
L3
L2
Deposit H
Infrastructure
CDHI-002
Western Hill
Infrastructure
Western Hill
Infrastructure
Deposit H
Infrastructure
West Angelas
AA1
Deposit F
Infrastructure

Legend

- Caves
- Study Area
- Operating Mine

Fauna Habitat

- Disturbed
- Drainage Line
- Footslopes and Plains
- Gorge/Gully
- Hillcrest and Hillslope
- Mixed Acacia Woodland
- PEC Cracking Clay

N

biologic Environmental Survey

Scale: 1:62,000

0 1 2 3 Km

Coordinate System: GDA2020 MGA Zone 50
Projection: Transverse Mercator
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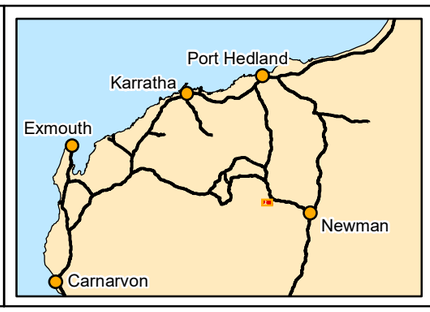

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Mt Ella, Deposit J and Deposit G Flora and Fauna Survey

Figure 3.2: Broad fauna habitats of the Study Area

3.3. Field Survey

During the current survey, a total of 42 species of vertebrate fauna species were recorded, comprising 13 mammals (ten native and three introduced), 24 birds and five reptiles (Appendix C). One significant species was recorded during the field survey, western pebble-mound mouse (Figure 3.3; Appendix D). The species was recorded on 19 occasions from secondary evidence within DHI (n = 7) and DFI (n = 12), comprising four (all DFI) active, 12 recently inactive (five in DFI and seven in DHI) and three inactive (all DFI) pebble-mounds (Appendix D). The species is likely to occur throughout the Study Area, particularly Hillcrest and Hillslope and Footslopes and Plain habitats, where suitable stony substrates permitting burrow excavation and mound construction occur.

Although ghost bat was not recorded during the current survey, the species has previously been recorded on multiple occasions within DHI at a previously known cave (L3), which has been subject of long-term monitoring for the species (Table 3.4; Figure 3.1). Evidence of the species has been recorded at L3 as far back as 1980, where the species was recorded from direct observation. To date, the species has been recorded on multiple occasions, primarily from secondary evidence (scats) and to a lesser extent ultrasonic call recordings, with scat genotyping indicating up to four individuals have utilised the roost (Biologic, 2022b). Recent monitoring suggests this cave is currently being utilised as a Category 3 cave. Based on the presence of a large historic scat pile, it is likely that this cave was previously used as a Category 2 prior to increased disturbance from mining activities. Although ghost bat usage of the cave has fluctuated during monitoring undertaken between 2014 to present (Biologic, 2022b), continued usage of the cave as a roost is likely to occur, though may be intermittent.

In addition to the occurrence of roosting within the Study Area, the species is likely to forage and/or disperse within Footslopes and Plain and Mixed Acacia Woodland habitats occurring within the Study Area, particularly areas supporting open vegetation cover and suitable perching trees. Frequency of occurrence within the Study Area to forage and/or disperse is likely to be dependent on the occurrence of roost caves (particularly diurnal roosts) proximal to the Study Area. Three previously known caves (i.e. recorded prior to current survey) directly adjacent to the DHI which are also subject to long-term monitoring (caves A1, A2 and L2) are known to be utilised by the species (Biologic, 2022b). Based on long-term monitoring data, A1 has been classified as a Category 2 cave, A2 is a Category 4 cave and L2 is a Category 3 (Biologic, 2022b). An additional long-term monitoring roost (cave AA1), located approximately 1.8 km south-west of DFI, has recorded up to 25 individuals from scat genotyping and is a confirmed Category 2 roost (Biologic, 2022b).

Excluding the two significant species confirmed within the Study Area (ghost bat and western pebble-mound mouse), based on known species' distributions, previous records and the habitats present within the Study Area, of the significant species identified in the desktop assessment as potentially occurring in the study area, one species was deemed Highly Likely (Pilbara barking gecko), five species were deemed Likely (Pilbara leaf-nosed bat, grey falcon, peregrine falcon, fork-tailed swift and northern short-tailed mouse) and four were deemed possible (northern quoll, Pilbara olive python, brush-tailed mulgara and Pilbara flat-headed blind-snake) (Table 3.4).

The remaining 12 species are considered Highly Unlikely (n = 9) or Unlikely (n = 3) to occur within the Survey Area, primarily due to the absence of suitable habitat (Table 3.4). Where a species' likelihood of occurrence differs between the three survey areas (i.e. WHI, DHI, DFI), further explanation is provided for relevant species below.

Pilbara barking gecko is considered highly likely to occur as a resident in Hillcrest and Hillslope habitat within DHI and DFI where suitable rock cover occurs. Pilbara barking geckos have previously been recorded approximately 2.6 km west of DHI and is considered Highly Likely to occur (Table 3.4; Figure 3.1). No suitable habitat occurs within WHI.

Pilbara leaf-nosed bat has previously been recorded from ultrasonic calls approximately 300 meters south of WHI and is considered Likely to occur (Table 3.4; Figure 3.1). Calls recorded were indicative of foraging or dispersing individuals (Ecologia, 2014), which suggest individuals were originating from a presumed Category 1–2 roost located within the south-wet corner Karijini National Park (Biologic, 2019); however, the occurrence of other roosts in the area cannot be ruled out. Although the exact location of the Karijini roost is not confirmed, the boundary of the national park is located approximately 6.3 km west of WHI. Within the Study Area, the species' occurrence is likely to be limited to foraging and/or dispersal activities, during which night roosting may occur within the three caves recorded in DHI, which may provide Category 4 roost sites for the species. Foraging and/or dispersal habitat for Pilbara leaf-nosed bat is provided, at varying capacities, within all six broad fauna habitats mapped within the Study Area. Habitat rating (HR) of potential foraging habitat the six fauna habitats occurring within the Study Area (as defined by Bat Call WA (2021b)) ranges from moderate (HR2; Gorge/ Gully, Footslopes and Plain, Mixed Acacia Woodlands and Drainage Line) to low (HR1; Hillcrest and Hillslope and PEC Cracking Clay), with areas mapped as Disturbed are considered poor (HR0). Foraging and/or dispersal activity of the species within the Study Area is likely to be dependent on the proximity of roost caves (particularly diurnal roosts) proximal to the Study Area. No potential diurnal Category 1–3 roost caves for the species occur within the Study Area.

Although no potential Category 1–3 roost caves for the species occur within the Study Area, it is possible critical roosts occur within foraging distance, indicating the likely occurrence of foraging habitat within the Study Area. Despite the precise location not yet been confirmed, the presumed Category 1–2 roosts believed to occur in the south-east corner of Karijini National Park (Biologic, 2019) and in the vicinity of the Angelo River Project, approximately 30 km south of the Study Area (Biologic, in prep.-a), and it is possible that additional Category 1–3 roost caves, particularly category 3, occur in the broader vicinity of the Study Area, which may influence to occurrence of foraging and/or dispersing individuals within the Study Area.

Grey falcon and peregrine falcon have previously been recorded within 20 km of the Study Area, grey falcon approximately 4.3 km between WHI and DHI survey areas and peregrine falcon approximately 18 km north-east of the Study Area (Table 3.4; Figure 3.1). Both species are considered Likely to occur within the Study Area; however, their frequency of occurrence is likely to be dependent on the proximity of nesting sites. Within the Study Area, potential nesting habitat is provided within Gorge/Gully and some instances of breakaway in Hillcrest and Hillslope habitats within DHI and DFI for peregrine falcon.

Nesting for grey falcon may be provided within parts of DHI where suitable tall infrastructure (i.e. tall powerline and/or communications towers) occurs. Foraging for both species is likely to occur throughout most habitats of the Study Area, primarily within Footslopes and Plain.

The fork-tailed swift was not recorded during the current survey; however, the species has previously been recorded (2013) approximately 150 m south of DFI (Table 2.4; Figure 3.1). The species is a wide ranging but sparsely distributed species that occurs in a wide range of dry and/or open habitats (Johnstone & Storr, 1998). The species does not breed in Australia, migrating from breeding grounds in the northern Hemisphere. During its occurrence in Australia, the species is almost exclusively aerial, feeding and possibly also roosting aerially (DoE, 2018). Therefore, the species is considered Likely to occur within the Study Area as an infrequent visitor, during which it may forage in the airspace above all habitats occurring within the Study Area; however, landing or nesting within the Study Area is unlikely.

The northern short-tailed mouse, which has previously been recorded approximately 3.4 km south-west of DHI (Table 3.4; Figure 3.1) is considered Likely to occur as a resident within PEC Cracking Clay, Mixed Acacia Woodland and Footslopes and Plain habitats. The species occurrence, however, is likely to be variable and may fluctuate seasonally when resources for the species are more abundant, particularly following rainfall events

Of the four significant species considered Possible to occur within the Study Area (northern quoll, Pilbara olive python, brush-tailed mulgara and Pilbara flat-headed blind-snake), critical (primary breeding/ nesting, foraging and dispersal) habitat likely to support the species present within the Study Area is marginal and/or often occurring in smaller isolated patches with limited connectivity. Additionally, many species considered Possible have previously only been recorded in low abundance locally (i.e. northern quoll and Pilbara olive python).

Northern quoll has previously been recorded from secondary evidence (scats) approximately 2.8 km north-west of WHI (Table 3.4; Figure 3.1). The species is considered Possible to occur, primarily within Gorge/Gully and instances of breakaway in Hillcrest and Hillslope of DHI and DFI, which provide suitable areas of potential denning/ shelter habitat. These habitats and, to a lesser extent, Drainage Line, may also provide foraging and/or dispersal habitat for the species, particularly where they provide connectivity to other areas of critical habitat. Suitable habitat is not present within WHI.

Pilbara olive python has previously been recorded approximately 2.8 km north-west of WHI (Table 3.4; Figure 3.1) and is considered Possible to occur within the Study Area. The species may occur as a resident within Gorge/Gully habitat of DHI and DFI, particularly where pooling of water is likely to occur for prolonged periods following rainfall. The species may also occur more broadly in Hillcrest and Hillslope and Drainage Line habitats to forage and/or disperse. No suitable habitat present within WHI.

The nearest record of brush-tailed mulgara is located approximately 41 km south south-west of the Study Area (Table 3.4; Figure 3.1); however, it is considered Possible to occur within the Study Area. The species is often recorded from a range of sandy and stony plain habitats and may occur as a resident in Footslopes and Plain or Mixed Acacia Woodland habitats of the Study Area where suitable

vegetation cover and sandy or loamy substrates permitting burrowing are present. The species occurrence and abundance within the Study Area is likely to fluctuate seasonally when resources are more or less abundant.

The Pilbara flat-headed blind-snake has previously been recorded approximately 9.6 km south-west of DHI (Table 3.4; Figure 3.1) and is considered Possible to occur within the Study Area as a resident. It may occur within Gorge/Gully and instances of breakaway within Hillcrest and Hillslope habitat of DHI and DFI, particularly where moist substrates and leaf litter accumulation occurs over prolonged periods. Suitable habitat is not present within WHI.

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Western Hill Infrastructure
Western Hill Infrastructure
Deposit H Infrastructure
West Angelas
Deposit F Infrastructure

Legend

- Study Area
- Operating Mine

Fauna Habitat

- Disturbed
- Drainage Line
- Footslopes and Plains
- Gorge/Gully
- Hillcrest and Hillslope
- Mixed Acacia Woodland
- PEC Cracking Clay

- Western pebble-mound mouse

N

biologic Environmental Survey

Scale: 1:62,000

0 1 2 3 Km

Coordinate System: GDA2020 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA2020 Created 16/11/2022

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Figure 3.3: Significant species recorded in the Study Area

Table 3.4: Likelihood of occurrence of significant fauna species within the Study Area

Species	Conservation Status			Preferred Broad Habitats	Nearest Records to the Study Area	Potential Habitat Within the Study Area						Comments	Likelihood of occurrence		
	EPBC Act	BC Act	DBCA			Footslopes and Plain	Hillcrest and Hillslope	Gorge/Gully	Mixed Acacia Woodland	Drainage Line	PEC Cracking Clay		WHI	DHI	DFI
Mammals															
Dasyuridae															
brush-tailed mulgara (*Dasycercus blythi*)			P4	Brush-tailed mulgara show a preference for spinifex *Triodia* spp. grasslands on sand plains and the swales between low dunes (Pavey *et al.*, 2012; Woolley, 2006). Mature spinifex hummocks appear to be important for protection from introduced predators (Körtner *et al.*, 2007).	~41 km SSW (2014) (DBCA, 2021c)	•			•			May occur as a resident in Footslope or Plain or Mixed Acacia Woodland habitats where suitable substrates permitting burrow construction are present. Occurrence and abundance likely to fluctuate seasonally when resources are abundant.	Possible	Possible	Possible
northern quoll (*Dasyurus hallucatus*)	EN	EN		The species tends to inhabit rocky habitats which offer protection from predators and are generally more productive in terms of availability of resources (Braithwaite & Griffiths, 1994) (Oakwood, 2000). Other microhabitat features important to the species include rock cover, proximity to permanent water and time-since last fire (Woinarski *et al.*, 2008).	~2.8 km NW WHI (2018) (Biologic, 2021a)		•	•		•		May occur as a resident within Gorge/Gully and, where instances of breakaway occur, within Hillcrest and Hillslope habitats, primarily within DHI. Additionally, Hillcrest and Hillslope and instances of Drainage Line habitat may also provide foraging and/or dispersal habitat, particularly were providing connectivity between areas of primary habitat within and in the vicinity of the Study Area. Suitable habitat not present within WHI. Scarcely recorded in broader area.	Unlikely	Possible	Possible
Hipposideridae															
Pilbara leaf-nosed bat (*Rhinonicteris aurantia* (Pilbara form))	VU	VU		The Pilbara leaf-nosed bat roosts within caves and abandoned mines with high humidity (95%) and temperature (32°C) (Armstrong, 2001). The species forages in caves and along waterbodies with fringing vegetation (TSSC, 2016b).	~300 m S WHI (2013) (Rio Tinto, 2021a)	• (HR = 2)	• (HR = 1)	• (HR = 2)	• (HR = 2)	• (HR = 2)	• (HR = 1)	May occur within the Study Area during foraging and/or dispersal activities. Foraging may occur in Priority 2 (gullies within Gorge/Gully), Priority 3 (instances of rocky outcrop occurring with Hillcrest and Hillslope) and Priority 5 (open grassland and woodland, within Footslopes and Plain or Mixed Acacia Woodland) habitats (as defined by TSSC (2016b)). Drainage Line habitat may also provide a water source and occasional foraging habitat, particularly where pooling occurs following rainfall. Habitat rating (HR; as defined by Bat Call WA (2021b)) of potential foraging habitat within the Study Area ranges from moderate (2) to low (1). Occurrence likely to be limited and influenced by the proximity of the Study Area to suitable roost caves. Caves present within Gorge/Gully habitat within DHI may provide Category 4 roost sites for the species (as defined by Bat Call WA (2021b)). No potential roost caves present within WHI and DFI.	Likely	Likely	Possible
Megadermatidae															
ghost bat (*Macroderma gigas*)	VU	VU		Ghost bats roost in deep, complex caves beneath bluffs of low, rounded hills, granite rock piles and abandoned Mines (Armstrong & Anstee, 2000). These features often occur within habitats including gorge/ gully, hill crest/ hill slope and low hills (Armstrong & Anstee, 2000). Forages broadly across habitats, particularly woodland and open woodland habitats, including eucalypt and mulga woodlands (Biologic, 2020; Richards *et al.*, 2008; Tidemann *et al.*, 1985; TSSC, 2016a).	Within DHI (2020) (Biologic, 2014, 2022b)	•		•	•			Previously confirmed within Study Area from multiple records at a single location (cave L3) within DHI (Figure 3.1), including from direct observation (1978–79), call recording (2012, 2013) and secondary evidence (scats; 1998–2021) (Biologic, 2022b). A Category 3 roost (cave L3) for the species occurs within the Study Area, in the northern portion of DHI (Biologic, 2022b). Based on results of long-term monitoring of ghost bat utilisation of the cave, the species has intermittently used the cave between 2014–2021. Additional caves within Gorge/Gully habitat in DHI may provide Category 4 roost sites for the species. No potential roost caves present within WHI and DFI. Species likely to forage and/or dispersal within Footslopes and Plain and Mixed Acacia Woodland habitats of the Study Area, particularly within and surrounding DHI; however, may also occur within WHI and DFI. Occurrence likely to be limited and influenced by the proximity of roost sites within and in the vicinity of the Study Area.	Possible	Confirmed (Biologic, 2014, 2022b)	Possible

Species	Conservation Status			Preferred Broad Habitats	Nearest Records to the Study Area	Potential Habitat Within the Study Area						Comments	Likelihood of occurrence		
	EPBC Act	BC Act	DBCA			Footslopes and Plain	Hillcrest and Hillslope	Gorge/Gully	Mixed Acacia Woodland	Drainage Line	PEC Cracking Clay		WHI	DHI	DFI
Muridae															
northern short-tailed mouse (*Leggadina lakedownensis*)			P4	The species occupies a diverse range of habitats from the monsoon tropical coast to semiarid climates, including spinifex and tussock grasslands, samphire and sedgelands, *Acacia* shrublands, tropical eucalypt and Melaleuca woodlands and stony ranges; however, the species is usually found in seasonally inundated habitats on red or white sandy-clay soils (Moro & Kutt, 2008)	~3.4 km SW DHI (1997) (DBCA, 2021c)	•			•		•	May occur as a resident within Footslopes and Plain, Mixed Acacia Woodland and PEC Cracking Clay habitats of the Study Area. Occurrence and abundance likely to fluctuate seasonally when resources are abundant.	Possible	Likely	Possible
western pebble-mound mouse (*Pseudomys chapmani*)			P4	This species occurs on the gentler slopes of rocky ranges where the ground is covered with a stony mantle and vegetated by hard spinifex, often with a sparse overstorey of eucalypts and scattered shrubs (Anstee, 1996; Start *et al.*, 2000).	Within WHI (2018) and DFI (2013) (Rio Tinto, 2021a)	•	•					Recorded on multiple occasions within the Study Area during the current survey (Figure 3.3; Appendix D) and previously within and in the vicinity of the Study Area (Figure 3.1). Likely to occur as a resident within Hillcrest and Hillslope and Footslopes and Plain habitats throughout the Study Area where suitable stony substrates permitting burrow and mound construction present.	Confirmed (Rio Tinto, 2021a)	Confirmed (this survey)	Confirmed (Rio Tinto, 2021a)
Thylacomyidae															
greater bilby (*Macrotis lagotis*)	VU	VU		Occurs in a variety of habitats including spinifex hummock grassland and *Acacia* shrubland, on soft soils (Burrows *et al.*, 2012). In the Pilbara often associated with major drainage line sandy terraces (How *et al.*, 1991).	~10 km N WHI (1983) (DBCA, 2021c)							Suitable habitat not present.	Unlikely	Unlikely	Unlikely
Aves															
Apodidae															
fork-tailed swift (*Apus pacificus*)	MI	MI		Inhabits dry/open habitats, inclusive of riparian woodlands and tea-tree swamps, low scrub, heathland or saltmarsh, as well as treeless grassland and sandplains covered with spinifex, open farmland and inland and coastal sand-dunes (Johnstone & Storr, 1998). Almost exclusively aerial.	~150 m S DFI (2013) (Rio Tinto, 2021a)	•	•	•	•	•	•	May infrequently occur within the airspace above all habitats of the Study Area during foraging and/or migratory activities; however, unlikely to land or nest.	Likely	Likely	Likely
Charadriidae															
oriental plover (*Charadrius veredus*)	MI	MI		Occurs in a variety of habitats, including coastal habitats, such as estuarine mudflats and sandbanks, on sandy or rocky ocean beaches as well as open inland environments such as, semi-arid or arid grasslands, where the grass is short and sparse (Johnstone & Storr, 2004).	~125 km NE (2011) (DBCA, 2021a)							Suitable habitat not present.	Highly Unlikely	Highly Unlikely	Highly Unlikely
Falconidae															
peregrine falcon (*Falco peregrinus*)		OS		Occupies arid areas and is most often encountered along cliffs above rivers, ranges and wooded watercourses where it hunts birds (Johnstone & Storr, 1998). It typically nests on rocky ledges occurring on tall, vertical cliff faces between 25 m and 50 m high (Olsen *et al.*, 2004; Olsen & Olsen, 1989).	~18 km NE (2007) (DBCA, 2021c)	•	•	•		•	•	May occasionally occur within the Study Area to forage, particularly within Footslopes and Plain and, to a lesser extent, other habitats more broadly. Frequency of visitation may vary depending on proximity of nesting sites in the vicinity of the Study Area. Nesting may occur within Gorge/Gully habitat and instances of breakaway within Hillcrest and Hillslope habitat of DHI and DFI. No suitable nesting habitat present within WHI.	Possible	Likely	Likely
grey falcon (*Falco hypoleucos*)	VU	VU		Inhabits timbered lowlands, particularly *Acacia* shrubland and along inland drainage systems. Also frequents spinifex and tussock grassland habitats to forage (Burbidge *et al.*, 2010; Olsen & Olsen, 1986).	~4.3 km NW WHI (1997) (DBCA, 2021c)	•			•	•	•	Likely to occur within the Study Area to forage, particularly within Footslopes and Plain, and, to a lesser extent, other habitats more broadly. Frequency of visitation likely to vary depending on proximity of nesting location within or in vicinity of Study Area. Nesting may occur withing parts of DHI where suitable tall infrastructure (i.e. powerline or transmission towers)	Likely	Likely	Likely

Species	Conservation Status			Preferred Broad Habitats	Nearest Records to the Study Area	Potential Habitat Within the Study Area						Comments	Likelihood of occurrence		
	EPBC Act	BC Act	DBCA			Footslopes and Plain	Hillcrest and Hillslope	Gorge/Gully	Mixed Acacia Woodland	Drainage Line	PEC Cracking Clay		WHI	DHI	DFI
												occurs. No suitable nesting habitat present within WHI and DFI.			
Hirundinidae															
barn swallow (*Hirundo rustica*)	MI	MI		The barn swallow is a non-breeding summer visitor to the Pilbara. It favors areas near water (Johnstone *et al.*, 2013).	~200 km N (2005) (DBCA, 2021a)							Suitable habitat not present.	Highly Unlikely	Highly Unlikely	Highly Unlikely
Motacillidae															
grey wagtail (*Motacilla cinerea*)	MI	MI		A rare vagrant to Western Australia where it has been recorded within various habitats with open waterbodies (Johnstone & Storr, 2004).	~120 km N (2012) (DBCA, 2021a)							Suitable habitat not present.	Highly Unlikely	Highly Unlikely	Highly Unlikely
yellow wagtail (*Motacilla flava*)	MI	MI		An uncommon but regular visitor to the Pilbara region (Johnstone *et al.*, 2013). Occupies a range of damp or wet habitats with low vegetation although favors edges of fresh water, especially sewage ponds (Johnstone & Storr, 2004).	~500 km NNE (2003) (DBCA, 2021a)							Suitable habitat not present.	Highly Unlikely	Highly Unlikely	Highly Unlikely
Psittacidae															
night parrot (*Pezoporus occidentalis*)	EN	CR		The night parrot prefers sandy/stony plain habitat with old-growth spinifex for roosting and nesting in conjunction with native grasses and herbs for foraging (DPaW, 2017).	~106 km NNE (2005) (DBCA, 2021a)							Suitable habitat not present.	Unlikely	Unlikely	Unlikely
Rostratulidae															
Australian painted snipe (*Rostratula benghalensis australis*)	EN	EN		Generally, occupies shallow terrestrial freshwater wetlands (i.e. temporary and permanent lakes, swamps and claypans) with rank emergent tussocks of grass, sedges, rushes or reeds, or samphire (Johnstone & Storr, 1998)	~100 km NW (2012) (DBCA, 2021a)							Suitable habitat not present.	Highly Unlikely	Highly Unlikely	Highly Unlikely
Scolopacidae															
sharp-tailed sandpiper (*Calidris acuminata*)	MI	MI		Favors flooded samphire flats and grasslands, mangrove creeks mudflats, beaches, river pools, saltwork ponds, sewage ponds and freshwater soaks (Johnstone *et al.*, 2013).	~110 km ENE (2007) (DBCA, 2021a)							Suitable habitat not present.	Highly Unlikely	Highly Unlikely	Highly Unlikely
curlew sandpiper (*Calidris ferruginea*)	CR/ MI	CR/ MI		Inhabits intertidal mudflats in sheltered coastal areas (i.e. estuaries, bays, inlets and lagoons) (Geering *et al.*, 2007). This rare species generally roosts on bare dry shingle, shell or sand beaches, sandspits and islets in or around coastal or near-coastal lagoons and other wetlands (Geering *et al.*, 2007).	~100 km E (2006) (DBCA, 2021a)							Suitable habitat not present.	Highly Unlikely	Highly Unlikely	Highly Unlikely
pectoral sandpiper (*Calidris melanotos*)	MI	MI		Coastal lagoons, estuaries, bays, swamps, lakes, inundated grasslands, saltmarshes, river pools, creeks, floodplains and artificial wetlands (Johnstone & Storr, 2004; Johnstone *et al.*, 2013). It prefers wetlands with open fringing mudflats and low, emergent or fringing vegetation (Geering *et al.*, 2007)	~300 km N (2014) (DBCA, 2021a)							Suitable habitat not present.	Highly Unlikely	Highly Unlikely	Highly Unlikely
common sandpiper (*Tringa hypoleucos*)	MI	MI		Estuaries and deltas of streams, as well as banks farther upstream; around lakes, pools, billabongs, reservoirs, dams and claypans (Geering *et al.*, 2007).	~120 km ENE (2018) (DBCA, 2021a)							Suitable habitat not present.	Highly Unlikely	Highly Unlikely	Highly Unlikely

Species	Conservation Status			Preferred Broad Habitats	Nearest Records to the Study Area	Potential Habitat Within the Study Area						Comments	Likelihood of occurrence		
	EPBC Act	BC Act	DBCA			Footslopes and Plain	Hillcrest and Hillslope	Gorge/Gully	Mixed Acacia Woodland	Drainage Line	PEC Cracking Clay		WHI	DHI	DFI
Reptiles															
Carphodactylidae															
Pilbara barking gecko (*Underwoodisaurus seorsus*)			P2	Little is known about the ecology of the Pilbara barking gecko, but the species is thought to prefer rocky areas, often associated with high elevation, with spinifex and low tree cover habitats (Chapple et al., 2019; Doughty & Oliver, 2011).	~2.6 km W DHI (1997) (DBCA, 2021c) ~5.5 km SW DFI (2021) (Biologic unpublished data [Angelo River detailed fauna survey])		•					Likely to occur as a resident within Hillcrest and Hillslope habitat of DHI and DFI, particularly areas of higher elevation. Suitable habitat not present within WHI.	Unlikely	Highly Likely	Highly Likely
Pythonidae															
Pilbara olive python (*Liasis olivaceus barroni*)	VU	VU		Associated with drainage systems, including areas with localised drainage and watercourses (Pearson, 1993). In the inland Pilbara the species is most often encountered near permanent waterholes in rocky ranges or among riverine vegetation (Pearson, 1993).	~2.8 km NW WHI (2018) (Biologic, 2021a) ~4.4 km E DHI (2018) (Biologic, 2021a)		•	•		•		May occur as a resident within Gorge/Gully habitat of DHI and DFI, particularly in areas where pooling water is likely to occur. May also occur more broadly within Hillcrest and Hillslope and Drainage Line habitats; however, occurrence likely to be limited to foraging and/or dispersal activities and dependent on proximity of critical (i.e. Gorge/Gully) habitat within and more broadly in the vicinity of the Study Area. Suitable habitat not present within WHI.	Unlikely	Possible	Possible
Scincidae															
lined soil-crevice skink (*Notoscincus butleri*)			P4	Recorded in areas dominated by spinifex and near water courses (Wilson & Swan, 2014). Records are restricted to a coastal area within the Lower Fortescue Hedland region.	~200 km NNW (2011) (DBCA, 2021a)							Study Area occurs outside species' current known range. Record returned in the desktop assessment likely to be erroneous.	Unlikely	Unlikely	Unlikely
Typhlopidae															
Pilbara flat-headed blind-snake (*Anilios ganei*)			P1	Little is known of the species' ecology, but it is often associated with moist soils and leaf litter within gorges and gullies (Wilson and Swan 2014), and potentially within a wide range of other stony habitats. The species has been recorded from numerous habitats but is most likely to be present in rocky terrain and along drainage lines (DBCA, 2021a).	~9.6 km SW DHI (2018) (Biologic, 2021a) ~14.5 km SSW DFI (2021) (Biologic unpublished data [Angelo River detailed fauna survey])		•	•				May occur as a resident in Gorge/Gully habitat and instances of breakaway within Hillcrest and Hillslope habitat, particularly where moist substrates and leaf litter accumulation occurs over prolonged periods. Suitable habitat not present within WHI.	Unlikely	Possible	Possible

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Appendix A: Vertebrate Fauna Habitat Assessments

Site ID	Coord.	WANG Consolidated Fauna Habitat Mapping Type (Biologic, 2021b)	Fauna Habitat Type (Rio Tinto, 2021b)	Landform	Aspect	Slope	Soil Type	Soil Avail.	Outcropping Rock Type	Rock Size	Veg. Litter	Dominant Veg. Type	Rocky Cracks / Crevices	Burrowing Suitability	Disturbances	Last Fire	Photo
Western Hill Infrastructure Area																	
VWHI-001	-23.1402, 118.6416	Footslopes and Plain	Stony Plain	Stony Plain	Flat	Flat	Clay Loam	Few Small Patches	Negligible	Negligible	Scarce	Acacia Shrubland, Spinifex Hummock Grassland	Nil	Nil	None Discernible	Moderate (3 to 5 yr)	
VWHI-002	-23.1420, 118.6415	Drainage Line	Minor Drainage Line	Stony Plain	Flat	Low	Clay Loam	Few Large Patches	Negligible	Pebbles (5-10cm)	Few Small Patches	Acacia Shrubland, Scattered Eucalypts, Tussock Grassland	Nil	Nil	None Discernible	Moderate (3 to 5 yr)	
VWHI-003	-23.1425, 118.6421	Footslopes and Plain	Stony Plain	Stony Plain	Flat	Flat	Clay Loam	Few Small Patches	Negligible	Negligible	Scarce	Acacia Shrubland, Spinifex Hummock Grassland	Nil	Nil	None Discernible	Moderate (3 to 5 yr)	
VWHI-004	-23.1390, 118.6560	Footslopes and Plain	Stony Plain	Stony Plain	Flat	Flat	Clay Loam	Few Small Patches	Negligible	Gravel (1-4cm)	Scarce	Acacia Shrubland, Spinifex Hummock Grassland	Nil	Low	Road/ Access Track	Moderate (3 to 5 yr)	
VWHI-005	-23.1402, 118.6608	Footslopes and Plain	Stony Plain	Stony Plain	Flat	Flat	Clay Loam	Scarce	Negligible	Gravel (1-4cm)	Scarce	Acacia Shrubland, Spinifex Hummock Grassland	Nil	Low	Road/ Access Track	Moderate (3 to 5 yr)	

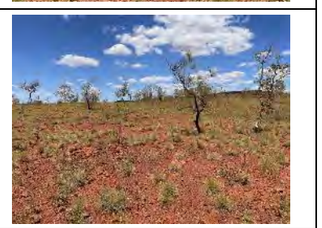
Site ID	Coord.	WANG Consolidated Fauna Habitat Mapping Type (Biologic, 2021b)	Fauna Habitat Type (Rio Tinto, 2021b)	Landform	Aspect	Slope	Soil Type	Soil Avail.	Outcropping Rock Type	Rock Size	Veg. Litter	Dominant Veg. Type	Rocky Cracks / Crevices	Burrowing Suitability	Disturbances	Last Fire	Photo
VWHI-006	-23.1424, 118.6657	Drainage Line	Minor Drainage Line	Stony Plain	Flat	Flat	Clay Loam	Many Small Patches	Negligible	Pebbles (5-10cm)	Few Small Patches	Scattered Eucalypts, Tussock Grassland	Nil	Nil	Road/ Access Track	Moderate (3 to 5 yr)	
VWHI-007	-23.1421, 118.6622	Footslopes and Plain	Alluvial Plain	Drainage Area/ Floodplain	Flat	Flat	Clay Loam	Many Large Patches	Negligible	Gravel (1-4cm)	Few Small Patches	Acacia Shrubland, Scattered Eucalypts, Spinifex Hummock Grassland, Tussock Grassland	Nil	Moderate	Cattle Grazing	Moderate (3 to 5 yr)	
VWHI-008	-23.1429, 118.6591	Footslopes and Plain	Alluvial Plain	Drainage Area/ Floodplain	Flat	Flat	Clay Loam	Many Large Patches	Negligible	Gravel (1-4cm)	Few Small Patches	Acacia Shrubland, Scattered Eucalypts, Tussock Grassland	Nil	Moderate	Cattle Grazing	Moderate (3 to 5 yr)	
VWHI-009	-23.1447, 118.6637	Footslopes and Plain	Mulga Woodland	Stony Plain	Flat	Flat	Clay Loam	Few Large Patches	Negligible	Gravel (1-4cm)	Scarce	Mulga Woodland, Tussock Grassland	Nil	Low	Road/ Access Track	Moderate (3 to 5 yr)	
Deposit H Infrastructure Area																	
VDHI-001	-23.1143, 118.7736	Hillcrest and Hillslope	Rocky Hill	Hillcrest/ Upper Hillslope	West	Low	Clay Loam	Scarce	Negligible	Gravel (1-4cm)	None Discernible	Scattered Eucalypts, Spinifex Hummock Grassland	Nil	Nil	Road/ Access Track	Recent (0 to 2 yr)	

Site ID	Coord.	WANG Consolidated Fauna Habitat Mapping Type (Biologic, 2021b)	Fauna Habitat Type (Rio Tinto, 2021b)	Landform	Aspect	Slope	Soil Type	Soil Avail.	Outcropping Rock Type	Rock Size	Veg. Litter	Dominant Veg. Type	Rocky Cracks / Crevices	Burrowing Suitability	Disturbances	Last Fire	Photo
VDHI-002	-23.1141, 118.7776	Gorge/ Gully	Gorge/ Gully	Gully	North/ West	Steep	Clay Loam	None Discernible	Major Outcropping (Ironstone)	Gravel (1-4cm)	Scarce	Scattered Eucalypts, Spinifex Hummock Grassland	Low	Nil	None Discernible	Recent (0 to 2 yr)	
VDHI-003	-23.1136, 118.7840	Hillcrest and Hillslope	Rocky Hill	Hillcrest/ Upper Hillslope	Flat	Low	Clay Loam	None Discernible	Limited Outcropping (Conglomerate)	Gravel (1-4cm)	Scarce	Scattered Eucalypts, Spinifex Hummock Grassland	Nil	Nil	Road/ Access Track	Moderate (3 to 5 yr)	
VDHI-004	-23.1130, 118.8030	Hillcrest and Hillslope	Rocky Hill	Hillcrest/ Upper Hillslope	Flat	Low	Clay Loam	Scarce	Limited Outcropping (Conglomerate)	Gravel (1-4cm)	None Discernible	Scattered Eucalypts, Spinifex Hummock Grassland	Nil	Nil	Road/ Access Track	Recent (0 to 2 yr)	
VDHI-005	-23.1156, 118.8112	Hillcrest and Hillslope	Rocky Hill	Hillcrest/ Upper Hillslope	Flat	Low	Clay Loam	Scarce	Negligible	Gravel (1-4cm)	None Discernible	Scattered Eucalypts, Spinifex Hummock Grassland	Nil	Nil	Road/ Access Track	Recent (0 to 2 yr)	
VDHI-006	-23.1272, 118.8229	Footslopes and Plain	Stony Plain	Breakaway	South	Flat	Clay Loam	Scarce	Minor Outcropping (BIF)	Gravel (1-4cm)	Scarce	Scattered Eucalypts, Spinifex Hummock Grassland	Low	Nil	Road/ Access Track	Recent (0 to 2 yr)	

Site ID	Coord.	WANG Consolidated Fauna Habitat Mapping Type (Biologic, 2021b)	Fauna Habitat Type (Rio Tinto, 2021b)	Landform	Aspect	Slope	Soil Type	Soil Avail.	Outcropping Rock Type	Rock Size	Veg. Litter	Dominant Veg. Type	Rocky Cracks / Crevices	Burrowing Suitability	Disturbances	Last Fire	Photo
VDHI-007	-23.1594, 118.8068	Footslopes and Plain (revised)	Stony Plain	Stony Plain	Flat	Flat	Clay Loam	Evenly Spread	Negligible	Gravel (1-4cm)	None Discernible	Grevillea shrubland, Spinifex Hummock Grassland	Nil	Low	Road/ Access Track	Recent (0 to 2 yr)	
VDHI-008	-23.1440, 118.8183	Drainage Line	Minor Drainage Line	Minor Drainage Line	Flat	Low	Sandy Loam	Many Large Patches	Limited Outcropping (Conglomerate)	Pebbles (5-10cm)	Few Small Patches	Acacia Shrubland, Scattered Eucalypts, Spinifex Hummock Grassland	Nil	Low	Road/ Access Track	Moderate (3 to 5 yr)	
VDHI-009	-23.1316, 118.8157	Footslopes and Plain (revised)	Stony Plain	Stony Plain	Flat	Flat	Clay Loam	Many Small Patches	Negligible	Gravel (1-4cm)	None Discernible	Scattered Eucalypts, Spinifex Hummock Grassland	Nil	Nil	Road/ Access Track	Recent (0 to 2 yr)	
VDHI-010	-23.1536, 118.8180	Footslopes and Plain (revised)	Stony Plain	Stony Plain	Flat	Flat	Clay Loam	Few Large Patches	Negligible	Gravel (1-4cm)	None Discernible	Grevillea Shrubland, Scattered Eucalypts, Spinifex Hummock Grassland	Nil	Nil	None Discernible	Recent (0 to 2 yr)	
VDHI-011	-23.1202, 118.8210	Gorge/Gully (revised)	Gorge/ Gully	Gully	West	Steep	Clay Loam	None Discernible	Major Outcropping (Conglomerate)	Gravel (1-4cm)	Many Small Patches	Acacia Shrubland, Scattered Eucalypts, Spinifex Hummock Grassland	Moderate	Nil	None Discernible	Moderate (3 to 5 yr)	

Site ID	Coord.	WANG Consolidated Fauna Habitat Mapping Type (Biologic, 2021b)	Fauna Habitat Type (Rio Tinto, 2021b)	Landform	Aspect	Slope	Soil Type	Soil Avail.	Outcropping Rock Type	Rock Size	Veg. Litter	Dominant Veg. Type	Rocky Cracks / Crevices	Burrowing Suitability	Disturbances	Last Fire	Photo
VDHI-012	-23.1175, 118.8186	Gorge/ Gully	Gorge/ Gully	Gorge	West	Steep	Clay Loam	None Discernible	Extensive Outcropping (Conglomerate)	Gravel (1-4cm)	Few Small Patches	Scattered Eucalypts, Spinifex Hummock Grassland	High	Nil	None Discernible	Moderate (3 to 5 yr)	
VDHI-013	-23.1578, 118.7767	Footslopes and Plain	Stony Plain	Stony Plain	Flat	Flat	Clay Loam	Few Large Patches	Negligible	Gravel (1-4cm)	Scarce	Acacia Shrubland, Spinifex Hummock Grassland	Nil	Low	Road/ Access Track	Recent (0 to 2 yr)	
VDHI-014	-23.1548, 118.7791	Hillcrest and Hillslope	Rocky Hill	Hillcrest/ Upper Hillslope	South	Steep	Clay Loam	None Discernible	Major Outcropping (Conglomerate)	Gravel (1-4cm)	None Discernible	Spinifex Hummock Grassland	Moderate	Nil	Road/ Access Track	Moderate (3 to 5 yr)	
VDHI-015	-23.1343, 118.8064	Footslopes and Plain (revised)	Stony Plain	Stony Plain	Flat	Flat	Clay Loam	Few Small Patches	Major Outcropping (Ironstone)	Gravel (1-4cm)	None Discernible	Scattered Grevillea, Spinifex Hummock Grassland	Low	Nil	Mining Exploration, Road/ Access Track	Moderate (3 to 5 yr)	
VDHI-016	-23.1358, 118.8057	Disturbed	Cleared/ Disturbed	Cleared/ Disturbed	Flat	Flat	Clay Loam	Few Large Patches	Negligible	Gravel (1-4cm)	None Discernible	None	Nil	Low	Mining Exploration, Road/ Access Track, Topsoil Stockpile	Moderate (3 to 5 yr)	

Site ID	Coord.	WANG Consolidated Fauna Habitat Mapping Type (Biologic, 2021b)	Fauna Habitat Type (Rio Tinto, 2021b)	Landform	Aspect	Slope	Soil Type	Soil Avail.	Outcropping Rock Type	Rock Size	Veg. Litter	Dominant Veg. Type	Rocky Cracks / Crevices	Burrowing Suitability	Disturbances	Last Fire	Photo
VDHI-017	-23.1305, 118.8114	Footslopes and Plain (revised)	Stony Plain	Stony Plain	Flat	Flat	Clay Loam	Few Large Patches	Negligible	Gravel (1-4cm)	Scarce	Acacia Shrubland, Spinifex Hummock Grassland	Nil	Low	Road/ Access Track	Moderate (3 to 5 yr)	
VDHI-018	-23.1555, 118.8126	Footslopes and Plain (revised)	Stony Plain	Stony Plain	Flat	Flat	Clay Loam	Few Small Patches	Negligible	Gravel (1-4cm)	Scarce	Acacia Shrubland, Spinifex Hummock Grassland	Nil	Nil	Road/ Access Track	Moderate (3 to 5 yr)	
VDHI-019	-23.1555, 118.8167	Footslopes and Plain (revised)	Stony Plain	Undulating Low Hills	North	Low	Clay Loam	Scarce	Limited Outcropping (BIF)	Gravel (1-4cm)	Scarce	Scattered Grevillea, Spinifex Hummock Grassland, Tussock Grassland	Low	Nil	None Discernible	Recent (0 to 2 yr)	
VDHI-020	-23.1476, 118.8220	Footslopes and Plain (revised)	Alluvial Plain	Drainage Area/ Floodplain	Flat	Flat	Clay Loam	Many Large Patches	Negligible	Gravel (1-4cm)	Few Small Patches	Mulga Woodland, Scattered Eucalypts, Tussock Grassland	Nil	Moderate	None Discernible	Moderate (3 to 5 yr)	
VDHI-021	-23.1519, 118.8219	Drainage Line	Minor Drainage Line	Minor Drainage Line	Flat	Flat	Sandy Loam	Evenly Spread	Negligible	Gravel (1-4cm)	Few Small Patches	Acacia Shrubland, Scattered Eucalypts, Tussock Grassland	Nil	Nil	None Discernible	Moderate (3 to 5 yr)	

Site ID	Coord.	WANG Consolidated Fauna Habitat Mapping Type (Biologic, 2021b)	Fauna Habitat Type (Rio Tinto, 2021b)	Landform	Aspect	Slope	Soil Type	Soil Avail.	Outcropping Rock Type	Rock Size	Veg. Litter	Dominant Veg. Type	Rocky Cracks / Crevices	Burrowing Suitability	Disturbances	Last Fire	Photo
VDHI-022	-23.1409, 118.8153	Footslopes and Plain (revised)	Mulga Woodland	Stony Plain	Flat	Flat	Clay Loam	Few Large Patches	Negligible	Gravel (1-4cm)	Many Small Patches	Mulga Woodland, Spinifex Hummock Grassland, Tussock Grassland	Nil	Nil	None Discernible	Old (6+ yr)	
VDHI-023	-23.1399, 118.8151	PEC Cracking Clay (revised)	Alluvial Plain	Drainage Area/ Floodplain	Flat	Flat	Clay Loam	Evenly Spread	Negligible	Gravel (1-4cm)	None Discernible	Tussock Grassland	Nil	Nil	None Discernible	Moderate (3 to 5 yr)	
VDHI-024	-23.1366, 118.8115	Hillcrest and Hillslope	Rocky Hill	Hillslope	South	Moderate	Clay Loam	None Discernible	Extensive Outcropping (BIF)	Gravel (1-4cm)	None Discernible	Acacia Shrubland, Spinifex Hummock Grassland	Low	Nil	None Discernible	Recent (0 to 2 yr)	
VDHI-025	-23.1335, 118.8220	Hillcrest and Hillslope	Rocky Hill	Hillslope	South	Moderate	Clay Loam	None Discernible	Extensive Outcropping (Conglomerate)	Gravel (1-4cm)	None Discernible	Scattered Grevillea, Spinifex Hummock Grassland	Low	Nil	None Discernible	Recent (0 to 2 yr)	
VDHI-026	-23.1136, 118.8218	Hillcrest and Hillslope	Rocky Hill	Hillcrest/ Upper Hillslope	North/ West	Moderate	Clay Loam	Scarce	Limited Outcropping	Gravel (1-4cm)	None Discernible	Scattered Eucalypts, Spinifex Hummock Grassland	Nil	Nil	None Discernible	Moderate (3 to 5 yr)	

Site ID	Coord.	WANG Consolidated Fauna Habitat Mapping Type (Biologic, 2021b)	Fauna Habitat Type (Rio Tinto, 2021b)	Landform	Aspect	Slope	Soil Type	Soil Avail.	Outcropping Rock Type	Rock Size	Veg. Litter	Dominant Veg. Type	Rocky Cracks / Crevices	Burrowing Suitability	Disturbances	Last Fire	Photo
VDHI-027	-23.1278, 118.8190	Footslopes and Plain (revised)	Stony Plain	Stony Plain	Flat	Flat	Clay Loam	Scarce	Limited Outcropping (BIF)	Gravel (1-4cm)	None Discernible	Spinifex Hummock Grassland	Nil	Nil	Road/ Access Track	Recent (0 to 2 yr)	
VDHI-028	-23.1240, 118.8201	Hillcrest and Hillslope	Breakaway/ Cliff	Breakaway	South	Moderate	Clay Loam	Few Small Patches	Major Outcropping (Conglomerate)	Gravel (1-4cm)	Few Large Patches	Mulga Woodland, Spinifex Hummock Grassland	Moderate	Nil	None Discernible	Old (6+ yr)	
VDHI-029	-23.1235, 118.8216	Gorge/ Gully (revised)	Gorge/ Gully	Gully	South	Steep	Clay Loam	Few Small Patches	Extensive Outcropping (Ironstone)	Small Rocks (11-20cm)	Many Large Patches	Mulga Woodland, Spinifex Hummock Grassland	Moderate	Nil	None Discernible	Old (6+ yr)	
VDHI-030	-23.1214, 118.8246	Hillcrest and Hillslope	Rocky Hill	Hillcrest/ Upper Hillslope	North/ West	Steep	Clay Loam	Scarce	Moderate Outcropping (Ironstone)	Gravel (1-4cm)	None Discernible	Scattered Eucalypts, Spinifex Hummock Grassland	Nil	Nil	None Discernible	Recent (0 to 2 yr)	
VDHI-031	-23.1218, 118.8222	Hillcrest and Hillslope	Rocky Hill	Hillcrest/ Upper Hillslope	North/ West	Steep	Clay Loam	Scarce	Limited Outcropping (Conglomerate)	Gravel (1-4cm)	None Discernible	Scattered Eucalypts, Spinifex Hummock Grassland	Nil	Nil	Road/ Access Track, Rubbish/ Litter	Recent (0 to 2 yr)	

Site ID	Coord.	WANG Consolidated Fauna Habitat Mapping Type (Biologic, 2021b)	Fauna Habitat Type (Rio Tinto, 2021b)	Landform	Aspect	Slope	Soil Type	Soil Avail.	Outcropping Rock Type	Rock Size	Veg. Litter	Dominant Veg. Type	Rocky Cracks / Crevices	Burrowing Suitability	Disturbances	Last Fire	Photo
VDHI-032	-23.1142, 118.8188	Gorge/ Gully	Gorge/ Gully	Gorge	North/ West	Very Steep	Clay Loam	Scarce	Extensive Outcropping (Conglomerate)	Small Rocks (11-20cm)	Few Small Patches	Scattered Eucalypts, Spinifex Hummock Grassland	High	Nil	None Discernible	Moderate (3 to 5 yr)	
VDHI-033	-23.1128, 118.8243	Gorge/Gully (revised)	Gorge/ Gully	Gorge	North/ East	Very Steep	Clay Loam	None Discernible	Major Outcropping (BIF)	Small Rocks (11-20cm)	Few Large Patches	Mulga Woodland, Scattered Eucalypts, Spinifex Hummock Grassland	High	Nil	None Discernible	Old (6+ yr)	
VDHI-034	-23.1597, 118.7987	Footslopes and Plain (revised)	Low Hills and Slopes	Hillslope	South	Moderate	Clay Loam	Scarce	Limited Outcropping (BIF)	Gravel (1-4cm)	Scarce	Scattered Eucalypts, Spinifex Hummock Grassland	Nil	Low	None Discernible	Recent (0 to 2 yr)	
VDHI-035	-23.1572, 118.7882	Hillcrest and Hillslope	Low Hills and Slopes	Gully	South	Low	Clay Loam	Scarce	Negligible	Gravel (1-4cm)	Scarce	Acacia Shrubland, Eucalypt Woodland, Spinifex Hummock Grassland	Nil	Low	None Discernible	Moderate (3 to 5 yr)	
VDHI-036	-23.1137, 118.7875	Gorge/ Gully	Gorge/ Gully	Breakaway	South	Moderate	Clay Loam	Few Small Patches	Major Outcropping (Conglomerate)	Small Rocks (11-20cm)	Few Small Patches	Mulga Woodland, Scattered Eucalypts, Spinifex Hummock Grassland	High	Nil	Mining Exploration	Old (6+ yr)	

Site ID	Coord.	WANG Consolidated Fauna Habitat Mapping Type (Biologic, 2021b)	Fauna Habitat Type (Rio Tinto, 2021b)	Landform	Aspect	Slope	Soil Type	Soil Avail.	Outcropping Rock Type	Rock Size	Veg. Litter	Dominant Veg. Type	Rocky Cracks / Crevices	Burrowing Suitability	Disturbances	Last Fire	Photo
VDHI-037	-23.1120, 118.7883	Hillcrest and Hillslope	Breakaway/ Cliff	Breakaway	North	Moderate	Clay Loam	Few Small Patches	Major Outcropping (Conglomerate)	Gravel (1-4cm)	Few Small Patches	Scattered Eucalypts, Spinifex Hummock Grassland	Moderate	Nil	None Discernible	Moderate (3 to 5 yr)	
Deposit F Infrastructure Area																	
VDFI-001	-23.1802, 118.8502	Hillcrest and Hillslope	Rocky Hill	Hillslope	North	Low	Clay Loam	None Discernible	Negligible	Negligible	None Discernible	Scattered Eucalypts, Spinifex Hummock Grassland	Nil	Nil	Road/ Access Track	Moderate (3 to 5 yr)	
VDFI-002	-23.1784, 118.8424	Footslopes and Plain	Low Hills and Slopes	Footslope	North	Low	Clay Loam	Scarce	Limited Outcropping (CID)	Gravel (1-4cm)	None Discernible	Scattered Eucalypts, Spinifex Hummock Grassland	Nil	Nil	Mining Exploration, Road/ Access Track	Moderate (3 to 5 yr)	
VDFI-003	-23.1808, 118.8480	Hillcrest and Hillslope	Rocky Hill	Hillcrest/ Upper Hillslope	North	Moderate	Clay Loam	Scarce	Negligible	Gravel (1-4cm)	None Discernible	Scattered Eucalypts, Spinifex Hummock Grassland	Nil	Nil	Mining Exploration, Road/ Access Track	Recent (0 to 2 yr)	
VDFI-004	-23.1853, 118.8564	Hillcrest and Hillslope	Rocky Hill	Hillcrest/ Upper Hillslope	Flat	Moderate	Clay Loam	None Discernible	Limited Outcropping (CID)	Gravel (1-4cm)	None Discernible	Scattered Eucalypts, Spinifex Hummock Grassland	Nil	Nil	Road/ Access Track	Moderate (3 to 5 yr)	

Site ID	Coord.	WANG Consolidated Fauna Habitat Mapping Type (Biologic, 2021b)	Fauna Habitat Type (Rio Tinto, 2021b)	Landform	Aspect	Slope	Soil Type	Soil Avail.	Outcropping Rock Type	Rock Size	Veg. Litter	Dominant Veg. Type	Rocky Cracks / Crevices	Burrowing Suitability	Disturbances	Last Fire	Photo
VDFI-005	-23.1837, 118.8551	Hillcrest and Hillslope	Gorge/ Gully	Gully	North/ West	Steep	Clay Loam	Scarce	Major Outcropping (BIF)	Gravel (1-4cm)	Few Small Patches	Scattered Eucalypts, Spinifex Hummock Grassland	Moderate	Nil	None Discernible	Moderate (3 to 5 yr)	
VDFI-006	-23.1797, 118.8455	Hillcrest and Hillslope	Rocky Hill	Hillslope	North	Moderate	Clay Loam	None Discernible	Limited Outcropping (Conglomerate)	Gravel (1-4cm)	None Discernible	Scattered Eucalypts, Spinifex Hummock Grassland	Low	Nil	None Discernible	Moderate (3 to 5 yr)	
VDFI-007	-23.1785, 118.8515	Footslopes and Plain	Stony Plain	Stony Plain	Flat	Low	Clay Loam	Scarce	Negligible	Gravel (1-4cm)	None Discernible	Acacia Shrubland, Scattered Eucalypts, Spinifex Hummock Grassland	Nil	Nil	Mining Exploration, Road/ Access Track	Moderate (3 to 5 yr)	
VDFI-008	-23.1793, 118.8545	Footslopes and Plain	Stony Plain	Stony Plain	Flat	Low	Clay Loam	Scarce	Negligible	Gravel (1-4cm)	None Discernible	Scattered Eucalypts, Spinifex Hummock Grassland	Nil	Nil	Mining Exploration, Road/ Access Track	Moderate (3 to 5 yr)	
VDFI-009	-23.1818, 118.8525	Hillcrest and Hillslope	Rocky Hill	Hillcrest/ Upper Hillslope	North	Moderate	Clay Loam	Scarce	Negligible	Gravel (1-4cm)	None Discernible	Scattered Eucalypts, Spinifex Hummock Grassland	Nil	Nil	None Discernible	Recent (0 to 2 yr)	

Site ID	Coord.	WANG Consolidated Fauna Habitat Mapping Type (Biologic, 2021b)	Fauna Habitat Type (Rio Tinto, 2021b)	Landform	Aspect	Slope	Soil Type	Soil Avail.	Outcropping Rock Type	Rock Size	Veg. Litter	Dominant Veg. Type	Rocky Cracks / Crevices	Burrowing Suitability	Disturbances	Last Fire	Photo
VDFI-010	-23.1879, 118.8580	Hillcrest and Hillslope	Breakaway/ Cliff	Breakaway	South	Steep	Clay Loam	Scarce	Extensive Outcropping (Conglomerate)	Gravel (1-4cm)	Scarce	Acacia Shrubland, Scattered Eucalypts, Spinifex Hummock Grassland	Nil	Nil	Road/ Access Track	Moderate (3 to 5 yr)	

Appendix B: Summary of Caves Recorded within the Study Area

Cave ID	Site	Coordinates	Habitat	Position	Aspect	Cave Exposure	Entrance Type	Entrance Shape	Entrance Width (m)	Entrance Height (m)	Floor Slope	Cave Depth (m)	No. Chambers	Max Chamber Height (m)	Ghost Bat		Pilbara Leaf-nosed Bat		Photo
															Records	Significance (Bat Call WA, 2021a)	Records	Significance (Bat Call WA, 2021b)	
CDHI-001	VDHI-012	-23.1133 118.7754	Gorge/Gully	Upper Slope	East	Semi Exposed	Cavern	Round/ Oval	3	3	Flat	6	1	3.5	Nil	Category 4	Nil	Category 4	
CDHI-002	VDHI-012	-23.1172 118.8198	Gorge/Gully	Mid Slope	North	Sheltered	Cavern	Round/ Oval	8	4	Incline	10	1	4	Nil	Category 4	Nil	Category 4	
L3	VDHI-036	-23.1137 118.7873	Gorge/Gully	Mid Slope	South	Sheltered	Cavern	Horizontal	12	2.5	Incline	29	2	5.5	Nil (this survey) Previous records include direct observation (1978–79), scats (1998, 2000, 20032, 2004, 2012–2021) and ultrasonic call recording (2012, 2013) (Biologic, 2022b).	Category 3 (possibly Category 2 historically)	Nil	Category 4	

Appendix C: Vertebrate Fauna Recorded During the Current Survey

Species	Common Name	Conservation Status[1]			Survey Area		
		EPBC Act	BC Act	DBCA	WHI	DHI	DFI
MAMMALS							
BOVIDAE							
Bos taurus	European cattle				x		
CANIDAE							
Canis familiaris	dog/ dingo				x		
EMBALLONURIDAE							
Taphozous georgianus	common sheath-tailed bat					x	
Taphozous hilli	Hill's sheath-tailed bat				x	x	x
FELIDAE							
Felis catus	cat					x	
MACROPODIDAE							
Osphranter robustus	euro					x	x
Petrogale rothschildi	Rothschild's rock wallaby					x	
MOLOSSIDAE							
Chaerephon jobensis colonicus	greater northern free-tailed bat				x	x	x
Ozimops lumsdenae	northern free-tailed bat				x		x
MURIDAE							
Pseudomys chapmani	western pebble-mound mouse			P4		x	x
VESPERTILIONIDAE							
Chalinolobus gouldii	Gould's wattled bat				x	x	x
Scotorepens greyii	little broad-nosed bat				x	x	x
Vespadelus finlaysoni	Finlayson's cave-bat					x	x
BIRDS							
ACANTHIZIDAE							
Smicrornis brevirostris	weebill				x		
ARTAMIDAE							
Artamus cinereus	black-faced woodswallow					x	
Artamus minor	little woodswallow					x	
CAMPEPHAGIDAE							
Coracina novaehollandiae	black-faced cuckoo-shrike					x	
COLUMBIDAE							
Geopelia cuneata	diamond dove				x		
Geophaps plumifera	spinifex pigeon					x	x
CORVIDAE							
Corvus orru	Torresian crow				x	x	
CRATICIDAE							
Cracticus nigrogularis	pied butcherbird				x		x
CUCULIDAE							
Chrysococcyx basalis	Horsfield's bronze cuckoo				x		

Species	Common Name	Conservation Status[1]			Survey Area		
		EPBC Act	BC Act	DBCA	WHI	DHI	DFI
ESTRILDIDAE							
Taeniopygia guttata	zebra finch				x	x	x
FALCONIDAE							
Falco berigora	brown falcon				x		
LOCUSTELLIDAE							
Megalurus mathewsi	rufous songlark				x		
MALURIDAE							
Malurus lamberti	variegated fairy-wren				x		
Malurus leucopterus	white-winged fairy-wren				x	x	
MELIPHAGIDAE							
Gavicalis virescens	singing honeyeater				x	x	
Manorina flavigula	yellow-throated miner				x	x	
Ptilotula keartlandi	grey-headed honeyeater					x	
MEROPIDAE							
Merops ornatus	rainbow bee-eater				x		
OREOICIDAE							
Oreoica gutturalis	crested bellbird				x		
PACHYCEPHALIDAE							
Pachycephala rufiventris	rufous whistler				x	x	
PODARGIDAE							
Podargus strigoides	tawny frogmouth					x	
PSITTACIDAE							
Melopsittacus undulatus	budgerigar				x	x	
RHIPIDURIDAE							
Rhipidura leucophrys	willie wagtail				x		x
TURNICIDAE							
Turnix velox	little button-quail				x		
REPTILES							
AGAMIDAE							
Ctenophorus caudicinctus	western ring-tailed dragon				x	x	x
Gowidon longirostris	long-nosed dragon				x		
SCINCIDAE							
Cryptoblepharus ustulatus						x	x
VARANIDAE							
Varanus gouldii	sand goanna				x		
Varanus panoptes rubidus	yellow-spotted monitor					x	

Appendix D: Significant Vertebrate Fauna Species Recorded During the Field Survey

Survey Area	Site	Habitat	Zone	Easting	Northing	Date	Species	Common Name	EPBC Act	BC Act	DBCA	Abundance (Estimate)	Record Type	Comments	Photo
DFI	Opportunistic	Footslopes and Plain	50	689927	7435468	25/02/2022	*Pseudomys chapmani*	western pebble-mound mouse			P4	1	Burrow/ Mound	Active	
DFI	Opportunistic	Footslopes and Plain	50	689671	7435413	25/02/2022	*Pseudomys chapmani*	western pebble-mound mouse			P4	1	Burrow/ Mound	Recently Inactive	
DFI	Opportunistic	Hillcrest and Hillslope	50	689395	7435347	25/02/2022	*Pseudomys chapmani*	western pebble-mound mouse			P4	1	Burrow/ Mound	Active On edge of old drill pad	
DFI	Opportunistic	Hillcrest and Hillslope	50	689025	7435478	25/02/2022	*Pseudomys chapmani*	western pebble-mound mouse			P4	1	Burrow/ Mound	Recently Inactive	

Survey Area	Site	Habitat	Zone	Easting	Northing	Date	Species	Common Name	EPBC Act	BC Act	DBCA	Abundance (Estimate)	Record Type	Comments	Photo
DFI	Opportunistic	Hillcrest and Hillslope	50	689650	7435239	25/02/2022	*Pseudomys chapmani*	western pebble-mound mouse			P4	1	Burrow/ Mound	Inactive	
DHI	Opportunistic	Hillcrest and Hillslope	50	684412	7442672	24/02/2022	*Pseudomys chapmani*	western pebble-mound mouse			P4	1	Burrow/ Mound	Recently Inactive	
DHI	Opportunistic	Hillcrest and Hillslope	50	685014	7442627	24/02/2022	*Pseudomys chapmani*	western pebble-mound mouse			P4	1	Burrow/ Mound	Recently Inactive	
DHI	Opportunistic	Hillcrest and Hillslope	50	684837	7442702	24/02/2022	*Pseudomys chapmani*	western pebble-mound mouse			P4	1	Burrow/ Mound	Recently Inactive	

Survey Area	Site	Habitat	Zone	Easting	Northing	Date	Species	Common Name	EPBC Act	BC Act	DBCA	Abundance (Estimate)	Record Type	Comments	Photo
DHI	Opportunistic	Hillcrest and Hillslope	50	684638	7442704	24/02/2022	*Pseudomys chapmani*	western pebble-mound mouse			P4	1	Burrow/ Mound	Recently Inactive	
DHI	Opportunistic	Hillcrest and Hillslope	50	682234	7442729	24/02/2022	*Pseudomys chapmani*	western pebble-mound mouse			P4	1	Burrow/ Mound	Recently Inactive	
DFI	Opportunistic	Hillcrest and Hillslope	50	689848	7434765	22/02/2022	*Pseudomys chapmani*	western pebble-mound mouse			P4	1	Burrow/ Mound	Recently Inactive	
DFI	Opportunistic	Hillcrest and Hillslope	50	689872	7434789	22/02/2022	*Pseudomys chapmani*	western pebble-mound mouse			P4	1	Burrow/ Mound	Recently Inactive	

Survey Area	Site	Habitat	Zone	Easting	Northing	Date	Species	Common Name	EPBC Act	BC Act	DBCA	Abundance (Estimate)	Record Type	Comments	Photo
DFI	Opportunistic	Hillcrest and Hillslope	50	689818	7434791	22/02/2022	*Pseudomys chapmani*	western pebble-mound mouse			P4	1	Burrow/ Mound	Inactive	
DFI	Opportunistic	Hillcrest and Hillslope	50	690009	7434752	22/02/2022	*Pseudomys chapmani*	western pebble-mound mouse			P4	1	Burrow/ Mound	Recently Inactive	
DFI	Opportunistic	Hillcrest and Hillslope	50	689220	7435450	22/02/2022	*Pseudomys chapmani*	western pebble-mound mouse			P4	1	Burrow/ Mound	Active	
DFI	Opportunistic	Footslopes and Plain	50	688482	7435487	22/02/2022	*Pseudomys chapmani*	western pebble-mound mouse			P4	1	Burrow/ Mound	Active	

Survey Area	Site	Habitat	Zone	Easting	Northing	Date	Species	Common Name	EPBC Act	BC Act	DBCA	Abundance (Estimate)	Record Type	Comments	Photo
DFI	Opportunistic	Footslopes and Plain	50	688482	7435505	22/02/2022	*Pseudomys chapmani*	western pebble-mound mouse			P4	1	Burrow/ Mound	Inactive	
DHI	Opportunistic	Hillcrest and Hillslope	50	686816	7442596	27/02/2022	*Pseudomys chapmani*	western pebble-mound mouse			P4	1	Burrow/ Mound	Recently inactive	
DHI	Opportunistic	Hillcrest and Hillslope	50	684950	7442656	24/02/2022	*Pseudomys chapmani*	western pebble-mound mouse			P4	1	Burrow/ Mound	Recently inactive	No Photo Available

E.2: West Angelas Beyond 2020 Mt Ella East and Dep J Detailed and Targeted Survey

Biologic Environmental Survey Pty Ltd
24–26 Wickham Street
East Perth, WA, 6004

30 November 2022

Attn: Elizabeth Mason and Stephanie Stack

Rio Tinto Iron Ore

Dear Elizabeth and Stephanie,

Please find below a memo summarising the targeted vertebrate fauna survey completed by Biologic Environmental Survey Pty Ltd (Biologic) within unsurveyed areas for the Mt Ella East and Deposit J areas for the West Angelas Project Envelope.

Yours sincerely,

Amy Hutchison
Zoologist
amy@biologicenv.com.au
(08) 6365 5066 | 0447 108 635

Reviewed by R. Ellis 28th November 2022.

1. INTRODUCTION AND OBJECTIVES

Biologic were commissioned to undertake a basic and targeted vertebrate fauna survey of historically surveyed and unsurveyed areas of the Mt Ella East and Deposit J areas within the West Angelas Project Envelope (herein the Study Area) (Figure 1.1). The Study Area is located within the West Angelas Revised Proposed Development Envelope and comprises two survey areas covering a total of 1,664.77 hectares (ha) (Figure 1.1), comprising:

- Mt Ella East area – 1,525.07 ha; and
- Deposit J area – 139.70 ha.

The overarching objective of this assessment was to undertake a single season basic and targeted vertebrate fauna survey to identify the occurrence of vertebrate fauna species within the Study Area, with a particular focus on significant species (as per EPA (2020)), to inform future development and environmental approvals within the West Angelas Development Envelope. Significant species that were the focus of this survey are based on species identified in a previous desktop assessment completed for the broader West Angelas Revised Proposal Development Envelope, which encompasses the Study Area (Biologic, 2021b).

1.1. Conformance and Licensing

This assessment, particularly where suitable habitat for significant species was present, was carried out in a manner consistent with the following guidelines and recommendations from the Department of Climate Change, Energy, the Environment and Water (DCCEEW; formerly DAWE, DEHWA, DSEWPaC, DoE), the Environmental Protection Authority (EPA), relevant survey-specific license conditions and, where relevant, Rio Tinto guidelines and standards:

- DoE (2016) Environment Protection and Biodiversity Conservation (EPBC) Act referral guideline for the endangered northern quoll *Dasyurus hallucatus*;
- DEWHA (2010a) Survey guidelines for Australia's threatened bats;
- DEWHA (2010b) Survey guidelines for Australia's threatened birds;
- DoE (2013a) Matters of National Environmental Significance: Significant impact guidelines 1.1;
- DSEWPaC (2011b) Survey guidelines for Australia's threatened mammals;
- DSEWPaC (2011a) Survey guidelines for Australia's threatened reptiles;
- EPA (2020) Technical Guidance: Terrestrial vertebrate fauna surveys for environmental impact assessment; and
- Rio Tinto (2021b) RTIO fauna habitat guidelines and definitions.

Fauna sampling was conducted under a Department of Biodiversity, Conservation and Attractions (DBCA) Regulation 27 "Fauna Taking (Biological Assessment) License" (BA27000578) issued to Chris Knuckey. In accordance with Section 40 of the Biodiversity Conservation (BC) Act, threatened species sampling was completed under a DBCA "Authorisation to Take or Disturbed Threatened Species" (authorisation number TFA 2019-0183-4) issued to Chris Knuckey.

675000 680000 685000 690000

7435000

7430000

West Angelas

Legend

Study Area

Operating Mine

IBRA Region

Pilbara Region

IBRA Subregion

Chichester

Fortescue

Hamersley

Roebourne

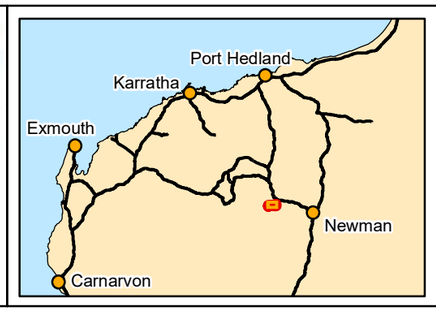
N

biologic Environmental Survey

Scale: 1:53,000

0 1 2 3 Km

Coordinate System: GDA2020 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA2020 Created 26/10/2022



RIO TINTO IRON ORE

Mt Ella East and Deposit J Fauna Survey

Figure 1.1: Study Area and regional context

1.2. Background to Protection of Vertebrate Fauna

Terrestrial fauna may be considered significant species for a range of reasons (EPA, 2016), including:

- being identified as a threatened or priority species;
- being a species with restricted distribution;
- enduring a degree of historical impact from threatening processes; or
- providing an important function required to maintain the ecological integrity of a significant ecosystem.

All native fauna in Western Australia (WA) are protected at a state level under the BC Act and at a national level under the EPBC Act. Any action that has the potential to impact native fauna needs to be approved by relevant state and/or federal departments in accordance with the WA *Environmental Protection Act 1986* (EP Act) and the federal EPBC Act. While all native fauna are protected under these Acts, some species are afforded extra protection. These include species that are considered Threatened under the EPBC Act and/or BC Act, or; migratory bird species that are protected under international agreements and subsequently listed as Migratory under the EPBC Act and/or BC Act (Table 1.1). Furthermore, any species that may be threatened but for which there is insufficient information available to allocate a threatened status under the EBPC Act and/or BC Act, can also be listed as Priority species by DBCA (Table 1.1).

For the purposes of this assessment, significant species are those that are afforded protection under the EPBC Act, BC Act and/or listed as Priority by DBCA (Table 1.1). A summary of applicable legislation and status' is provided in Table 1.1.

Table 1.1: Definitions and terms for significant species

Act, Agreement or List	Status Codes
Federal	
EPBC Act In Australia, native fauna are protected under the EPBC Act. This Act makes provisions for an independent committee (the Threatened Species Scientific Committee [TSSC]), which is charged with maintaining a list of threatened species. Threatened species are listed under one of six categories, depending on their specific conservation status. Migratory bird species are those listed under international agreements and protected under the EPBC Act as a MNES. Relevant international agreements include the Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention), China-Australia Migratory Bird Agreement (CAMBA), Japan-Australia Migratory Bird Agreement (JAMBA), and Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA).	*Extinct:* • EX – Extinct • EW – Extinct in the Wild *Threatened:* • CR – Critically Endangered • EN – Endangered • VU – Vulnerable • CD – Conservation Dependent *Other:* • MI – Migratory
State	
BC Act In WA, native fauna are protected under the BC Act. Species in special need of protection are listed as being Extinct, Threatened or Specially Protected. Within these groups, species are listed under one of eight categories, depending on their specific conservation status. Migratory bird species are those listed under the Bonn Convention and/or CAMBA, JAMBA and ROKAMBA agreements.	*Extinct:* • EX – Extinct *Threatened:* • CR – Critically Endangered • EN – Endangered • VU – Vulnerable *Specially Protected:* • MI – Migratory • CD – Conservation Dependent • OS – Other specially protected fauna
DBCA Priority List The DBCA maintains a list of Priority species that are considered to be possibly threatened but have not been assigned statutory protection under the BC Act, as not enough information is available for an accurate determination of conservation status. These species are generally in urgent need of survey to determine their distribution and abundance.	*Poorly Known:* • P1 – Priority 1 • P2 – Priority 2 • P3 – Priority 3 *Rare, Near Threatened and other* • P4 – Priority

2. METHODS

2.1. Taxonomy and Nomenclature

The latest checklist of mammal, reptile and amphibian names published by the WAM (2022) was used as a guide to the current taxonomy and nomenclature of these groups. For birds, the current checklist of Australian birds maintained by Birdlife Australia (based on Christidis & Boles, 2008) was used in conjunction with the ABRS (2021) species list. While compiling a list of fauna potentially occurring in the Study Area, all records were checked to ensure the latest taxonomy, using recent papers and lists, was used.

2.2. Desktop Assessment

A desktop assessment was undertaken utilising information from a previous desktop assessment conducted by Biologic (2021b) for the broader West Angelas Beyond 2020 Development Envelope, which encompasses the Study Area. Additionally, any significant species records from the Biologic (2021b) field surveys were also considered for this assessment. The desktop assessment also incorporates any significant species records from Biologic (2021a), which included sampling within a subset of the Study Area. The desktop assessment was used to further refine sampling methods to ensure appropriate sampling was undertaken for all target species and to allow an accurate assessment of their occurrence or likelihood of occurrence within the Study Area.

2.3. Field Survey

2.3.1. Survey Timing and Personnel

The field survey was undertaken between the 2nd and 7th of July 2022 by Senior Zoologist Louis Masarei and Zoologist Amy Hutchison, whom collectively have over ten years of experience undertaking fauna surveys within the Pilbara region, including targeted surveys for the significant species that were the focus of this assessment (Table 2.1).

Table 2.1: Project Team and experience

Personnel	Position and Role	Qualification	Experience
Louis Masarei	Senior Zoologist • field survey	BSc Conservation Biology & Marine and Coastal Management	7 years' EIA (consulting) 7 years' field survey 7 years' vertebrate zoology/ ecology 7 years' Pilbara field survey/ EIA
Amy Hutchison	Zoologist • field survey • reporting	BSc Zoology and Marine Science	3 years' EIA (consulting) 6 years' field survey 6 years' vertebrate zoology/ ecology 3 years' Pilbara field survey/ EIA

2.3.2. Climate and Weather

Observed weather conditions prior to and during the survey are shown in Figure 2.1, alongside long-term climatic data for Newman Airport (station #007176). In the 12 months prior to the survey (March 2021 to February 2022), mean minimum and maximum temperatures recorded at Newman Airport were similar to the long-term averages for most months (Figure 2.1). Rainfall in the 12 months preceding the survey was variable, with below long-term averages recorded through most months, except for November 2021, and February, May, and June 2022. May and June 2022 recorded well above the annual long-term average (59 mm v 19 mm and 23 mm v 16 mm respectively), and November 2021 (14 mm v 12 mm) and February 2022 (73 mm v 72 mm) had rainfall consistent with long-term averages (Figure 2.1). In total, the rainfall received in the 12 months prior to the survey (August 2021 to July 2022; 226.8 mm) was well below the annual long-term average (324.4 mm) (BoM, 2022).

Observed maximum temperatures during the survey were similar to the long-term average, while minimum temperatures were slightly lower (Figure 2.1) (BoM, 2022). No rainfall was recorded during the survey (Figure 2.1).

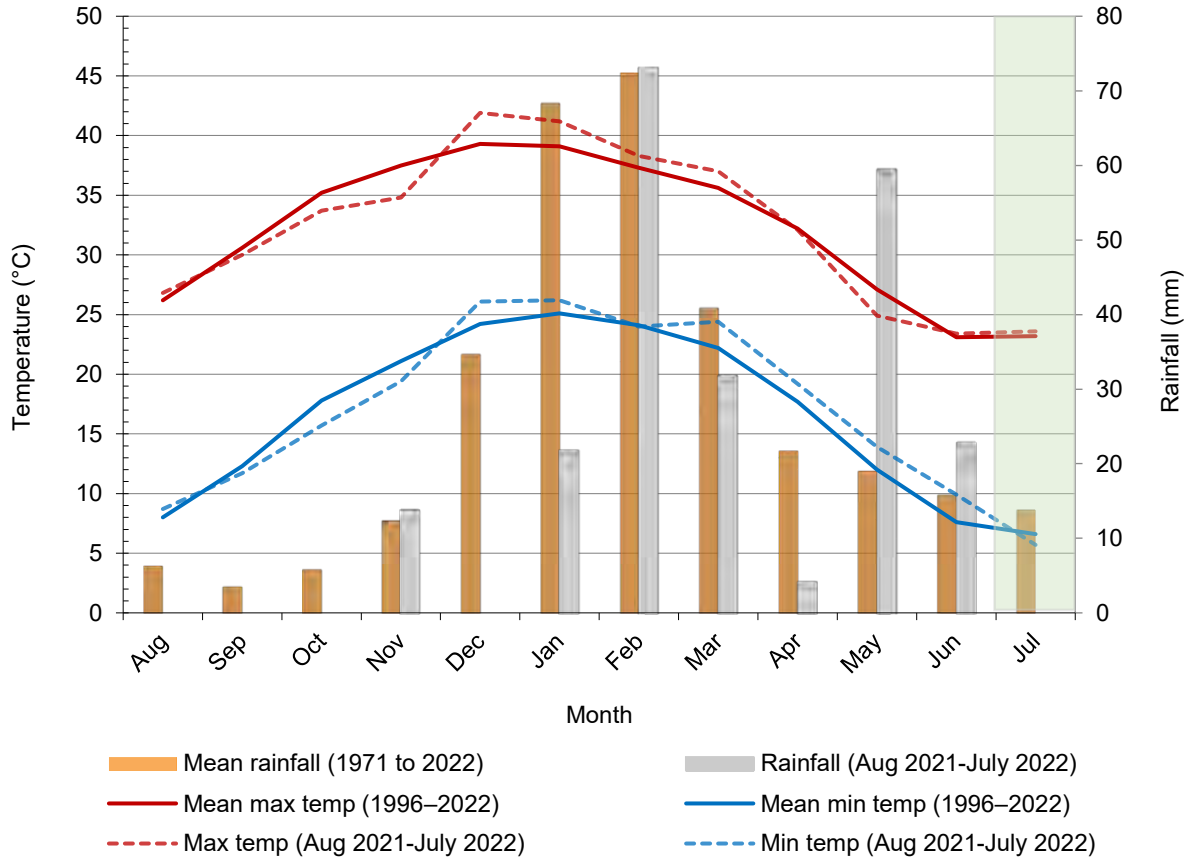


Figure 2.1: Monthly rainfall and long-term average rainfall for Newman Aero (Station ID 007176) with approximate survey timing shown in shaded box

Table 2.2: Climatic conditions recorded for Newman Airport during the field survey

Date	Min. temp (°C)	Max. temp (°C)	Rainfall (mm)
02/07/2022	2.9	19.8	0
03/07/2022	1.8	19.3	0
04/07/2022	1.1	20.0	0
05/07/2022	-1.3	19.7	0
06/07/2022	-0.5	20.8	0
07/07/2022	0.0	22.0	0
08/07/2022	0.4	22.5	0
Average/ total	**0.7**	**20.3**	**0**

2.3.3. Sampling and Survey Methods

Habitat Assessments and Mapping

Broad fauna habitats were previously defined and delineated for the West Angelas Development Envelope by Biologic (2021c), which encompasses the Study Area. During the field survey, Biologic (2021c) habitat mapping was ground truthed to verify fauna habitats previously mapped and their likelihood of supporting significant species. Habitat assessments were undertaken at a total of 18 locations (15 within Mt Ella East and three within Deposit J) within the Study Area during the field survey to define and delineate fauna habitats (Table 2.3; Figure 2.2; Appendix A).

Following the field survey, broad fauna habitat mapping completed by Biologic (2021c) was reviewed with consideration of results of the field survey and, where deemed necessary, amended and refined to reflect field observations. Habitat assessments were conducted using methodology and terminology modified from the *Australian Soil and Land Survey Field Handbook* (National Committee on Soil and Terrain, 2009). The characteristics recorded during the habitat assessments were:

- site information: location and photo;
- habitat: broad habitat type, landform, aspect, slope, soil type and availability, rocky outcropping presence and type;
- ground cover: rock size, vegetation litter and woody debris;
- vegetation: broad vegetation type, structure and dominant species;
- condition: time since fire, disturbance and overall habitat condition; and
- microhabitat: rocky cracks/ crevices, burrowing suitability, hollow presence and abundance, water presence.

Table 2.3: Fauna sampling effort

Site ID	Latitude	Longitude	Habitat assessment	Camera trap transects (nights)	Targeted search[1] (person hrs) and target species	Ultrasonic recording (nights)
Mt Ella East						
VMEE-01	-23.2199	118.8823	•	40	2 (NQ, PLNB, GB, POP)	
VMEE-02	-23.2233	118.843	•		4.5 (NQ, PLNB, GB, POP)	3
VMEE-03	-23.2185	118.8434	•	40	2 (NQ, PLNB, GB, POP)	
VMEE-04	-23.2194	118.8581	•	40	2 (NQ, PLNB, GB, POP)	
VMEE-05	-23.2116	118.8883	•		2 (NQ, PLNB, GB, POP)	3
VMEE-06	-23.2144	118.8928	•		1.5 (NQ, PLNB, GB, POP)	
VMEE-07	-23.2204	118.8940	•		1.4 (NQ, PLNB, GB, POP)	
VMEE-08	-23.2213	118.8870	•		2 (NQ, PLNB, GB, POP)	
VMEE-09	-23.2238	118.8835	•			3
VMEE-10	-23.2088	118.8937	•			3
VMEE-11	-23.2163	118.8438	•			3
VMEE-12	-23.2086	118.8634	•			3
VMEE-13	-23.2153	118.8799	•		2 (NQ, PLNB, GB, POP)	2
VMEE-14	-23.2125	118.8918	•		2 (NQ, PLNB, GB, POP)	
VMEE-15	-23.2227	118.8645	•			
Total (MEE)			**15**	**120**	**21.4**	**20**
Deposit J						
VDEJ-01	-23.2311	118.7091	•		2 (NQ, PLNB, GB, POP)	3
VDEJ-02	-23.2373	118.7095	•			
VDEJ-03	-23.2106	118.7496	•			3
Total (Dep J)			**3**	**0**	**2**	**6**
Total (Study Area)			**18**	**120**	**23.4**	**26**

[1] NQ = northern quoll, PLNB = Pilbara leaf-nosed bat, GB = ghost bat, POP = Pilbara olive python.

Cave Assessments

During the current survey, cave assessments were conducted for any accessible caves recorded within the Study Area (*n* = 6; Appendix B). The cave assessments were designed to characterise the physical features of each structure and to identify the potential importance to the ghost bat and the Pilbara leaf-nosed bat. Each cave assessment recorded the following characteristics:

- entrance location and photograph;
- entrance type, position, aspect, exposure, width, and height;
- cave depth and internal floor slope;
- chambers: main chamber height, and number of total chambers;
- water presence;
- indicative roost type; and
- presence of target species: no. individuals, and/or secondary evidence.

Each cave was categorised based on data from the cave assessments, including the presence of any target bat species via primary or secondary evidence (i.e. calls, scats and individual remains). Due to the long-term nature of some classification criteria for cave categories (i.e. the need for long-term presence data), a precautionary approach was taken when considering classification of cave categories. The categories of cave significance for Pilbara leaf-nosed bats followed the classifications defined by Bat Call (2021b):

- **Category 1** (permanent diurnal/ maternity roost): Maternity roosts where seasonal presence of young is proven. Often supporting presence of a large colony. Critical habitat for the daily and long-term survival of the species.
- **Category 2** (permanent diurnal roost): Diurnal roosts occupied year-round, often by smaller colonies to Category 1 roosts, without confirmed maternity usage (presence of young). Critical habitat for the daily and long-term survival of the species.
- **Category 3** (semi-permanent diurnal roost): Diurnal roost with occasional/ intermittent occupancy, not occupied year-round. May be used during the breeding cycle and may also facilitate long distant distance dispersal, particularly around autumn. Often occurring as a 'satellite' roost associated with nearby Category 1 and/or Category 2 roosts. Critical habitat for the long-term survival of the species.
- **Category 4** (nocturnal refuge): Roosts occupied or entered at night for resting, feeding or other purposes, with perching not a requirement. Not considered critical habitat for the species; however, important for persistence in a local area.

For ghost bat, cave significance followed the classifications defined by Bat Call (2021a):

- **Category 1** (maternity/ diurnal roost with permanent occupancy): Permanently occupied roost tending to have large fluctuating populations. Due to permanent presence maternity usage is assumed. Structurally, caves are often deep and dark with one or more elevated roosting chambers that provide a stable microhabitat. Critical for the ongoing presence of ghost bat in the area.
- **Category 2** (maternity/ diurnal roost with regular occupancy): Ghost bat presence regular, but not permanent/ continuous over long periods. Pregnant or pup-carrying individuals may be present. Similar to Category 1 caves, but often less complex, with only a single inner chamber and are often in less productive areas only used by the species periodically. Bats present for 25% to 75% but may be abandoned for weeks or months. Typically have several other caves, shelters and overhangs within a few hundred meters (m), which together make up an 'apartment block' grouping that supports the ongoing presence of the species. Critical for the ongoing presence of the species in the area.
- **Category 3** (diurnal roost with occasional occupancy): Diurnal roosts where the species roosts occasionally, or rarely. Structurally, less well-developed and often used as feeding sites (as evidenced by middens with food scraps) or temporary refuges. Scats and/or small food middens present but may be no evidence of roosting bats or observations of roosting not consistent. May facilitate long-distance movements of individuals more broadly across the landscape. When adjacent to Category 2 roosts, considered part of an 'apartment block' and therefore critical habitat for the ongoing presence of the species in the area. Where occurring in isolation, not considered critical habitat essentially for the long-term viability of a local population.
- **Category 4** (nocturnal roost with opportunistic usage): Roosts used in at least an opportunistic manner by itinerant individuals and may comprise single visitations to longer periods including periods of rest or feeding during foraging. Includes majority of shallow caves, shelters and deep overhangs in the Pilbara. Not considered critical habitat.

Targeted Searches

Where suitable habitat considered to potentially support significant species was identified, targeted searches were undertaken. Due to access limitations, a helicopter was used to facilitate broad access and assessment of the Study Area, with areas identified as suitable habitat or providing significant habitat features (i.e. caves) subject to more intensive ground truthing. Targeted searches comprised searching for occurrence of target species from direct observation, secondary evidence (i.e. tracks, scats, sloughs and foraging evidence) and/or habitat features (i.e. dens, roost caves and water features) likely to be utilised by target species. A total of 23.4 person hours of targeted searches was undertaken at 11 sites during the field survey, targeting northern quoll, ghost bat, Pilbara leaf-nosed bat and Pilbara olive python (Table 2.3).

Camera Trap Transects for Northern Quoll

Camera trap transects were established at three sites within the Study Area. In accordance with methods recommended by DoE (2016), the transect comprised ten camera traps placed approximately 50 to 100 m apart and were left *in-situ* for four consecutive nights, for a total of 120 camera trap sampling nights. Where possible, cameras were oriented to facilitate differentiation of individuals via spot patterning (following Hohnen *et al.*, 2012) and baited with universal bait mixture (comprising oats, peanut butter and sardines) contained within a non-reward receptacle (perforated and capped PVC pipe).

Ultrasonic Recorders for Pilbara Leaf-nosed Bat and Ghost Bat

SongMeter ultrasonic bat recorders were deployed at nine locations during the field survey, including one cave (Table 2.3; Figure 2.2). At each location, recorders were placed in, or in the vicinity of, areas of prospective roosting or foraging and dispersal habitats most likely to be utilised by bats. Each recorder was deployed for three consecutive nights, in accordance with EPA (2020), except the recorder located at a cave which was deployed for two nights, equating to a total of 26 recording nights during the field survey. Audio settings, selectable filters and triggers were set to detect all species known to occur within the region, including echolocation and social calls of the ghost bat and Pilbara leaf-nosed bat (McKenzie & Bullen, 2009). Bat calls were analysed by Robert Bullen of Bat Call WA.

Opportunistic Records

At all times while surveying, all records pertaining to species not previously recorded during the survey, particularly significant species, were documented. These records include those from primary (i.e. direct observation of species) or secondary (e.g. burrows, scratchings, diggings and scats) evidence.

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West Angelas

VDEJ-03

VDEJ-01

VDEJ-02

VMEE-12

VMEE-11

VMEE-03

VMEE-04

VMEE-02

VMEE-15

VMEE-10

VMEE-05

VMEE-14

VMEE-06

VMEE-13

VMEE-01

VMEE-07

VMEE-08

VMEE-09

Legend

- Study Area
- Operating Mine

Sampling Method

- Camera Trap
- Habitat Assessment
- Ultrasonic Recorder

Traverse

- Helicopter
- Targeted

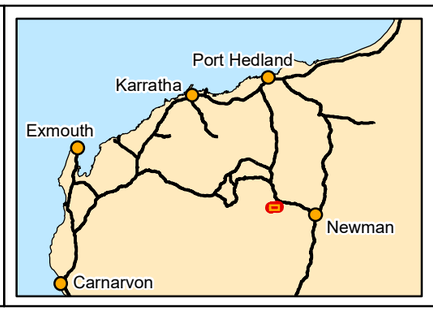
N

biologic Environmental Survey

Scale: 1:53,000

0 1 2 3 Km

Coordinate System: GDA2020 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA2020 Created 30/11/2022



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Mt Ella East and Deposit J Fauna Survey

Figure 2.2: Sample sites and traverses

2.3.4. Likelihood of Vertebrate Fauna Occurrence

Following completion of the field survey, significant species identified by the Biologic (2021b) desktop assessment were assessed for their likelihood of occurring within the Study Area using a decision matrix (Table 2.4). In the decision matrix, each species was assigned to one of six categories of likelihood: Confirmed, Highly Likely, Likely, Possible, Unlikely, or Highly Unlikely.

The decision matrix is intended to be an indicative guide only, and the way in which it is interpreted may vary between species, depending on a given species' habitat preferences and ability to disperse, as well as the reliability and availability of contextual information. For example, a species with a limited dispersal capability will have a reduced likelihood of occurring in the Study Area compared with a species with greater dispersal capability. It is also recognised that a lack of records in the vicinity of the Study Area may indicate limited sampling effort rather than species' absence, and that previous records may include historic or presumed erroneous information which may misrepresent a species' current distribution. Where the determination of a species' likelihood of occurrence within the Study Area deviates from the decision matrix, detailed justification for any variation is provided.

Table 2.4: Species likelihood of occurrence decision matrix

		Habitat suitability of Study Area			
		Breeding habitat present	**Foraging and dispersal habitat present**	**Marginally suitable habitat[2] present**	**No suitable habitat present**
Species Records[1]	**Recorded in Study Area**	Confirmed	Confirmed	Confirmed	Confirmed
	Recorded within 10 km of Study Area	Highly Likely	Likely	Possible	Possible
	Recorded within 10–50km of Study Area	Likely	Possible	Possible	Unlikely
	Recorded within 50–100 km of Study Area	Possible	Possible	Unlikely	Unlikely
	Recorded >100 km of Study Area	Possible	Unlikely	Unlikely	Highly Unlikely
	Species considered locally/regionally extinct	Unlikely	Unlikely	Highly Unlikely	Highly Unlikely

[1] Only records within the previous 50 years are considered.

[2] Marginally suitable habitat is habitat which is possibly used by a species but is unlikely to be depended upon; for example, it may be used only when in proximity to core breeding, foraging or dispersal habitat.

2.3.5. Vertebrate Fauna Habitat Significance

Broad fauna habitat types mapped within the Study Area were assessed for their ability to support significant vertebrate fauna species and classified as being of high, medium or low, following criteria defined by Biologic (2021b) (Table 2.5).

For the purposes of this assessment, critical habitat followed that of DoE (2013b), being areas necessary "for activities such as foraging, breeding, roosting, or dispersal". Within this, habitat types were recognised as providing primary habitat (i.e. critical habitat as per the definition above), or secondary habitat (i.e. habitats not critical for foraging, breeding, roosting or dispersal, but may support such activities and/or habitats of marginal suitability for such activities). Due to differing habitat preferences of conservation significant species (including habitat features and/or microhabitats), habitat significance was assessed on a species-by-species basis.

It should be noted that assessment of habitat significance applies only to habitat occurring within the Study Area, and therefore may not be representative of significance applied to the same habitat in other areas outside the Study Area. For example, a habitat within the Study Area may be deemed unsuitable due to the absence of certain habitat features which are required for the species persistence, despite the same habitat occurring outside the Study Area being considered of greater significance. The significance of a habitats within the Study Area may also be influenced by other habitats occurring within the Study Area and more broadly, including areas adjacent to the Study Area, particularly if representative of primary habitat.

Table 2.5: Fauna habitat significance assessment criteria

Score	Possible criteria (score results from any possible criterion being met)[1]
High	Fauna listed as threatened under the EPBC Act or BC Act have been recorded from this habitat type within the Study Area.
	Habitat known to be suitable core habitat[1] for EPBC Act and/or BC Act listed threatened fauna, and there are records of this species within 40 km^2.
	Habitat is regionally uncommon and known to support species listed as: • Threatened fauna under the EPBC Act and/or BC Act, but it is not their core habitat (e.g. may be used periodically/ seasonally or for dispersal). • Other Specially Protected Species under the BC Act. • DBCA listed Priority fauna, which are known to be solely reliant on this habitat.
Moderate	Habitat known to support EPBC Act and/or BC Act listed Migratory fauna.
	Habitat that is regionally uncommon (e.g., occurs in small and isolated areas) and supports a particularly diverse and uncommon faunal assemblage.
	Habitat is widespread and known to support species listed as: • Threatened fauna under the EPBC Act and/or BC Act, but it is not their core habitat (e.g., may be used periodically/ seasonally or for dispersal). • Other Specially Protected Species under the BC Act. • DBCA listed Priority fauna, which are known to be solely reliant on this habitat.
Low	Habitat that may meet the definition of core habitat[1] for EPBC Act and/or BC Act listed threatened fauna, however there are no records of this species within 40 kms.
	Habitat is widespread/common and does not solely support any DBCA listed Priority fauna.

[1] Core habitat is defined as containing the critical habitat elements for survival and reproduction of a species (Bingham & Noon, 1997) or as otherwise defined within relevant species recovery plans and guidelines. Note in instances where survey work over this area has been limited, then a precautionary approach is generally applied, and the species will be considered likely to be present.

2.3.6. Limitations

The survey was not restricted by any material limitations that significantly impacted the objectives and/or results of the survey and/or the determined likelihood of occurrence assessments for significant species, as outlined by EPA (2020). Low temperatures and windy conditions, in addition to the use and disturbance from helicopter are likely to have influenced reduced activity and low diversity of species recorded overall; however, it is not considered to have detrimentally affected the results of the survey.

A significant amount of survey work has been undertaken in the wider local area and surrounding region leading to a good understanding of the faunal assemblage in the greater West Angelas area. These previous survey results were available for review and utilised in the desktop assessment and fauna habitat mapping. Due to the previous survey effort and lack of critical habitat for significant species, a the basic/ targeted fauna survey effort is considered adequate.

3. RESULTS AND DISCUSSION

3.1. Desktop Assessment

A total of 24 species of significance were identified as potentially occurring within the Study Area from the desktop assessment completed for the West Angelas Beyond 2020 detailed fauna assessment (Biologic, 2021b) (Table 3.1; Figure 3.1). One significant species, the western pebble-mound mouse (*Pseudomys chapmani* – Priority 4 DBCA), has previously been recorded within the Study Area. The species has been recorded on 20 occasions from secondary evidence (pebble-mounds), including two active, nine recently inactive and nine inactive (Figure 3.1).

A further five species have previously been recorded within 5 km of the Stud Area, including:

- fork-tailed swift (*Apus pacificus* – Migratory EPBC Act and BC Act), ~850 m west;
- Pilbara flat-headed blind-snake (*Anilios ganei* – Priority 1 DBCA); ~1.2 km east-northeast;
- ghost bat (*Macroderma gigas* – Vulnerable EPBC Act and BC Act) – ~1.4 km west;
- northern short-tailed mouse (*Leggadina lakedownensis* – Priority 4 DBCA), ~3.2 km north; and
- Pilbara barking gecko (*Underwoodisaurus seorsus* – Priority 2 DBCA); ~3.4 km northwest.

Table 3.1: Significant species identified as potentially occurring in the Biologic (2021b) desktop assessment

Scientific Name	Common Name	Conservation Status		
		EPBC Act	BC Act	DBCA
Mammals				
Dasyuridae				
Dasycercus blythi	brush-tailed mulgara			P4
Dasyurus hallucatus	northern quoll	EN	EN	
Hipposideridae				
Rhinonicteris aurantia Pilbara form	Pilbara leaf-nosed bat	VU	VU	
Megadermatidae				
Macroderma gigas	ghost bat	VU	VU	
Muridae				
Leggadina lakedownensis	northern short-tailed mouse			P4
Pseudomys chapmani	western pebble-mound mouse			P4
Thylacomyidae				
Macrotis lagotis	greater bilby	VU	VU	
Aves				
Apodidae				
Apus pacificus	fork-tailed swift	MI	MI	
Charadriidae				
Charadrius veredus	oriental plover	MI	MI	

Scientific Name	Common Name	Conservation Status		
		EPBC Act	BC Act	DBCA
Falconidae				
Falco peregrinus	peregrine falcon		OS	
Falco hypoleucos	grey falcon	VU	VU	
Hirundinidae				
Hirundo rustica	barn swallow	MI	MI	
Motacillidae				
Motacilla cinerea	grey wagtail	MI	MI	
Motacilla flava	yellow wagtail	MI	MI	
Psittacidae				
Pezoporus occidentalis	night parrot	EN	CR	
Rostratulidae				
Rostratula benghalensis australis	Australian painted snipe	EN	EN	
Scolopacidae				
Calidris acuminata	sharp-tailed sandpiper	MI	MI	
Calidris ferruginea	curlew sandpiper	CR/ MI	CR/ MI	
Calidris melanotos	pectoral sandpiper	MI	MI	
Tringa hypoleucos	common sandpiper	MI	MI	
Reptiles				
Carphodactylidae				
Underwoodisaurus seorsus	Pilbara barking gecko			P2
Pythonidae				
Liasis olivaceus barroni	Pilbara olive python	VU	VU	
Scincidae				
Notoscincus butleri	lined soil-crevice skink			P4
Typhlopidae				
Anilios ganei	Pilbara flat-headed blind-snake			P1

680000 720000 760000

7440000

7400000

Packsaddle Rd

West Angelas Rd

MAC-E

MAC-C

Hope Downs 1

South Flank

West Angelas

Great Northern Hwy

Eagle Pool Rd

Hope Downs

Turee Creek Rd

DBCA Database

Bird

- VU - grey falcon
- IA - fork-tailed swift
- OS - peregrine falcon

Mammal

- EN - northern quoll
- VU - ghost bat
- VU- greater bilby
- VU - Pilbara leaf-nosed bat
- P4 - brush-tailed mulgara
- P4 - northern short-tailed mouse
- P4 - western pebble-mound mouse

Reptile

- VU - Pilbara olive python
- P1 - Pilbara flat-headed blind-snake
- P2 - unpatterned robust slider
- P2 - Pilbara barking gecko

Legend

- Study Area
- Operating Mine
- Local Road
- State Road

Biologic 2021a Database

Mammal

- P4 - western pebble-mound mouse

RTIO Database

Bird

- P4 - letter-winged kite
- IA - fork-tailed swift

Mammal

- VU - ghost bat
- VU - Pilbara leaf-nosed bat
- P4 - western pebble-mound mouse, ngadji

Reptile

- P2 - Pilbara barking gecko

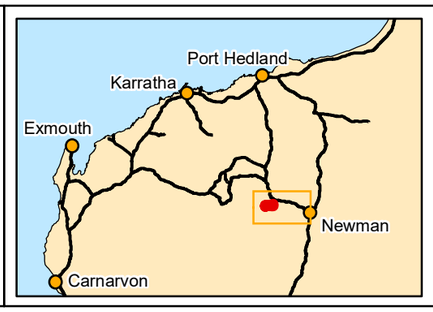
N

biologic Environmental Survey

Scale: 1:349,000

0 10 20 Km

Coordinate System: GDA2020 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA2020 Created 30/11/2022



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Mt Ella East and Deposit J Fauna Survey

Figure 3.1: Significant fauna recorded in the desktop assessment

3.2. Broad Fauna Habitats

Following completion of the field survey, broad fauna habitat mapping within the Study Area Biologic (2021b) was revised to reflect observed habitats more accurately as a result of ground truthing during the field survey. Changes to the Biologic (2021b) fauna habitat mapping comprised further delineation of habitats not clearly visible from aerial imagery (i.e. new areas of Gorge/Gully within Hillcrest and Hillslope).

A total of five broad fauna habitat types are mapped across the Study Area (Table 3.2; Table 3.3; Figure 3.2), comprising, in decreasing order of extent: Hillcrest and Hillslope (53.56%), Footslopes and Plain (34.07%), Gorge/Gully (7.25%), Mixed Acacia Woodland (3.09%), and Drainage Line (0.70%) (Table 3.2; Table 3.3). The remaining 1.33% of the Study Area comprised Disturbed areas, including land that has been cleared of vegetation for access tracks, topsoil stockpiles and/or exploration activities (i.e. drill pads).

Table 3.2: Extent of broad fauna habitats within the Study Area

Fauna Habitat	Extent Within Study Area					
	Mt Ella East		Deposit J		Total (all areas)	
	Area (ha)	%	Area (ha)	%	Area (ha)	%
Hillcrest and Hillslope	803.15	52.66%	88.55	63.38%	891.70	53.56%
Footslopes and Plain	536.25	35.16%	30.91	22.13%	567.16	34.07%
Gorge/Gully	102.30	6.71%	18.38	13.16%	120.68	7.25%
Mixed Acacia Woodland	51.43	3.37%	-	-	51.43	3.09%
Drainage Line	10.96	0.72%	0.74	0.53%	11.70	0.70%
Disturbed	20.98	1.38%	1.12	0.80%	22.10	1.33%
Total	**1,525.07**	**100.00%**	**139.70**	**100.00%**	**1,664.77**	**100.00%**

Of the five broad fauna habitats identified within the Study Area, two (Hillcrest and Hillslope, and Gorge/Gully) were deemed to be of high significance for vertebrate fauna, as they are likely to provide critical (i.e. primary breeding, foraging and dispersal) habitat for multiple significant species, including northern quoll, ghost bat, Pilbara leaf-nosed bat and Pilbara olive python (Table 3.3). Of the remaining three habitats, one (Drainage Line) was deemed to be of moderate value, as it provides secondary or supporting habitat (i.e. foraging and/or dispersal) for multiple significant species; however, does not represent critical habitat for any target MNES species Drainage Line habitat is relatively common and widespread in the surrounding region, and significant species occurrence within them is dependent on the occurrence of critical or high value habitat (i.e. breeding, nesting and/or roosting) proximal to the Study Area. The remaining habitats (Footslopes and Plain, and Mixed Acacia Woodland) within the Study Area were deemed to be of low value (Table 3.3). All broad fauna habitats mapped within the Study Area are relatively common and widespread within the broader vicinity of the Study Area and throughout the Pilbara region.

3.2.1. Habitat Features

Caves

Caves can be important features within a landscape, particularly in arid zone systems, often providing stable microclimates, shelter and protection (Medellin *et al.*, 2017). Six caves were recorded within the Study Area (Figure 3.2; Appendix B), one of which (CMEE-05) contained approximately 6,000 ghost bat scats. All six caves recorded within the Study Area occurred within Gorge/Gully habitat (Appendix B). Based on cave assessments, CMEE-05 is considered a Category 2 cave for ghost bat, and the other five caves (CMEE-01-04, CMEE-06) are considered a Category 4, as defined by Bat Call (2021a). All caves are considered Category 4 for Pilbara leaf-nosed bat, as defined by Bat Call (2021b).

Water Features

No water features likely to support significant species were recorded within the Study Area during the field survey. Temporary ephemeral pools may occur within Gorge/Gully habitat following rainfall events; however, are not likely to persist for prolonged periods outside the wet season.

Table 3.3: Fauna habitat descriptions

Habitat Type	Description	Extent within the Study Area	Habitat for target Species	Representative Photo
Hillcrest and Hillslope **Extent in Study Area:** 891.70 ha (53.56%) **Vertebrate Fauna Significance:** High	Hillcrest and Hillslope habitat comprises hills and undulating stony plains of higher elevation, supporting hard spinifex with a mantle of gravel and larger rocks with occasional minor outcropping. Vegetation is dominated by scattered *Eucalyptus* trees and *Acacia* and/or *Grevillea* shrubs over open *Triodia* hummock grassland with.	Hillcrest and Hillslope habitat occurs throughout the majority of the Study Area. This habitat is a common and widespread habitat throughout the surrounding region.	• **Pilbara leaf-nosed bat** – secondary foraging and/or dispersal (if proximal to primary roosting and breeding habitat) • **Pilbara olive python** – secondary foraging and/or dispersal (if proximal to primary habitat) • **fork-tailed swift** – secondary foraging and/or dispersal • **western pebble-mound mouse –** breeding, foraging and dispersal habitat • **Pilabra barking gecko –** breeding, foraging and dispersal habitat	
Footslopes and Plain **Extent in Study Area:** 567.16 ha (34.07%) **Vertebrate Fauna Significance:** Low	Footslopes and Plain habitat comprises low-lying open plains and the low rolling hills below upland areas. Vegetation is dominated by scattered *Eucalyptus* trees mixed *Acacia* and *Grevillea* shrubs over open *Triodia* hummock grassland on stony and/or clay loam substrates.	Footslope and Plain habitat occurs in the northern Portion of Mt Ella East and the north-west portion of Deposit J. The habitat is common and widespread both within the Study Area and in the broader vicinity of the Study Area.	• **Pilbara leaf-nosed bat –** secondary foraging and/or dispersal (if proximal to primary roosting and breeding habitat) • **ghost bat –** secondary foraging and/or dispersal (if proximal to primary roosting and breeding habitat) • **grey falcon –** secondary foraging (if proximal to primary nesting and breeding habitat) • **peregrine falcon –** secondary foraging and/or dispersal (if proximal to primary nesting and breeding habitat) • **fork-tailed swift –** secondary foraging and/or dispersal • **brush-tailed mulgara – b**reeding, foraging and dispersal habitat • **northern short-tailed mouse** – breeding, foraging and dispersal habitat • **western pebble-mound mouse –** breeding, foraging and dispersal habitat	
Gorge/Gully **Extent in Study Area:** 120.68 ha (7.25%) **Vertebrate Fauna Significance:** High	Often surrounded by Hillcrest and Hillslope habitat. This habitat often contains exposed rock outcropping and breakaway. Usually dominated by open *Eucalyptus* woodlands, *Acacia* and *Grevillea* shrublands and *Triodia* low hummock grasslands vegetation.	Within the Study Area, Gorge/Gully habitat occurs within Hillcrest and Hillslope habitat. This habitat is a common habitat throughout the surrounding region.	• **northern quoll –** primary denning/ shelter, foraging and/or dispersal habitat • **Pilbara leaf-nosed bat –** primary roosting, foraging and/or dispersal (secondary foraging/ dispersal if roosting not proximal) • **ghost bat** – primary roosting, foraging and/or dispersal (secodary foraging/ dispersal if roosting not proximal) • **Pilbara olive python** –breeding, foraging and dispersal habitat • **peregrine falcon –** primary breeding (where rocky areas cliffs and/or reakaway of high elevation occur) • **Pilbara flat-headed blind-snake** – breeding, foraging and dispersal habitat	

Habitat Type	Description	Extent within the Study Area	Habitat for target Species	Representative Photo
Mixed Acacia Woodland **Extent in Study Area:** 51.43 ha (3.09%) **Vertebrate Fauna Significance:** Low	Mixed Acacia Woodland habitat comprises *Acacia* shrubland of varying density, often dominated by varying mulga (*Acacia aneura*), over open understory comprising scattered small shrubs and/or tussock and hummock grasses on stony and/or clay loam substrates. The habitat is often associated with plains subject to sheet flow following rainfall.	Within the Study Area, the occurrence of Mixed Acacia Woodland is limited to three extents in the north of Mt Ella East, within Footslopes and Plain habitat. Mixed Acacia Woodland habitat is considered common and widespread in the broader vicinity of the Study Area.	• **Pilbara leaf-nosed bat –** secondary foraging and/or dispersal (if proximal to primary roosting and breeding habitat) • **ghost bat –** primary foraging and/or dispersal (if proximal to primary roosting and breeding habitat,) • **fork-tailed swift –** secondary foraging and/or dispersal • **brush-tailed mulgara –** breeding, foraging and dispersal habitat • **northern short-tailed mouse –** breeding, foraging and dispersal habitat	
Drainage Line **Extent in Study Area:** 11.70 ha (0.70%) **Vertebrate Fauna Significance:** Moderate	Drainage Line habitat often occurs as an intersecting habitat within lower-lying areas of Footslope and Plain habitat. Presence and persistence of water within Drainage Line habitat variable, is often influenced by rainfall and/or artificial water sources (i.e. dewatering discharge). Vegetation within the habitat is variable depending on presence of water, often comprising fringing vegetation dominated scattered *Eucalypts* and *Acacia* species over mixed shrub and tussock grassland understory.	Drainage Line habitat intersects the Study Area at multiple locations; however, only occupies a small portion overall (Figure 3.2). The habitat is a commonly occurring habitat in the broader vicinity of the Study Area.	• **Pilbara leaf-nosed bat –** secondary foraging and/or dispersal (if proximal to primary roosting and breeding habitat) • **Pilbara olive python –** secondary foraging and/or dispersal (if proximal to instances of critical habitat) • **fork-tailed swift –** secondary foraging and/or dispersal	
Disturbed **Extent in Study Area:** 22.10 ha (1.33%) **Vertebrate Fauna Significance:** Negligible	Disturbed and/or cleared areas (i.e. roads and access tracks, drill pads and other clearing)	Variable extents of disturbance occur throughout the Mt Ella East, primarily in the northern portion within Footslopes and Plain habitat, primarily associated with mine access roads, exploration activity (drill pads and associated tracks) and numerous small access tracks (Figure 3.2).	• **fork-tailed swift –** secondary foraging and/or dispersal	

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7435000 7430000 7425000

West Angelas

CMEE-01 CMEE-02 CMEE-03 CMEE-04 CMEE-05 CMEE-06

Legend

- Study Area
- Operating Mine

Fauna Habitat

- Disturbed
- Drainage Line
- Footslopes and Plains
- Gorge/ Gully
- Hillcrest and Hillslope
- Mixed Acacia Woodland
- Cave

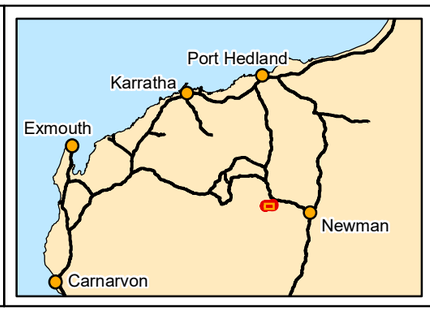
N

biologic Environmental Survey

Scale: 1:53,000

0 1 2 3 Km

Coordinate System: GDA2020 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA2020 Created 30/11/2022



RIO TINTO IRON ORE

Mt Ella East and Deposit J Fauna Survey

Figure 3.2: Broad fauna habitats and habitat features of the Study Area

3.3. Field Survey

During the current survey, a total of 16 species of vertebrate fauna species were opportunistically recorded, comprising 13 mammals and three birds (Appendix C). The low general species diversity recorded during the survey can be attributed to the sub-optimal weather conditions that occurred (i.e. low temperatures and windy conditions), as well as likely disturbance of some species (i.e. birds) from helicopter use. It should however be noted that the primary focus of the survey was to ground-truth existing fauna habitat mapping and survey for significant species, particularly MNES listed species, of which these factors are not considered to have impeded the sampling of these species, nor the assessment of their likelihood of occurrence.

Two significant species were recorded within the Study Area during the field survey, ghost bat and western pebble-mound mouse. Ghost bat was recorded from secondary evidence (scats) within a cave (CMEE-05) located in Gorge/Gully habitat (Figure 3.3; Appendix D). Approximately 6,000 scats were observed within CMEE-05, spread out across three middens with the freshest scats aged between one and six months (Figure 3.3; Appendix B). In addition to roosting with Gorge/Gully and Hillcrest and Hillslope habitat, the species is likely to forage and/or disperse within Footslopes and Plain, and Mixed Acacia Woodland habitat occurring within the Study Area, particularly areas supporting open vegetation cover and suitable perching trees.

Two western pebble-mound mouse mounds (one inactive and one recently inactive) were recorded within the Study Area during the field survey within Hillcrest and Hillslope habitat. An active mound was also recorded approximately 480 m east of the Study Area (Figure 3.3). The species is likely to occur as a resident within Hillcrest and Hillslope and Footslopes and Plains habitats, where suitable resources permitting burrow excavation and pebble-mound construction occur.

Of the remaining 22 significant species identified in the desktop assessment, based on known species' distributions, previous records and the habitats present within the Study Area, seven species were deemed Likely to occur (northern quoll, Pilbara leaf-nosed bat, northern short-tailed mouse, fork-tailed swift, peregrine falcon Pilbara olive python, and Pilbara barking gecko,) and three were deemed Possible (grey falcon, brush-tailed mulgara, and Pilbara flat-headed blind-snake) (Table 3.4). The remaining 12 species are considered Highly Unlikely (n = 10) or Unlikely (n = 2) to occur within the Survey Area, primarily due to the absence of suitable habitat (Table 3.4).

Northern quoll has previously been recorded from secondary evidence (scats) approximately 14 km northwest of Deposit J (Biologic, 2021b) (Table 3.4; Figure 3.1). The species is considered Likely to occur, primarily within Gorge/Gully, and instances of breakaway in Hillcrest and Hillslope in the Study Area, which provide suitable areas of potential denning/shelter habitat. These habitats and, to a lesser extent, Drainage Line, may also provide foraging and/or dispersal habitat for the species, particularly where they provide connectivity to other areas of critical habitat.

Pilbara leaf-nosed bat has previously been recorded approximately 5.1 km north-west of Deposit J and is considered Likely to occur (Table 3.4; Figure 3.1). Within the Study Area, the species' occurrence is likely to be limited to foraging and/or dispersal activities, during which night roosting may occur. Foraging and/or dispersal habitat for Pilbara leaf-nosed bat is provided, at varying capacities, within all five broad fauna habitats mapped within the Study Area. The habitat rating (HR) of potential foraging habitat within the five fauna habitats occurring within the Study Area (as defined by Bat Call (2021b)) ranges from moderate (HR2; Footslopes and Plain, Gorge/Gully, and Drainage Line), to low (HR1; Hillcrest and Hillslope, and Mixed Acacia Woodland), with areas mapped as Disturbed considered poor (HR0). Foraging and/or dispersal activity of the species within the Study Area is likely to be dependent on the proximity of roost caves (particularly category 1–2 roosts) with Pilbara leaf-nosed bats foraging up to 20 km from their roosts (Bat Call, 2021b). Although no potential category 1–3 roost caves for the species occur within the Study Area, there are six Category 4 caves within the Study Area which may be utilised by the species (Appendix C).

The northern short-tailed mouse, which has previously been recorded approximately 3.2 km north of Deposit J (Table 3.4; Figure 3.1) is considered Likely to occur as a resident within the Footslopes and Plain habitat. The species occurrence, however, is likely to be variable and may fluctuate seasonally when resources for the species are more abundant, particularly following rainfall events.

The fork-tailed swift has previously been recorded (2013) approximately 850 m west of the Study Area (Table 2.4; Figure 3.1) (DBCA, 2021b). The species is considered Likely to occur within the Study Area as an infrequent visitor, during which it may forage in the airspace above all habitats occurring within the Study Area; however, landing or nesting within the Study Area is unlikely.

Peregrine falcon has previously been recorded approximately 21.3 km south southwest of Deposit J (Table 2.4; Figure 3.1) (DBCA, 2021b). The species is considered Likely to occur within the Study Area; however, the frequency of occurrence is likely to be dependent on the proximity of nesting sites. Within the Study Area, potential nesting habitat is provided within Gorge/Gully, and some instances of breakaway in Hillcrest and Hillslope. Foraging for is likely to occur throughout most habitats of the Study Area, primarily within Footslopes and Plain. The extent and frequency of occurrence within the Study Area is likely to be attributed to the proximity of nesting within or in the vicinity of the Study Area.

Pilbara olive python has previously been recorded approximately 8.8 km north northwest of Mt Ella East (Table 3.4; Figure 3.1) and is considered Likely to occur within the Study Area. The species may occur as a resident within Gorge/Gully habitat, particularly where pooling of water is likely to occur for prolonged periods following rainfall. The species may also occur more broadly in Hillcrest and Hillslope and Drainage Line habitats to forage and/or disperse.

Pilbara barking gecko has previously been recorded approximately 3 km west of Mt Ella East (Biologic unpublished data [Angelo River detailed fauna survey]) (Table 3.4) and is considered Likely to occur within the Study Area as a resident. The species is likely to occur as a resident within Hillcrest and Hillslope habitat, particularly areas of higher elevation.

Of the three significant species considered Possible to occur within the Study Area (grey falcon, brush-tailed mulgara, and Pilbara flat-headed blind-snake), critical (primary breeding/ nesting, foraging and dispersal) habitat likely to support the species present within the Study Area is marginal and/or often occurring in smaller isolated patches with limited connectivity. Additionally, many species considered Possible have previously only been recorded in low abundance locally

Grey falcon has previously been recorded approximately 11.4 km north northwest of Deposit J (DBCA, 2021b) (Table 3.4; Figure 3.1). The species is considered Possible to occur within the Study Area; however, the frequency of occurrence is likely to be dependent on the proximity of nesting sites. Within the Study Area, potential nesting habitat is not provided for grey falcon, due to a lack of tall trees and suitable tall infrastructure (i.e. tall powerline and/or communications towers). Foraging is likely to occur throughout most habitats of the Study Area, primarily within Footslopes and Plain.

The nearest record of brush-tailed mulgara is located approximately 30.3 km south south-west of Deposit J (DBCA, 2021b) (Table 3.4; Figure 3.1); however, it is considered Possible to occur within the Study Area. The species is often recorded from a range of sandy and stony plain habitats and may occur as a resident in Footslopes and Plain habitat of the Study Area where suitable vegetation cover and sandy or loamy substrates permitting burrowing are present. The species occurrence and abundance within the Study Area is likely to fluctuate seasonally depending on resource abundance.

The Pilbara flat-headed blind-snake has previously been recorded approximately 10.2 km southwest of Mt Ella East (Biologic unpublished data [Angelo River detailed fauna survey]) (Table 3.4; Figure 3.1) and is considered Possible to occur within the Study Area as a resident. It may occur within Gorge/Gully, and instances of breakaway within Hillcrest and Hillslope habitat, particularly where moist substrates and leaf litter accumulation occurs over prolonged periods.

675000 680000 685000 690000

7435000 7430000

West Angelas

Legend

Study Area

Operating Mine

Significant Species

Ghost bat

Western pebble-mound mouse

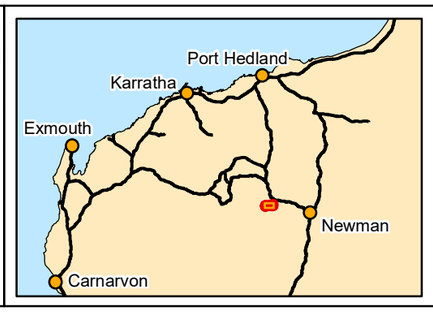
N

biologic Environmental Survey

Scale: 1:53,000

0 1 2 3 Km

Coordinate System: GDA2020 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA2020 Created 27/10/2022



RIO TINTO IRON ORE

Mt Ella East and Deposit J Fauna Survey

Figure 3.3: Significant fauna recorded during the current survey

Table 3.4: Likelihood of occurrence of significant fauna species within the Study Area

Species	Conservation Status			Preferred Broad Habitats	Nearest Records to the Study Area	Potential Habitat Within the Study Area					Comments	Likelihood of occurrence	
	EPBC Act	BC Act	DBCA			Footslopes and Plains	Gorge/Gully	Hillcrest and Hillslope	Mixed Acacia Woodland	Drainage Line		Mt Ella East	Dep J
Mammals													
Dasyuridae													
brush-tailed mulgara (*Dasycercus blythi*)			P4	Brush-tailed mulgara show a preference for spinifex *Triodia* spp. grasslands on sand plains and the swales between low dunes (Pavey *et al.*, 2012; Woolley, 2006). Mature spinifex hummocks appear to be important for protection from introduced predators (Körtner *et al.*, 2007).	~30.3 km SSW Dep J (2014) (DBCA, 2021b)	•			•		May occur as a resident in Footslope and Plain habitat where suitable substrates permitting burrow construction are present. Occurrence and abundance likely to fluctuate seasonally when resources are abundant.	Possible	Possible
northern quoll (*Dasyurus hallucatus*)	EN	EN		The species tends to inhabit rocky habitats which offer protection from predators and are generally more productive in terms of availability of resources (Braithwaite & Griffiths, 1994) (Oakwood, 2000). Other microhabitat features important to the species include rock cover, proximity to permanent water and time-since last fire (Woinarski *et al.*, 2008).	~14 km NW Dep J (2018) (Biologic, 2021b)		•	•		•	May occur as a resident within Gorge/Gully habitat and, where instances of breakaway occur, within Hillcrest and Hillslope habitats. Additionally, Hillcrest and Hillslope and instances of Drainage Line habitat may also provide foraging and/or dispersal habitat, particularly were providing connectivity between areas of primary habitat within and in the vicinity of the Study Area.	Likely	Likely
Hipposideridae													
Pilbara leaf-nosed bat (*Rhinonicteris aurantia* (Pilbara form))	VU	VU		The Pilbara leaf-nosed bat roosts within caves and abandoned mines with high humidity (95%) and temperature (32°C) (Armstrong, 2001). The species forages in caves and along waterbodies with fringing vegetation (TSSC, 2016b).	~5.1 km NW Dep J (2013) (DBCA, 2021b)	• (HR = 2)	• (HR = 2)	• (HR = 1)	• (HR = 1)	• (HR = 2)	May occur within the Study Area during foraging and/or dispersal activities. Foraging may occur in Priority 2 (gullies within Gorge/Gully), Priority 3 (instances of rocky outcrop occurring with Hillcrest and Hillslope) and Priority 5 (open grassland and woodland, within Footslopes and Plain or Mixed Acacia Woodland) habitats (as defined by TSSC (2016b)). Drainage Line habitat may also provide a water source and occasional foraging habitat, particularly where pooling occurs following rainfall. Habitat rating (HR; as defined by Bat Call (2021b)) of potential foraging habitat within the Study Area ranges from moderate (2) to low (1). Occurrence likely to be limited and influenced by the proximity of suitable roost caves. No potential roost caves present within Dep J.	Likely	Possible
Megadermatidae													
ghost bat (*Macroderma gigas*)	VU	VU		Ghost bats roost in deep, complex caves beneath bluffs of low, rounded hills, granite rock piles and abandoned Mines (Armstrong & Anstee, 2000). These features often occur within habitats including gorge/gully, hill crest/ hill slope and low hills (Armstrong & Anstee, 2000). Forages broadly across habitats, particularly woodland and open woodland habitats, including eucalypt and mulga woodlands (Biologic, 2020; Richards *et al.*, 2008; Tidemann *et al.*, 1985; TSSC, 2016a).	~1.4 km W MEE (2018) (Biologic, 2021b)	•	•				Species likely to forage and/or disperse within Footslopes and Plain habitat of the Study Area. Occurrence likely to be limited and influenced by the proximity of roost sites within and in the vicinity of the Study Area. Potential roost caves are present within the Mt Ella East Study Area within Gorge/Gully habitat. No potential roost caves are present within the Deposit J Study Area.	Confirmed during current survey	Likely
Muridae													
northern short-tailed mouse (*Leggadina lakedownensis*)			P4	The species occupies a diverse range of habitats from the monsoon tropical coast to semiarid climates, including spinifex and tussock grasslands, samphire and sedgelands, *Acacia* shrublands, tropical eucalypt and Melaleuca woodlands and stony ranges; however, the species is usually found in seasonally inundated habitats on red or white sandy-clay soils (Moro & Kutt, 2008).	~3.2 km N Dep J (1997) (DBCA, 2021b)	•					May occur as a resident within Footslopes and Plain, habitat of the Study Area. Occurrence and abundance likely to fluctuate seasonally when resources are abundant.	Likely	Likely
western pebble-mound mouse (*Pseudomys chapmani*)			P4	This species occurs on the gentler slopes of rocky ranges where the ground is covered with a stony mantle and vegetated by hard spinifex, often with a sparse overstorey of eucalypts and scattered shrubs (Anstee, 1996; Start *et al.*, 2000).	Within MEE (Rio Tinto, 2021a) ~360 m SSE Dep J (2014) (Rio Tinto, 2021a)	•		•			Likely to occur as a resident within Hillcrest and Hillslope and Footslopes and Plain habitats throughout the Study Area where suitable stony substrates permitting burrow and mound construction present.	Confirmed (Rio Tinto, 2021a)	Highly Likely
Thylacomyidae													

Species	Conservation Status			Preferred Broad Habitats	Nearest Records to the Study Area	Potential Habitat Within the Study Area					Comments	Likelihood of occurrence	
	EPBC Act	BC Act	DBCA			Footslopes and Plains	Gorge/Gully	Hillcrest and Hillslope	Mixed Acacia Woodland	Drainage Line		Mt Ella East	Dep J
greater bilby (*Macrotis lagotis*)	VU	VU		Occurs in a variety of habitats including spinifex hummock grassland and *Acacia* shrubland, on soft soils (Burrows *et al.*, 2012). In the Pilbara often associated with major drainage line sandy terraces (How *et al.*, 1991).	~20.7 km NNW Dep J (1984) (DBCA, 2021b)						Suitable habitat not present.	Unlikely	Unlikely
Aves													
Apodidae													
fork-tailed swift (*Apus pacificus*)	MI	MI		Inhabits dry/open habitats, inclusive of riparian woodlands and tea-tree swamps, low scrub, heathland or saltmarsh, as well as treeless grassland and sandplains covered with spinifex, open farmland and inland and coastal sand-dunes (Johnstone & Storr, 1998). Almost exclusively aerial.	~850 m W MEE (2013) (DBCA, 2021b)	•	•	•	•	•	May infrequently occur within the airspace above all habitats of the Study Area during foraging and/or migratory activities; however, unlikely to land or nest.	Likely	Likely
Charadriidae													
oriental plover (*Charadrius veredus*)	MI	MI		Occurs in a variety of habitats, including coastal habitats, such as estuarine mudflats and sandbanks, on sandy or rocky ocean beaches as well as open inland environments such as, semi-arid or arid grasslands, where the grass is short and sparse (Johnstone & Storr, 2004).	~125 km NE (2011) (DBCA, 2021a)						Suitable habitat not present.	Highly Unlikely	Highly Unlikely
Falconidae													
peregrine falcon (*Falco peregrinus*)		OS		Occupies arid areas and is most often encountered along cliffs above rivers, ranges and wooded watercourses where it hunts birds (Johnstone & Storr, 1998). It typically nests on rocky ledges occurring on tall, vertical cliff faces between 25 m and 50 m high (Olsen *et al.*, 2004; Olsen & Olsen, 1989).	~21.3 km SSW Dep J (2014) (DBCA, 2021b)	•	•	•	•	•	May occasionally occur within the Study Area to forage, particularly within Footslopes and Plain and, to a lesser extent, other habitats more broadly. Frequency of visitation may vary depending on proximity of nesting sites in the vicinity of the Study Area. Nesting may occur within Gorge/Gully and Breakaway habitat and instances of breakaway within Hillcrest and Hillslope habitat.	Likely	Likely
grey falcon (*Falco hypoleucos*)	VU	VU		Inhabits timbered lowlands, particularly *Acacia* shrubland and along inland drainage systems. Also frequents spinifex and tussock grassland habitats to forage (Burbidge *et al.*, 2010; Olsen & Olsen, 1986).	~11.4 km NNW Dep J (1997) (DBCA, 2021b)	•				•	May occur within the Study Area to forage, particularly within Footslopes and Plain, and, to a lesser extent, other habitats more broadly. Frequency of visitation likely to vary depending on proximity of nesting location in vicinity of Study Area as there is no suitable nesting habitat within the Study Area.	Possible	Possible
Hirundinidae													
barn swallow (*Hirundo rustica*)	MI	MI		The barn swallow is a non-breeding summer visitor to the Pilbara. It favors areas near water (Johnstone *et al.*, 2013).	~200 km N (2005) (DBCA, 2021a)						Suitable habitat not present.	Highly Unlikely	Highly Unlikely
Motacillidae													
grey wagtail (*Motacilla cinerea*)	MI	MI		A rare vagrant to Western Australia where it has been recorded within various habitats with open waterbodies (Johnstone & Storr, 2004).	~120 km N (2012) (DBCA, 2021a)						Suitable habitat not present.	Highly Unlikely	Highly Unlikely
yellow wagtail (*Motacilla flava*)	MI	MI		An uncommon but regular visitor to the Pilbara region (Johnstone *et al.*, 2013). Occupies a range of damp or wet habitats with low vegetation although favors edges of fresh water, especially sewage ponds (Johnstone & Storr, 2004).	~500 km NNE (2003) (DBCA, 2021a)						Suitable habitat not present.	Highly Unlikely	Highly Unlikely
Psittacidae													
night parrot (*Pezoporus occidentalis*)	EN	CR		The night parrot prefers sandy/stony plain habitat with old-growth spinifex for roosting and nesting in conjunction with native grasses and herbs for foraging (DPaW, 2017).	~106 km NNE (2005) (DBCA, 2021a)						Suitable habitat not present.	Unlikely	Unlikely
Rostratulidae													

Species	Conservation Status			Preferred Broad Habitats	Nearest Records to the Study Area	Potential Habitat Within the Study Area					Comments	Likelihood of occurrence	
	EPBC Act	BC Act	DBCA			Footslopes and Plains	Gorge/Gully	Hillcrest and Hillslope	Mixed Acacia Woodland	Drainage Line		Mt Ella East	Dep J
Australian painted snipe (*Rostratula benghalensis australis*)	EN	EN		Generally, occupies shallow terrestrial freshwater wetlands (i.e. temporary and permanent lakes, swamps and claypans) with rank emergent tussocks of grass, sedges, rushes or reeds, or samphire (Johnstone & Storr, 1998).	~100 km NW (2012) (DBCA, 2021a)						Suitable habitat not present.	Highly Unlikely	Highly Unlikely
Scolopacidae													
sharp-tailed sandpiper (*Calidris acuminata*)	MI	MI		Favors flooded samphire flats and grasslands, mangrove creeks mudflats, beaches, river pools, saltwork ponds, sewage ponds and freshwater soaks (Johnstone *et al.*, 2013).	~110 km ENE (2007) (DBCA, 2021a)						Suitable habitat not present.	Highly Unlikely	Highly Unlikely
curlew sandpiper (*Calidris ferruginea*)	CR / MI	CR/ MI		Inhabits intertidal mudflats in sheltered coastal areas (i.e. estuaries, bays, inlets and lagoons) (Geering *et al.*, 2007). Generally roosts on bare dry shingle, shell or sand beaches, sandspits and islets in or around coastal or near-coastal lagoons and other wetlands (Geering *et al.*, 2007).	~100 km E (2006) (DBCA, 2021a)						Suitable habitat not present.	Highly Unlikely	Highly Unlikely
pectoral sandpiper (*Calidris melanotos*)	MI	MI		Coastal lagoons, estuaries, bays, swamps, lakes, inundated grasslands, saltmarshes, river pools, creeks, floodplains and artificial wetlands (Johnstone & Storr, 2004; Johnstone *et al.*, 2013). It prefers wetlands with open fringing mudflats and low, emergent or fringing vegetation (Geering *et al.*, 2007)	~300 km N (2014) (DBCA, 2021a)						Suitable habitat not present.	Highly Unlikely	Highly Unlikely
common sandpiper (*Tringa hypoleucos*)	MI	MI		Estuaries and deltas of streams, as well as banks farther upstream; around lakes, pools, billabongs, reservoirs, dams and claypans (Geering *et al.*, 2007).	~120 km ENE (2018) (DBCA, 2021a)						Suitable habitat not present.	Highly Unlikely	Highly Unlikely
Reptiles													
Carphodactylidae													
Pilbara barking gecko (*Underwoodisaurus seorsus*)			P2	Little is known about the ecology of the Pilbara barking gecko, but the species is thought to prefer rocky areas, often associated with high elevation, with spinifex and low tree cover habitats (Chapple et al., 2019; Doughty & Oliver, 2011).	~3.4 km NW MEE (1997) (DBCA, 2021b) ~3 km W MEE (2021) (Biologic unpublished data [Angelo River detailed fauna survey])			•			Likely to occur as a resident within Hillcrest and Hillslope habitat, particularly areas of higher elevation.	Likely	Likely
Pythonidae													
Pilbara olive python (*Liasis olivaceus barroni*)	VU	VU		Associated with drainage systems, including areas with localised drainage and watercourses (Pearson, 1993). In the inland Pilbara the species is most often encountered near permanent waterholes in rocky ranges or among riverine vegetation (Pearson, 1993).	~8.8 km NNW MEE (2018) (Biologic, 2021b)		•	•		•	May occur as a resident within Gorge/Gully habitat, particularly in areas where pooling water is likely to occur. May also occur more broadly within Hillcrest and Hillslope and Drainage Line habitats during foraging and/or dispersal activities and dependent on proximity of critical (i.e. Gorge/Gully) habitat within and more broadly in the vicinity of the Study Area.	Likely	Likely
Scincidae													
lined soil-crevice skink (*Notoscincus butleri*)			P4	Recorded in areas dominated by spinifex and near water courses (Wilson & Swan, 2014). Records are restricted to a coastal area within the Lower Fortescue Hedland region.	~200 km NNW (2011) (DBCA, 2021a)						Study Area occurs outside species' current known range. Desktop assessment record likely to be erroneous.	Highly Unlikely	Highly Unlikely
Typhlopidae													
Pilbara flat-headed blind-snake (*Anilios ganei*)			P1	Little is known of the species' ecology, but it is often associated with moist soils and leaf litter within gorges and gullies (Wilson and Swan 2014), and potentially within a wide range of other stony habitats. Recorded from numerous habitats but is most likely to be present in rocky terrain and along drainage lines (DBCA, 2021a).	~1.2 km ENE Dep J (2018) (Biologic, 2021b) ~10.2 km SW MEE (2021) (Biologic unpublished data [Angelo River detailed fauna survey])		•	•			May occur as a resident in Gorge/Gully and instances of breakaway within Hillcrest and Hillslope habitat, particularly where moist substrates and leaf litter accumulation occurs over prolonged periods.	Possible	Possible

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Appendix A: Vertebrate Fauna Habitat Assessments

Site ID	Coord.	WANG Consolidated Fauna Habitat Mapping Type (Biologic, 2021c)	Fauna Habitat Type (Rio Tinto, 2021b)	Landform	Aspect	Slope	Soil Type	Soil Avail.	Outcropping Rock Type	Rock Size	Veg. Litter	Dominant Veg. Type	Rocky Cracks / Crevices	Burrowing Suitability	Disturbances	Last Fire	Photo
Mt Ella East																	
VMEE-01	-23.2194, 118.8581	Hillcrest and Hillslope	Rocky Hill	Hillcrest/ Upper Hillslope	North	Steep	Clay Loam	None Discernible	Major Outcropping (BIF)	Small Rocks (11-20cm)	Many Small Patches	Scattered Eucalypts, Spinifex Hummock Grassland	Moderate	Nil	None Discernible	Moderate (3 to 5 yr)	
VMEE-02	-23.2116, 118.8883	Gorge/Gully	Gorge/Gully	Gully	South	Very Steep	Clay Loam	None Discernible	Major Outcropping (BIF)	Small Rocks (11-20cm)	Few Small Patches	Scattered Eucalypts, Spinifex Hummock Grassland	High	Nil	None Discernible	Old (6+ yr)	
VMEE-03	-23.2144, 118.8928	Gorge/Gully	Gorge/Gully	Gully	South/ East	Very Steep	Clay Loam	None Discernible	Major Outcropping (BIF)	Pebbles (5-10cm)	Few Small Patches	Mulga Woodland, Scattered Eucalypts, Spinifex Hummock Grassland	High	Nil	None Discernible	Old (6+ yr)	
VMEE-04	-23.2204, 118.894	Gorge/Gully	Gorge/Gully	Gorge	South/ West	Very Steep	Clay Loam	None Discernible	Moderate Outcropping (BIF)	Pebbles (5-10cm)	Few Large Patches	Scattered Eucalypts, Spinifex Hummock Grassland	High	Nil	None Discernible	Old (6+ yr)	

Site ID	Coord.	WANG Consolidated Fauna Habitat Mapping Type (Biologic, 2021c)	Fauna Habitat Type (Rio Tinto, 2021b)	Landform	Aspect	Slope	Soil Type	Soil Avail.	Outcropping Rock Type	Rock Size	Veg. Litter	Dominant Veg. Type	Rocky Cracks / Crevices	Burrowing Suitability	Disturbances	Last Fire	Photo
VMEE-05	-23.2213, 118.887	Gorge/Gully	Gorge/Gully	Gully	South/ West	Steep	Clay Loam	None Discernible	Major Outcropping (BIF)	Small Rocks (11-20cm)	Few Small Patches	Acacia Shrubland, Scattered Eucalypts, Spinifex Hummock Grassland	High	Nil	None Discernible	Moderate (3 to 5 yr)	
VMEE-06	-23.2238, 118.8835	Gorge/Gully	Gorge/Gully	Gully	West	Steep	Clay Loam	None Discernible	Major Outcropping (BIF)	Gravel (1-4cm)	Few Small Patches	Scattered Eucalypts, Spinifex Hummock Grassland	High	Nil	None Discernible	Moderate (3 to 5 yr)	
VMEE-07	-23.2088, 118.8937	Gorge/Gully	Gorge/Gully	Gorge	South/ East	Very Steep	Clay Loam	Scarce	Major Outcropping (BIF)	Pebbles (5-10cm)	Few Large Patches	Scattered Eucalypts, Spinifex Hummock Grassland	High	Nil	None Discernible	Old (6+ yr)	
VMEE-08	-23.2163, 118.8438	Hillcrest and Hillslope	Rocky Hill	Hillcrest/ Upper Hillslope	South/ East	Steep	Clay Loam	None Discernible	Moderate Outcropping (BIF)	Gravel (1-4cm)	Few Small Patches	Eucalypt Woodland, Spinifex Hummock Grassland	Low	Nil	None Discernible	Old (6+ yr)	

Site ID	Coord.	WANG Consolidated Fauna Habitat Mapping Type (Biologic, 2021c)	Fauna Habitat Type (Rio Tinto, 2021b)	Landform	Aspect	Slope	Soil Type	Soil Avail.	Outcropping Rock Type	Rock Size	Veg. Litter	Dominant Veg. Type	Rocky Cracks / Crevices	Burrowing Suitability	Disturbances	Last Fire	Photo
VMEE-09	-23.2086, 118.8634	Drainage Line	Major Drainage Line	Major Drainage Line	South/ West	Low	Clay Loam	Few Small Patches	Negligible	Pebbles (5-10cm)	Many Large Patches	Scattered Eucalypts, Spinifex Hummock Grassland	Nil	Nil	None Discernible	Old (6+ yr)	
VMEE-10	-23.2153, 118.8799	Gorge/Gully	Gorge/Gully	Gully	South/ West	Steep	Clay Loam	None Discernible	Major Outcropping (BIF)	Pebbles (5-10cm)	Scarce	Mulga Woodland, Spinifex Hummock Grassland	High	Nil	None Discernible	Moderate (3 to 5 yr)	
VMEE-11	-23.2125, 118.8918	Gorge/Gully	Gorge/Gully	Drainage Area/ Floodplain	Flat	Flat	Clay Loam	Few Small Patches	Negligible	Gravel (1-4cm)	Few Small Patches	Acacia Shrubland, Spinifex Hummock Grassland	Nil	Low	Road/ Access Track	Old (6+ yr)	
VMEE-12	-23.2227, 118.8645	Footslopes and Plain	Alluvial Plain	Gully	West	Very Steep	Clay Loam	None Discernible	Major Outcropping (BIF)	Pebbles (5-10cm)	Scarce	Scattered Eucalypts, Spinifex Hummock Grassland	High	Nil	None Discernible	Moderate (3 to 5 yr)	

Site ID	Coord.	WANG Consolidated Fauna Habitat Mapping Type (Biologic, 2021c)	Fauna Habitat Type (Rio Tinto, 2021b)	Landform	Aspect	Slope	Soil Type	Soil Avail.	Outcropping Rock Type	Rock Size	Veg. Litter	Dominant Veg. Type	Rocky Cracks / Crevices	Burrowing Suitability	Disturbances	Last Fire	Photo
VMEE-13	-23.2194, 118.8581	Gorge/Gully	Gorge/Gully	Gully	South/ West	Very Steep	Clay Loam	None Discernible	Major Outcropping (BIF)	Pebbles (5-10cm)	Scarce	Scattered Eucalypts, Spinifex Hummock Grassland	High	Nil	None Discernible	Old (6+ yr)	
VMEE-14	-23.2116, 118.8883	Gorge/Gully	Gorge/Gully	Gully	East	Moderate	Clay Loam	None Discernible	Moderate Outcropping (BIF)	Pebbles (5-10cm)	Few Small Patches	Acacia Shrubland, Scattered Eucalypts, Spinifex Hummock Grassland, Tussock Grassland	Moderate	Nil	None Discernible	Recent (0 to 2 yr)	
VMEE-15	-23.2144, 118.8928	Hillcrest and Hillslope	Rocky Hill	Undulating Low Hills	East	Low	Clay Loam	None Discernible	Negligible	Gravel (1-4cm)	Scarce	Scattered Eucalypts, Spinifex Hummock Grassland	Nil	Nil	Road/ Access Track	Moderate (3 to 5 yr)	
Deposit J																	
VDEJ-01	-23.2311, 118.7091	Gorge/Gully	Gorge/Gully	Gully	South/ West	Very Steep	Clay Loam	None Discernible	Major Outcropping (BIF)	Pebbles (5-10cm)	Few Small Patches	Acacia Shrubland, Scattered Eucalypts, Spinifex Hummock Grassland	Moderate	Nil	None Discernible	Old (6+ yr)	

Site ID	Coord.	WANG Consolidated Fauna Habitat Mapping Type (Biologic, 2021c)	Fauna Habitat Type (Rio Tinto, 2021b)	Landform	Aspect	Slope	Soil Type	Soil Avail.	Outcropping Rock Type	Rock Size	Veg. Litter	Dominant Veg. Type	Rocky Cracks / Crevices	Burrowing Suitability	Disturbances	Last Fire	Photo
VDEJ-02	-23.2373, 118.7095	Hillcrest and Hillslope	Rocky Hill	Undulating Low Hills	South	Low	Clay Loam	None Discernible	Negligible	Pebbles (5-10cm)	Scarce	Acacia Shrubland, Scattered Eucalypts, Spinifex Hummock Grassland	Nil	Nil	None Discernible	Moderate (3 to 5 yr)	
VDEJ-03	-23.2106, 118.7496	Hillcrest and Hillslope	Rocky Hill	Gully	South/ West	Cliff	Clay Loam	Scarce	Extensive Outcropping (BIF)	Small Rocks (11-20cm)	Few Small Patches	Mulga Woodland, Scattered Eucalypts, Spinifex Hummock Grassland	High	Nil	None Discernible	Old (6+ yr)	

Appendix B: Summary of Caves Recorded Within the Study Area

Cave ID	Site	Coordinates	Habitat	Position	Aspect	Cave Exposure	Entrance Type	Entrance Shape	Entrance Width (m)	Entrance Height (m)	Floor Slope	Cave Depth (m)	No. Chambers	Max Chamber Height (m)	Ghost Bat		Pilbara Leaf-nosed Bat		Photo
															Records	Significance (Bat Call, 2021a)	Records	Significance (Bat Call, 2021b)	
CMEE-01	VMEE-02	-23.2218, 118.84048	Gorge/Gully	Upper Slope	South-East	Semi Exposed	Cavern	Round/Oval	7	3	Decline	10	1	3.0	Nil	Category 4	Nil	Category 4	
CMEE-02	VMEE-02	-23.2220, 118.8409	Gorge/Gully	Upper Slope	South	Sheltered	Cavity	Round/Oval	2.5	1	Flat	10	1	1.0	Nil	Category 4	Nil	Category 4	
CMEE-03	VMEE-02	-23.2254, 118.8437	Gorge/Gully	Mid Slope	South	Sheltered	Cavern	Round/Oval	4	4	Incline	15	1	2.0	Nil	Category 4	Nil	Category 4	
CMEE-04	VMEE-02	-23.2254, 118.8438	Gorge/Gully	Mid Slope	South-East	Sheltered	Cavern	Round/Oval	4.1	3.5	Incline	20	1	3.7	Nil	Category 4	Nil	Category 4	

Cave ID	Site	Coordinates	Habitat	Position	Aspect	Cave Exposure	Entrance Type	Entrance Shape	Entrance Width (m)	Entrance Height (m)	Floor Slope	Cave Depth (m)	No. Chambers	Max Chamber Height (m)	Ghost Bat		Pilbara Leaf-nosed Bat		Photo
															Records	Significance (Bat Call, 2021a)	Records	Significance (Bat Call, 2021b)	
CMEE-05	VMEE-13	-23.2141, 118.8794	Gorge/Gully	Upper Slope	South-West	Semi Exposed	Cavern	Round/Oval	7	3.5	Flat	32	3	5.0	~6,000 scats across 3 middens. Age of freshest scats: recent (1 to 6 months)	Category 2	Nil	Category 4	
CMEE-06	VMEE-13	-23.2173, 118.8778	Gorge/Gully	Mid Slope	South	Semi Exposed	Cavern	Round/Oval	11.5	5	Incline	13	3	2.0	Nil	Category 4	Nil	Category 4	

Appendix C: Vertebrate Fauna Recorded During the Current Survey

Species	Common Name	Conservation Status[1]		
		EPBC Act	BC Act	DBCA
MAMMALS				
CANIDAE				
Canis familiaris dingo	Dingo, dog			
DASYURIDAE				
Pseudantechinus woolleyae	Woolley's pseudantechinus			
EMBALLONURIDAE				
Taphozous georgianus	common sheath-tailed bat			
Taphozous hilli	Hill's sheath-tailed bat			
MACROPODIDAE				
Petrogale rothschildi	Rothschild's rock-wallaby			
MEGADERMATIDAE				
Macroderma gigas	ghost bat	VU	VU	VU
MOLOSSIDAE				
Austronomus australis	white-striped free-tailed bat			
Chaerephon jobensis colonicus	greater northern free-tailed bat			
MURIDAE				
Pseudomys chapmani	western pebble-mound mouse			P4
Zyzomys argurus	common rock-rat			
VESPERTILIONIDAE				
Chalinolobus gouldii	Gould's wattled bat			
Scotorepens greyii	little broad-nosed bat			
Vespadelus finlaysoni	Finlayson's cave-bat			
BIRDS				
FALCONIDAE				
Falco berigora	brown falcon			
MALURIDAE				
Amytornis striatus	striated grasswren			
PACHYCEPHALIDAE				
Colluricincla harmonica	grey shrike-thrush			

Appendix D: Significant Vertebrate Fauna Species Recorded During the Field Survey

Survey Area	Site	Habitat	Zone	Easting	Northing	Date	Species	Common Name	EPBC Act	BC Act	DBCA	Record Type	Comments	Photo
MEE	Opportunistic	Gorge/Gully	50	693742	7431349	05/07/2022	*Macroderma gigas*	ghost bat	VU	VU		Scats	~6,000 scats across 3 middens. Age of freshest scats: recent (1 to 6 months)	No photo available
MEE	Opportunistic	Hillcrest and Hillslope	50	693540	7430688	04/07/2022	*Pseudomys chapmani*	western pebble-mound mouse			P4	Burrow/ Mound	Recently Inactive	
MEE	Opportunistic	Hillcrest and Hillslope	50	694379	7431717	04/07/2022	*Pseudomys chapmani*	western pebble-mound mouse			P4	Burrow/ Mound	Inactive	

Survey Area	Site	Habitat	Zone	Easting	Northing	Date	Species	Common Name	EPBC Act	BC Act	DBCA	Record Type	Comments	Photo
N/A	Opportunistic	Hillcrest and Hillslope	50	692329	7431534	04/07/2022	*Pseudomys chapmani*	western pebble-mound mouse			P4	Burrow/ Mound	Active	

E.3: West Angelas Beyond 2020 Deposit H and F North Reconnaissance Survey

Biologic Environmental Survey Pty Ltd
24–26 Wickham Street
East Perth, WA, 6004

15 December 2022

Attn: Elizabeth Mason and Carolyn Ellis

Rio Tinto Iron Ore

Dear Elizabeth and Carolyn,

Please find below a memo summarising the targeted vertebrate fauna survey completed by Biologic Environmental Survey Pty Ltd (Biologic) within unsurveyed areas for the Deposit F North and Deposit H areas for the West Angelas Project Envelope.

Yours sincerely,

Amy Hutchison
Zoologist
amy@biologicenv.com.au
(08) 6365 5066 | 0447 108 635

Reviewed by R. Ellis and C. Knuckey 15th December 2022.

1. INTRODUCTION AND OBJECTIVES

Biologic were commissioned to undertake a basic and targeted vertebrate fauna survey of historically surveyed and unsurveyed areas for Deposit F North and Deposit H within the West Angelas Project Envelope (herein collectively referred to as the Study Area) (Figure 1.1). The Study Area is located within the West Angelas Revised Proposed Development Envelope and comprises two survey areas covering a total of 357.73 hectares (ha) (Figure 1.1), comprising:

- Deposit F North area – 319.67 ha; and
- Deposit H area – 38.06 ha.

The overarching objective of this assessment was to undertake a single season basic and targeted vertebrate fauna survey to identify the occurrence of vertebrate fauna species within the Study Area, with a particular focus on significant species (as per EPA (2020)), to inform future development and environmental approvals within the West Angelas Development Envelope. Significant species that were the focus of this survey are based on species identified in a previous desktop assessment completed for the broader West Angelas Revised Proposal Development Envelope, which encompasses the Study Area (Biologic, 2021a).

1.1. Conformance and Licensing

This assessment, particularly where suitable habitat for significant species was present, was carried out in a manner consistent with the following guidelines and recommendations from the Department of Climate Change, Energy, the Environment and Water (DCCEEW; formerly DAWE, DEHWA, DSEWPaC, DoE), the Environmental Protection Authority (EPA), relevant survey-specific license conditions and, where relevant, Rio Tinto guidelines and standards:

- DoE (2016) Environment Protection and Biodiversity Conservation (EPBC) Act referral guideline for the endangered northern quoll *Dasyurus hallucatus*;
- DEWHA (2010a) Survey guidelines for Australia's threatened bats;
- DEWHA (2010b) Survey guidelines for Australia's threatened birds;
- DoE (2013) Matters of National Environmental Significance: Significant impact guidelines 1.1;
- DSEWPaC (2011b) Survey guidelines for Australia's threatened mammals;
- DSEWPaC (2011a) Survey guidelines for Australia's threatened reptiles;
- EPA (2020) Technical Guidance: Terrestrial vertebrate fauna surveys for environmental impact assessment; and
- Rio Tinto (2021b) RTIO fauna habitat guidelines and definitions.

Fauna sampling was conducted under a DBCA Regulation 27 "Fauna Taking (Biological Assessment) License" (BA27000578) issued to Chris Knuckey. In accordance with Section 40 of the Biodiversity Conservation (BC) Act, threatened species sampling was completed under a DBCA "Authorisation to Take or Disturbed Threatened Species" (authorisation number TFA 2019-0183-4) issued to Chris Knuckey.

688000

694000

700000

7440000

7434000

Great Northern Hwy

Deposit H

Deposit
F North

West Angelas

Port Hedland
Karratha
Newman

Legend

- Study Area
- Operating Mine
- State Road
- Pilbara Region

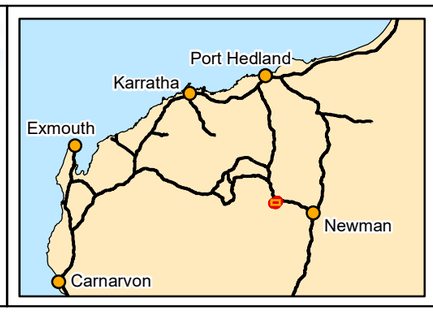
N

biologic Environmental Survey

Scale: 1:50,000

0 1 2 3 Km

Coordinate System: GDA2020 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA2020 Created 01/09/2022



RIO TINTO IRON ORE

Deposit F North and Deposit H Flora and Fauna Survey

Figure 1.1: Study Area and regional context

1.2. Background to Protection of Vertebrate Fauna

Terrestrial fauna may be considered significant species for a range of reasons (EPA, 2016), including:

- being identified as a threatened or priority species;
- being a species with restricted distribution;
- enduring a degree of historical impact from threatening processes; or
- providing an important function required to maintain the ecological integrity of a significant ecosystem.

All native fauna in Western Australia (WA) are protected at a state level under the BC Act and at a national level under the EPBC Act. Any action that has the potential to impact native fauna needs to be approved by relevant state and/or federal departments in accordance with the WA *Environmental Protection Act 1986* (EP Act) and the federal EPBC Act. While all native fauna are protected under these Acts, some species are afforded extra protection. These include species that are considered Threatened under the EPBC Act and/or BC Act, or; migratory bird species that are protected under international agreements and subsequently listed as Migratory under the EPBC Act and/or BC Act (Table 1.1). Furthermore, any species that may be threatened but for which there is insufficient information available to allocate a threatened status under the EBPC Act and/or BC Act, can also be listed as Priority species by DBCA (Table 1.1).

For the purposes of this assessment, significant species are those that are afforded protection under the EPBC Act, BC Act and/or listed as Priority by DBCA (Table 1.1). A summary of applicable legislation and status' is provided in Table 1.1.

Table 1.1: Definitions and terms for significant species

Act, Agreement or List	Status Codes
Federal	
EPBC Act In Australia, native fauna are protected under the EPBC Act. This Act makes provisions for an independent committee (the Threatened Species Scientific Committee [TSSC]), which is charged with maintaining a list of threatened species. Threatened species are listed under one of six categories, depending on their specific conservation status. Migratory bird species are those listed under international agreements and protected under the EPBC Act as a MNES. Relevant international agreements include the Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention), China-Australia Migratory Bird Agreement (CAMBA), Japan-Australia Migratory Bird Agreement (JAMBA), and Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA).	*Extinct:* • EX – Extinct • EW – Extinct in the Wild *Threatened:* • CR – Critically Endangered • EN – Endangered • VU – Vulnerable • CD – Conservation Dependent *Other:* • MI – Migratory
State	
BC Act In WA, native fauna are protected under the BC Act. Species in special need of protection are listed as being Extinct, Threatened or Specially Protected. Within these groups, species are listed under one of eight categories, depending on their specific conservation status. Migratory bird species are those listed under the Bonn Convention and/or CAMBA, JAMBA and ROKAMBA agreements.	*Extinct:* • EX – Extinct *Threatened:* • CR – Critically Endangered • EN – Endangered • VU – Vulnerable *Specially Protected:* • MI – Migratory • CD – Conservation Dependent • OS – Other specially protected fauna
DBCA Priority List The DBCA maintains a list of Priority species that are considered to be possibly threatened but have not been assigned statutory protection under the BC Act, as not enough information is available for an accurate determination of conservation status. These species are generally in urgent need of survey to determine their distribution and abundance.	*Poorly Known:* • P1 – Priority 1 • P2 – Priority 2 • P3 – Priority 3 *Rare, Near Threatened and other* • P4 – Priority

2. METHODS

2.1. Taxonomy and Nomenclature

The latest checklist of mammal, reptile and amphibian names published by the WAM (2022) was used as a guide to the current taxonomy and nomenclature of these groups. For birds, the current checklist of Australian birds maintained by Birdlife Australia (based on Christidis & Boles, 2008) was used in conjunction with the ABRS (2021) species list. While compiling a list of fauna potentially occurring in the Study Area, all records were checked to ensure the latest taxonomy, using recent papers and lists, was used.

2.2. Desktop Assessment

A desktop assessment was undertaken utilising information from a previous desktop assessment conducted by Biologic (2021a) for the broader West Angelas Beyond 2020 Development Envelope, which encompasses the Study Area. Additionally, any significant species records from the Biologic (2021a) field surveys were also considered for this assessment. The desktop assessment was used to further refine sampling methods to ensure appropriate sampling was undertaken for all target species and to allow an accurate assessment of their occurrence or likelihood of occurrence within the Study Area.

2.3. Field Survey

2.3.1. Survey Timing and Personnel

The field survey was undertaken between the 2nd and 7th of July 2022 by Senior Zoologist Louis Masarei and Zoologist Amy Hutchison, whom collectively have over ten years of experience undertaking fauna surveys within the Pilbara region, including targeted surveys for the significant species that were the focus of this assessment (Table2.1).

Table2.1: Project Team and experience

Personnel	Position and Role	Qualification	Experience
Louis Masarei	Senior Zoologist • field survey	BSc Conservation Biology & Marine and Coastal Management	7 years' EIA (consulting) 7 years' field survey 7 years' vertebrate zoology/ ecology 7 years' Pilbara field survey/ EIA
Amy Hutchison	Zoologist • field survey • reporting	BSc Zoology and Marine Science	3 years' EIA (consulting) 6 years' field survey 6 years' vertebrate zoology/ ecology 3 years' Pilbara field survey/ EIA

2.3.2. Climate and Weather

Observed weather conditions prior to and during the survey are shown in Figure 2.1, alongside long-term climatic data for Newman Airport (station #007176). In the 12 months prior to the survey (March 2021–February 2022), mean minimum and maximum temperatures recorded at Newman Airport were similar to the long-term averages for most months (Figure 2.1). Rainfall in the 12 months preceding the survey was variable, with below long-term averages recorded through most months, except for November 2021, and February, May, and June 2022. May and June 2022 recorded well above the annual long-term average (59 mm v 19 mm; 23 mm v 16 mm), and November 2021 (14 mm v 12 mm) and February 2022 (73 mm v 72 mm) had rainfall consistent with long-term averages (Figure 2.1). In total, the rainfall received in the 12 months prior to the survey (August 2021 to July 2022; 226.8 mm) was well below the annual long-term average (324.4 mm) (BoM, 2022).

Observed maximum temperatures during the survey were similar to the long-term average, while minimum temperatures were slightly lower (Table 2.2) (BoM, 2022). No rainfall was recorded during the survey (Table 2.2).

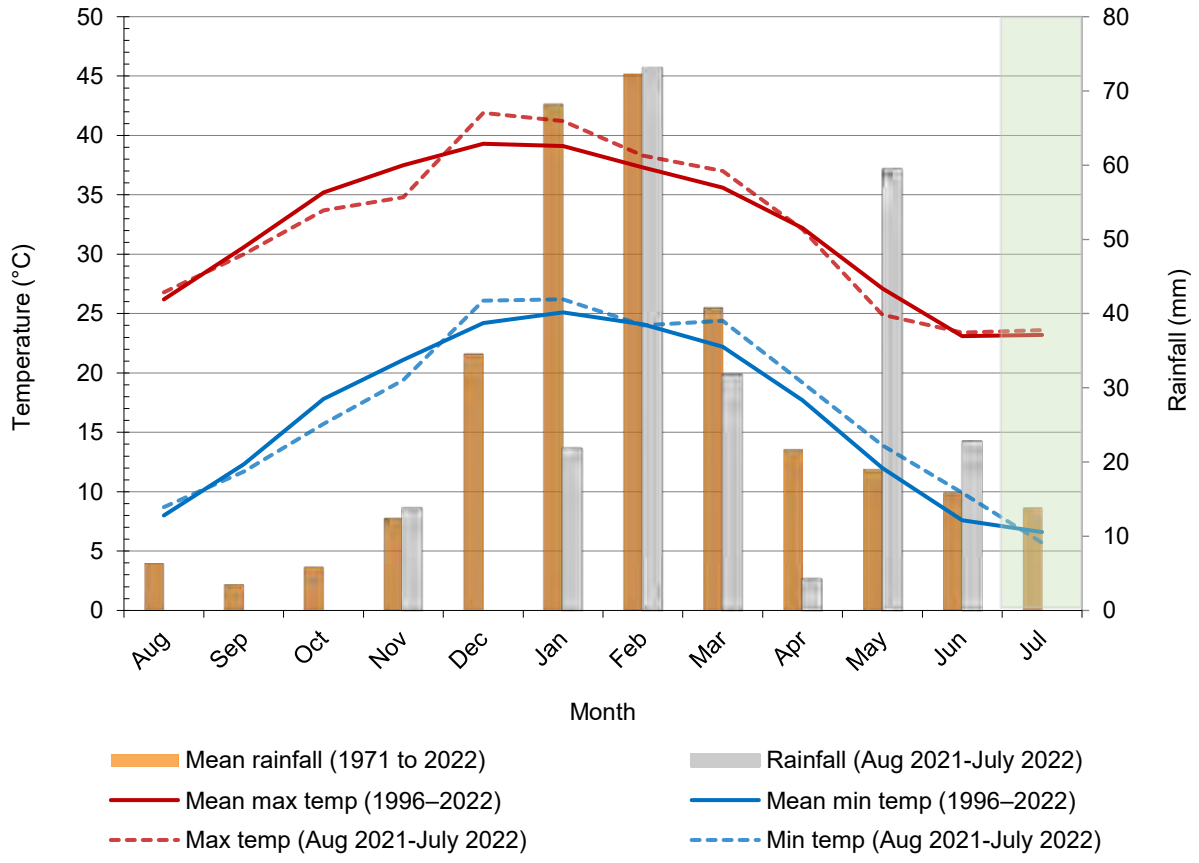


Figure 2.1: Monthly rainfall and long-term average rainfall for Newman Aero (Station ID 007176) with approximate survey timing shown in shaded box

Table 2.2: Climatic conditions recorded for Newman Airport during the field survey

Date	Min. temp (°C)	Max. temp (°C)	Rainfall (mm)
02/07/2022	2.9	19.8	0
03/07/2022	1.8	19.3	0
04/07/2022	1.1	20.0	0
05/07/2022	-1.3	19.7	0
06/07/2022	-0.5	20.8	0
07/07/2022	0.0	22.0	0
Average/ total	**0.7**	**20.3**	**0**

2.3.3. Sampling and Survey Methods

Habitat Assessments and Mapping

Broad fauna habitats were previously defined and delineated for the West Angelas Development Envelope by Biologic (2021b), which encompasses the Study Area. During the field survey, Biologic (2021b) habitat mapping was ground truthed to verify fauna habitats previously mapped and their likelihood of supporting significant species. Habitat assessments were undertaken at a total of five locations within the Study Area during the field survey to define and delineate fauna habitats (Table 2.3; Figure 2.2; Appendix A). Following the field survey, broad fauna habitat mapping completed by Biologic (2021b) was reviewed with consideration of results of the field survey and, where deemed necessary, amended and refined to reflect field observations. Habitat assessments were conducted using methodology and terminology modified from the *Australian Soil and Land Survey Field Handbook* (National Committee on Soil and Terrain, 2009). The characteristics recorded during the habitat assessments were:

- site information: location and photo;
- habitat: broad habitat type, landform, aspect, slope, soil type and availability, rocky outcropping presence and type;
- ground cover: rock size, vegetation litter and woody debris;
- vegetation: broad vegetation type, structure and dominant species;
- condition: time since fire, disturbance and overall habitat condition; and
- microhabitat: rocky cracks/ crevices, burrowing suitability, hollow presence and abundance, water presence.

Table 2.3: Fauna sampling effort

Site ID	Latitude	Longitude	Habitat assessment	Camera trap transects (nights)	Targeted search[1] (person hrs) and target species	Ultrasonic recording (nights)
Deposit H						
VDEH-01	-23.1279	118.9291	•		0.5 (NQ, PLNB, GB, POP)	3
Total (DEH)			**1**	**0**	**0.5**	**3**
Deposit F North						
VDFN-01	-23.1706	118.8860	•	40	2 (NQ, POP)	
VDFN-02	-23.1692	118.8289	•			
VDFN-03	-23.1723	118.8402	•		1 (NQ, PLNB, GB, POP)	
VDFN-04	-23.1720	118.8507	•		0.5 (NQ, POP)	3
Total (DFN)			**4**	**40**	**3.5 (NQ, POP), 1 (PLNB, GB)**	**3**
Total (Study Area)			**5**	**40**	**4 (NQ, POP), 1.5 (PLNB, GB)**	**6**

[1] NQ = northern quoll, PLNB = Pilbara leaf-nosed bat, GB = ghost bat, POP = Pilbara olive python.

Water Feature Assessments

During the survey, searches were undertaken for any water features occurring within the Study Area, particularly those that had the potential to support significant species (i.e. critical habitat for Pilbara olive python or water sources for Pilbara leaf-nosed bat). Each water feature was assessed to characterise key features and identify the likelihood of target species utilising them. The characteristics recorded during water feature assessments include:

- dimensions: length, width, depth;
- water presence: above the surface, in the intermediate zone;
- location and photograph;
- vegetation: obligate phreatophytes, emergent macrophytes; and
- presence of fauna.

Targeted Searches

Where suitable habitat considered to potentially support significant species was identified, targeted traverse searches were undertaken. Due to access limitations, a helicopter was used to facilitate broad access and assessment of the Study Area, with areas identified as suitable habitat or providing significant habitat features (i.e. caves) subject to more intensive ground truthing. Targeted searches comprised searching for occurrence of target species from direct observation, secondary evidence (i.e. tracks, scats, sloughs and foraging evidence) and/or habitat features (i.e. dens, roost caves and water features) likely to be utilised by target species. A total of 5.5 person hours of targeted searches was undertaken at four sites during the field survey, targeting northern quoll, ghost bat, Pilbara leaf-nosed bat and/or Pilbara olive python (Table 2.3).

Camera Trap Transects for Northern Quoll

A camera trap transect was established at one site within the Study Area. In accordance with methods recommended by DoE (2016), the transect comprised ten camera traps placed approximately 50 to 100 m apart and were left *in-situ* for four consecutive nights, for a total of 40 camera trap sampling nights. Where possible, cameras were oriented to facilitate differentiation of individuals via spot patterning (following Hohnen *et al.*, 2012) and baited with universal bait mixture (comprising oats, peanut butter and sardines) contained within a non-reward receptacle (perforated and capped PVC pipe).

Ultrasonic Recorders for Pilbara Leaf-nosed Bat and Ghost Bat

SongMeter (SM; Wildlife Acoustics Inc.) ultrasonic bat recorders were deployed at two locations during the field survey (Table 2.3; Figure 2.2). At each location, recorders were placed in, or in the vicinity of, areas of prospective roosting or foraging and dispersal habitats most likely to be utilised by bats. Each recorder was deployed for three consecutive nights, in accordance with EPA (2020), equating to a total of six recording nights during the field survey. Audio settings, selectable filters and triggers were set to detect all species known to occur within the region, including echolocation and social calls of the ghost bat and Pilbara leaf-nosed bat (McKenzie & Bullen, 2009). Bat calls were analysed by Robert Bullen of Bat Call WA.

Opportunistic Records

At all times while surveying, all records pertaining to species not previously recorded during the survey, particularly significant species, were documented. These records include those from primary (i.e. direct observation of species) or secondary (e.g. burrows, scratchings, diggings and scats) evidence.

688000

692000

696000

7440000

7436000

VDEH-01

VDFN-02

VDFN-03

VDFN-04

VDFN-01

Legend

Study Area

Sampling Type

- Habitat assessment
- Ultrasonic recorder
- Camera trap transect

Traverse

- Helicopter Traverse
- Targeted

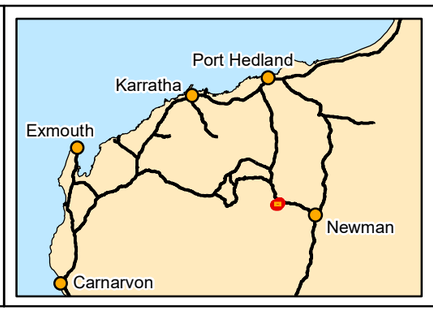
N

biologic Environmental Survey

Scale: 1:30,000

0 0.5 1 1.5 Km

Coordinate System: GDA2020 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA2020 Created 15/12/2022



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Deposit F North and Deposit H Flora and Fauna Survey

Figure 2.2: Sample sites and traverses

2.3.4. Likelihood of Vertebrate Fauna Occurrence

Following completion of the field survey, significant species identified by the Biologic (2021a) desktop assessment were assessed for their likelihood of occurring within the Study Area using a decision matrix (Table 2.4). In the decision matrix, each species was assigned to one of six categories of likelihood: Confirmed, Highly Likely, Likely, Possible, Unlikely, or Highly Unlikely.

The decision matrix is intended to be an indicative guide only, and the way in which it is interpreted may vary between species, depending on a given species' habitat preferences and ability to disperse, as well as the reliability and availability of contextual information. For example, a species with a limited dispersal capability will have a reduced likelihood of occurring in the Study Area compared with a species with greater dispersal capability. It is also recognised that a lack of records in the vicinity of the Study Area may indicate limited sampling effort rather than species' absence, and that previous records may include historic or presumed erroneous information which may misrepresent a species' current distribution.

Where the determination of a species' likelihood of occurrence within the Study Area deviates from the decision matrix, detailed justification for any variation is provided.

Table 2.4: Species likelihood of occurrence decision matrix

		Habitat suitability of Study Area			
		Breeding habitat present	**Foraging and dispersal habitat present**	**Marginally suitable habitat[2] present**	**No suitable habitat present**
Species Records[1]	**Recorded in Study Area**	Confirmed	Confirmed	Confirmed	Confirmed
	Recorded within 10 km of Study Area	Highly Likely	Likely	Possible	Possible
	Recorded within 10–50km of Study Area	Likely	Possible	Possible	Unlikely
	Recorded within 50–100 km of Study Area	Possible	Possible	Unlikely	Unlikely
	Recorded >100 km of Study Area	Possible	Unlikely	Unlikely	Highly Unlikely
	Species considered locally/regionally extinct	Unlikely	Unlikely	Highly Unlikely	Highly Unlikely

[1] Only records within the previous 50 years are considered.

[2] Marginally suitable habitat is habitat which is possibly used by a species but is unlikely to be depended upon; for example, it may be used only when in proximity to core breeding, foraging or dispersal habitat.

2.3.5. Vertebrate Fauna Habitat Significance

Broad fauna habitat types mapped within the Study Area were assessed for their ability to support significant vertebrate fauna species and classified as being of high, medium or low, following criteria defined by Biologic (2021a) (Table 2.5).

For the purposes of this assessment, critical habitat followed that of DoE (2013), being areas necessary "for activities such as foraging, breeding, roosting, or dispersal". Within this, habitat types were recognised as providing primary habitat (i.e. critical habitat as per the definition above), or secondary habitat (i.e. habitats not critical for foraging, breeding, roosting or dispersal, but may support such activities and/or habitats of marginal suitability for such activities). Due to differing habitat preferences of conservation significant species (including habitat features and/or microhabitats), habitat significance was assessed on a species-by-species basis.

It should be noted that assessment of habitat significance applies only to habitat occurring within the Study Area, and therefore may not be representative of significance applied to the same habitat in other areas outside the Study Area. For example, a habitat within the Study Area may be deemed unsuitable due to the absence of certain habitat features which are required for the species persistence, despite the same habitat occurring outside the Study Area being considered of greater significance. The significance of a habitats within the Study Area may also be influenced by other habitats occurring within the Study Area and more broadly, including areas adjacent to the Study Area, particularly if representative of primary habitat.

Table 2.5: Fauna habitat significance assessment criteria

Score	Possible criteria (score results from any possible criterion being met)[1]
High	Fauna listed as threatened under the EPBC Act or BC Act have been recorded from this habitat type within the Study Area.
	Habitat known to be suitable core habitat[1] for EPBC Act and/or BC Act listed threatened fauna, and there are records of this species within 40 km^2.
	Habitat is regionally uncommon and known to support species listed as: • Threatened fauna under the EPBC Act and/or BC Act, but it is not their core habitat (e.g. may be used periodically/ seasonally or for dispersal). • Other Specially Protected Species under the BC Act. • DBCA listed Priority fauna, which are known to be solely reliant on this habitat.
Moderate	Habitat known to support EPBC Act and/or BC Act listed Migratory fauna.
	Habitat that is regionally uncommon (e.g., occurs in small and isolated areas) and supports a particularly diverse and uncommon faunal assemblage.
	Habitat is widespread and known to support species listed as: • Threatened fauna under the EPBC Act and/or BC Act, but it is not their core habitat (e.g., may be used periodically/ seasonally or for dispersal). • Other Specially Protected Species under the BC Act. • DBCA listed Priority fauna, which are known to be solely reliant on this habitat.
Low	Habitat that may meet the definition of core habitat[1] for EPBC Act and/or BC Act listed threatened fauna, however there are no records of this species within 40 kms.
	Habitat is widespread/common and does not solely support any DBCA listed Priority fauna.

[1] Core habitat is defined as containing the critical habitat elements for survival and reproduction of a species (Bingham & Noon, 1997) or as otherwise defined within relevant species recovery plans and guidelines. Note in instances where survey work over this area has been limited, then a precautionary approach is generally applied, and the species will be considered likely to be present.

2.3.6. Limitations

The survey was not restricted by any material limitations that significantly impacted the objectives and/or results of the survey and/or the determined likelihood of occurrence assessments for significant species, as outlined by EPA (2020). Low temperatures and windy conditions, in addition to the use and disturbance from helicopter are likely to have influenced reduced activity and low diversity of species recorded overall; however, it is not considered to have detrimentally affected the results of the survey.

A significant amount of survey work has been undertaken in the wider local area and surrounding region leading to a good understanding of the faunal assemblage in the greater West Angelas area. These previous survey results were available for review and utilised in the desktop assessment and fauna habitat mapping. Due to the previous survey effort and lack of critical habitat for significant species, a the basic/ targeted fauna survey effort is considered adequate.

3. RESULTS AND DISCUSSION

3.1. Desktop Assessment

A total of 24 species of significance were identified as potentially occurring within the Study Area from the desktop assessment completed for the West Angelas Beyond 2020 detailed fauna assessment (Biologic, 2021a) (Table 3.1).One species has previously been recorded within the Study Area. The western pebble-mound mouse (*Pseudomys chapmani* – Priority 4 DBCA) was recorded once from secondary evidence (pebble-mound) within Dep F North (Figure 3.1) (Rio Tinto, 2021a). It has also previously been recorded on 89 occasions within 5 km of the Study Area (Biologic, 2021a; DBCA, 2021b; Rio Tinto, 2021a).

A further five significant species have previously been recorded within 5 km of the Study Area, including (Biologic, 2021a; DBCA, 2021b; Rio Tinto, 2021a):

- Pilbara leaf-nosed bat (*Rhinonicteris aurantia* (Pilbara form) – Vulnerable EPBC Act and BC Act) – one record (ultrasonic call recording), nearest ~3.5 km north-east Dep H;
- ghost bat (*Macroderma gigas* – Vulnerable EPBC Act and BC Act) – six records (3 scat records, 3 individuals), nearest ~1.7 km south of Dep F North at known maternity cave AA1;
- Pilbara olive python (*Liasis olivaceus barroni* – Vulnerable EPBC Act and BC Act) – two records (camera trap and direct observation), nearest ~33 m north Dep H;
- fork-tailed swift (*Apus pacificus* – Migratory EPBC Act and BC Act) – three records (direct observations), nearest ~2 km south Dep F North; and
- Pilbara barking gecko (*Underwoodisaurus seorsus* – Priority 2 DBCA) – two records (direct observations), both records ~1.8 km south-west Dep F North.

Table 3.1: Significant species identified as potentially occurring in the Biologic (2021a) desktop assessment

Scientific Name	Common Name	Conservation Status		
		EPBC Act	BC Act	DBCA
Mammals				
Dasyuridae				
Dasycercus blythi	brush-tailed mulgara			P4
Dasyurus hallucatus	northern quoll	EN	EN	
Hipposideridae				
Rhinonicteris aurantia Pilbara form	Pilbara leaf-nosed bat	VU	VU	
Megadermatidae				
Macroderma gigas	ghost bat	VU	VU	
Muridae				
Leggadina lakedownensis	northern short-tailed mouse			P4
Pseudomys chapmani	western pebble-mound mouse			P4
Thylacomyidae				
Macrotis lagotis	greater bilby	VU	VU	

Scientific Name	Common Name	Conservation Status		
		EPBC Act	BC Act	DBCA
Aves				
Apodidae				
Apus pacificus	fork-tailed swift	MI	MI	
Charadriidae				
Charadrius veredus	oriental plover	MI	MI	
Falconidae				
Falco peregrinus	peregrine falcon		OS	
Falco hypoleucos	grey falcon	VU	VU	
Hirundinidae				
Hirundo rustica	barn swallow	MI	MI	
Motacillidae				
Motacilla cinerea	grey wagtail	MI	MI	
Motacilla flava	yellow wagtail	MI	MI	
Psittacidae				
Pezoporus occidentalis	night parrot	EN	CR	
Rostratulidae				
Rostratula benghalensis australis	Australian painted snipe	EN	EN	
Scolopacidae				
Calidris acuminata	sharp-tailed sandpiper	MI	MI	
Calidris ferruginea	curlew sandpiper	CR/ MI	CR/ MI	
Calidris melanotos	pectoral sandpiper	MI	MI	
Tringa hypoleucos	common sandpiper	MI	MI	
Reptiles				
Carphodactylidae				
Underwoodisaurus seorsus	Pilbara barking gecko			P2
Pythonidae				
Liasis olivaceus barroni	Pilbara olive python	VU	VU	
Scincidae				
Notoscincus butleri	lined soil-crevice skink			P4
Typhlopidae				
Anilios ganei	Pilbara flat-headed blind-snake			P1

640000 680000 720000

7440000 7400000

Packsaddle Rd
West Angelas Rd
Great Northern Hwy
Eagle Pool Rd
Turee Creek Rd

DBCA Database

Bird
- VU - grey falcon
- IA - fork-tailed swift
- OS- peregrine falcon

Mammal
- EN - northern quoll
- VU - ghost bat
- VU- greater bilby
- VU - Pilbara leaf-nosed bat
- P4 - brush-tailed mulgara
- P4 - northern short-tailed mouse
- P4 - western pebble-mound mouse

Reptile
- VU - Pilbara olive python
- P1- Pilbara flat-headed blind-snake
- P2 - unpatterned robust slider
- P2 - Pilbara barking gecko

RTIO Database

Bird
- P4 - letter-winged kite
- IA - fork-tailed swift

Mammal
- VU - ghost bat
- VU - Pilbara leaf-nosed bat
- P4 - western pebble-mound mouse, ngadji

Reptile
- P2- Pilbara barking gecko

Legend
- Study Area
- Local Road
- State Road

Biologic (2021a)

Bird
- IA - fork-tailed swift

Mammal
- EN - northern quoll
- P4 - western pebble-mound mouse
- VU - ghost bat
- VU - Pilbara leaf-nosed bat

Reptile
- VU - Pilbara olive python

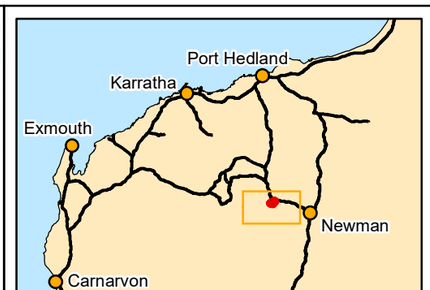
N

biologic Environmental Survey

Scale: 1:349,000

0 10 20 Km

Coordinate System: GDA2020 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA2020 Created 15/12/2022



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Deposit F North and Deposit H Flora and Fauna Survey

Figure 3.1: Significant fauna recorded in the desktop assessment

3.2. Broad Fauna Habitats

Following completion of the field survey, broad fauna habitat mapping within the Study Area Biologic (2021a) was revised to reflect observed habitats more accurately as a result of ground truthing during the field survey. Changes to the Biologic (2021a) fauna habitat mapping comprised further delineation of habitats not clearly visible from aerial imagery (i.e. new areas of Gorge/Gully within Hillcrest and Hillslope).

A total of four broad fauna habitat types are mapped across the Study Area (Table 3.2; Table 3.4; Figure 3.2), comprising, in decreasing order of extent: Footslopes and Plain (54.83%), Hillcrest and Hillslope (41.71%), Drainage Line (2.80%), and Gorge/Gully (0.29%) (Table 3.2; Table 3.4). The remaining 0.37% of the Study Area comprised Disturbed areas, including land that has been cleared of vegetation for access tracks, topsoil stockpiles and/or exploration activities (i.e. drill pads).

Table 3.2: Extent of broad fauna habitats within the Study Area

Fauna Habitat	Extent Within Study Area					
	Deposit F North		Deposit H		Total (all areas)	
	Area (ha)	%	Area (ha)	%	Area (ha)	%
Footslopes and Plain	183.78	57.49%	12.35	32.46%	196.13	54.83%
Hillcrest and Hillslope	124.91	39.07%	24.30	63.84%	149.21	41.71%
Drainage Line	8.98	2.81%	1.05	2.76%	10.03	2.80%
Gorge/Gully	0.67	0.21%	0.36	0.94%	1.03	0.29%
Disturbed	1.33	0.42%	-	-	1.33	0.37%
Total	**319.67**	**100.00%**	**38.06**	**100.00%**	**357.73**	**100.00%**

Of the four broad fauna habitat types identified within the Study Area, two (Gorge/Gully and Hillcrest/Hillslope) were deemed to be of high significance for vertebrate fauna, as they are likely to provide critical (primary breeding, foraging and dispersal) habitat for multiple significant species, including northern quoll, ghost bat, Pilbara leaf-nosed bat and Pilbara olive python (Table 3.4). Of the remaining two habitats, one (Drainage Line) was deemed to be of moderate value, as it provides secondary or supporting habitat (foraging and/or dispersal) for multiple significant species; however, does not represent critical habitat for any target MNES species (Table 3.4). This habitat is relatively common and widespread in the broader vicinity of the Study Area, and significant species occurrence within it is often dependent on the occurrence of critical or high value habitat (i.e. primary breeding, nesting and/or roosting habitat) proximal to the Study Area. The occurrence of the remaining habitat (Footslopes and Plain) within the Study Area was deemed to be of low value to vertebrate fauna (Table 3.4). All broad fauna habitats mapped within the Study Area are relatively common and widespread within the broader vicinity of the Study Area and throughout the Pilbara region.

3.2.1. Habitat Features

Water Features

One temporary ephemeral pool was recorded during the survey within Deposit F North (Table 3.3). This water feature was recorded within Drainage Line habitat and may temporarily support significant species in the area, particularly northern quoll and Pilbara olive python; however, this is likely to be limited due to the small size of the water feature and lack of others in the vicinity. No water features likely to support significant species were recorded within Deposit H. Temporary ephemeral pools may occur within Gorge/Gully habitat following rainfall events; however, are not likely to persist for prolonged periods outside the wet season.

Table 3.3: Water feature recorded during the survey

Water feature ID	Coordinates	Length (m)	Width (m)	Depth (m)	Emergent macrophyte present	Aquatic vegetation	Pool Type	Photo
WDFN-01	-23.1708, 118.8850	5	2	0.3	No	-	Temporary ephemeral	

Table 3.4: Fauna habitat descriptions

Habitat Type	Description	Extent within the Study Area	Habitat for Significant Species	Representative Photo
Footslopes and Plain **Extent in Study Area:** 196.13 ha (54.83%) **Vertebrate Fauna Significance:** Low	Footslopes and Plain habitat comprise low-lying open plains and the low rolling hills below upland areas. Vegetation is dominated by scattered *Eucalyptus* trees mixed *Acacia* and *Grevillea* shrubs over open *Triodia* hummock grassland on stony and/or clay loam substrates.	Footslopes and Plain habitat occurs throughout the majority of the Study Area. The habitat is common and widespread both within the Study Area and in the broader vicinity of the Study Area.	• **Pilbara leaf-nosed bat –** secondary foraging and/or dispersal (if proximal to primary roosting and breeding habitat) • **ghost bat –** secondary foraging and/or dispersal (if proximal to primary roosting and breeding habitat) • **grey falcon –** secondary foraging (if proximal to primary nesting and breeding habitat) • **peregrine falcon –** secondary foraging and/or dispersal (if proximal to primary nesting and breeding habitat) • **fork-tailed swift –** secondary foraging and/or dispersal • **brush-tailed mulgara – b**reeding, foraging and dispersal habitat • **northern short-tailed mouse** – breeding, foraging and dispersal habitat • **western pebble-mound mouse –** breeding, foraging and dispersal habitat	
Hillcrest and Hillslope **Extent in Study Area:** 149.21 ha (41.72%) **Vertebrate Fauna Significance:** High	Hillcrest and Hillslope habitat comprises hills and undulating stony plains of higher elevation, supporting hard spinifex with a mantle of gravel and larger rocks with occasional minor outcropping. Vegetation is dominated by scattered *Eucalyptus* trees and *Acacia* and/or *Grevillea* shrubs over open *Triodia* hummock grassland with. This habitat also includes instances of outcropping and breakaway within its occurrence.	Hillcrest and Hillslope habitat occupies a large portion of Dep F North and Dep H, often forming part of a larger occurrence of the habitat that extends beyond the Study Area This habitat is a common and widespread habitat throughout the surrounding region.	• **northern quoll –** primary denning/ shelter (withn instances of breakaway, otherwise secondary foraging and/or dispersal) • **Pilbara leaf-nosed bat –** primary roosting (within instances of breakaway, otherwise secondary foraging and/or dispersal if roosting not proximal) • **ghost bat** – primary roosting (within instances of breakaway, otherwise secondary foraging and/or dispersal if roosting not proximal) • **Pilbara olive python** – secondary foraging and/or dispersal (if proximal to primary habitat) • **fork-tailed swift** – secondary foraging and/or dispersal • **western pebble-mound mouse –** breeding, foraging and dispersal habitat • **Pilabra barking gecko –** breeding, foraging and dispersal habitat	
Drainage Line **Extent in Study Area:** 10.03 ha (2.80%) **Vertebrate Fauna Significance:** Moderate	Drainage Line habitat often occurs as an intersecting habitat within lower-lying areas of Footslopes and Plain habitat. Presence and persistence of water within Drainage Line habitat variable, often influenced by rainfall. Vegetation within the habitat is variable depending on presence of water, often comprising fringing vegetation dominated scattered *Eucalypts* and *Acacia* species over mixed shrub and tussock grassland understory.	Drainage Line habitat intersects the Study Area at multiple locations; however, only occupies a small portion overall. The habitat is a commonly occurring habitat in the broader vicinity of the Study Area.	• **Pilbara leaf-nosed bat –** secondary foraging and/or dispersal (if proximal to primary roosting and breeding habitat) • **Pilbara olive python –** secondary foraging and/or dispersal (particularly if proximal to instances of primary habitat) • **fork-tailed swift –** secondary foraging and/or dispersal	

Habitat Type	Description	Extent within the Study Area	Habitat for Significant Species	Representative Photo
Gorge/Gully **Extent in Study Area:** 1.03 ha (0.29%) **Vertebrate Fauna Significance:** High	Often surrounded by Hillcrest and Hillslope habitat. This habitat often contains exposed rock outcropping and breakaway. Usually dominated by open *Eucalyptus* woodlands, *Acacia* and *Grevillea* shrublands and *Triodia* low hummock grasslands vegetation.	Within the Study Area Gorge/Gully habitat occurs once amongst Hillcrest and Hillslope habitat within Dep F North and Dep H. This habitat is a common habitat throughout the surrounding region.	• **northern quoll –** primary denning/ shelter, foraging and/or dispersal habitat • **Pilbara leaf-nosed bat –** primary roosting, foraging and/or dispersal (secondary foraging/ dispersal if roosting not proximal) • **ghost bat** – primary roosting, foraging and/or dispersal (secodary foraging/ dispersal if roosting not proximal) • **Pilbara olive python** –breeding, foraging and dispersal habitat • **peregrine falcon –** primary breeding (where rocky areas of high elevation occur) • **Pilbara flat-headed blind-snake** – breeding, foraging and dispersal habitat	
Disturbed **Extent in Study Area:** 1.30 ha (0.36%) **Vertebrate Fauna Significance:** Negligible	Disturbed and/or cleared areas (i.e. roads and access tracks, mine pits and infrastructure, drill pads and other clearing)	Disturbance within the Study Area is restricted to access tracks and drill pads within the west of Dep F North.	• **fork-tailed swift –** secondary foraging and/or dispersal	

660000
680000
700000
720000
7460000
7440000
7420000

West Angelas Rd
Hope Downs 1
South Flank
Deposit H
Great Northern Hwy
Deposit F North
West Angelas

Legend

- Study Area
- Operating Mine
- Local Road
- State Road

Fauna Habitat

- Disturbed
- Drainage Line
- Footslopes and Plains
- Gorge/ Gully
- Hillcrest and Hillslope

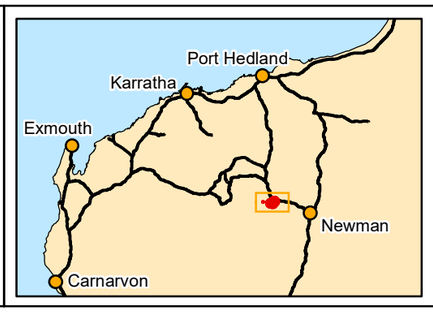
N

biologic Environmental Survey

Scale: 1:200,000

0 4 8 12 Km

Coordinate System: GDA2020 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA2020 Created 01/09/2022



RIO TINTO IRON ORE

Deposit F North and Deposit H Flora and Fauna Survey

Figure 3.2: Broad fauna habitats in the Study Area

3.3. Field Survey

During the current survey, a total of 14 vertebrate fauna species were recorded, comprising seven mammals (six native and one introduced), and seven birds (Appendix B). No significant species were recorded during the field survey.

Of the 24 significant species identified in the desktop assessment, based on known species' distributions, previous records and the habitats present within the Study Area were used to determine the potential of the 24 significant species identified in the desktop assessment occurring in the study area. The likelihood of occurrence within Deposit F North and Deposit H differs due to the differences in habitat and distances from previous records. For the purposes of this assessment the highest rating has been used to assess potential to occur within the Study Area. One species was confirmed to have been previously recorded within the Study Area (western pebble-mound mouse), one species was deemed Highly Likely (ghost bat), five species were deemed Likely (Pilbara leaf-nosed bat, Pilbara olive python, peregrine falcon, fork-tailed swift and northern short-tailed mouse) and four were deemed possible (northern quoll, brush-tailed mulgara, grey falcon and Pilbara flat-headed blind-snake) (Table 3.5). The remaining 13 species are considered Highly Unlikely (n = 9) or Unlikely (n = 4) to occur within the Survey Area, primarily due to the absence of suitable habitat (Table 3.5).

No evidence of western pebble-mound mouse was recorded within the Study Area during the current survey; however, the species has previously been confirmed as occurring within Dep F North in 2010 (Figure 3.1). The species was recorded once during a flora and vegetation survey from secondary evidence (pebble-mound) (Rio Tinto, 2021a). Additionally, the species has previously been recorded on 89 occasions within 5 km of the Study Area (Biologic, 2021a; DBCA, 2021b; Rio Tinto, 2021a).

Although ghost bat was not recorded during the current survey, the species has previously been recorded on multiple occasions within 2 km of Dep F North at maternity cave AA1, which has been the subject of long-term monitoring for the species (Table 3.5; Figure 3.1). Evidence of the species has been recorded at AA1 as far back as 1980, where the species was recorded from direct observation. To date, the species has been recorded on multiple occasions, primarily from secondary evidence (scats) and to a lesser extent direct observations, with scat genotyping indicating up to 39 individuals have utilised the roost (Biologic, 2022). Previous monitoring has demonstrated that this has been used as a Category 2 cave. Although ghost bat usage of the cave has fluctuated during monitoring undertaken between 2014 to present (Biologic, 2022), continued usage of the cave as a roost is likely to occur, though may be intermittent.

In addition to the occurrence of roosting nearby, the species is likely to forage and/or disperse within Footslopes and Plain habitat occurring within the Study Area, particularly areas supporting open vegetation cover and suitable perching trees. Frequency of occurrence within the Study Area to forage and/or disperse is likely to be dependent on the occurrence of roost caves (particularly diurnal roosts) proximal to the Study Area.

Pilbara leaf-nosed bat has previously been recorded from ultrasonic calls approximately 3.5 km north-east of Dep H and is considered Likely to occur (Table 3.5; Figure 3.1). Calls recorded were indicative of foraging individuals and not consistent with the presence of a permanent roost nearby (Astron, 2018). Within the Study Area, the species' occurrence is likely to be limited to foraging and/or dispersal activities, during which night roosting may occur. Foraging and/or dispersal habitat for Pilbara leaf-nosed bat is provided, at varying capacities, within all five broad fauna habitats mapped within the Study Area. The habitat rating (HR) of potential foraging habitat within the five fauna habitats occurring within the Study Area (as defined by Bat Call WA (2021)) ranges from moderate (HR2; Footslopes and Plain, Gorge/Gully and Drainage Line), to low (HR1; Hillcrest and Hillslope), with areas mapped as Disturbed considered poor (HR0). Foraging and/or dispersal activity of the species within the Study Area is likely to be dependent on the proximity of roost caves (particularly Category 1–2 roosts) with Pilbara leaf-nosed bats foraging up to 20 km from their roosts (Bat Call WA, 2021).

Although no potential Category 1–3 roost caves for the species occur within the Study Area, it is possible critical roosts occur within foraging distance, indicating the likely occurrence of foraging habitat within the Study Area. Despite the precise location not yet been confirmed, a presumed Category 1–2 roost is believed to occur in the south-east corner of Karijini National Park, approximately 25 km west of the Study Area (Biologic, 2019). Additionally, based on recent ultrasonic sampling for the Angelo River Project, another presumed Category 1–2 roost is considered to potentially occur in the vicinity (Biologic, in prep.), approximately 30 km to the south-west of the Study Area. It is possible that additional Category 1–3 roost caves, particularly category 3, occur in the broader vicinity of the Study Area, which may influence to occurrence of foraging and/or dispersing individuals within the Study Area.

Pilbara olive python has previously been recorded approximately 33 m north and 4.58 km west of Dep H (Table 3.5; Figure 3.1) and is considered Likely to occur within the Study Area. The species may occur as a resident within Gorge/Gully habitat Dep F North and Dep H, particularly where pooling of water is likely to occur for prolonged periods following rainfall. The species may also occur more broadly in Hillcrest and Hillslope and Drainage Line habitats to forage and/or disperse.

Peregrine falcon has previously been recorded approximately 14.7 km north of Dep H (Table 3.5; Figure 3.1). The species is considered Likely to occur within the Study Area; however, the frequency of occurrence is likely to be dependent on the proximity of nesting sites. Within the Study Area, potential nesting habitat is provided within Gorge/Gully, and some instances of breakaway in Hillcrest and Hillslope. Foraging is likely to occur throughout most habitats of the Study Area, primarily within Footslopes and Plain.

The fork-tailed swift has previously been recorded (2013) approximately 1.9 km south of Dep F North (Table 3.5; Figure 3.1). The species is a wide ranging but sparsely distributed species that occurs in a wide range of dry and/or open habitats (Johnstone & Storr, 1998). The species does not breed in Australia, migrating from breeding grounds in the northern hemisphere. During its occurrence in Australia, the species is almost exclusively aerial, feeding and possibly also roosting aerially (DoE, 2018). Therefore, the species is considered Likely to occur within the Study Area as an infrequent

visitor, during which it may forage in the airspace above all habitats occurring within the Study Area; however, landing or nesting within the Study Area is unlikely.

The northern short-tailed mouse, which has previously been recorded approximately 8.2 km west south-west of Dep F North (Table 3.5; Figure 3.1) is considered Likely to occur as a resident within the Footslopes and Plain habitat. The species occurrence, however, is likely to be variable and may fluctuate seasonally when resources for the species are more abundant, particularly following rainfall events

Of the four significant species considered Possible to occur within the Study Area (northern quoll, brush-tailed mulgara, grey falcon, and Pilbara flat-headed blind-snake), critical (primary breeding/ nesting, foraging and dispersal) habitat likely to support the species present within the Study Area is marginal and/or often occurs in smaller isolated patches with limited connectivity. Additionally, many species considered Possible have previously only been recorded in low abundance locally (i.e. northern quoll).

Northern quoll has previously been recorded from secondary evidence (scats) approximately 15.6 km north-east of Dep H (Biologic, 2021a) (Table 3.5; Figure 3.1). The species is considered Possible to occur, primarily within Gorge/Gully, and instances of breakaway in Hillcrest and Hillslope in the Study Area, which provide suitable areas of potential denning/shelter habitat. These habitats and, to a lesser extent, Drainage Line, may also provide foraging and/or dispersal habitat for the species, particularly where they provide connectivity to other areas of critical habitat.

The nearest record of brush-tailed mulgara is located approximately 43 km south south-west of Dep F North (DBCA, 2021b) (Table 3.5; Figure 3.1); however, it is considered Possible to occur within the Study Area. The species is often recorded from a range of sandy and stony plain habitats and may occur as a resident in Footslopes and Plain habitat of the Study Area where suitable vegetation cover and sandy or loamy substrates permitting burrowing are present. The species occurrence and abundance within the Study Area is likely to fluctuate seasonally when resources are more or less abundant.

Grey falcon has previously been recorded approximately 12.1 km north of Dep H (DBCA, 2021b) (Table 3.5; Figure 3.1). The species is considered Possible to occur within the Study Area; however, the frequency of occurrence is likely to be dependent on the proximity of nesting sites. Within the Study Area, potential nesting habitat is not provided for grey falcon, due to a lack of tall trees and suitable tall infrastructure (i.e. tall powerline and/or communications towers). Foraging is likely to occur throughout most habitats of the Study Area, primarily within Footslopes and Plain.

The Pilbara flat-headed blind-snake has previously been recorded approximately 15.3 km south south-west of Dep F North (Biologic unpublished data [Angelo River detailed fauna survey]) (Table 3.5; Figure 3.1) and is considered Possible to occur within the Study Area as a resident. It may occur within Gorge/Gully, and instances of breakaway within Hillcrest and Hillslope habitat, particularly where moist substrates and leaf litter accumulation occurs over prolonged periods.

Table 3.5: Likelihood of occurrence of significant fauna species within the Study Area

Species	Conservation Status			Preferred Broad Habitats	Nearest Records to the Study Area	Potential Habitat Within the Study Area				Comments	Likelihood of Occurrence	
	EPBC Act	BC Act	DBCA			Footslopes and Plain	Hillcrest and Hillslope	Gorge/Gully	Drainage Line		Dep F North	Dep H
Mammals												
Dasyuridae												
brush-tailed mulgara (*Dasycercus blythi*)			P4	Brush-tailed mulgara show a preference for spinifex *Triodia* spp. grasslands on sand plains and the swales between low dunes (Pavey *et al.*, 2012; Woolley, 2006). Mature spinifex hummocks appear to be important for protection from introduced predators (Körtner *et al.*, 2007).	~43 km SSW Dep F North (2014) (DBCA, 2021b)	•				May occur as a resident in Footslope and Plain habitat where suitable substrates permitting burrow construction are present. Occurrence and abundance likely to fluctuate seasonally when resources are abundant.	Possible	Possible
northern quoll (*Dasyurus hallucatus*)	EN	EN		The species tends to inhabit rocky habitats which offer protection from predators and are generally more productive in terms of availability of resources (Braithwaite & Griffiths, 1994) (Oakwood, 2000). Other microhabitat features important to the species include rock cover, proximity to permanent water and time-since last fire (Woinarski *et al.*, 2008).	~15.6 km NE H (2018) (Biologic, 2021a)		•	•	•	May occur as a resident within Gorge/Gully and, where instances of breakaway occur, within Hillcrest and Hillslope habitats. Additionally, Hillcrest and Hillslope and instances of Drainage Line habitat may also provide foraging and/or dispersal habitat, particularly were providing connectivity between areas of primary habitat within and in the vicinity of the Study Area.	Possible	Possible
Hipposideridae												
Pilbara leaf-nosed bat (*Rhinonicteris aurantia* (Pilbara form))	VU	VU		The Pilbara leaf-nosed bat roosts within caves and abandoned mines with high humidity (95%) and temperature (32°C) (Armstrong, 2001). The species forages in caves and along waterbodies with fringing vegetation (TSSC, 2016b).	~3.5 km NE Dep H (2018) (Rio Tinto, 2021a)	• (HR = 2)	• (HR = 1)	• (HR = 2)	• (HR = 2)	May occur within the Study Area during foraging and/or dispersal activities. Foraging may occur in Priority 2 (gullies within Gorge/Gully), Priority 3 (instances of rocky outcrop occurring with Hillcrest and Hillslope) and Priority 5 (open grassland and woodland, within Footslopes and Plain or Mixed Acacia Woodland) habitats (as defined by TSSC (2016b)). Drainage Line habitat may also provide a water source and occasional foraging habitat, particularly where pooling occurs following rainfall. Habitat rating (HR; as defined by Bat Call WA (2021)) of potential foraging habitat within the Study Area ranges from moderate (2) to low (1). Occurrence likely to be limited and influenced by the proximity of the Study Area to suitable roost caves. No potential roost caves present within Dep F North and Dep H.	Likely	Possible
Megadermatidae												
ghost bat (*Macroderma gigas*)	VU	VU		Ghost bats roost in deep, complex caves beneath bluffs of low, rounded hills, granite rock piles and abandoned Mines (Armstrong & Anstee, 2000). These features often occur within habitats including gorge/ gully, hill crest/ hill slope and low hills (Armstrong & Anstee, 2000). Forages broadly across habitats, particularly woodland and open woodland habitats, including eucalypt and mulga woodlands (Biologic, 2020; Richards *et al.*, 2008; Tidemann *et al.*, 1985; TSSC, 2016a).	~1.7 km S Dep F North (2018) (Rio Tinto, 2021a)	•		•		Species likely to forage and/or dispersal within Footslopes and Plain habitat of the Study Area. Occurrence likely to be limited and influenced by the proximity of roost sites within and in the vicinity of the Study Area. No potential roost caves are present within the Study Area.	Highly Likely	Highly Likely
Muridae												
northern short-tailed mouse (*Leggadina lakedownensis*)			P4	The species occupies a diverse range of habitats from the monsoon tropical coast to semiarid climates, including spinifex and tussock grasslands, samphire and sedgelands, *Acacia* shrublands, tropical eucalypt and Melaleuca woodlands and stony ranges; however, the species is usually found in seasonally inundated habitats on red or white sandy-clay soils (Moro & Kutt, 2008)	~8.2 km WSW Dep F North (1997) (DBCA, 2021b)	•				May occur as a resident within Footslopes and Plain, habitat of the Study Area. Occurrence and abundance likely to fluctuate seasonally when resources are abundant.	Likely	Possible

Species	Conservation Status			Preferred Broad Habitats	Nearest Records to the Study Area	Potential Habitat Within the Study Area				Comments	Likelihood of Occurrence	
	EPBC Act	BC Act	DBCA			Footslopes and Plain	Hillcrest and Hillslope	Gorge/Gully	Drainage Line		Dep F North	Dep H
western pebble-mound mouse (*Pseudomys chapmani*)			P4	This species occurs on the gentler slopes of rocky ranges where the ground is covered with a stony mantle and vegetated by hard spinifex, often with a sparse overstorey of eucalypts and scattered shrubs (Anstee, 1996; Start *et al.*, 2000).	Within Dep F North (Rio Tinto, 2021a)	•	•			Likely to occur as a resident within Hillcrest and Hillslope and Footslopes and Plain habitats throughout the Study Area where suitable stony substrates permitting burrow and mound construction present.	Confirmed (Rio Tinto, 2021a)	Highly Likely
Thylacomyidae												
greater bilby (*Macrotis lagotis*)	VU	VU		Occurs in a variety of habitats including spinifex hummock grassland and *Acacia* shrubland, on soft soils (Burrows *et al.*, 2012). In the Pilbara often associated with major drainage line sandy terraces (How *et al.*, 1991).	~24.9 km WNW Dep F North (1983) (DBCA, 2021b)					Suitable habitat not present.	Unlikely	Unlikely
Aves												
Apodidae												
fork-tailed swift (*Apus pacificus*)	MI	MI		Inhabits dry/open habitats, inclusive of riparian woodlands and tea-tree swamps, low scrub, heathland or saltmarsh, as well as treeless grassland and sandplains covered with spinifex, open farmland and inland and coastal sand-dunes (Johnstone & Storr, 1998). Almost exclusively aerial.	~1.9 km S Dep F North (2013) (DBCA, 2021b)	•	•	•	•	May infrequently occur within the airspace above all habitats of the Study Area during foraging and/or migratory activities; however, unlikely to land or nest.	Likely	Likely
Falconidae												
peregrine falcon (*Falco peregrinus*)		OS		Occupies arid areas and is most often encountered along cliffs above rivers, ranges and wooded watercourses where it hunts birds (Johnstone & Storr, 1998). It typically nests on rocky ledges occurring on tall, vertical cliff faces between 25 m and 50 m high (Olsen *et al.*, 2004; Olsen & Olsen, 1989).	~14.7 km N Dep H (2007) (DBCA, 2021b)	•	•	•	•	May occasionally occur within the Study Area to forage, particularly within Footslopes and Plain and, to a lesser extent, other habitats more broadly. Frequency of visitation may vary depending on proximity of nesting sites in the vicinity of the Study Area. Nesting may occur within Gorge/Gully and instances of breakaway within Hillcrest and Hillslope habitat.	Likely	Likely
grey falcon (*Falco hypoleucos*)	VU	VU		Inhabits timbered lowlands, particularly *Acacia* shrubland and along inland drainage systems. Also frequents spinifex and tussock grassland habitats to forage (Burbidge *et al.*, 2010; Olsen & Olsen, 1986).	~12.1 km N Dep H (2008) (DBCA, 2021b)	•			•	May occur within the Study Area to forage, particularly within Footslopes and Plain, and, to a lesser extent, other habitats more broadly. Frequency of visitation likely to vary depending on proximity of nesting location in vicinity of Study Area as there is no suitable nesting habitat within the Study Area.	Possible	Possible
Charadriidae												
oriental plover (*Charadrius veredus*)	MI	MI		Occurs in a variety of habitats, including coastal habitats, such as estuarine mudflats and sandbanks, on sandy or rocky ocean beaches as well as open inland environments such as, semi-arid or arid grasslands, where the grass is short and sparse (Johnstone & Storr, 2004).	~125 km NE (2011) (DBCA, 2021a)					Suitable habitat not present.	Highly Unlikely	Highly Unlikely
Hirundinidae												
barn swallow (*Hirundo rustica*)	MI	MI		The barn swallow is a non-breeding summer visitor to the Pilbara. It favors areas near water (Johnstone *et al.*, 2013).	~200 km N (2005) (DBCA, 2021a)					Suitable habitat not present.	Highly Unlikely	Highly Unlikely
Motacillidae												
grey wagtail (*Motacilla cinerea*)	MI	MI		A rare vagrant to Western Australia where it has been recorded within various habitats with open waterbodies (Johnstone & Storr, 2004).	~120 km N (2012) (DBCA, 2021a)					Suitable habitat not present.	Highly Unlikely	Highly Unlikely
yellow wagtail (*Motacilla flava*)	MI	MI		An uncommon but regular visitor to the Pilbara region (Johnstone *et al.*, 2013). Occupies a range of damp or wet habitats with low vegetation although favors edges of fresh water, especially sewage ponds (Johnstone & Storr, 2004).	~500 km NNE (2003) (DBCA, 2021a)					Suitable habitat not present.	Highly Unlikely	Highly Unlikely

Species	Conservation Status			Preferred Broad Habitats	Nearest Records to the Study Area	Potential Habitat Within the Study Area				Comments	Likelihood of Occurrence	
	EPBC Act	BC Act	DBCA			Footslopes and Plain	Hillcrest and Hillslope	Gorge/Gully	Drainage Line		Dep F North	Dep H
Psittacidae												
night parrot (*Pezoporus occidentalis*)	EN	CR		The night parrot prefers sandy/stony plain habitat with old-growth spinifex for roosting and nesting in conjunction with native grasses and herbs for foraging (DPaW, 2017).	~106 km NNE (2005) (DBCA, 2021a)					Suitable habitat not present.	Unlikely	Unlikely
Rostratulidae												
Australian painted snipe (*Rostratula benghalensis australis*)	EN	EN		Generally, occupies shallow terrestrial freshwater wetlands (i.e. temporary and permanent lakes, swamps and claypans) with rank emergent tussocks of grass, sedges, rushes or reeds, or samphire (Johnstone & Storr, 1998)	~100 km NW (2012) (DBCA, 2021a)					Suitable habitat not present.	Highly Unlikely	Highly Unlikely
Scolopacidae												
sharp-tailed sandpiper (*Calidris acuminata*)	MI	MI		Favors flooded samphire flats and grasslands, mangrove creeks mudflats, beaches, river pools, saltwork ponds, sewage ponds and freshwater soaks (Johnstone *et al.*, 2013).	~110 km ENE (2007) (DBCA, 2021a)					Suitable habitat not present.	Highly Unlikely	Highly Unlikely
curlew sandpiper (*Calidris ferruginea*)	CR/ MI	CR/ MI		Inhabits intertidal mudflats in sheltered coastal areas (i.e. estuaries, bays, inlets and lagoons) (Geering *et al.*, 2007). This rare species generally roosts on bare dry shingle, shell or sand beaches, sandspits and islets in or around coastal or near-coastal lagoons and other wetlands (Geering *et al.*, 2007).	~100 km E (2006) (DBCA, 2021a)					Suitable habitat not present.	Highly Unlikely	Highly Unlikely
pectoral sandpiper (*Calidris melanotos*)	MI	MI		Coastal lagoons, estuaries, bays, swamps, lakes, inundated grasslands, saltmarshes, river pools, creeks, floodplains and artificial wetlands (Johnstone & Storr, 2004; Johnstone *et al.*, 2013). It prefers wetlands with open fringing mudflats and low, emergent or fringing vegetation (Geering *et al.*, 2007)	~300 km N (2014) (DBCA, 2021a)					Suitable habitat not present.	Highly Unlikely	Highly Unlikely
common sandpiper (*Tringa hypoleucos*)	MI	MI		Estuaries and deltas of streams, as well as banks farther upstream; around lakes, pools, billabongs, reservoirs, dams and claypans (Geering *et al.*, 2007).	~120 km ENE (2018) (DBCA, 2021a)					Suitable habitat not present.	Highly Unlikely	Highly Unlikely
Reptiles												
Carphodactylidae												
Pilbara barking gecko (*Underwoodisaurus seorsus*)			P2	Little is known about the ecology of the Pilbara barking gecko, but the species is thought to prefer rocky areas, often associated with high elevation, with spinifex and low tree cover habitats (Chapple et al., 2019; Doughty & Oliver, 2011).	~1.8 km SW Dep F North (1997) (DBCA, 2021b) ~5.9 km SW Dep F North (2021) (Biologic unpublished data [Angelo River detailed fauna survey])		•			May occur as a resident within Hillcrest and Hillslope habitat, particularly areas of higher elevation. Unlikely to occur due to lack of high elevation within the Study Area.	Unlikely	Unlikely

Species	Conservation Status			Preferred Broad Habitats	Nearest Records to the Study Area	Potential Habitat Within the Study Area				Comments	Likelihood of Occurrence	
	EPBC Act	BC Act	DBCA			Footslopes and Plain	Hillcrest and Hillslope	Gorge/Gully	Drainage Line		Dep F North	Dep H
Pythonidae												
Pilbara olive python (*Liasis olivaceus barroni*)	VU	VU		Associated with drainage systems, including areas with localised drainage and watercourses (Pearson, 1993). In the inland Pilbara the species is most often encountered near permanent waterholes in rocky ranges or among riverine vegetation (Pearson, 1993).	~33 m N Dep H (1900) (DBCA, 2021b) ~4.5 km W Dep H (2018) (Biologic, 2021a)		•	•	•	May occur as a resident within Gorge/Gully habitat, particularly in areas where pooling water is likely to occur. May also occur more broadly within Hillcrest and Hillslope and Drainage Line habitats; however, occurrence likely to be limited to foraging and/or dispersal activities and dependent on proximity of critical (i.e. Gorge/Gully) habitat within and more broadly in the vicinity of the Study Area.	Possible	Likely
Scincidae												
lined soil-crevice skink (*Notoscincus butleri*)			P4	Recorded in areas dominated by spinifex and near water courses (Wilson & Swan, 2014). Records are restricted to a coastal area within the Lower Fortescue Hedland region.	~200 km NNW (2011) (DBCA, 2021a)					Study Area occurs outside species' current known range. Record returned in the desktop assessment likely to be erroneous.	Unlikely	Unlikely
Typhlopidae												
Pilbara flat-headed blind-snake (*Anilios ganei*)			P1	Little is known of the species' ecology, but it is often associated with moist soils and leaf litter within gorges and gullies (Wilson and Swan 2014), and potentially within a wide range of other stony habitats. The species has been recorded from numerous habitats but is most likely to be present in rocky terrain and along drainage lines (DBCA, 2021a).	~5.5 km N Dep H (1999) (DBCA, 2021b) ~15.3 km SSW Dep F North (2021) (Biologic unpublished data [Angelo River detailed fauna survey])		•	•		May occur as a resident in Gorge/Gully and instances of breakaway within Hillcrest and Hillslope habitat, particularly where moist substrates and leaf litter accumulation occurs over prolonged periods.	Possible	Possible

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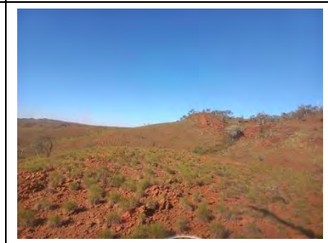
Appendix A: Vertebrate Fauna Habitat Assessments

Site ID	Coord.	WANG Consolidated Fauna Habitat Mapping Type (Biologic, 2021b)	Fauna Habitat Type (Rio Tinto, 2021b)	Landform	Aspect	Slope	Soil Type	Soil Avail.	Outcropping Rock Type	Rock Size	Veg. Litter	Dominant Veg. Type	Rocky Cracks / Crevices	Burrowing Suitability	Disturbances	Last Fire	Photo
Deposit H																	
VDEH-01	-23.1279, 118.9291	Gorge/Gully	Gorge/Gully	Gully	East	Moderate	Clay Loam	None Discernible	Moderate Outcropping (BIF)	Gravel (1-4cm)	Few Small Patches	Scattered Eucalypts, Spinifex Hummock Grassland	Moderate	Nil	None Discernible	Old (6+ yr)	
Deposit F North																	
VDFN-01	-23.1706, 118.8860	Drainage Line	Minor Drainage Line	Major Drainage Line	South/ West	Flat	Sandy Loam	Few Large Patches	Limited Outcropping (BIF)	Gravel (1-4cm)	Many Small Patches	Acacia Shrubland, Scattered Eucalypts, Tussock Grassland	Low	Moderate	None Discernible	Old (6+ yr)	
VDFN-02	-23.1699, 118.8289	Hillcrest and Hillslope	Breakaway/ Cliff	Hillcrest/ Upper Hillslope	South	Moderate	Clay Loam	None Discernible	Moderate Outcropping (BIF)	Pebbles (5-10cm)	Scarce	Scattered Eucalypts, Scattered Acacias, Spinifex Hummock Grassland	High	Nil	None Discernible	Recent (0 to 2 yr)	
VDFN-03	-23.1720, 118.8402	Gorge/Gully	Gorge/Gully	Gully	South	Low	Clay Loam	None Discernible	Moderate Outcropping (BIF)	Pebbles (5-10cm)	Few Small Patches	Scattered Eucalypts, Tussock Grassland	High	Nil	None Discernible	Old (6+ yr)	

Site ID	Coord.	WANG Consolidated Fauna Habitat Mapping Type (Biologic, 2021b)	Fauna Habitat Type (Rio Tinto, 2021b)	Landform	Aspect	Slope	Soil Type	Soil Avail.	Outcropping Rock Type	Rock Size	Veg. Litter	Dominant Veg. Type	Rocky Cracks / Crevices	Burrowing Suitability	Disturbances	Last Fire	Photo
VDFN-04	-23.1720, 118.8507	Drainage Line	Minor Drainage Line	Minor Drainage Line	Flat	Flat	Clay Loam	Few Small Patches	Limited Outcropping (BIF)	Pebbles (5-10cm)	Few Small Patches	Acacia Shrubland, Tussock Grassland	Low	Moderate	Road/ Access Track	Recent (0 to 2 yr)	

Appendix B: Vertebrate Fauna Recorded During the Current Survey

Species	Common Name	Conservation Status			Survey Area	
		EPBC Act	BC Act	DBCA	DEH	DFN
MAMMALS						
CANIDAE						
Canis familiaris	dog/ dingo					x
EMBALLONURIDAE						
Taphozous hilli	Hill's sheath-tailed bat				x	x
MOLOSSIDAE						
Austronomus australis	white-striped free-tailed bat				x	x
Chaerephon jobensis colonicus	greater northern free-tailed bat				x	
MURIDAE						
Zyzomys argurus	common rock-rat					x
VESPERTILIONIDAE						
Chalinolobus gouldii	Gould's wattled bat				x	x
Vespadelus finlaysoni	Finlayson's cave-bat				x	
BIRDS						
ACCIPITRIDAE						
Hamirostra melanosternon	black-breasted buzzard					x
COLUMBIDAE						
Geophaps plumifera	spinifex pigeon					x
CORVIDAE						
Corvus orru	Torresian crow					x
CRATICIDAE						
Cracticus nigrogularis	pied butcherbird					x
MALURIDAE						
Malurus lamberti	variegated fairy-wren					x
MELIPHAGIDAE						
Gavicalis virescens	singing honeyeater					x
OREOICIDAE						
Oreoica gutturalis	crested bellbird					x

E.4: West Angelas Deposit G Basic and Targeted Vertebrate Fauna Survey

Biologic Environmental Survey Pty Ltd
PO Box 179
Floreat, WA, 6014

15 December 2022

Attn: Elizabeth Mason and Carolyn Ellis

Rio Tinto Iron Ore

Dear Elizabeth and Carolyn,

Please find below a memo summarising the basic and targeted vertebrate fauna survey completed by Biologic Environmental Survey (Biologic) within unsurveyed areas of the Deposit G area for the West Angelas Project Envelope.

Yours sincerely,

Ryan Ellis
Principal Zoologist
ryan@biologicenv.com.au
(08) 6365 5066 | 0448 808 796

Reviewed by C. Knuckey 15th December 2022.

1. INTRODUCTION AND OBJECTIVES

Biologic were commissioned to undertake a basic and targeted vertebrate fauna survey of historically surveyed and unsurveyed areas of the Deposit G area within the West Angelas Project Envelope (herein the Study Area) (Figure 1.1). The Study Area is located centrally within the approved West Angelas Development Envelope and comprises a single area covering a total of 330.20 hectares (ha) (Figure 1.1).

The overarching objective of this assessment was to undertake a single season basic and targeted vertebrate fauna survey to identify the occurrence of vertebrate fauna species within the Study Area, with a particular focus on significant species (as per EPA (2020)), to inform future development and environmental approvals within the area. Significant species that were the focus of this survey are based on species identified in a previous desktop assessment completed for the broader West Angelas Revised Proposal Development Envelope, which encompasses the Study Area (Biologic, 2021a).

1.1. Conformance and Licensing

This assessment, particularly where suitable habitat for significant species was present, was carried out in a manner consistent with the following guidelines and recommendations from the Department of Climate Change, Energy, the Environment and Water (DCCEEW; formerly DAWE, DEHWA, DSEWPaC, DoE), the Environmental Protection Authority (EPA), relevant survey-specific license conditions and, where relevant, Rio Tinto guidelines and standards:

- DoE (2016) Environment Protection and Biodiversity Conservation (EPBC) Act referral guideline for the endangered northern quoll *Dasyurus hallucatus*;
- DEWHA (2010a) Survey guidelines for Australia's threatened bats;
- DEWHA (2010b) Survey guidelines for Australia's threatened birds;
- DoE (2013) Matters of National Environmental Significance: Significant impact guidelines 1.1;
- DSEWPaC (2011a) Survey guidelines for Australia's threatened mammals;
- DSEWPaC (2011b) Survey guidelines for Australia's threatened reptiles;
- EPA (2020) Technical Guidance: Terrestrial vertebrate fauna surveys for environmental impact assessment; and
- Rio Tinto (2021b) RTIO fauna habitat guidelines and definitions.

Fauna sampling was conducted under a DBCA Regulation 27 "Fauna Taking (Biological Assessment) License" (BA27000578) issued to Chris Knuckey. In accordance with Section 40 of the Biodiversity Conservation (BC) Act, threatened species sampling was completed under a DBCA "Authorisation to Take or Disturbed Threatened Species" (authorisation number TFA 2019-0183-4) issued to Chris Knuckey.

674000 675000 676000 677000 678000

7441000

7440000

Legend

Study Area — Pilbara Region

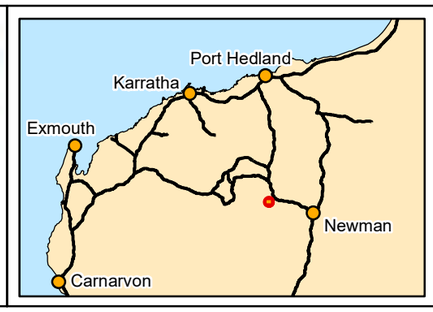
N

biologic Environmental Survey

Scale: 1:12,500

0 0.25 0.5 0.75 Km

Coordinate System: GDA2020 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA2020 Created 09/05/2022



RIO TINTO IRON ORE

Mt Ella, Depsit J and Deposit G Flora and Fauna Survey

Figure 1.1: Study Area and regional context

1.2. Background to Protection of Vertebrate Fauna

Terrestrial fauna may be considered significant species for a range of reasons, including:

- being identified as a threatened or priority species;
- being a species with restricted distribution;
- enduring a degree of historical impact from threatening processes; or
- providing an important function required to maintain the ecological integrity of a significant ecosystem (EPA, 2016).

All native fauna in Western Australia (WA) are protected at a state level under the BC Act and at a national level under the EPBC Act. Any action that has the potential to impact native fauna needs to be approved by relevant state and/or federal departments in accordance with the WA *Environmental Protection Act 1986* (EP Act) and the federal EPBC Act. While all native fauna is protected under these Acts, some species are afforded extra protection. These include species that are considered Threatened under the EPBC Act and/or BC Act, or; migratory bird species that are protected under international agreements and subsequently listed as Migratory under the EPBC Act and/or BC Act (Table 1.1). Furthermore, any species that may be threatened but for which there is insufficient information available to allocate a threatened status under the EBPC Act and/or BC Act, can also be listed as Priority species by DBCA (Table 1.1).

For the purposes of this assessment, significant species are those that are afforded protection under the EPBC Act, BC Act and/or listed as Priority by DBCA (Table 1.1). A summary of applicable legislation and status' is provided in Table 1.1.

Table 1.1: Definitions and terms for significant species

Act, Agreement or List	Status Codes
Federal	
EPBC Act In Australia, native fauna are protected under the EPBC Act. This Act makes provisions for an independent committee (the Threatened Species Scientific Committee [TSSC]), which is charged with maintaining a list of threatened species. Threatened species are listed under one of six categories, depending on their specific conservation status. Migratory bird species are those listed under international agreements and protected under the EPBC Act as a MNES. Relevant international agreements include the Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention), China-Australia Migratory Bird Agreement (CAMBA), Japan-Australia Migratory Bird Agreement (JAMBA), and Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA).	*Extinct:* • EX – Extinct • EW – Extinct in the Wild *Threatened:* • CR – Critically Endangered • EN – Endangered • VU – Vulnerable • CD – Conservation Dependent *Other:* • MI – Migratory
State	
BC Act In WA, native fauna are protected under the BC Act. Species in special need of protection are listed as being Extinct, Threatened or Specially Protected. Within these groups, species are listed under one of eight categories, depending on their specific conservation status. Migratory bird species are those listed under the Bonn Convention and/or CAMBA, JAMBA and ROKAMBA agreements.	*Extinct:* • EX – Extinct *Threatened:* • CR – Critically Endangered • EN – Endangered • VU – Vulnerable *Specially Protected:* • MI – Migratory • CD – Conservation Dependent • OS – Other specially protected fauna
DBCA Priority List The DBCA maintains a list of Priority species that are considered to be possibly threatened but have not been assigned statutory protection under the BC Act, as not enough information is available for an accurate determination of conservation status. These species are generally in urgent need of survey to determine their distribution and abundance.	*Poorly Known:* • P1 – Priority 1 • P2 – Priority 2 • P3 – Priority 3 *Rare, Near Threatened and other* • P4 – Priority

2. METHODS

2.1. Taxonomy and Nomenclature

The latest checklist of mammal, reptile and amphibian names published by the WAM (2022) was used as a guide to the current taxonomy and nomenclature of these groups. For birds, the current checklist of Australian birds maintained by Birdlife Australia (based on Christidis & Boles, 2008) was used in conjunction with the ABRS (2021) species list. While compiling a list of fauna potentially occurring in the Study Area, all records were checked to ensure the latest taxonomy, using recent papers and lists, was used.

2.2. Desktop Assessment

A desktop assessment was undertaken utilising information from a previous desktop assessment conducted by Biologic (2021a) for the broader West Angelas Beyond 2020 Development Envelope, which encompasses the Study Area. Additionally, any significant species records from the Biologic (2021a) field surveys were also considered for this assessment. The desktop assessment was used to further refine sampling methods to ensure appropriate sampling was undertaken for all target species and to allow an accurate assessment of their occurrence or likelihood of occurrence within the Study Area.

2.3. Field Survey

2.3.1. Survey Timing and Personnel

The field survey was undertaken over two days between the 21st and 24th of February 2022 by Principal Zoologist Ryan Ellis and Senior Zoologist Phil Runham, whom collectively have over 25 years of experience undertaking fauna surveys within the Pilbara region, including targeted surveys for the significant species that were the focus of this assessment (Table 2.1).

Table 2.1: Project Team and experience

Personnel	Position and Role	Qualification	Experience
Ryan Ellis	Principal Zoologist • project management • field survey • reporting	BESc Wildlife and Conservation Biology Dip Conservation and Land Management	12 years' EIA (consulting) 16 years' field survey 16 years' vertebrate zoology/ ecology
Phil Runham	Senior Zoologist • field survey	PhD Zoology Post Grad Dip Zoology BSc Zoology	16 years' EIA (consulting) 22 years' field survey 22 years' vertebrate zoology/ ecology

2.3.2. Climate and Weather

Observed weather conditions prior to and during the survey are shown in Figure 2.1, alongside long-term climatic data for Newman Airport (station #007176). In the 12 months prior to the survey (March 2021–February 2022), mean minimum and maximum temperatures recorded at Newman Airport were similar to the long-term averages for most months (Figure 2.1). Rainfall in the 12 months preceding the survey was variable, with below long-term averages recorded through most months, except for April 2021, which recorded well above the annual long-term average (56 mm v 21 mm), November 2021 (14 mm v 12 mm) and February 2022 (73 mm v 72 mm), which had rainfall consistent with long-term averages Figure 2.1. In total, the rainfall received in the 12 months prior to the survey (March 2021 to February 2022; 191.60 mm) was well below the annual long-term average (324.4 mm) (BoM, 2021).

Observed minimum temperatures during the survey were similar to the long-term average, while maximum temperatures were slightly higher (Table 2.2) (BoM, 2021). No rainfall was recorded during the survey (Table 2.2); however, a total of 73.0 mm was recorded in the two weeks prior (BoM, 2021).

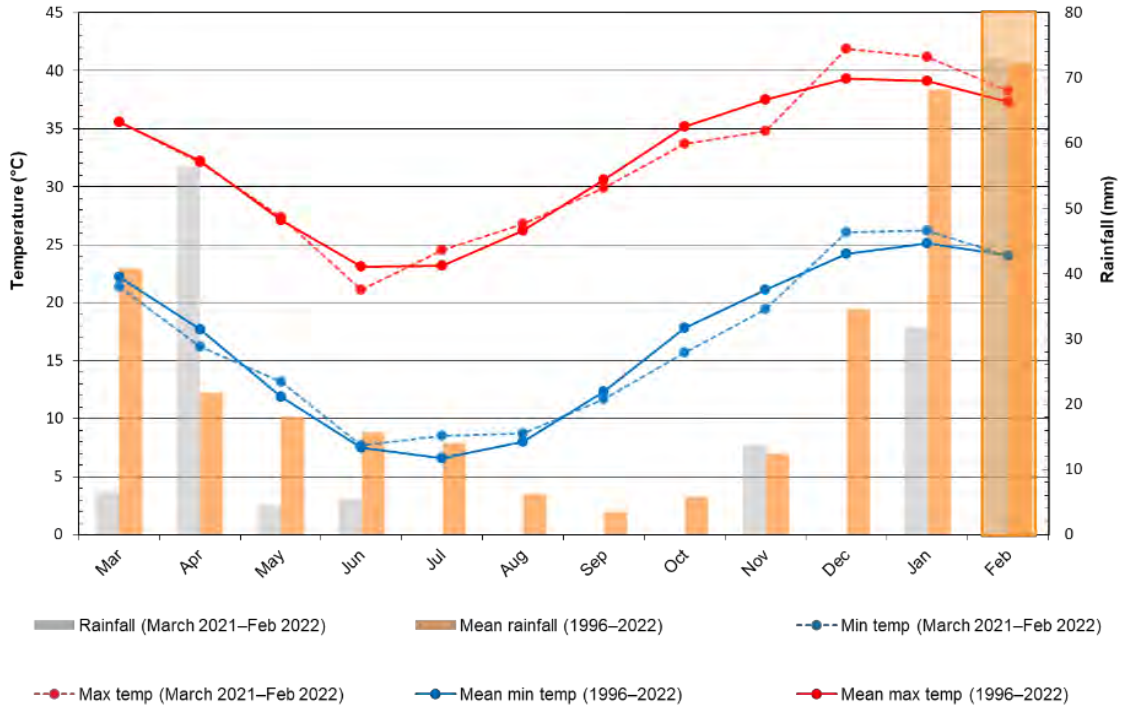


Figure 2.1: Monthly rainfall and long-term average rainfall for Newman Aero (Station ID 007176) (BoM, 2021) with approximate survey timing shown in shaded box

Table 2.2: Climatic conditions recorded for Newman Airport during the field survey

Date	Min. temp (°C)	Max. temp (°C)	Rainfall (mm)
21/02/2022	19.6	39.6	0
22/02/2022	20.1	40.7	0
23/02/2022	22.8	42.1	0
24/02/2022	24.2	42.2	0
Average/ total	**21.7**	**41.2**	**0**

2.3.3. Sampling and Survey Methods

Habitat Assessments and Mapping

Broad fauna habitats were previously defined and delineated for the West Angelas Development Envelope by Biologic (2021b), which encompasses the Study Area. During the field survey, Biologic (2021b) habitat mapping was ground truthed to verify fauna habitats and their significance to vertebrate fauna. Habitat assessments were undertaken at a total of nine locations within the Study Area during the field survey to define and delineate fauna habitats (Table 2.3; Figure 2.2; Appendix A). Following the field survey, broad fauna habitat mapping completed by Biologic (2021b) was reviewed with consideration of results of the field survey and, where deemed necessary, amended and refined to reflect field observations. Habitat assessments were conducted using methodology and terminology modified from the *Australian Soil and Land Survey Field Handbook* (National Committee on Soil and Terrain, 2009). The characteristics recorded during the habitat assessments were:

- site information: location and photo;
- habitat: broad habitat type, landform, aspect, slope, soil type and availability, rocky outcropping presence and type;
- ground cover: rock size, vegetation litter and woody debris;
- vegetation: broad vegetation type, structure and dominant species;
- condition: time since fire, disturbance and overall habitat condition; and
- microhabitat: rocky cracks/ crevices, burrowing suitability, hollow presence and abundance, water presence.

Water Feature and Cave Assessments

During the survey, searches were undertaken for any water features or caves occurring within the Study Area, particularly those that had the potential to support significant species (i.e. roosting caves for Pilbara leaf-nosed bat or ghost bat or water features likely to support Pilbara olive python).

Table 2.3: Fauna sampling effort

Site ID	Latitude	Longitude	Habitat assessment	Active searches (person hrs)	Bird census (min)	Targeted search (person hrs)[1]	Ultrasonic recording (nights)
VDEG-001	-23.1402	118.7210	●	1	20		3
VDEG-002	-23.1259	118.7250	●	1	20	searches undertaken for WPMM (1 hr)	
VDEG-003	-23.1372	118.7222	●	1	20		
VDEG-004	-23.1433	118.7106	●	1	20		
VDEG-005	-23.1441	118.7219	●	1	20		
VDEG-006	-23.1407	118.7167	●	1	20	searches undertaken for POP (1 hr)	
VDEG-007	-23.1345	118.7158	●	1	20		

Site ID	Latitude	Longitude	Habitat assessment	Active searches (person hrs)	Bird census (min)	Targeted search (person hrs)[1]	Ultrasonic recording (nights)
VDEG-008	-23.1275	118.7212	●	1	20		
VDEG-009	-23.1316	118.7260	●	1	20		
Total			**9**	**9**	**180**	**2**	**3**

[1] POP = Pilbara olive python, WPMM = western pebble-mound mouse.

Active Searches

Active searching was undertaken opportunistically throughout the Study Area, including at all locations habitat assessments were completed (Table 2.3; Figure 2.2). Sampling sites were selected to represent all broad fauna habitats and habitat features or microhabitats occurring within the Study Area. Active searching was undertaken for approximately nine person hours through the Study Area during the field survey.

Bird Census

A 20-minute bird census was undertaken at all nine locations habitat assessments were completed within the Study Area, equating to approximately three person hours in total (Table 2.3). Each census was completed over an area of approximately 2 ha and, where possible, confined to the habitat type represented by the site's habitat assessment. During each census, birds were identified by visual appearance, their characteristic calls and flight behaviour. Additionally, any birds opportunistically observed throughout the Study Area were also recorded.

Targeted Searches

Where suitable habitat considered to potentially support significant species identified in the desktop assessment was identified within the Study Area, targeted searches were undertaken. Targeted searches comprised searching for occurrence of target species from direct observation, secondary evidence (i.e. tracks, scats, sloughs and foraging evidence) and/or habitat features of importance to the species (i.e. dens, roost caves and water features). A total of two person hours of targeted searches was undertaken at two sites during the field survey, targeting Pilbara olive python and western pebble-mound mouse (Table 2.3).

Ultrasonic Recorders for Pilbara Leaf-nosed Bat and Ghost Bat

A SongMeter (SM; Wildlife Acoustics Inc.) ultrasonic bat recorder was deployed at a single location during the survey (Table 2.3; Figure 2.2). Due to the absence of any potential roosting habitat within the Study Area, the recorder was placed within a patch of open *Acacia* woodland in Footslopes and Plains habitat adjacent to a minor drainage line, representing prospective foraging and/or dispersal habitat. The recorder was deployed for three consecutive nights for a total of three recording nights. Audio settings, selectable filters and triggers were set to detect all species known to occur within the region, specifically ghost bat and Pilbara leaf-nosed bat (McKenzie & Bullen, 2009). Bat calls were analysed by Robert Bullen of Bat Call WA.

674000 675000 676000 677000 678000

7441000

7440000

VDEG-002
VDEG-008
VDEG-009
VDEG-007
VDEG-002
VDEG-001
VDEG-006
VDEG-005
VDEG-005

Legend

Study Area

Sampling Type

Acoustic recording

Habitat assessment

Traverse

Opportunistic and Driving

N

biologic Environmental Survey

Scale: 1:12,500

0 0.25 0.5 0.75 Km

Coordinate System: GDA2020 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA2020 Created 15/12/2022

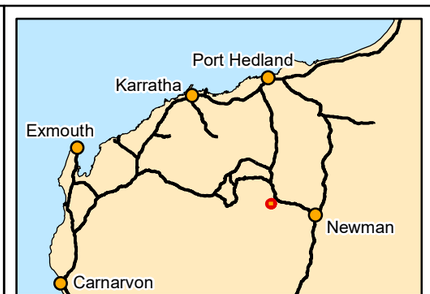


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Figure 2.2: Sample sites and traverses

Opportunistic Records

At all times while surveying, all records pertaining to species not previously recorded during the survey, particularly significant species, were documented. These records include those from primary (i.e. direct observation of species) or secondary (e.g. burrows, scratchings, diggings and scats) evidence.

2.3.4. Likelihood of Vertebrate Fauna Occurrence

Following completion of the field survey, significant species identified by the Biologic (2021a) desktop assessment were assessed for their likelihood of occurring within the Study Area using a decision matrix (Table 2.4). In the decision matrix, each species was assigned to one of six categories of likelihood: Confirmed, Highly Likely, Likely, Possible, Unlikely, or Highly Unlikely.

The decision matrix is intended to be an indicative guide only, and the way in which it is interpreted may vary between species, depending on a given species' habitat preferences and ability to disperse, as well as the reliability and availability of contextual information. For example, a species with a limited dispersal capability will have a reduced likelihood of occurring in the Study Area compared with a species with greater dispersal capability. It is also recognised that a lack of records in the vicinity of the Study Area may indicate limited sampling effort rather than species' absence, and that previous records may include historic or presumed erroneous information which may misrepresent a species' current distribution.

Where the determination of a species' likelihood of occurrence within the Study Area deviates from the decision matrix, detailed justification for any variation is provided.

Table 2.4: Species likelihood of occurrence decision matrix

		Habitat suitability of Study Area			
		Breeding habitat present	**Foraging and dispersal habitat present**	**Marginally suitable habitat[2] present**	**No suitable habitat present**
Species Records[1]	**Recorded in Study Area**	Confirmed	Confirmed	Confirmed	Confirmed
	Recorded within 10 km of Study Area	Highly Likely	Likely	Possible	Possible
	Recorded within 10–50km of Study Area	Likely	Possible	Possible	Unlikely
	Recorded within 50–100 km of Study Area	Possible	Possible	Unlikely	Unlikely
	Recorded >100 km of Study Area	Possible	Unlikely	Unlikely	Highly Unlikely
	Species considered locally/regionally extinct	Unlikely	Unlikely	Highly Unlikely	Highly Unlikely

[1] Only records within the previous 50 years are considered.

[2] Marginally suitable habitat is habitat which is possibly used by a species but is unlikely to be depended upon; for example, it may be used only when in proximity to core breeding, foraging or dispersal habitat.

2.3.5. Vertebrate Fauna Habitat Significance

Broad fauna habitat types mapped within the Study Area were assessed for their ability to support significant vertebrate fauna species and classified as being of high, medium or low, following criteria defined by Biologic (2021b) (Table 2.5). For the purposes of this assessment, critical habitat followed that of DoE (2013b), being areas necessary "for activities such as foraging, breeding, roosting, or dispersal". Within this, habitat types were recognised as providing primary habitat (i.e. critical habitat as per the definition above), or secondary habitat (i.e. habitats not critical for foraging, breeding, roosting or dispersal, but may support such activities and/or habitats of marginal suitability for such activities). Due to differing habitat preferences of conservation significant species (including habitat features and/or microhabitats), habitat significance was assessed on a species-by-species basis.

It should be noted that assessment of habitat significance applies only to habitat occurring within the Study Area, and therefore may not be representative of significance applied to the same habitat in other areas outside the Study Area. For example, a habitat within the Study Area may be deemed unsuitable due to the absence of certain habitat features which are required for the species persistence, despite the same habitat occurring outside the Study Area being considered of greater significance. The significance of a habitats within the Study Area may also be influenced by other habitats occurring within the Study Area and more broadly, including areas adjacent to the Study Area, particularly if representative of primary habitat.

Table 2.5: Fauna habitat significance assessment criteria

Score	Possible criteria (score results from any possible criterion being met)[1]
High	Fauna listed as threatened under the EPBC Act or BC Act have been recorded from this habitat type within the Study Area.
	Habitat known to be suitable core habitat[1] for EPBC Act and/or BC Act listed threatened fauna, and there are records of this species within 40 km^2.
	Habitat is regionally uncommon and known to support species listed as: • Threatened fauna under the EPBC Act and/or BC Act, but it is not their core habitat (e.g. may be used periodically/ seasonally or for dispersal). • Other Specially Protected Species under the BC Act. • DBCA listed Priority fauna, which are known to be solely reliant on this habitat.
Moderate	Habitat known to support EPBC Act and/or BC Act listed Migratory fauna.
	Habitat that is regionally uncommon (e.g., occurs in small and isolated areas) and supports a particularly diverse and uncommon faunal assemblage.
	Habitat is widespread and known to support species listed as: • Threatened fauna under the EPBC Act and/or BC Act, but it is not their core habitat (e.g., may be used periodically/ seasonally or for dispersal). • Other Specially Protected Species under the BC Act. • DBCA listed Priority fauna, which are known to be solely reliant on this habitat.
Low	Habitat that may meet the definition of core habitat[1] for EPBC Act and/or BC Act listed threatened fauna, however there are no records of this species within 40 kms.
	Habitat is widespread/common and does not solely support any DBCA listed Priority fauna.

[1] Core habitat is defined as containing the critical habitat elements for survival and reproduction of a species (Bingham & Noon, 1997) or as otherwise defined within relevant species recovery plans and guidelines. Note in instances where survey work over this area has been limited, then a precautionary approach is generally applied, and the species will be considered likely to be present.

2.3.6. Limitations

No potential limitations which are expected to have significantly impacted the results of the survey and/or the determined likelihood of occurrence assessments for significant species within the Study Area, as outlined by EPA (2020), were encountered during the survey. Although the current survey comprised only basic and targeted sampling, and no assessment was undertaken to determine broad faunal assemblages of the Study Area, vertebrate fauna assemblages are well documented from previous surveys undertaken within the vicinity of the Study Area which provide relevant contextual data. The current survey has utilised relevant components of previous surveys in the vicinity of the Study Area (i.e. desktop assessment, fauna habitat mapping and significant species records and likelihood of occurrence assessments) to build on the existing knowledge of vertebrate fauna assemblages and the occurrence of significant species within the Study Area and adjacent areas. With consideration of existing contextual survey effort and results in the vicinity of the Study Area, the broad fauna habitats present, including the absence of critical habitat for target MNES species, the combined basic and targeted level of survey effort within the Study Area is considered adequate for providing sufficient information on the vertebrate fauna values of the Study Area.

3. RESULTS AND DISCUSSION

3.1. Desktop Assessment

A total of 24 species of significance were identified as potentially occurring within the Study Area from the desktop assessment completed for the West Angelas Beyond 2020 detailed fauna assessment (Biologic, 2021a) (Table 3.1; Figure 3.1). No significant species have previously been recorded within the Study Area; however, five species have previously been recorded within 5 km, including:

- Pilbara leaf-nosed bat (*Rhinonicteris aurantia* (Pilbara form) – Vulnerable EPBC Act and BC Act) – 5.2 km south-west;
- grey falcon (*Falco hypoleucos* – Vulnerable EPBC Act and BC Act), ~2.3 km north-west;
- fork-tailed swift (*Apus pacificus* – Migratory EPBC Act and BC Act), ~1.7 km west;
- northern short-tailed mouse (*Leggadina lakedownensis* – Priority 4 DBCA), ~3.9 km south-southeast; and
- western pebble-mound mouse (*Pseudomys chapmani* – Priority 4 DBCA), ~280 m east.

Table 3.1: Significant species identified as potentially occurring in the Biologic (2021a) desktop assessment

Scientific Name	Common Name	Conservation Status		
		EPBC Act	BC Act	DBCA
Mammals				
Dasyuridae				
Dasycercus blythi	brush-tailed mulgara			P4
Dasyurus hallucatus	northern quoll	EN	EN	
Hipposideridae				
Rhinonicteris aurantia Pilbara form	Pilbara leaf-nosed bat	VU	VU	
Megadermatidae				
Macroderma gigas	ghost bat	VU	VU	
Muridae				
Leggadina lakedownensis	northern short-tailed mouse			P4
Pseudomys chapmani	western pebble-mound mouse			P4
Thylacomyidae				
Macrotis lagotis	greater bilby	VU	VU	
Aves				
Apodidae				
Apus pacificus	fork-tailed swift	MI	MI	
Charadriidae				
Charadrius veredus	oriental plover	MI	MI	
Falconidae				
Falco peregrinus	peregrine falcon		OS	

Scientific Name	Common Name	Conservation Status		
		EPBC Act	BC Act	DBCA
Falco hypoleucos	grey falcon	VU	VU	
Hirundinidae				
Hirundo rustica	barn swallow	MI	MI	
Motacillidae				
Motacilla cinerea	grey wagtail	MI	MI	
Motacilla flava	yellow wagtail	MI	MI	
Psittacidae				
Pezoporus occidentalis	night parrot	EN	CR	
Rostratulidae				
Rostratula benghalensis australis	Australian painted snipe	EN	EN	
Scolopacidae				
Calidris acuminata	sharp-tailed sandpiper	MI	MI	
Calidris ferruginea	curlew sandpiper	CR/ MI	CR/ MI	
Calidris melanotos	pectoral sandpiper	MI	MI	
Tringa hypoleucos	common sandpiper	MI	MI	
Reptiles				
Carphodactylidae				
Underwoodisaurus seorsus	Pilbara barking gecko			P2
Pythonidae				
Liasis olivaceus barroni	Pilbara olive python	VU	VU	
Scincidae				
Notoscincus butleri	lined soil-crevice skink			P4
Typhlopidae				
Anilios ganei	Pilbara flat-headed blind-snake			P1

640000 680000 720000

7440000 7400000

Packsaddle Rd
West Angelas Rd
MAC-C
MAC-E
Hope Downs 1
South Flank
Great Northern Hwy
Eagle Pool Rd
Snowy Mount
Turee Creek Rd

DBCA Database

Bird
- VU - grey falcon
- IA - fork-tailed swift
- OS- peregrine falcon

Mammal
- EN - northern quoll
- VU - ghost bat
- VU- greater bilby
- VU - Pilbara leaf-nosed bat
- P4 - brush-tailed mulgara
- P4 - northern short-tailed mouse
- P4 - western pebble-mound mouse

Reptile
- VU - Pilbara olive python
- P1- Pilbara flat-headed blind-snake
- P2 - unpatterned robust slider
- P2 - Pilbara barking gecko

RTIO Database

Bird
- P4 - letter-winged kite
- IA - fork-tailed swift

Mammal
- VU - ghost bat
- VU - Pilbara leaf-nosed bat
- P4 - western pebble-mound mouse, ngadji

Reptile
- P2- Pilbara barking gecko

Legend
- Study Area
- Operating Mine
- Local Road
- State Road

Biologic (2021a)

Bird
- IA - fork-tailed swift

Mammal
- EN - northern quoll
- P4 - western pebble-mound mouse
- VU - ghost bat
- VU - Pilbara leaf-nosed bat

Reptile
- VU - Pilbara olive python

N

biologic Environmental Survey

Scale: 1:349,000

0 10 20 Km

Coordinate System: GDA2020 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA2020 Created 15/12/2022

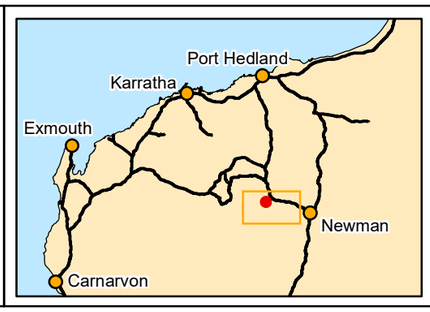

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Figure 2.4: Significant fauna recorded in the desktop assessment

3.2. Broad Fauna Habitats

Previous broad scale fauna habitat mapping of the Study Area completed by Biologic (2021a) was ground truthed and verified during the field survey. Existing mapping was consistent with the broad fauna habitat types and their extent occurring within the Study Area, therefore no changes or amendments were required made to the existing Biologic (2021a) mapping. A total of four broad fauna habitat types have been identified and mapped within the Study Area by Biologic (2021a) (Table 3.2; Figure 3.2), comprising, in decreasing order of extent (Table 3.2):

- Footslopes and Plain (265.82 ha; 80.50%);
- Drainage Line (4.56 ha; 1.38%);
- Hillcrest and Hillslope (2.65 ha; 0.80%); and
- Mixed Acacia Woodland (2.60 ha; 0.62%).

The remaining 16.70% (55.10 ha) of the Study Area comprised Disturbed areas, including land that has been cleared of vegetation for access tracks and/or exploration activities (i.e. drill pads).

The majority of the Study Area comprises Footslopes and Plain (80.50%), which is characterised by low-lying stony and/or alluvial plains and footslopes, often supporting open vegetation dominated by scattered mulga and/or eucalypts over mixed shrubs and low hummock grasslands on rocky and/or clay loam substrates. Of the four broad fauna habitats identified within the Study Area, one (Hillcrest/ Hillslope) is deemed to deemed of be of high value in the broader vicinity; however, it's occurrence within the Study Area is deemed to be low (Table 3.2). This is attributed to the absence of suitable habitat features (i.e. caves) which are often associated with the habitat in larger expanses of its occurrence outside the Study Area. Drainage Line was deemed to be of moderate value, as it may provide supporting habitat (foraging and/or dispersal) for a number of significant species (Table 3.2). The remaining habitats (Footslopes and Plain and Mixed Acacia Woodland) were deemed to be of low value (Table 3.2). These habitats are, however, relatively common and widespread in the surrounding region, and significant species occurrence within them is dependent on the occurrence of critical or high value habitat (i.e. breeding, nesting and/or roosting) proximal to the Study Area.

All broad fauna habitats mapped within the Study Area are relatively common and widespread within the broader vicinity of the Study Area and throughout the Pilbara region. While these habitats generally support significant species in the broader area, within the Study Area, they do not appear to be of increased value due to the absence of critical habitats within or adjacent to which are likely to be reliant upon by any significant species potentially occurring.

3.2.1. Habitat Features

A small flowing stream was recorded within mapped Drainage Line habitat during the field survey; however, it is likely the result of a dewatering discharge point from adjacent mining operations to the east of the Study Area. Vegetation within the vicinity of the stream is not indicative of groundwater dependence or influence by a permanent spring. No habitats supporting potential roost caves occur within the Study Area.

Table 3.2: Fauna habitat descriptions

Habitat Type	Description	Extent within the Study Area	Habitat for target Species	Representative Photo
Footslopes and Plain **Extent in Study Area: 265.82** ha (80.50%) **Vertebrate Fauna Significance:** Low	Footslopes and Plain habitat comprises low-lying open plains and the low rolling hills below upland areas. Vegetation is dominated by scattered *Eucalyptus* trees mixed *Acacia* and *Grevillea* shrubs over open *Triodia* hummock grassland on stony and/or clay loam substrates.	Footslopes and Plain habitat occurs throughout the majority of the Study Area (Figure 3.2). The habitat is common and widespread both within the Study Area and in the broader vicinity of the Study Area.	• **Pilbara leaf-nosed bat –** secondary foraging and/or dispersal (if proximal to primary roosting and breeding habitat, otherwise secondary foraging and/or dispersal) • **ghost bat –** primary foraging and/or dispersal (if proximal to primary roosting and breeding habitat, otherwise secondary foraging and/or dispersal) • **grey falcon –** secondary foraging (if proximal to primary nesting and breeding habitat) • **peregrine falcon –** primary foraging and/or dispersal (if proximal to primary nesting and breeding habitat) • **fork-tailed swift –** secondary foraging and/or dispersal • **brush-tailed mulgara –** core (breeding, foraging and dispersal) habitat • **northern short-tailed mouse** – core (breeding, foraging and dispersal) habitat • **western pebble-mound mouse –** core (breeding, foraging and dispersal) habitat	
Hillcrest and Hillslope **Extent in Study Area: 2.56** ha (0.80%) **Vertebrate Fauna Significance:** High/ Low	Hillcrest and Hillslope habitat comprises hills and undulating stony plains of higher elevation, supporting hard spinifex with a mantle of gravel and larger rocks with occasional minor outcropping. Vegetation is dominated by scattered *Eucalyptus* trees and *Acacia* and/or *Grevillea* shrubs over open *Triodia* hummock grassland with.	Hillcrest and Hillslope habitat occupies a small area in the southeast of the Study Area, forming part of a larger occurrence of the habitat that extends beyond the Study Area (Figure 3.2). The limited occurrence of this habitat within the Study Area is likely to be of low significance to vertebrate fauna, compared to its occurrence in the broader vicinity, which is considered high due to the occurrence of roost caves. This habitat is a common and widespread habitat throughout the surrounding region.	• **Pilbara leaf-nosed bat** – secondary foraging and/or dispersal (if proximal to primary roosting and breeding habitat, otherwise secondary foraging and/or dispersal) • **fork-tailed swift** – secondary foraging and/or dispersal • **western pebble-mound mouse –** core (breeding, foraging and dispersal) habitat	
Mixed Acacia Woodland **Extent in Study Area:** 2.06 ha (0.62%) **Vertebrate Fauna Significance:** Low	Mixed Acacia Woodland habitat comprises *Acacia* shrubland of varying density, often dominated by varying mulga (*Acacia aneura*), over open understory comprising scattered small shrubs and/or tussock and hummock grasses on stony and/or clay loam substrates. The habitat is often associated with plains subject to sheet flow following rainfall.	Within the Study Area, the occurrence of Mixed Acacia Woodland is limited to two small extents along the southern and eastern boundary, both of which form part of larger occurrences of the habitat beyond the Study Area (Figure 3.2). Mixed Acacia Woodland habitat is considered common and widespread in the broader vicinity of the Study Area.	• **Pilbara leaf-nosed bat –** secondary foraging and/or dispersal (if proximal to primary roosting and breeding habitat) • **ghost bat –** primary foraging and/or dispersal (if proximal to primary roosting and breeding habitat, otherwise secondary foraging and/or dispersal) • **fork-tailed swift –** secondary foraging and/or dispersal • **brush-tailed mulgara –** core (breeding, foraging and dispersal) habitat • **northern short-tailed mouse –** core (breeding, foraging and dispersal) habitat	

Habitat Type	Description	Extent within the Study Area	Habitat for target Species	Representative Photo
Drainage Line **Extent in Study Area:** 4.56 ha (1.38%) **Vertebrate Fauna Significance:** Moderate	Drainage Line habitat often occurs as an intersecting habitat within lower-lying areas of Footslopes and Plain habitat. Presence and persistence of water within Drainage Line habitat variable, is often influenced by rainfall and/or artificial water sources (i.e. dewatering discharge). Vegetation within the habitat is variable depending on presence of water, often comprising fringing vegetation dominated scattered *Eucalypts* and *Acacia* species over mixed shrub and tussock grassland understory. At the time of the field survey, flowing water was present within parts of Drainage Line habitat; however, with the exception of a small patch of *Typha*, the drainage line did not support vegetation that would suggest it is influenced by a permanent natural water source (i.e. natural spring). The occurrence of *Typha* indicates the likely influence of long-term infiltration of water because of dewatering discharge from adjacent mining operations east of the Study Area.	Drainage Line habitat intersects the Study Area at multiple locations; however, only occupies a small portion overall (Figure 3.2). The habitat is a commonly occurring habitat in the broader vicinity of the Study Area.	• **Pilbara leaf-nosed bat –** secondary foraging and/or dispersal (if proximal to primary roosting and breeding habitat) • **Pilbara olive python –** secondary foraging and/or dispersal (particularly if proximal to instances of critical habitat) • **fork-tailed swift –** secondary foraging and/or dispersal	
Disturbed **Extent in Study Area:** 55.10 ha (16.70%) **Vertebrate Fauna Significance:** Negligible	Disturbed and/or cleared areas (i.e. roads and access tracks, drill pads and other clearing)	Variable extents of disturbance occur throughout parts of the Study Area, primarily in the northern and eastern portions, primarily associated with the West Angelas rail line and mine access roads, exploration activity (drill pads and associated tracks) and numerous small access tracks (Figure 3.2).	• **fork-tailed swift –** secondary foraging and/or dispersal	

674000 675000 676000 677000 678000

7441000

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Legend

Study Area

Fauna Habitat

- Disturbed
- Drainage Line
- Footslopes and Plains
- Hillcrest and Hillslope
- Mixed Acacia Woodland

N

biologic Environmental Survey

Scale: 1:12,500

0 0.25 0.5 0.75 Km

Coordinate System: GDA2020 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA2020 Created 01/06/2022

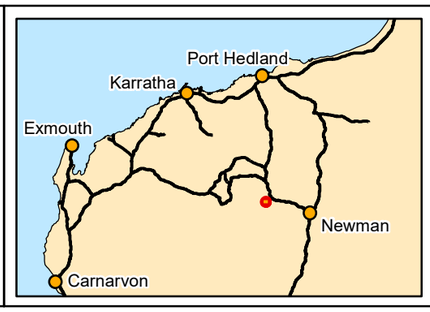

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Figure 3.2: Broad fauna habitats of the Study Area

3.3. Field Survey

During the current survey, a total of 25 species of vertebrate fauna species were recorded, comprising seven mammals (all bats), 16 birds, one reptile and one amphibian (Appendix B). No significant species were recorded during the field survey.

Of the 24 significant species identified in the desktop assessment, based on known species' distributions, previous records and the habitats present within the Study Area, one species was deemed Highly Likely to occur (western pebble-mound mouse), one was deemed Likely (fork-tailed swift) and seven were deemed Possible (Pilbara leaf-nosed bat, ghost bat, grey falcon, Pilbara olive python, peregrine falcon, brush-tailed mulgara and northern short-tailed mouse) (Table 3.3). The remaining 15 species are considered Highly Unlikely (n = 9) or Unlikely (n = 6) to occur within the Survey Area, primarily due to the absence of suitable habitat (Table 3.3).

No western pebble-mound mouse, or evidence of the species occurrence (i.e. pebble-mounds) were recorded within the Study Area during the field survey; however, the species has previously been recorded (2014) approximately 280 m east of the Study Area and is considered Highly Likely to occur (Table 2.4; Figure 3.1). The species is likely to occur as a resident within Hillcrest and Hillslope and Footslopes and Plains habitats, where suitable resources permitting burrow excavation and pebble-mound construction occur.

The fork-tailed swift was not recorded during the current survey; however, the species has previously been recorded (2013) approximately 1.7 km northwest of the Study Area (Table 2.4; Figure 3.1). The species is a wide ranging but sparsely distributed species that occurs in a wide range of dry and/or open habitats (Johnstone & Storr, 1998). The species does not breed in Australia, migrating from breeding grounds in the northern Hemisphere. During its occurrence in Australia, the species is almost exclusively aerial, feeding and possibly also roosting aerially (DoE, 2018). Therefore, the species is considered Likely to occur within the Study Area as an infrequent visitor, during which it may forage in the airspace above all habitats occurring within the Study Area; however, landing or nesting within the Study Area is unlikely.

Of the seven significant species considered possible to occur within the Study Area, critical (breeding/ nesting, foraging and dispersal) habitat likely to support the species was not recorded within the Study Area. All seven species are only considered as potentially occurring due to the presence of moderate value supporting habitat (i.e. foraging and dispersal) within the Study Area, for which utilisation and occurrence of habitats within the Study Area by these species is likely to be dependent on the presence of critical and/or high value habitat (i.e. denning and shelter, roosting (i.e. diurnal roost caves) and/or nesting habitat) proximal to the Study Area.

Pilbara leaf-nosed bat and ghost bat have previously been recorded approximately 5.2 km south-west and 5.3 km east north-east of the Study Area, respectively (Table 2.4; Figure 3.1) (Biologic, 2021c; DBCA, 2021b). Both species are considered to possibly occur within the Study Area; however, their occurrence is likely to be infrequent and limited to foraging and/or dispersal activities only. Foraging and/or dispersal habitat for Pilbara leaf-nosed bat is present, at varying capacities, within all four broad

fauna habitats mapped within the Study Area. Habitat rating (HR) of potential foraging habitat the four fauna habitats occurring within the Study Area (as defined by Bat Call WA (2022)) ranges from moderate (HR2; Footslopes and Plains and Drainage Line) to low (HR1; Hillcrest and Hillslope and Mixed Acacia Woodland), with areas mapped as Disturbed considered poor (HR0). Ghost bat may forage and/or disperse within Footslopes and Plains and Mixed Acacia Woodland habitats of the Study Area, particularly areas supporting open vegetation cover and suitable perching trees.

The frequency and extent of ghost bat and Pilbara leaf-nosed bat foraging within the Study Area is likely to be dependent on occurrence of roost caves proximal to the Study Area. Despite the precise location not yet been confirmed, a presumed Category 1–2 roost FOR Pilbara leaf-nosed bat is believed to occur in the south-east corner of Karijini National Park, approximately 13 km west of the Study Area (Biologic, 2019). Additionally, based on recent ultrasonic sampling for the Angelo River Project, another presumed Category 1–2 roost is considered to potentially occur in the vicinity (Biologic, in prep.), approximately 30 km to the south-west of the Study Area.

Three caves subject to long-term monitoring for ghost bat (caves A1, A2 and L2) are known to be utilised by the species (Biologic, 2022). Based on long-term monitoring data, A1 has been classified as a Category 2 cave, A2 is a Category 4 cave and L2 is a Category 3 (Biologic, 2022). An additional long-term monitoring roost (cave AA1), located approximately 11 km south-west of DFI, has recorded up to 25 individuals from scat genotyping and is a confirmed Category 2 roost (Biologic, 2022). It is possible that additional Category 1–3 roost caves, particularly category 3, for both ghost bat and Pilbara leaf-nosed bat occur in the broader vicinity of the Study Area, which may influence to occurrence of foraging and/or dispersing individuals within the Study Area.

Foraging and/or dispersal activity of both species within the Study Area is likely to be dependent on the presence of roost caves (particularly diurnal roosts) proximal to the Study Area. No potential roost caves for either species occur within the Study Area; however, inferred roosting by ghost bats (scats) has been recorded at three caves located approximately 5.3–6.3 km east north-east of the Study Area. Based on long-term monitoring of these caves (based on scat evidence), the species occurrence and utilisation has varied from 2015 to date, indicating roost usage may be intermittent (Biologic, 2021c).

Grey falcon and peregrine falcon have previously been recorded approximately 2.3 km north-west (1997) and 26.5 m northeast (2007) of the Study Area, respectively (Table 2.4; Figure 3.1) (DBCA, 2021b). Both species are considered to possibly occur within the Study Area; however, their occurrence is likely to be limited to foraging and/or dispersal events. Both species are widely distributed and will forage over large areas, therefore the frequency of occurrence within the Study Area is likely to be dependent on the proximity of nesting sites. No suitable nesting habitat for grey falcon and peregrine falcon occur within the Study Area, such as tall trees and infrastructure (i.e. power line or communications towers) for grey falcon and tall trees or rocky ledges (i.e. cliff faces) for peregrine falcon; however, potential nesting sites may occur in close proximity to the Study Area.

Pilbara olive python has previously been recorded from secondary evidence (scat) approximately 8.8 km west of the Study Area (Table 2.4; Figure 3.1) (Biologic, 2021a). The species may occasionally occur within Drainage Line habitat, particularly where water is present for prolonged periods. The species' occurrence is likely to be limited to foraging and/or dispersal activities and dependent on the proximity of high value critical habitat (i.e. Gorge/ Gully) in the vicinity of the Study Area.

The Brush-tailed Mulgara is often recorded from habitats comprising a range of sandy to stony plains and its likelihood of occurrence within the Study Area is Possible. The nearest record of the species is located approximately 40 km south southwest of the Study Area (Table 2.4; Figure 3.1) (DBCA, 2021b); however, the species likelihood of occurrence is considered Possible due to the presence of suitable habitat for the species. Within the Study Area, the species may occur as a resident in Mixed Acacia Woodland and Footslopes and Plain habitats, where suitable vegetation cover and sandy or loamy substrates permitting burrowing are present. Similarly, the northern short-tailed mouse, which has previously been recorded approximately 3.9 km south-southwest of the Study Area (Table 2.4; Figure 3.1) (DBCA, 2021b) is also considered Possible to occur as a resident within Mixed Acacia Woodland and Footslopes and Plain habitats. The occurrence of both species, however, is likely to be variable and may fluctuate seasonally when resources for the species are more abundant, particularly following rainfall events.

Table 3.3: Likelihood of occurrence of significant fauna species within the Study Area

Species	Conservation Status			Preferred Broad Habitats	Nearest Records to the Study Area	Potential Habitat Within the Study Area					Likelihood of occurrence	Comments
	EPBC Act	BC Act	DBCA			Footslopes and Plain	Disturbed	Hillcrest and Hillslope	Mixed Acacia Woodland	Drainage Line		
Mammals												
Dasyuridae												
brush-tailed mulgara (*Dasycercus blythi*)			P4	Brush-tailed mulgara show a preference for spinifex *Triodia* spp. grasslands on sand plains and the swales between low dunes (Pavey *et al.*, 2012; Woolley, 2006). Mature spinifex hummocks appear to be important for protection from introduced predators (Körtner *et al.*, 2007).	~40 km SSW (2014) (DBCA, 2021b)	•			•		Possible	May occur as a resident in Footslopes and Plain or Mixed Acacia Woodland habitats where suitable substrates permitting burrow construction are present.
northern quoll (*Dasyurus hallucatus*)	EN	EN		The species tends to inhabit rocky habitats which offer protection from predators and are generally more productive in terms of availability of resources (Braithwaite & Griffiths, 1994) (Oakwood, 2000). Other microhabitat features important to the species include rock cover, proximity to permanent water and time-since last fire (Woinarski *et al.*, 2008).	~8 km WNW (2018) (Biologic, 2021a)						Unlikely	Suitable habitat not present.
Hipposideridae												
Pilbara leaf-nosed bat (*Rhinonicteris aurantia* (Pilbara form))	VU	VU		The Pilbara leaf-nosed bat roosts within caves and abandoned mines with high humidity (95%) and temperature (32°C) (Armstrong, 2001). The species forages in caves and along waterbodies with fringing vegetation (TSSC, 2016b).	~5.2 km SW (2013) (DBCA, 2021b)	• (HR = 2)		• (HR = 1)	• (HR = 1)	• (HR = 2)	Possible	May infrequently occur within the Study Area during foraging and/or dispersal activities. Foraging may occur in Priority 5 (open grassland and woodland, within Footslopes and Plain or Mixed Acacia Woodland habitats) habitats (as defined by TSSC (2016b)). Drainage Line habitat may also provide a water source and occasional foraging habitat, particularly where pooling occurs. Habitat rating (HR; as defined by Bat Call WA (2022)) of potential foraging habitat within the Study Area ranges from moderate (2) to low (1). Occurrence however, likely to be limited and influenced by the proximity of the Study Area to suitable roost caves. No potential roost caves present within the Study Area.
Megadermatidae												
ghost bat (*Macroderma gigas*)	VU	VU		Ghost bats roost in deep, complex caves beneath bluffs of low, rounded hills, granite rock piles and abandoned Mines (Armstrong & Anstee, 2000). These features often occur within habitats including gorge/gully, hill crest/ hill slope and low hills (Armstrong & Anstee, 2000). Forages broadly across habitats, particularly woodland and open woodland habitats, including eucalypt and mulga woodlands (Biologic, 2020; Richards *et al.*, 2008; Tidemann *et al.*, 1985; TSSC, 2016a).	~5.3 km ENE (2014) (Biologic, 2014, 2021c)	•			•		Possible	Species may occur infrequently within the Study Area to forage and/or dispersal within Footslopes and Plain and Mixed Acacia Woodland habitats. Occurrence likely to be limited and influenced by the proximity if the Study Area to suitable roost caves. No roost caves present within the Study Area. Roosting has been inferred (from scats) at three caves subject to long-term monitoring approximately 5.3 km (Cave A1 and A2) and 6.3 km (Cave L3) ENE of the Study Area. The species occurrence (based on scat evidence) however, has varied between sampling events from 2015 to present) (Biologic, 2021c).
Muridae												
northern short-tailed mouse (*Leggadina lakedownensis*)			P4	The species occupies a diverse range of habitats from the monsoon tropical coast to semiarid climates, including spinifex and tussock grasslands, samphire and sedgelands, *Acacia* shrublands, tropical eucalypt and Melaleuca woodlands and stony ranges; however, the species is usually found in seasonally inundated habitats on red or white sandy-clay soils (Moro & Kutt, 2008)	~3.9 km SSW (1997) (DBCA, 2021b)	•			•		Possible	May occur as a resident within Mulga Woodland and/or Footslopes and Plain habitats of the Study. Occurrence and abundance likely to fluctuate seasonally when resources are abundant.
western pebble-mound mouse (*Pseudomys chapmani*)			P4	This species occurs on the gentler slopes of rocky ranges where the ground is covered with a stony mantle and vegetated by hard spinifex, often with a sparse overstorey of eucalypts and scattered shrubs (Anstee, 1996; Start *et al.*, 2000).	~280 m E (2014) (Rio Tinto, 2021a)	•		•			Highly Likely	Likely to occur in Footslopes and Plain and/or Hillcrest and Hillslope where suitable stony substrates permitting burrow and mound construction present.

Species	Conservation Status			Preferred Broad Habitats	Nearest Records to the Study Area	Potential Habitat Within the Study Area					Likelihood of occurrence	Comments
	EPBC Act	BC Act	DBCA			Footslopes and Plain	Disturbed	Hillcrest and Hillslope	Mixed Acacia Woodland	Drainage Line		
Thylacomyidae												
greater bilby (*Macrotis lagotis*)	VU	VU		Occurs in a variety of habitats including spinifex hummock grassland and *Acacia* shrubland, on soft soils (Burrows *et al.*, 2012). In the Pilbara often associated with major drainage line sandy terraces (How *et al.*, 1991).	~13 km NW (1983) (DBCA, 2021b)						Unlikely	Suitable habitat not present.
Aves												
Apodidae												
fork-tailed swift (*Apus pacificus*)	MI	MI		Inhabits dry/open habitats, inclusive of riparian woodlands and tea-tree swamps, low scrub, heathland or saltmarsh, as well as treeless grassland and sandplains covered with spinifex, open farmland and inland and coastal sand-dunes (Johnstone & Storr, 1998). Almost exclusively aerial.	~1.7 km NW (2013) (DBCA, 2021b)	•	•	•	•	•	Likely	May infrequently occur within the airspace above all habitats of the Study Area during foraging and/or migratory activities; however, unlikely to land or nest.
Charadriidae												
oriental plover (*Charadrius veredus*)	MI	MI		Occurs in a variety of habitats, including coastal habitats, such as estuarine mudflats and sandbanks, on sandy or rocky ocean beaches as well as open inland environments such as, semi-arid or arid grasslands, where the grass is short and sparse (Johnstone & Storr, 2004).	~125 km NE (2011) (DBCA, 2021a)						Highly Unlikely	Suitable habitat not present.
Falconidae												
peregrine falcon (*Falco peregrinus*)		OS		Occupies arid areas and is most often encountered along cliffs above rivers, ranges and wooded watercourses where it hunts birds (Johnstone & Storr, 1998). It typically nests on rocky ledges occurring on tall, vertical cliff faces between 25 m and 50 m high (Olsen *et al.*, 2004; Olsen & Olsen, 1989).	~26.5 km NE (2007) (DBCA, 2021b)	•					Possible	May occasionally occur within the Study Area to forage, particularly within Footslopes and Plain and/or, to a lesser extent, other habitats more broadly. Nesting unlikely to occur within the Study Area as suitable nesting sites (tall trees and/or rocky ledges) not present. Frequency of visitation may vary depending on proximity of nesting sites in the vicinity of the Study Area.
grey falcon (*Falco hypoleucos*)	VU	VU		Inhabits timbered lowlands, particularly *Acacia* shrubland and along inland drainage systems. Also frequents spinifex and tussock grassland habitats to forage (Burbidge *et al.*, 2010; Olsen & Olsen, 1986).	~2.3 km NW (1997) (DBCA, 2021b)	•					Possible	May possibly occur within the Study Area to forage, particularly within Footslopes and Plain, and/or, to a lesser extent, other habitats more broadly. Nesting unlikely to occur within the Study Area as suitable high nesting structures (trees, power line and/or transmission towers) not present. Frequency of visitation likely to vary depending on proximity of nesting location.
Hirundinidae												
barn swallow (*Hirundo rustica*)	MI	MI		The barn swallow is a non-breeding summer visitor to the Pilbara. It favors areas near water (Johnstone *et al.*, 2013).	~200 km N (2005) (DBCA, 2021a)						Highly Unlikely	Suitable habitat not present.
Motacillidae												
grey wagtail (*Motacilla cinerea*)	MI	MI		A rare vagrant to Western Australia where it has been recorded within various habitats with open waterbodies (Johnstone & Storr, 2004).	~120 km N (2012) (DBCA, 2021a)						Highly Unlikely	Suitable habitat not present.
yellow wagtail (*Motacilla flava*)	MI	MI		An uncommon but regular visitor to the Pilbara region (Johnstone *et al.*, 2013). Occupies a range of damp or wet habitats with low vegetation although favors edges of fresh water, especially sewage ponds (Johnstone & Storr, 2004).	~500 km NNE (2003) (DBCA, 2021a)						Highly Unlikely	Suitable habitat not present.
Psittacidae												
night parrot (*Pezoporus occidentalis*)	EN	CR		The night parrot prefers sandy/stony plain habitat with old-growth spinifex for roosting and nesting in conjunction with native grasses and herbs for foraging (DPaW, 2017).	~106 km NNE (2005) (DBCA, 2021a)						Unlikely	Suitable habitat not present.

Species	Conservation Status			Preferred Broad Habitats	Nearest Records to the Study Area	Potential Habitat Within the Study Area					Likelihood of occurrence	Comments
	EPBC Act	BC Act	DBCA			Footslopes and Plain	Disturbed	Hillcrest and Hillslope	Mixed Acacia Woodland	Drainage Line		
Rostratulidae												
Australian painted snipe (*Rostratula benghalensis australis*)	EN	EN		Generally, occupies shallow terrestrial freshwater wetlands (i.e. temporary and permanent lakes, swamps and claypans) with rank emergent tussocks of grass, sedges, rushes or reeds, or samphire (Johnstone & Storr, 1998)	~100 km NW (2012) (DBCA, 2021a)						Highly Unlikely	Suitable habitat not present.
Scolopacidae												
sharp-tailed sandpiper (*Calidris acuminata*)	MI	MI		Favors flooded samphire flats and grasslands, mangrove creeks mudflats, beaches, river pools, saltwork ponds, sewage ponds and freshwater soaks (Johnstone *et al.*, 2013).	~110 km ENE (2007) (DBCA, 2021a)						Highly Unlikely	Suitable habitat not present.
curlew sandpiper (*Calidris ferruginea*)	CR / MI	CR/ MI		Inhabits intertidal mudflats in sheltered coastal areas (i.e. estuaries, bays, inlets and lagoons) (Geering *et al.*, 2007). This rare species generally roosts on bare dry shingle, shell or sand beaches, sandspits and islets in or around coastal or near-coastal lagoons and other wetlands (Geering *et al.*, 2007).	~100 km E (2006) (DBCA, 2021a)						Highly Unlikely	Suitable habitat not present.
pectoral sandpiper (*Calidris melanotos*)	MI	MI		Coastal lagoons, estuaries, bays, swamps, lakes, inundated grasslands, saltmarshes, river pools, creeks, floodplains and artificial wetlands (Johnstone & Storr, 2004; Johnstone *et al.*, 2013). It prefers wetlands with open fringing mudflats and low, emergent or fringing vegetation (Geering *et al.*, 2007)	~300 km N (2014) (DBCA, 2021a)						Highly Unlikely	Suitable habitat not present.
common sandpiper (*Tringa hypoleucos*)	MI	MI		Estuaries and deltas of streams, as well as banks farther upstream; around lakes, pools, billabongs, reservoirs, dams and claypans (Geering *et al.*, 2007).	~120 km ENE (2018) (DBCA, 2021a)						Highly Unlikely	Suitable habitat not present.
Reptiles												
Carphodactylidae												
Pilbara barking gecko (*Underwoodisaurus seorsus*)			P2	Little is known about the ecology of the Pilbara barking gecko, but the species is thought to prefer rocky areas, often associated with high elevation, with spinifex and low tree cover habitats (Chapple et al., 2019; Doughty & Oliver, 2011).	~9.8 km ESE (1997) (DBCA, 2021b) ~12 km SE (2021) (Biologic unpublished data [Angelo River detailed fauna survey])						Unlikely	Suitable habitat not present.
Pythonidae												
Pilbara olive python (*Liasis olivaceus barroni*)	VU	VU		Associated with drainage systems, including areas with localised drainage and watercourses (Pearson, 1993). In the inland Pilbara the species is most often encountered near permanent waterholes in rocky ranges or among riverine vegetation (Pearson, 1993).	~8.8 km W (2018) (Biologic, 2021a)					•	Possible	May occur occasionally within Drainage Line habitat. Occurrence likely to be limited to foraging and/or dispersal activities and dependent on proximity of critical (i.e. Gorge/ Gully and/or Major Drainage) habitats more broadly in the vicinity of the Study Area.
Scincidae												
lined soil-crevice skink (*Notoscincus butleri*)			P4	Recorded in areas dominated by spinifex and near water courses (Wilson & Swan, 2014). Records are restricted to a coastal area within the Lower Fortescue Hedland region.	~200 km NNW (2011) (DBCA, 2021a)						Unlikely	Study Area occurs outside species' current known range. Record returned in the desktop assessment likely to be erroneous.
Typhlopidae												
Pilbara flat-headed blind-snake (*Anilios ganei*)			P1	Little is known of the species' ecology, but it is often associated with moist soils and leaf litter within gorges and gullies (Wilson and Swan 2014), and potentially within a wide range of other stony habitats. The species has been recorded from numerous habitats but is most likely to be present in rocky terrain and along drainage lines (DBCA, 2021a).	~10 km S (2018) (Biologic, 2021a)						Unlikely	Suitable habitat not present.

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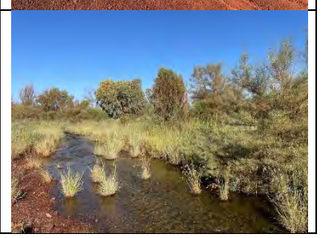
Appendix A: Vertebrate Fauna Habitat Assessments

Site ID	Coord.	Date	Habitat Type	Landform	Aspect	Slope	Soil Type	Soil Avail.	Outcropping Rock Type	Rock Size	Veg. Litter	Dominant Veg. Type	Rocky Cracks / Crevices	Burrowing Suitability	Disturbances	Last Fire	Photo
VDEG-001	-23.1402, 118.7210	21/02/2022	Footslopes and Plain	Drainage Area/ Floodplain	Flat	Flat	Sandy Clay Loam	Many Small Patches	Negligible	Gravel (1-4cm)	Many Small Patches	Mulga Woodland	Nil	Low	Cattle Grazing, Road/ Access Track	Old (6+ yr)	
VDEG-002	-23.1259, 118.7250	21/02/2022	Disturbed	Stony Plain	Flat	Flat	Clay Loam	Few Small Patches	Negligible	Gravel (1-4cm)	Scarce	Acacia Shrubland, Scattered Eucalypts, Spinifex Hummock Grassland, Tussock Grassland	Nil	Nil	Road/ Access Track	Moderate (3 to 5 yr)	
VDEG-003	-23.1372, 118.7222	24/02/2022	Footslopes and Plain	Drainage Area/ Floodplain	Flat	Flat	Clay Loam	Many Small Patches	Negligible	Negligible	Few Small Patches	Scattered Eucalypts, Tussock Grassland	Nil	Low	Road/ Access Track	Moderate (3 to 5 yr)	
VDEG-004	-23.1433, 118.7106	24/02/2022	Footslopes and Plain	Drainage Area/ Floodplain	Flat	Flat	Clay Loam	Evenly Spread	Negligible	Negligible	Many Small Patches	Scattered Eucalypts, Tussock Grassland	Nil	Low	Road/ Access Track	Moderate (3 to 5 yr)	
VDEG-005	-23.1441, 118.7219	24/02/2022	Disturbed	Stony Plain	Flat	Flat	Clay Loam	Few Small Patches	Negligible	Gravel (1-4cm)	Few Large Patches	Mulga Woodland, Spinifex Hummock Grassland	Nil	Low	Mining Exploration, Road/ Access Track	Old (6+ yr)	
VDEG-006	-23.1407, 118.7167	24/02/2022	Disturbed	Drainage Area/ Floodplain	Flat	Flat	Clay Loam	Many Small Patches	Negligible	Pebbles (5-10cm)	Scarce	Acacia Shrubland, Scattered Eucalypts, Tussock Grassland	Nil	Low	Road/ Access Track	Moderate (3 to 5 yr)	

Site ID	Coord.	Date	Habitat Type	Landform	Aspect	Slope	Soil Type	Soil Avail.	Outcropping Rock Type	Rock Size	Veg. Litter	Dominant Veg. Type	Rocky Cracks / Crevices	Burrowing Suitability	Disturbances	Last Fire	Photo
VDEG-007	-23.1345, 118.7158	24/02/2022	Footslopes and Plain	Stony Plain	Flat	Flat	Clay Loam	Few Large Patches	Negligible	Gravel (1-4cm)	Few Small Patches	Mulga Woodland, Spinifex Hummock Grassland	Nil	Nil	None Discernible	Old (6+ yr)	
VDEG-008	-23.1275, 118.7212	24/02/2022	Footslopes and Plain	Stony Plain	Flat	Flat	Clay Loam	Few Large Patches	Negligible	Gravel (1-4cm)	Scarce	Acacia Shrubland, Scattered Eucalypts, Spinifex Hummock Grassland	Nil	Nil	None Discernible	Moderate (3 to 5 yr)	
VDEG-009	-23.1316, 118.7258	24/02/2022	Footslopes and Plain	Stony Plain	Flat	Flat	Clay Loam	Evenly Spread	Negligible	Gravel (1-4cm)	Few Small Patches	Mulga Woodland, Spinifex Hummock Grassland	Nil	Low	None Discernible	Old (6+ yr)	

Appendix B: Vertebrate Fauna Recorded During the Current Survey

Species	Common Name	Conservation Status[1]		
		EPBC Act	BC Act	DBCA
MAMMALS				
EMBALLONURIDAE				
Saccolaimus flaviventris	yellow-bellied sheath-tailed bat			
Taphozous hilli	Hill's sheath-tailed bat			
MOLOSSIDAE				
Chaerephon jobensis colonicus	greater northern free-tailed bat			
VESPERTILIONIDAE				
Chalinolobus gouldii	Gould's wattled bat			
Scotorepens greyii	little broad-nosed bat			
Vespadelus finlaysoni	Finlayson's cave-bat			
BIRDS				
ARTAMIDAE				
Artamus cinereus	black-faced woodswallow			
CACATUIDAE				
Cacatua roseicapilla	galah			
Cacatua sanguinea	little corella			
CAMPEPHAGIDAE				
Coracina novaehollandiae	black-faced cuckoo-shrike			
COLUMBIDAE				
Ocyphaps lophotes plumifera	crested pigeon			
CORVIDAE				
Corvus orru	Torresian crow			
CUCULIDAE				
Centropus phasianinus	pheasant coucal			
Chrysococcyx basalis	Horsfield's bronze cuckoo			
ESTRILDIDAE				
Taeniopygia guttata	zebra finch			
LOCUSTELLIDAE				
Megalurus mathewsi	rufous songlark			
MALURIDAE				
Malurus leucopterus	white-winged fairy-wren			
MELIPHAGIDAE				
Gavicalis virescens	singing honeyeater			
MEROPIDAE				
Merops ornatus	rainbow bee-eater			
PSITTACIDAE				
Melopsittacus undulatus	budgerigar			
Platycercus zonarius	Australian ringneck			
RHIPIDURIDAE				
Rhipidura leucophrys	willie wagtail			

Species	Common Name	Conservation Status[1]		
		EPBC Act	BC Act	DBCA
REPTILES				
AGAMIDAE				
Ctenophorus caudicinctus	western ring-tailed dragon			
AMPHIBIANS				
HYLIDAE				
Litoria rubella	little red tree frog			

E.5: West Angelas Fauna Habitat Mapping

Biologic Environmental Survey Pty Ltd
PO Box 179
Floreat, WA, 6014

5 August 2021

Attn: Elizabeth Mason and Stephanie Stack

Rio Tinto Iron Ore

Level 12, Central Park

152-158 St Georges Terrace

Perth WA 6000

Dear Elizabeth and Stephanie,

Please find below a memo summarising the methods and outcomes of the West Angelas Development Envelope Fauna Habitat Mapping undertaken by Biologic Environmental Survey (Biologic).

1. Introduction and Objectives

Biologic were commissioned to undertake fauna habitat mapping for the West Angelas Revised Proposal Development Envelope (herein the Development Envelope). Additionally, regional mapping of habitats and their significance for vertebrate fauna species listed as Matters of National Environmental Significance (MNES) under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) was also undertaken within a 20-kilometre (km) radius of the Development Envelope (herein the Regional Extrapolated Mapping Area).

1.1 Objectives

The objectives of the fauna habitat mapping and extrapolated mapping were:

- Undertake a desktop assessment of fauna habitat mapping previously completed within the Development Envelope;
- Using the results of the desktop assessment and select data resources as a guide, complete revised and updated fauna habitat mapping of the Development Envelope;
- Undertake regional fauna habitat mapping of key MNES habitats within the Regional Extrapolated Mapping Area (as identified in Biologic, 2021a); and
- Provide a short technical memo to accompany fauna habitat mapping data, detailing methods and techniques used and any limitations.

2. Methods

2.1 Review of previous reports and mapping

A review of fauna habitats previously mapped was undertaken to determine likely fauna habitats occurring within the Development Envelope and the previously unmapped Regional Extrapolated Mapping Area beyond the Development Envelope. Biologic mapped the broad fauna habitats within the Development Area, and where possible was consistent with the fauna habitat types defined in previous fauna habitat mapping (Biologic, 2021a; ecologia, 2014); however, some habitat types were merged and/or not mapped due to the inability to map at a fine scale without ground-truthing. The Development Envelope mapping was undertaken using the following spatial data as guidance (as required by Rio Tinto):

- West Angelas Beyond 2020 Level 2 Vertebrate Fauna, SRE Invertebrate and Fauna Assessment Phase 1 & 2 (Biologic, 2021a);
- DBCA Cracking Clay PEC mapping; and
- MAR Area s45C mapping provided by Rio Tinto.

Additional supplementary spatial data was used as guidance:

- Greater West Angelas Terrestrial Fauna Assessment (ecologia, 2014);
- West Angelas Vegetation Mapping (Biologic, 2021b);
- Pre-European Vegetation Mapping;
- Aerial imagery – this spatial data can inform broad landforms including the presence of outcropping, gorges and gullies, and mulga-dominant plains; and
- Topographic data – this data can inform broad landform features such as slope and altitude, which can identify plains, ridges, and gorges.

2.1.1 Nomenclature of previous habitat naming

New fauna habitat mapping was developed by Biologic, and where possible, were aligned with existing mapping to ensure consistency (Biologic, 2021a; ecologia, 2014). No consolidation of the previous spatial data within the Development Envelopment was undertaken. Habitat classification was aligned with the six broad fauna habitats defined by Biologic (2021a) (Table 2.1). As requested by Rio Tinto at the time habitat mapping was completed, the habitat delineation and categorisation of Biologic (2021a) followed that of previous assessments conducted within the area, primarily classifications defined by ecologia (2014). As such, determination of habitat classifications for the mapping largely follows the pre-determined classifications of ecologia (2014).

A summary of the fauna habitat classifications defined in the Development Envelopment are provided in Table 2.1 (Biologic, 2021a; ecologia, 2014).

Table 2.1 : Habitat classification and descriptions adopted from Biologic (2021a) **and ecologia (2014)**

Habitat Type	Description
Biologic (2021a)	
Drainage Line	Drainage Line habitat is variable in structure and condition. Temporary, semi-permanent – permanent water pools can occur within this habitat, usually after rainfall events. Vegetation within this habitat is often dominated by *Eucalyptus* or *Melaleuca* species over a variable understory comprising mixed small to medium shrubs (*Acacia* sp.) and tussock grasses over sandy creek beds. Vegetation adjacent to the main channel or channels is denser, taller and more diverse than adjacent terrain. The structure and condition of vegetation often varies seasonally, particularly following rainfall events. Vegetation condition often subject to heavy cattle grazing.
Footslopes and Plain	Footslopes and Plain comprises low-lying open plains and the rolling hills below upland areas. Vegetation within this habitat varies in composition; however, is generally dominated by scattered mulga and *Acacia pruinocarpa* forming an over-storey, with a mid-storey comprising *Eremophila* and *Ptilotus* spp., over low hummock grasslands of *Triodia wiseana, T. basedowii, T. longifolia and T. pungens*. Scattered *Corymbia hamersleyana, Eucalyptus leucophloia, E. gamophylla* were also present.
Gorge/Gully	Gorges and gullies are rugged, steep-sided valleys incised into the surrounding landscape. Gorges tend to be deeply incised, with vertical cliff faces, while gullies are more open (but not as open as Drainage Area habitat or valleys). Caves and deep, rocky crevices are most often encountered in this habitat type, as are water pools. Vegetation can vary and can be dense and complex in areas of soil deposition or sparse and simple where exposed outcropping or erosion has occurred.
Hilcrest and Hillslope	Hillcrest and Hillslope habitat tends to be more open and structurally simple than other fauna habitats. A common feature of this habitat is a rocky substrate, often with exposed bedrock, and skeletal red soils. These can contain cracks and crevices, but not to the same extent as within rocky upland areas of Gorge/Gully habitat. This habitat is usually dominated by open *Eucalyptus* woodlands, *Acacia* and *Grevillea* scrublands and *Triodia* low hummock grasslands.
Mixed Acacia Woodland	Mixed Acacia Woodland habitat comprises areas where vegetation is a dense mix of *Acacia*, with a mixture of mulga (*Acacia aneura*), *Acacia maitlandii* and *Acacia pruninocarpa* over a mixture of sparse small shrubs and grasses, such a *Triodia* and *Senna* species and *Ptilotus* sp. Dense leaf litter, and woody debris is a common feature of this habitat type. The soils consist of loam clay with continuous layers of small ironstone pebbles on the surface. The habitat is mostly flat with no or very small drainage channels.
ecologia (2014)	
Cracking Clay	Cracking clay habitat is characterised by open and sparse low vegetation with approximately half of its area being bare ground. Isolated shrubs of *Salsola australis, Boerhavia paludosa* and *Ptilotus nobilis* subsp. *nobilis* occur over open tussock grassland of *Aristida* sp., *Brachyachne* sp. and *Astrebla pectinata.* The soil is often dark orange sand-clay to clay with an undulating surface caused by crabholes and gilgai. Rocks and pebbles are often very rare and when present, the rock type is consistently ironstone.

2.2 Extrapolated habitat mapping within previously unmapped areas

Extrapolation of habitat mapping was completed within the Regional Extrapolated Mapping Area where no previous mapping has occurred. The habitat classification was aligned with habitats defined by Biologic (2021a) and ecologia (2014). The scale of mapping was aligned with Biologic (2021a) where possible (1:100,000). This extrapolated mapping was undertaken without any ground-truthing, and as such took also into consideration the following;

- the adjacent habitat mapping and associated descriptions;
- Pre-European vegetation mapping;
- aerial imagery – this spatial data can inform broad landforms including the presence of outcropping, gorges and gullies, and mulga-dominant plains; and
- topographic data – this data can inform broad landform features such as slope and altitude, which can identify plains, ridges, and gorges.

The attributes of the new mapping were adjusted to reflect the Rio Tinto data standards where possible due to the lack of ground-truthing in these areas.

2.1 Regional MNES fauna habitat extrapolation

Extrapolation of habitats of significance was undertaken within the Regional Extrapolated Mapping Area for six MNES species:

- northern quoll (*Dasyurus hallucatus*) – Endangered;
- greater bilby (*Macrotis lagotis*) – Vulnerable;
- ghost bat (*Macroderma gigas*) – Vulnerable;
- Pilbara leaf-nosed bat (*Rhinonicteris aurantius* 'Pilbara form') – Vulnerable;
- night parrot (*Pezoporus occidentalis*) – Endangered; and
- Pilbara olive python (*Liasis olivaceus barroni*) – Vulnerable.

For the purposes of this assessment, critical habitat followed that of DoE (2013), being areas necessary "for activities such as foraging, breeding, roosting, or dispersal". Habitat critical to the survival of a species is defined by DoE (2013) as areas *"necessary for activities such as foraging, breeding, roosting, or dispersal, the long-term maintenance of the species, to maintain genetic diversity and long term evolutionary development, or for the reintroduction of populations or recovery of the species"*. Habitats considered marginally suitable were deemed to be of moderate significance.

As requested by Rio Tinto, habitat significance assigned to habitats herein align with those adopted by Biologic (2021a) for each of the habitat types occurring within the Development Envelope and Regional Extrapolated Mapping Area (Table 2.2). Due to the degree of variation within the broad fauna habitat mapped and likely differing degree of significance for particular species in any one area, the significance scores assigned by Biologic (2021a) were used to guide the scoring of habitat more broadly mapped within the regional habitat mapping.

As habitat preferences of some conservation significant species differ (including habitat features and/or microhabitats), habitat significance was assessed on a species-by-species basis to provide species specific classification of habitats.

The regional mapping was undertaken without any ground-truthing, and as such took into consideration the same factors as outlined in Section 2.2. The disturbance spatial data provided by Rio Tinto was available for the Development Envelope but did not extend to the regional extrapolation area. As such, fine-scale disturbance (roads, drill-pads, tracks) was not mapped throughout the regional extrapolation, although large-scale mining activity (mining pits, camps, large infrastructure) was mapped.

Table 2.2 Habitats of significance at West Angelas for MNES species, adapted from Biologic (2021a)

Habitat Type	Significance to target species					
	Northern quoll	**Greater bilby**	**Pilbara leaf-nosed bat**	**Ghost bat**	**Night parrot**	**Pilbara olive python**
Gorge/Gully	**High -** Provides core habitat (shelter, denning and foraging). Consistent with core habitat as described by DoE (2013).	Provides nil habitat.	**High –** Provides core roosting habitat (caves). Provides Consistent with core habitat as described by DoE (2013).	**High –** Provides core roosting habitat (caves). Provides Consistent with core habitat as described by DoE (2013).	Provides nil habitat.	**High -** Provides core denning and shelter habitat. Consistent with core habitat as described by DoE (2013).
Drainage Line	**Moderate** - Provides potential foraging and dispersal habitat. Consistent with core habitat as described by DoE (2013).	Provides nil habitat	**Moderate** - Provides high value foraging and dispersal habitat. Consistent with core habitat as described by DoE (2013).	**Moderate** - Provides high value foraging and dispersal habitat. Consistent with core habitat as described by DoE (2013).	Provides nil habitat.	**High -** Provides shelter, foraging, and dispersal habitat. Consistent with core habitat as described by DoE (2013).
Hillcrest and Hillslope	**Moderate** - Provides potential foraging and dispersal habitat. Consistent with core habitat as described by DoE (2013).	Provides nil habitat.	**Low** - Provides limited foraging habitat potential.	**Low** - Provides limited foraging habitat potential.	Provides nil habitat.	**Low** - Provides limited foraging habitat potential.
Footslopes and Plain	**Low -** Provides low quality foraging and dispersal habitat.	**Low -** Provides low quality foraging and burrowing habitat.	**Moderate** - Provides value foraging and dispersal habitat. Consistent with core habitat as described by DoE (2013).	**Moderate** - Provides value foraging and dispersal habitat. Consistent with core habitat as described by DoE (2013).	**Low -** Provides low quality nesting/ foraging habitat depending on the quality of vegetation present.	**Low -** Provides low quality foraging and dispersal habitat.
Mixed Acacia Woodland	**Low -** Provides low quality foraging and dispersal habitat.	**Low -** Provides low quality foraging and burrowing habitat.	**Moderate** - Provides high value foraging and dispersal habitat. Consistent with core habitat as described by DoE (2013).	**Moderate** - Provides value foraging and dispersal habitat. Consistent with core habitat as described by DoE (2013).	**Low -** Provides low quality nesting/ foraging habitat depending on the quality of vegetation present.	**Low -** Provides low quality foraging and dispersal habitat.
Cracking Clay	**Low -** Provides low quality foraging and dispersal habitat.	**Low -** Provides low quality foraging and burrowing habitat.	**Moderate** - Provides value foraging and dispersal habitat. Consistent with core habitat as described by DoE (2013).	**Moderate** - Provides value foraging and dispersal habitat. Consistent with core habitat as described by DoE (2013).	**Low -** Provides low quality nesting/ foraging habitat depending on the quality of vegetation present.	**Low -** Provides low quality foraging and dispersal habitat.
Disturbed	Provides nil habitat.	Provides nil habitat.	Provides nil habitat.	Provides nil habitat.	Provides nil habitat.	Provides nil habitat.

3. Limitations

The limitations associated with the fauna habitat mapping and extrapolation mapping completed within the Development Envelope and Regional Extrapolated Mapping Area are outlined below:

- Both the Development Area mapping and Regional Extrapolation Mapping Area of significant fauna habitats inevitably involved a high level of interpretation as these processes were done through desktop methods alone, and without ground-truthing via habitat assessments or sampling to verify classification and/or significance. Therefore, a degree of error may occur for some areas where large scale extrapolation has occurred, particularly where habitats or habitat features cannot be readily distinguished from aerial imagery (i.e. Cracking Clay habitat).
- The extrapolation of new habitats was also limited to a broad scale as comparable to that of Biologic (2021a), and as such does not necessarily depict fine-scale habitat features.
- Natural variation of each extrapolated habitat exists in the regional setting of the Development Envelope.
- The scale at which the extrapolated habitats were mapped would not allow for accurate mapping of 'Minor Drainage Line' habitat; as such, all drainage areas were consolidated as "Drainage Lines".
- The disturbance spatial data provided by Rio Tinto was available for the Development Envelope but did not extend to the Regional Extrapolation Mapping Area; therefore regional disturbance is not accurately delineated due the degree of variation in disturbance shown in available aerial imagery (i.e. older aerial imagery is unlikely to show current disturbance throughout the mapped area).
- The TEC PEC (cracking clay) spatial data provided by Rio Tinto was available for the Development Envelope but did not extend to the Regional Extrapolation Mapping Area, therefore the habitat was not mapped regionally as it cannot be readily distinguished from aerial imagery.

4. Results and Discussion

The delineation of fauna habitat mapping within the Development Envelope and Regional Extrapolated Mapping Area was informed via desktop assessment and aerial imagery including land system mapping, pre-European vegetation mapping and topography (contours). The desktop assessment involved a review of available spatial data from surveys completed within the Development Envelope and the Regional Extrapolated Mapping Area. The habitat types identified within the Development Envelope and Regional Extrapolated Mapping Area, and the land systems in which these habitats occur, are considered typical of the region.

A total of 41,492.39 hectares (ha) was mapped within the Development Envelope, as well as 326,000 ha of extrapolated mapping undertaken to accommodate a 20 km buffer around the Development Envelope boundary (Table 4.1; Figure 4.1). Seven fauna habitats (including Disturbed) were mapped comprising, in increasing order of extent; Hillcrest and Hillslope, Footslope and Plain, Disturbed, Mixed

Acacia Woodland, Gorge/Gully, Drainage Line and Cracking Clay covering 36.83%, 33.63%, 17.00%, 7.97%, 2.36%, 1.17% and 1.04% of the Development Area, respectively (Table 4.1). The Regional Extrapolated Mapping Area mapping included in increasing order of extent; Footslopes and Plain (56.75%), Hillcrest and Hillslope (34.06%), Gorge/Gully 6.77%, Disturbed (1.05%), Drainage Line (1.04%), and Mixed Acacia Woodland (0.32%) (Table 4.1).

This Development Envelope and Regional Extrapolated Mapping Area mapping includes habitats considered of significance to MNES species (Table 2.2; Table 4.1), including Gorge/Gully and Drainage Line habitats. Gorge/Gully is considered of high significance for the northern quoll, ghost bat, Pilbara leaf-nosed bat and Pilbara olive python and covers approximately 2.36% (979.75 ha) of the Development Envelope and 6.77% (22,068.27 ha) of the Regional Extrapolated Mapping Area (Table 2.2; Table 4.1; Table 4.2). Drainage Line habitat is classified as high significance for the Pilbara olive python and moderate significance for the northern quoll, ghost bat and Pilbara leaf-nosed bat, covering approximately 1.17% (485.65 ha) of the Development Envelope and 1.04% (3,386.63 ha) of the Regional Extrapolated Mapping Area (Table 2.2; Table 4.1; Table 4.2).

Table 4.1: Summary of extrapolated habitat mapped for the current project

Habitat	Area (ha)	Extent in the area (%)
Development Area		
Hillcrest and Hillslope	15,282.80	36.83
Footslopes and Plain	13,952.36	33.63
Disturbed	7,053.87	17.00
Mixed Acacia Woodland	3308.19	7.97
Gorge/Gully	979.75	2.36
Drainage Line	485.65	1.17
Cracking Clay	429.79	1.04
Total	**41,492.39**	**-**
Regional Extrapolated Mapping Area		
Footslopes and Plain	185,014.12	56.75%
Hillcrest and Hillslope	111,051.46	34.06%
Gorge/Gully	22,068.27	6.77%
Disturbed	3,426.51	1.05%
Drainage Line	3,386.63	1.04%
Mixed Acacia Woodland	1,053.0	0.32%
Total	**326,000**	**-**

Table 4.2 Summary of habitat significance by area for each MNES species potentially present

Habitat significance	Northern quoll		Greater bilby		Pilbara leaf-nosed bat		Ghost bat		Night parrot		Pilbara olive python	
	Development Envelope	Regional Extrapolated Mapping Area	Development Envelope	Regional Extrapolated Mapping Area	Development Envelope	Regional Extrapolated Mapping Area	Development Envelope	Regional Extrapolated Mapping Area	Development Envelope	Regional Extrapolated Mapping Area	Development Envelope	Regional Extrapolated Mapping Area
High	979.75	22,068.27	0	0	979.75	22,068.27	979.75	22,068.27	0	0	1,465.40	25,454.9
Moderate	15,768.45	114,438.08	0	0	17,746.20	189,453.77	17,746.20	189,453.77	0	0	0	0
Low	21.774.21	186,067.14	17,690.34	186,067.14	15,282.80	11,1051.46	15,282.80	111,051.46	17,690.34	186,067.14	32,973.14	29,7118.6
Nil	7,053.87	3,426.51	23,802.07	139,932.87	7,053.87	3,426.51	7,053.87	3,426.51	23,802.07	139,932.87	7,053.87	3,426.51

660000
670000
680000
690000
7440000
7430000
Great Northern Hwy

Legend

- Study Area
- State Road

Fauna Habitat Mapping

Broad Fauna Habitat

- Cracking Clay
- Disturbed
- Drainage Line
- Footslopes and Plains
- Gorge/Gully
- Hillcrest and Hillslope
- Mixed Acacia Woodland

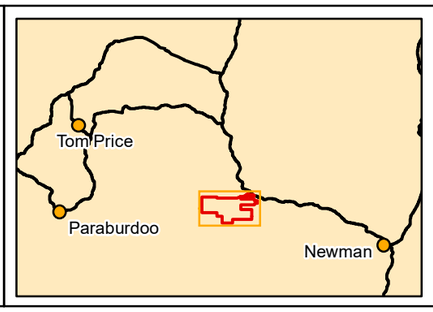
N

biologic Environmental Survey

Scale: 1:99,500

0 2 4 Km

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994 Created 04/08/2021



RIO TINTO IRON ORE
West Angelas
Fauna Habitat Mapping

Figure 4.1: Fauna habitats in the Development Envelope

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E.6: West Angelas Beyond 2020 Targeted Vertebrate Fauna Survey

West Angelas Beyond 2020:

Targeted Vertebrate Fauna Survey

Biologic Environmental Survey

Report to Rio Tinto Iron Ore

January 2021

DOCUMENT STATUS				
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GLOSSARY

BC Act	*Western Australian Biodiversity Conservation Act 2016*
DBCA	Department Biodiversity, Conservation and Attractions
DPaW	Department of Parks and Wildlife
DEWHA	Department of Environment, Water, Heritage and the Arts
DoE	Department of the Environment
DoEE	Department of the Environment and Energy
DSEWPaC	Department of Sustainability, Environment, Water, Population and Communities
EPA	Western Australian Environmental Protection Authority
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
Dep-F	Deposit F North
Dep-H	Deposit H
Dep-J	Deposit J
IUCN	International Union for the Conservation of Nature
MNES	Matters of National Environmental Significance
MtEE	Mount Ella East
PEC	Priority Ecological Communities
TEC	Threatened Ecological Communities
WAM	Western Australian Museum
WH	Western Hill

EXECUTIVE SUMMARY

Rio Tinto Iron Ore (Rio Tinto) commissioned Biologic Environmental Survey (Biologic) to undertake a targeted vertebrate fauna survey within their West Angelas Beyond 2020 project area, which is located adjacent to the West Angelas mine site. The area surveyed, hereafter referred to as the Study Area, covers approximately 11,762 hectares (ha) and is located approximately 105 kilometers (km) north-west of Newman in Western Australia. The Study Area comprises five deposits: Western Hill, Deposit J & Mt Ella East, Deposit F North and Deposit H.

The overarching objective of the assessment was to fill knowledge gaps surrounding the occurrence of species of conservation significance within the Study Area. Specifically, to determine the spatial and quantitative extent of occurrence for species listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the *Biodiversity Conservation Act 2016* (BC Act), comprising:

- Northern Quoll (*Dasyurus hallucatus*) – Endangered (EPBC Act & BC Act)
- Night Parrot (*Pezoporus occidentalis*) – Endangered (EPBC) and Critically Endangered (BC Act)
- Greater Bilby (*Macrotis lagotis*) – Vulnerable (EPBC Act & BC Act)
- Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia*) – Vulnerable (EPBC Act & BC Act)
- Ghost Bat (*Macroderma gigas*) – Vulnerable (EPBC Act & BC Act)
- Pilbara Olive Python (*Liasis olivaceus barroni*) – Vulnerable (EPBC Act & BC Act)
- Northern Brushtail Possum (*Trichosurus vulpecula arnhemensis*) – Vulnerable (BC Act)

The current targeted survey was undertaken between the 26th June and the 7th July 2019. Sampling methods comprised targeted searches, ultrasonic bat recordings, motion cameras, opportunistic observations and acoustic bird recordings.

Three water features (one in Deposit H and two within Deposit J) have also been recorded within the Study Area.

To date, four of the targeted species have been recorded within the Study Area including:

- Northern Quoll: This species has been recorded only once within the Study Area; an old scat pile found in a cave within the Western Hill Deposit during the baseline survey. Suitable habitat is provided by the Gorge or Gully habitats within the Study Area. Due to the species being uncommon within the Hamersley Ranges and the low number of records within the Study Area, despite the large amount of survey effort, it is likely that records in the Study Area represent individuals dispersing from a permanent population elsewhere.
- Ghost Bat: The West Angelas area has been known to support an active Ghost Bat population since 1975, confirmed by five caves annually monitored within 5 km of the Study Area. Eleven caves were recorded in the Study Area during the baseline survey and a further nine were recorded during the current survey. From the 20 caves recorded in the Study Area, one is considered a confirmed maternity roost, two potential maternity roosts, six potential diurnal roosts, five night roosts, and six potential night roosts. The presence of the species was confirmed within ten of these caves (seven cave locations within the Western Hill Deposit, two

caves within Deposit J and Mt Ella East, and one in Deposit H). Suitable roosting habitat is provided within the Gorge or Gully habitat type. Wooded areas such as Drainage Area, Minor Drainage, Footslope and Plain, Mulga Spinifex Woodland and Mixed Acacia Woodland habitat types provide foraging and dispersal habitat for the species.

- Pilbara Leaf-nosed Bat (PLNB): This species has been recorded within the Western Hill Deposit of the Study Area, twice in the baseline survey and once during the current survey through ultrasonic recorders. It is considered Likely that the species will forage in the Study Area. Individuals may forage across Gorge or Gully (Priority 1), Drainage Area, Minor Drainage Line (Priority 4) and Footslope and Plain, and Mixed Acacia Woodland (Priority 5) habitats as well as at three water features recorded within the Study Area. No diurnal roosts of the species have been located within the Study Area, though there is a roost approximately 13.5 km away within Karijini National Park (the Upper Turee Creek Roost) where individuals in the Study Area are likely originating from.
- Pilbara Olive Python: This species has been recorded at two locations within the Study Area, Western Hill Deposit via scat sample and Deposit H via motion camera. No additional records were made during the current survey. Denning and foraging habitat is provided by Drainage Line, Minor Drainage and Gorge or Gully habitat within the Study Area (particularly those that contain permanent and semi-permanent water). Considering the presence of these habitat features and previous records, the species is Highly Likely to permanently reside in the Study Area.

Despite extensive survey effort, Night Parrot, Greater Bilby and Northern Brushtail Possum have not been recorded in the Study Area:

- Night Parrot: The Study Area contains potentially suitable habitat for this species in Mulga Spinifex Woodland or Footslope and Plain; however, the species is regarded as rare, and as such it is deemed Unlikely that the species permanently forages within the Study Area.
- Greater Bilby: The Study Area contains potentially suitable habitat for this species in Footslope and Plain, Mulga Spinifex Woodland and Drainage Area; however, the species is regarded as rare within this region, and as such it is deemed Unlikely that the species permanently resides within the Study Area.
- Northern Brushtail Possum: The Study Area contains marginal denning and foraging habitat (contained within Gorge or Gully, Drainage Area and Minor Drainage habitats, as well as caves) for the species; however, the nearest record of the species is 230 km to the north-north west and therefore it is considered Highly Unlikely that a resident population exists.

1 INTRODUCTION

1.1 Background

Rio Tinto Iron Ore (Rio Tinto) commissioned Biologic Environmental Survey (Biologic) to undertake a targeted vertebrate fauna survey within their West Angelas Beyond 2020 project area, which is located adjacent to the West Angelas mine site. The area surveyed, hereafter referred to as the Study Area, covers approximately 11,762 hectares (ha) and is located approximately 105 kilometers (km) north-west of Newman in Western Australia. The Study Area comprises five deposits: Western Hill (WH), Deposit J (Dep-J), Mt Ella East (MtEE), Deposit F North (Dep-F) and Deposit H (Dep-H), Karijini National Park (Figure 1.1). Karijini National Park is located ~12 km west of the existing West Angela's Project Mine and borders the Study Area, specifically the WH Deposit, to the west.

1.2 Survey Objectives

The overarching objective of the assessment was to fill knowledge gaps surrounding the occurrence of species of conservation significance within the Study Area. Specifically, to determine the spatial and quantitative extent of occurrence for species listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the *Biodiversity Conservation Act 2016* (BC Act), comprising:

- Northern Quoll (*Dasyurus hallucatus*) – Endangered (EPBC Act & BC Act),
- Greater Bilby (*Macrotis lagotis*) – Vulnerable (EPBC Act & BC Act);
- Ghost Bat (*Macroderma gigas*) – Vulnerable (EPBC Act & BC Act);
- Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia*) – Vulnerable (EPBC Act & BC Act);
- Northern Brushtail Possum (*Trichosurus vulpecula arnhemensis*) – Vulnerable (BC Act).
- Night Parrot (*Pezoporus occidentalis*) – Endangered (EPBC Act) and Critically Endangered (BC Act); and
- Pilbara Olive Python (*Liasis olivaceus barroni*) – Vulnerable (EPBC Act & BC Act) ;

1.3 Compliance

This assessment was carried out in a manner consistent with the following documents developed by the Western Australian Environmental Protection Authority (EPA), the Department of Biodiversity, Conservation and Attractions (DBCA - formerly Department of Parks and Wildlife [DPaW]), and the Department of the Environment and Energy (DoEE - formerly the Department of Environment [DoE], Department of Sustainability, Water, Population, and Communities [DSEWPaC] and Department of Environment, Water, Heritage and Arts [DEWHA]):

- EPA (2016a) Technical Guidance: Sampling Methods for Terrestrial Vertebrate Fauna;
- EPA (2016b) Technical Guidance: Terrestrial Fauna Surveys;
- DPaW (2017) Interim guideline for the preliminary surveys of Night Parrot (*Pezoporus occidentalis*) in Western Australia;
- DoE (2016) EPBC Act referral guideline for the endangered northern quoll (*Dasyurus hallucatus)*;
- DBCA (2017) Guidelines for surveys to detect the presence of bilbies, and assess the importance of habitat in Western Australia;

- DEWHA (2010) Survey Guidelines for Australia's Threatened Bats;
- DSEWPaC (2011a) Survey Guidelines for Australia's Threatened Mammals.

660000 667500 675000 682500 690000 697500

7447500

7440000

7432500

7425000

Western Hill

West Angelas Mine

Deposit H

Deposit F North

Mt Ella East and Deposit J

PORT HEDLAND

NEWMAN

Legend

- Study Area
- Karijini National Park

Hamersley Subregion

- Hamersley Subregion

Habitat Type

- Cleared
- Drainage Area
- Footslope and Plain
- Gorge or Gully
- Hilltop, Hillslope, Ridge or Cliff
- Minor Drainage
- Mixed Acacia Woodland
- Mulga Spinifex Woodland

biologic Environmental Survey

N

1:100,000

0 0.75 1.5 3 4.5 6 km

RTIO - West Angelas Beyond 2020

Vertebrate Fauna Targeted Survey

Figure 1.1: Study Area and regional location

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

Size A3. Created 14/02/2020

1.4 Target Species

1.4.1 Northern Quoll (*Dasyurus hallucatus*)

The Northern Quoll is listed as Endangered under the EPBC Act and BC Act. The species was once widely distributed across northern Australia; however, it is now restricted to three isolated populations; the Pilbara, the Kimberley and Northern Territory, and Queensland, in addition to a number of islands along the north coast (DoE, 2016). Northern Quolls are opportunistic omnivores, consuming a wide range of invertebrates and small vertebrates but they also eat fruit, nectar, carrion and human refuse (Van Dyck & Strahan, 2008).

As a result of facultative die-off (semelparity), the abundance of the species is cyclical, and the annual reproduction is highly synchronised (Oakwood *et al.*, 2001). In the Pilbara, abundance is lowest toward the end of winter into early spring after the mating season, as a significant proportion of adult males die off and young have not yet begun to forage independently (Braithwaite & Griffiths, 1994; Oakwood, 2000). Conversely, the population density is thought to be highest in the summer months, prior to the mating season and when juveniles have begun foraging independently (Oakwood, 2000). Schmitt *et al.* (1989) reported relatively small home ranges in rugged habitat in the Kimberley (i.e. 2.3 ha for females and 1.8 ha for males), whereas in the western Pilbara, minimum activity areas are 75 – 443 ha for females and 5 – 1,109 ha for males (King, 1989).

The Northern Quoll is both arboreal and terrestrial, inhabiting ironstone and sandstone ridges, scree slopes, granite boulders and outcrops, drainage lines, riverine habitats (Braithwaite & Griffiths, 1994; Oakwood, 2002), dissected rocky escarpments, open forest of lowland savannah and woodland (Oakwood, 2002, 2008). Rocky habitats tend to support higher densities, as they offer protection from predators and are generally more productive in terms of availability of resources (Braithwaite & Griffiths, 1994; Oakwood, 2000). Other microhabitat features important to the species include: rock cover; proximity to permanent water and time-since last fire (Woinarski *et al.*, 2008). Dens occur in a wide range of situations including rock overhangs, tree hollows, hollow logs, termite mounds, goanna burrows and human dwellings/infrastructure, where individuals usually den alone (Oakwood, 2002; Woinarski *et al.*, 2008). At present, Northern Quolls are relatively common in the northern Pilbara region (generally within 150 km of the coast) but are much less common in southern and south-eastern parts of the region (Cramer *et al.*, 2016).

The species has experienced a precipitous decline in much of its former range in northern Queensland and the Northern Territory in direct association with the spread of the Cane Toad, *Rhinella marinus* (Braithwaite & Griffiths, 1994; Fitzsimons *et al.*, 2010). Other threats include predation from feral predators such as foxes (*Vulpes vulpes*) and feral cats (*Felis catus*), inappropriate fire regimes, disease, habitat degradation through grazing and weed invasion, and habitat destruction through mining and agriculture (Woinarski *et al.*, 2011). The potential invasion of the Pilbara by the Cane Toad is regarded as the most significant future threat to the Northern Quoll in the Pilbara; however, there is little knowledge of the relative impact of the other key threats, and their interactive effects, currently and in the future (Cramer *et al.*, 2016).

1.4.2 Greater Bilby (*Macrotis lagotis*)

The Greater Bilby is listed as Vulnerable under the EPBC Act and BC Act. It is one of many Australian arid zone marsupial species that are within a 'critical weight range' (35 g to 5,500 g) considered significant based on the high risk of predation by introduced foxes and feral cats (Johnson & Isaac, 2009). Greater Bilbies are semi-fossorial and nocturnal, remaining in their burrows during the day and intermittently during the night for rest and refuge. Greater Bilby populations naturally occur as scattered solitary individuals or small groups (Smythe & Philpott, 1968; Southgate, 1990a). They are regarded as having low site fidelity and high mobility (Southgate *et al.*, 2007); males regularly move three to five kilometres between burrows on consecutive days and have been recorded moving up to 15 km in a few weeks (Southgate & Possingham, 1995). This high mobility, together with low population density, ensures that the area of occupancy is often far less than the extent of occurrence. As Greater Bilbies are solitary in nature, lack territoriality and have large home ranges, it is likely that males adopt a roving strategy to find receptive females, consistent with an overlapping promiscuous mating system (Miller *et al.*, 2010).

Populations of Greater Bilby exist in the Pilbara bioregion (particularly the Chichester subregion, along the Fortescue River and north-east to Goldsworthy and Shay Gap), in the Dampier bioregion (along 80 Mile Beach north to Beagle Bay) and in the Central Kimberley and Ord-Victoria Plains bioregions south of the Fitzroy and Margaret Rivers (Southgate, 1990a). The distribution is highly fragmented within this area (Friend *et al.*, 2012).

Greater Bilbies 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 (Southgate, 1990b). Laterite and rock feature substrates are an important part of Greater Bilby habitat as they support shrub species, such as *Acacia kempeana, A. hilliana* and *A. rhodophylla*, which have root-dwelling larvae prone to supporting a constant food source (Dziminski & Carpenter, 2017; Southgate *et al.*, 2007). These habitats also contain spinifex hummocks, which are quite uniform and discrete, providing runways between hummocks and enabling easier movement and foraging (Southgate *et al.*, 2007). Minimal ground cover is a common feature in Greater Bilby habitats, as it allows easy foraging (Dawson, 2018). Habitat within the Pilbara bioregion seems to consist mostly of spinifex sand plain associated with major drainage line sandy terraces. In general, the distribution of Greater Bilbies can be limited by the availability of suitable burrowing habitat, such as dunes where burrow excavation is easier (Moseby & O'Donnell, 2003), and are not found in predominantly rocky areas or mountains where they would be unable to dig suitable burrow systems or dig for food.

1.4.3 Ghost Bat (*Macroderma gigas*)

The Ghost Bat is listed as Vulnerable under the EPBC Act, the BC Act and by the International Union for Conservation of Nature (IUCN). The Ghost Bat occurs in disjunct colonies across northern Australia (TSSC, 2016a). In the Pilbara region, the species occurs in all four subregions. The Pilbara population is estimated to be between 1,300 and 2,000 individuals (TSSC, 2016a). The largest population occurs within the Chichester subregion (estimated at approximately 1,500 individuals) where known populations are largely restricted to disused mines (TSSC, 2016a).

The distribution of Ghost Bats in the Pilbara is determined by the presence of suitable roosting sites. Natural roosts generally comprise deep, complex caves beneath bluffs or low rounded hills (Armstrong & Anstee, 2000). Centralised breeding sites in the Pilbara are largely restricted to abandoned mines in the Chichester Ranges; however, there are also a number of smaller maternity roosts in the Chichester and Hamersley Ranges (Armstrong & Anstee, 2000). Based on available data, breeding has been documented in natural caves at Mining Area C, Mt Brockman and West Angelas in the Hamersley subregion, and at Callawa and Tambrey Station in the Chichester subregion (Armstrong & Anstee, 2000). Ghost Bats move between a number of caves seasonally, or as dictated by weather conditions, and require a range of cave sites (Hutson *et al.*, 2001). Outside the breeding season, male bats are known to disperse widely, most likely during the wet season when conditions would allow bats to use caves that would otherwise not be suitable (Worthington-Wilmer *et al.*, 1994). Genetic studies indicate that females are likely to stay close to the maternity roosts (Worthington-Wilmer *et al.*, 1994).

Caves used by the species can be classified into five categories (Biologic, 2016):

- **Night Roost:** caves that are only utilised during the night, mostly to feed on prey items or to rest, and are typically shallow caves and shelters/overhangs that can be well lit during the day.
- **Night Roost/ Potential Diurnal Roosts:** in addition to being utilised to feed during the night, these caves are more complex in structure and provide suitable temperature and humidity conditions suitable for roosting during the day, but no Ghost Bats have been recorded using them during the day.
- **Diurnal Roosts:** caves that are used for shelter during the day.
- **Diurnal Roosts/ Potential Maternity Roosts:** in addition to being used for shelter during the day, these caves have attributes suitable to support breeding, and Ghost Bats have been recorded in these caves during the breeding season.
- **Maternity Roosts:** in addition to being used for shelter during the day, these caves have attributes suitable to support breeding, and Ghost Bats have been recorded in these caves during the breeding season, including pregnant females or females with pups.

Ghost Bats appear to have a short-range foraging strategy of up to 3 km (average 1.9 km), with vantage points changing approximately every 15 minutes, and average foraging areas of 61 ha having been recorded in the Northern Territory. It also appears that the bats generally return to the same area each night (Tidemann *et al.*, 1985), although it has been suggested that Ghost Bats in the arid zone are semi-transient through most areas and will readily travel large distances (>4 km) (Biologic, 2019a). Ghost Bats have a ‘sit and inspect’ foraging strategy; they hang on a perch where they visually inspect their surroundings for movement. Once their prey is detected it may be captured in the air, gleaned (taken from the surface of a substrate by a flying bat) from the ground or vegetation, or dropped on from a perch (Boles, 1999).

1.4.4 Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia*)

The Pilbara Leaf-nosed Bat is listed as Vulnerable under the EPBC Act and the BC Act. The Pilbara Leaf-nosed Bat is recognised as a geographically isolated population of the Orange Leaf-nosed Bat, distributed across northern Australia and separated from the Pilbara populations by approximately

400 km of the Great Sandy Desert (Armstrong, 2001). The Pilbara population is regarded as representing a single interbreeding population comprising multiple colonies (TSSC, 2016b). The most updated conservation advice (TSSC, 2016b) stated that there were at least 10 confirmed day roosts (including maternity roosts) and a further 23 unconfirmed roosts throughout the Pilbara region, although this is likely to be an underestimate based on unpublished data.

Pilbara Leaf-nosed Bats typically roost in undisturbed caves, deep fissures or abandoned mine shafts (Armstrong, 2000, 2001). The species' limited ability to conserve heat and water (Baudinette *et al.*, 2000) means they require warm (28-32 ºC) and very humid (85-100%) roost sites to persist in arid and semi-arid climates (Armstrong, 2001; Churchill, 1991). Roost sites with such attributes are relatively uncommon in the Pilbara and the limiting factor of the species' distribution (Armstrong, 2001). During the dry season (June to November), individuals are believed to aggregate in roosts that provide a suitably warm, humid microclimate (Armstrong, 2000, 2001; Bullen & McKenzie, 2011). While in the wet season (December to May), when conditions are generally wetter and more humid, individuals typically disperse roosting in seasonally suitable features (Armstrong, 2000, 2001; Bullen & McKenzie, 2011). TSSC (2016b) categorised underground refuges used by the species into four categories:

- **Permanent Diurnal Roosts** (Priority 1 – critical habitat for daily survival): are occupied year-round and are likely to be the focus for some part of the 9-month breeding cycle.
- **Non-Permanent Breeding Roosts** (Priority 2 - critical habitat for daily and long-term survival): are used during some part of the 9-month breeding cycle but not year-round.
- **Transitory Diurnal Roosts** (Priority 3 – critical habitat for daily and long-term survival): are occupied outside the breeding season and could facilitate long distance dispersal.
- **Nocturnal Refuge** (Priority 4 – not considered critical but important for persistence in a local area): are occupied or entered at night for resting, feeding or other purposes (excluding overhangs).

Additionally, foraging sites surrounding known or suspected roosts can be critical to the survival of the species. TSSC (2016b) categorised foraging habitat into five categories: gorges with pools (Priority 1); gullies (Priority 2); rocky outcrops (Priority 3); major watercourses (Priority 4); and open grassland and woodland (Priority 5) (TSSC, 2016b).

1.4.5 Northern Brushtail Possum (*Trichosurus vulpecula arnhemensis*)

The Northern Brushtail Possum is a recently listed WA species. It is not listed under the EPBC Act but is listed as Vulnerable under the BC Act. The WA Museum currently regards individuals within the Pilbara to represent the northern subspecies, *Trichosurus vulpecula arnhemensis* (BC Act Schedule 3); however, the Action Plan for Australian Mammals (Woinarski *et al.*, 2014) suggests the Brushtail Possum occurring in the Pilbara is the same subspecies as in the southwest '*hypoleucos*'. Moreover, genetic studies have shown that possums occurring on Barrow Island are more closely related to the southern form (Woinarski *et al.*, 2014). To determine if the representatives of this possum in the Pilbara are the listed northern form (*Trichosurus vulpecula arnhemensis*) or the southern form (*Trichosurus vulpecular hypoleucos),* genetic studies would be required.

The Brushtail Possum has a very restricted distribution and is infrequently recorded in the Pilbara region, with less than 20 records existing on NatureMap (DBCA, 2019a). Most records are from north of the Chichester Range and only a few are known from the Hamersley Range. Brushtail Possums generally exhibit flexibility in their habitat preferences (Kerle *et al.*, 1992) and occupy an array of habitat types provided enough tree hollows and ground refuges (such as hollow logs, rockpiles and the burrows of other animals) are available. On Barrow Island, Western Australia, little to no trees are available as refuge and therefore individuals are known to live on the ground (DEC, 2012). In the arid zone, Brushtail Possums were recorded and seemingly dense in rocky ranges, rocky outcrops, rivers with large *Eucalyptus* trees. Records also exist in coolabah claypans, limestone sinkholes and *Triodia* habitats within the arid zone (Kerle *et al.*, 1992); however, little ecological information is known about the Pilbara population, although it is most often recorded from major drainage lines that contain large hollow-bearing Eucalypts (DBCA, 2019a).

Several interacting ecological factors, primarily inappropriate fire regimes, feral predation by cats and foxes as well as habitat loss and fragmentation, are currently causing rapid and severe declines in the small and medium-sized mammal fauna of northern Australia (Woinarski *et al.*, 2014). The Northern Brushtail Possum is regarded as a 'critical weight range' mammal, and thus more susceptible to pressure from introduced predators (Burbidge & McKenzie, 1989). Within Western Australia, the former range of the Brushtail Possum has been considerably reduced by habitat clearing and fox predation, including in large areas of arid country. Predation by foxes, cats, dingos, large pythons and large monitors is particularly significant in areas where population numbers are low (DEC, 2012).

1.4.6 Night Parrot (*Pezoporus occidentalis*)

The Night Parrot is a small, elusive ground dwelling parrot endemic to Australia (DPaW, 2017). This highly cryptic and nocturnal parrot inhabits arid and semi-arid areas that comprise dense, low vegetation. Based on accepted records, the habitat of the Night Parrot consists of *Triodia* grasslands in stony or sandy environments (McGilp, 1931; North, 1898; Whitlock, 1924; Wilson, 1937), and of samphire and chenopod shrublands, including genera such as *Atriplex*, *Bassia* and *Maireana*, on floodplains and claypans, as well as on the margins of salt lakes, creeks or other sources of water (McGilp, 1931; Wilson, 1937). The current interim guidelines for preliminary surveys of Night Parrot in Western Australia suggest this species requires old-growth spinifex (*Triodia*) (often more than 50 years' unburnt) for roosting and nesting (DPaW, 2017). Although little is known about foraging sites, habitats that comprise various grasses and herbs are thought to be suitable. Foraging habitat is not necessarily within or adjacent to roosting habitat as the Night Parrot has been known to fly up to 40 km in a single night to forage (Murphy *et al.*, 2017b). It is reasonably assumed that the species may fly cumulative distances of up to 100 km per night during productive seasons and considerably greater than 100 km per night during drought conditions between roosting habitat and foraging habitat (Night Parrot Recovery Team, 2017). *Triodia* is likely to provide a good food resource, particularly in times of mass flowering and seeding. The succulent *Sclerolaena* also provides a source of food and moisture, and other succulent chenopods are also likely to be significant habitat (DPaW, 2017). As such, foraging areas include highly productive and floristically diverse alluvial habitats, stony herb fields, sparse ironstone pavements, and quaternary sand drifts and ridges (Night Parrot Recovery Team, 2017).

Foraging habitat is likely to be more important if it is adjacent to or within about 10 km of suitable roosting habitat (DPaW, 2017). During adult or juvenile dispersal, or nomadic movements, Night Parrots may travel distances in the order of several hundred kilometres.

The distribution of the Night Parrot is very poorly understood. The small number of confirmed or verifiable records prevents the population size from being assessed with any accuracy; however, the population size is speculatively estimated to consist of approximately 50 breeding birds that occur in five subpopulations. The largest of these subpopulations is estimated, with low reliability, to consist of 20 breeding birds (Garnett & Crowley, 2000)

1.4.7 Pilbara Olive Python (*Liasis olivaceus barroni*)

The Pilbara Olive Python is listed as Vulnerable under the EPBC Act and the BC Act. The Pilbara Olive Python is Western Australia's largest snake, averaging 2.5 metres (m) with records up to 4.5 m (Bush & Maryan, 2011; Cogger, 2014). The species has a dull olive-brown upper surface and is pale cream below (Burbidge, 2004; Cogger, 2014). This python is endemic to the Pilbara region, distributed from Burrup Peninsula, Ord Ranges and Meentheena south to Nanutarra and Newman (Bush & Maryan, 2011). This species is primarily nocturnal and tends to shelter in small caves or under vegetation during the day. During summer months they will emerge from daytime shelters soon after dark and continue to move until the early hours of the morning (DSEWPaC, 2011b). In the winter months, the species is primarily nocturnal, although adult pythons can sometimes be found basking in the morning sun (DSEWPaC, 2011b; Pearson, 2001). The breeding season of the Pilbara Olive Python takes place in the cooler months, which extends from June to August and males will travel up to three kilometres in search of a mate (DSEWPaC, 2011b). The species is a well-adapted ambush predator and common prey items include rock-wallabies, small Euros, fruit bats, waterbirds, doves/pigeons and there are instances of Northern Quoll (Oakwood & Miles, 1998).

The species commonly inhabits moist areas such as gorges, rivers, pools and surrounding hills, but can be found in a range of habitats (Burbidge, 2004; DSEWPaC, 2011b). In the Hamersley region, the Pilbara Olive Python is most often encountered in the vicinity of permanent waterholes in rocky ranges or among riverine vegetation (DSEWPaC, 2011b; Pearson, 1993). It is a common misconception that the species is reliant and restricted to areas near permanent water; however, the species is attracted to these areas due to the productivity and abundance of suitably-sized prey (Pearson, 2003). The species is known to occur at 17 locations within the Pilbara (Pearson, 1993), including populations at Pannawonica, Millstream, Tom Price and Burrup Peninsula (Pearson, 2003). Threats to the species include major fire events, competition for prey with introduced predators, habitat loss (TSSC, 2008), predation of food sources (quolls and rock-wallabies) by foxes, habitat destruction by gas and mining development, deliberate and accidental road kills, and deliberate killings around tourist and residential areas associated with mistaken identification as a venomous brown snake (Pearson, 2003).

2 METHODS

The overarching objective of this survey was to determine the occurrence of the targeted species of conservation significance within the Study Area (Figure 1.1). Seven species of conservation significance were focussed on for the targeted surveys at West Angelas. These include Northern Quoll (*Dasyurus hallucatus*), Night Parrot (*Pezoporus occidentalis*), Greater Bilby (*Macrotis lagotis*), Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia*), Ghost Bat (*Macroderma gigas*), Pilbara Olive Python (*Liasis olivaceus barroni*), and Northern Brushtail Possum (*Trichosurus vulpecula arnhemensis*), and the survey methods are discussed in detail below.

2.1 Timing

The current survey was undertaken from 26th June to the 7th July 2019 by two experienced zoologists, Talitha Moyle and Ray Lloyd. Additional deployments of acoustic recorders were completed by experienced biologist Scott Reiffer (Rio Tinto) prior to the survey (from the 29th May 2019). The study was conducted under DBCA Regulation 17 "Licence to Take Fauna for Scientific Purposes" issued to B. Downing (licence number 08-002839-1). Acoustic recorders deployed within Karijini National Park were under Reg 4 licence issued to Scott Reiffer (PILCALMR4-010/2019)

2.2 Climate and Weather

Long term climatic data was available from the Bureau of Meteorology (BoM) weather station at Newman airport (station 007151), located approximately 109 km ESE of the Study Area (BoM, 2019). The average minimum (7.4 °C) and maximum (24.6 °C) temperatures for the survey period were similar to the long term averages for June/July (Table 2.1). While the survey was undertaken, the wind was mild from 30 - 41 km/hour (hr) and during dusk surveys stayed around 30 km/hr. Rainfall in the six months leading up to the survey was well below average for this time of the year, with only 98 millimetres (mm) recorded compared to 236.1 mm (Figure 2.1). No rain was recorded during the survey period; however, 16 mm of rain was recorded in the five days before the survey (BoM, 2019).

Summer occurs from November to February and has mean maximum and minimum temperatures of 38.3 °C and 23.6 °C, respectively. Winter occurs from June to August and has mean maximum and minimum temperatures of 24.0 °C and 7.23 °C, respectively. Rainfall primarily occurs in the first half of the year and averages 329.5 mm on an annual basis.

Table 2.1: Weather conditions during the survey

Date	Temperature (°C)		Rain (mm)	Wind	
	Min	Max		Direction	Speed (km/h)
29/05/2019	11.4	27.6	0	ESE	30
30/05/2019	12.3	23.8	0	ENE	39
31/05/2019	11.4	23.8	0	E	35
1/06/2019	7.4	22.5	0	ENE	43
2/06/2019	6.4	23.2	0	ENE	43
3/06/2019	10.8	21.3	0	E	50
4/06/2019	6.6	22.1	0	E	50
5/06/2019	6.6	21.9	0	ENE	46

Date	Temperature (°C)		Rain (mm)	Wind	
	Min	Max		Direction	Speed (km/h)
6/06/2019	5.5	22.2	0	NE	52
7/06/2019	8.6	25.5	0	NNE	44
8/06/2019	14.0	23.8	0	NW	43
9/06/2019	14.2		1.8		
10/06/2019	2.6	23.2		NNW	30
11/06/2019	7.4	23.0	0	SW	56
12/06/2019	2.9	20.8	0	SSE	33
13/06/2019	2.8	22.0	0	SE	30
14/06/2019	3.0	22.3	0	E	26
15/06/2019	3.8	21.9	0	SE	41
16/06/2019	2.4	22.7	0	E	46
17/06/2019	3.1	22.9	0	ESE	37
18/06/2019	6.9	24.8	0	ENE	30
19/06/2019	8.2	26.0	0	ESE	22
20/06/2019	8.4	27.9	0	NNE	39
21/06/2019	12.9	20.9	12	N	41
22/06/2019	12.9	24.8	4	NE	35
23/06/2019	13.7	26.3	0	NNE	39
24/06/2019	14.3	28.3	0	SW	30
25/06/2019	12.2	26.9	0	N	24
26/06/2019	10.5	29.2	0	NNW	37
27/06/2019	8.0	29.1	0	NNW	41
28/06/2019	12.6	22.6	0	SSW	39
29/06/2019	3.2	19.4	0	E	43
30/06/2019	0.1	24.3	0	SW	30
1/07/2019	3.3	25.3	0	SW	30
2/07/2019	6.3	25.6	0	NNE	30
3/07/2019	7.0	26.1	0	NNE	30
4/07/2019	7.0	27.1	0	NNW	37
5/07/2019	16.4	21.2	0	SW	31
6/07/2019	9.0	21.5	0	SE	30
7/07/2019	5.2	24.1	0	NNE	39
8/07/2019	7.2	27.4	0	N	28
9/07/2019	8.1	27.7	0	ESE	24
10/07/2019	11.1	26.8	0	E	30
11/07/2019	10.4	24.0	0	SE	30
12/07/2019	8.7	26.0	0	E	33
13/07/2019	9.7	24.2	0	E	41
14/07/2019	8.1	22.0	0	E	35
15/07/2019	2.6	22.6	0	ENE	39
16/07/2019	3.2	23.8	0	ENE	37
17/07/2019	3.0	25.2	0	NE	33
18/07/2019	3.9	26.3	0	N	24
19/07/2019	12.8	28.5	0	SSW	33
20/07/2019	4.1	23.2	0	SE	41
21/07/2019	7.2	22.8	0	NNE	30
Average (current survey)	**7.8**	**24.3**	**0.3**		**36**

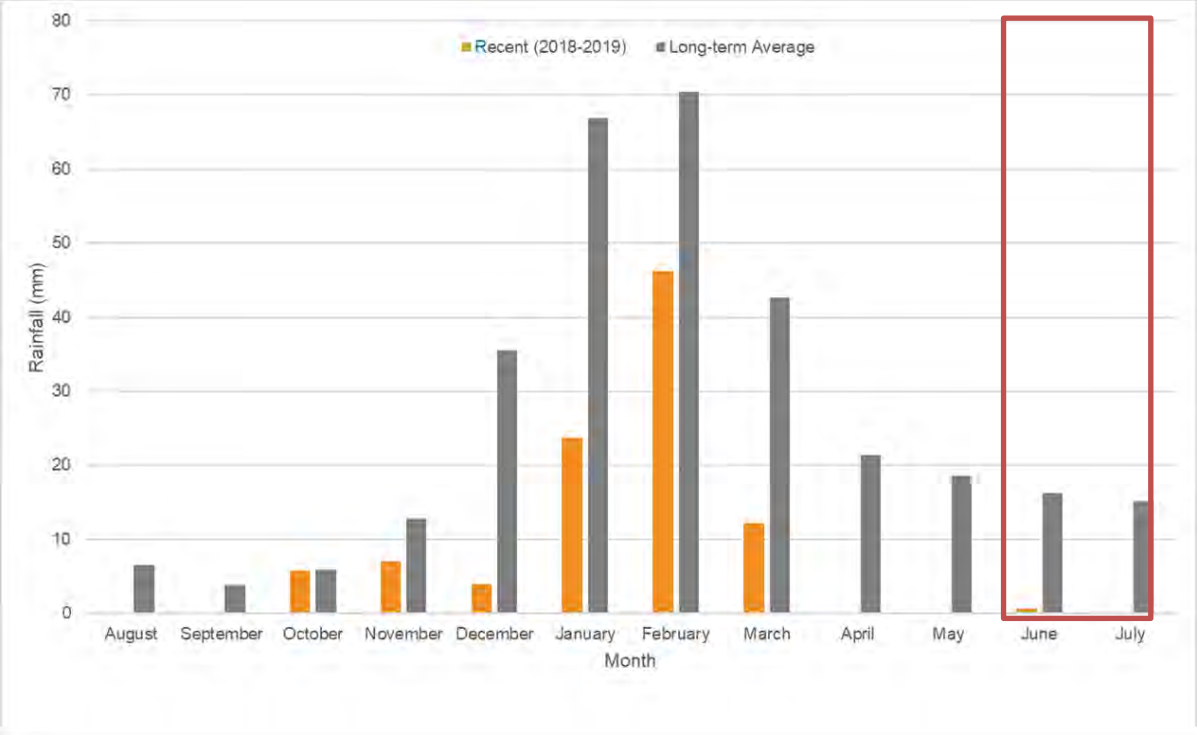

Figure 2.1: Rainfall recorded at Newman prior to the field survey (red indicates survey timing)

2.3 Sampling Techniques

All sampling techniques during the current survey were designed and implemented following recommendations with federal survey guidelines and advice as listed in Section 1.3 above.

2.3.1 Northern Quoll

2.3.1.1 Motion Camera Transects

Sampling for Northern Quoll was undertaken by deploying motion camera (Acorn Ltl5210A) transects within targeted habitat. Additionally, searches for scats were undertaken within suitable habitat.

The configuration of motion camera sites and the sampling effort followed recommendations of DoE (2016), as described below in (Table 2.2). Eight Northern Quoll sites were established across the Study Area (three transects within WH, two transects within Dep-H, two transects within Dep-J & MtEE and one transect within Dep-F). Each transect comprised 10 motion cameras, each placed 100 metres apart and left in place for four nights (320 sampling nights; Table 2.2). Cameras were baited to allow detailed inspection of an individual's patterning to assist with future population estimates (Hohnen *et al.*, 2012). Sites were established within good examples of Hilltop, Hillslope, Ridge or Cliff and Gorge or Gully habitat considered potential denning habitat.

During the baseline survey, single motion cameras were deployed for between two and nine nights at 40 locations within the Study Area, for a total of 139 sampling nights. Deployments targeted habitat most likely to support the species, such as rocky outcrops and locations containing sources of water. Three additional sites were selected for longer-term camera deployments. One of these was a cave (CWAN-04) at which scats of the Northern Quoll were recorded – two cameras were deployed here (VRT-WA62) for 141 nights between the Phase 1 (October 2018) and Phase 2 (March 2019) surveys,

resulting in a total of 282 sampling nights. The other two sites (VRT-WA63 and VRT-WA64) comprised rocky habitat considered likely to support the Northern Quoll. Each of these two sites consisted of ten motion cameras spaced 100 m apart (as recommended by DoE, 2016). These cameras were in place for 145 nights between the Phase 1 (October 2018) and Phase 2 (March 2019) surveys. The total motion camera trap nights for the Study Area, including the baseline survey and the targeted survey was 3,641 sampling nights.

Table 2.2: Motion camera survey locations within the Study Area

Site Name	Deposit	Latitude	Longitude	Species targeted	Habitat	Trap Nights
Motion camera transects – Northern Quoll/ Northern Brushtail Possum						
VWAN-19	WH	-23.118	118.625	Northern Quoll Pilbara Olive Python	Gorge or Gully	40
VWAN-20	WH	-23.121	118.603	Northern Quoll	Gorge or Gully	40
VWAN-21	WH	-23.111	118.660	Northern Quoll	Gorge or Gully	40
VWAN-24	Dep-J & MtEE	-23.232	118.716	Northern Quoll	Hilltop, Hillslope, Ridge or Cliff	40
VWAN-25	Dep-J & MtEE	-23.215	118.834	Northern Quoll	Gorge or Gully	40
VWAN-26	Dep-H	-23.121	118.865	Northern Quoll	Gorge or Gully	40
VWAN-27	Dep-H	-23.126	118.918	Northern Quoll	Gorge or Gully	40
VWAN-59	Dep-F	-23.171	118.842	Northern Quoll	Gorge or Gully	40
Total – motion camera trap nights- targeted survey						**320 nights**
Motion camera - baseline survey						
VRT-WA10	Dep-F	-23.174	118.851	Northern Quoll Pilbara Olive Python	Gorge or Gully	3
VRT-WA12	WH	-23.117	118.626	Northern Quoll Pilbara Olive Python	Hilltop, Hillslope, Ridge or Cliff	9
VRT-WA14	Dep-J & MtEE	-23.211	118.803	Northern Quoll Pilbara Olive Python	Hilltop, Hillslope, Ridge or Cliff	2
VRT-WA16 (WB-WAH1)	Dep-H	-23.120	118.869	Northern Quoll Pilbara Olive Python	Gorge or Gully	8
VRT-WA17	Dep-H	-23.134	118.855	Northern Quoll Pilbara Olive Python	Hilltop, Hillslope, Ridge or Cliff	4
VRT-WA18	WH	-23.133	118.583	General	Mulga Spinifex Woodland	3
VRT-WA20	Dep-F	-23.175	118.827	Northern Quoll Pilbara Olive Python	Hilltop, Hillslope, Ridge or Cliff	4
VRT-WA21	WH	-23.111	118.588	General/ Greater Bilby	Footslope and Plain	3
VRT-WA24	Dep-J & MtEE	-23.216	118.820	General	Hilltop, Hillslope, Ridge or Cliff	2
VRT-WA27	Dep-F	-23.175	118.861	General	Footslope and Plain	2
VRT-WA28	Dep-J & MtEE	-23.231	118.723	Northern Quoll Pilbara Olive Python	Drainage Area	2
VRT-WA41	WH	-23.126	118.667	Northern Quoll Pilbara Olive Python	Minor Drainage	3

Site Name	Deposit	Latitude	Longitude	Species targeted	Habitat	Trap Nights
VRT-WA42	WH	-23.118	118.624	Northern Quoll Pilbara Olive Python	Gorge or Gully	3
VRT-WA44	WH	-23.114	118.611	General	Hilltop, Hillslope, Ridge or Cliff	2
VRT-WA45	Dep-F	-23.187	118.879	Northern Quoll Pilbara Olive Python	Drainage Area	2
VRT-WA62	WH	-23.118	118.624	Northern Quoll Pilbara Olive Python	Gorge Gully	282
VRT-WA63	Dep-J & MtEE	-23.215	118.820	Northern Quoll Pilbara Olive Python	Hilltop, Hillslope, Ridge or Cliff	1450
VRT-WA64	Dep-H	-23.121	118.862	Northern Quoll Pilbara Olive Python	Hilltop, Hillslope, Ridge or Cliff	1450
VWAF-03	Dep-F	-23.177	118.857	General	Footslope and Plain	3
VWAF-04	Dep-F	-23.176	118.845	General	Footslope and Plain	3
VWAF-05	Dep-F	-23.177	118.833	General	Hilltop, Hillslope, Ridge or Cliff	3
VWAF-07	Dep-F	-23.173	118.840	Northern Quoll Pilbara Olive Python	Gorge or Gully	3
VWAF-10	Dep-F	-23.174	118.851	Northern Quoll Pilbara Olive Python	Gorge or Gully	3
VWAH-13	Dep-H	-23.128	118.912	General	Hilltop, Hillslope, Ridge or Cliff	2
VWAH-14	Dep-H	-23.125	118.918	General	Hilltop, Hillslope, Ridge or Cliff	2
VWAH-63	Dep-H	-23.129	118.835	General	Hilltop, Hillslope, Ridge or Cliff	3
VWAH-66	Dep-H	-23.119	118.883	Northern Quoll Pilbara Olive Python	Hilltop, Hillslope, Ridge or Cliff	4
VWAH-67	Dep-H	-23.129	118.894	Northern Quoll Pilbara Olive Python	Hilltop, Hillslope, Ridge or Cliff	5
VWAH-77	Dep-H	-23.125	118.873	Northern Quoll Pilbara Olive Python	Hilltop, Hillslope, Ridge or Cliff	4
VWAH-78	Dep-H	-23.132	118.860	Northern Quoll Pilbara Olive Python	Hilltop, Hillslope, Ridge or Cliff	4
VWAJ-70	Dep-J & MtEE	-23.236	118.738	Northern Quoll Pilbara Olive Python	Hilltop, Hillslope, Ridge or Cliff	5
VWAJ-71	Dep-J & MtEE	-23.229	118.771	Northern Quoll Pilbara Olive Python	Hilltop, Hillslope, Ridge or Cliff	5
VWAJ-72	Dep-J & MtEE	-23.211	118.833	Northern Quoll Pilbara Olive Python	Hilltop, Hillslope, Ridge or Cliff	5
VWAJ-73	Dep-J & MtEE	-23.211	118.807	Northern Quoll Pilbara Olive Python	Hilltop, Hillslope, Ridge or Cliff	5
VWAJ-74	Dep-J & MtEE	-23.227	118.739	Northern Quoll Pilbara Olive Python	Hilltop, Hillslope, Ridge or Cliff	4
VWAJ-75	Dep-J & MtEE	-23.209	118.781	Northern Quoll Pilbara Olive Python	Hilltop, Hillslope, Ridge or Cliff	5

Site Name	Deposit	Latitude	Longitude	Species targeted	Habitat	Trap Nights
VWAJ-75	Dep-J & MtEE	-23.209	118.781	Northern Quoll Pilbara Olive Python	Hilltop, Hillslope, Ridge or Cliff	2
VWAJ-76	Dep-J & MtEE	-23.224	118.718	Northern Quoll Pilbara Olive Python	Footslope and Plain	4
VWAJ-77	Dep-J & MtEE	-23.229	118.746	Northern Quoll Pilbara Olive Python	Hilltop, Hillslope, Ridge or Cliff	3
VWAW-68	WH	-23.114	118.657	Northern Quoll Pilbara Olive Python	Hilltop, Hillslope, Ridge or Cliff	4
VWAW-85	WH	-23.107	118.639	General	Mulga Spinifex Woodland	2
VWAW-87	WH	-23.109	118.620	General	Footslope and Plain	2
VWAW-89	WH	-23.117	118.596	General	Hilltop, Hillslope, Ridge or Cliff	2
Total- motion camera traps night- baseline						**3321**
Total- motion camera trap nights- baseline and targeted						**3641**

2.3.2 Ghost Bat & Pilbara Leaf-nosed Bat

2.3.2.1 Cave Searches and Assessments

Targeted searches were undertaken throughout suitable habitat of the Study Area to identify suitable roost locations for the Ghost Bat and Pilbara Leaf-nosed Bat (Figure 2.2, Figure 2.3, Figure 2.4). Cave searching was focussed in areas that had not been searched previously and were representative of suitable cave forming geology – specifically Brockman Iron Formation and Marra Mamba formations. These geologies have been identified as key geological units most likely to form deep caves in the area, suitable for Ghost Bats (Armstrong & Anstee, 2000). Searches were primarily conducted within the WH Deposit, Dep-H, Dep-J & MtEE areas. Approximately 28 targeted searches were completed, equating to approximately 100 person hours during the targeted survey.

Where caves were located, a detailed cave assessment was completed to identify the potential importance to each species of interest; categories for cave types are detailed in Section 1.4.3. Details such as cave size, depth, chambers, scats recorded, and bats seen in the caves were recorded.

Where suitable roosting caves were recorded, sheets measuring approximately 10 square metres, were deployed on top of existing middens (scat piles) to collect scats and provide confirmation of visitation within a given timeframe. Sheets were previously deployed in three caves within the WH Deposit (CWAN-04, CWAN-06 and CWAN -07) during the baseline surveys and were revisited during this survey to record the number of scats deposited during that time to determine a scat deposition rate (number of scats divided by sampling nights).

2.3.2.2 Ultrasonic Recorders

Overnight recordings of bat echolocation calls were undertaken with Song Meter (SM2, SM4) (SM; Wildlife Acoustics Inc.) ultrasonic bat recorders which have the ability to detect both Ghost Bats and Pilbara Leaf-nosed Bats. Units were deployed at eight locations, mainly targeting suitable caves (six at the entrance of caves at WH, one at the entrance of a cave within Dep-J & MtEE and one within gully habitat at Dep-J & MtEE) for a total of 24 sampling nights (Table 2.3). During the baseline surveys 68

sampling nights were recorded for a total of 92 nights over the baseline and targeted surveys. The jumper and audio settings used for the SM units followed the manufacturer's recommendations contained in the user manual (Wildlife Acoustics, 2011, 2017). Selectable filters and triggers were also set using the manufacturer's recommendations. Bat calls were analysed by Robert Bullen of Bat Call WA.

Table 2.3: Ultrasonic survey locations within the Study Area

Site Name	Deposit	Latitude	Longitude	Habitat	Trap Nights
Targeted survey					
VWAN-21	WH	-23.111	118.660	Gorge or Gully -Cave CWAN-29	2
VWAN-22	WH	-23.120	118.622	Gorge or Gully- Cave CWAN-31	3
VWAN-23	WH	-23.115	118.612	Gorge or Gully – Cave CWAN-06	5
VWAN-24	WH	-23.112	118.611	Gorge or Gully – Cave CWAN-07	5
VWAN-46	Dep-J & MtEE	-23.212	118.785	Hilltop, Hillslope, Ridge or Cliff Cave CWAN-08	1
VWAN-51	Dep-J & MtEE	-23.212	118.810	Gorge or Gully	2
VWAN-55	WH	-23.118	118.624	Cave CWAN-03	2
VWAN-100	WH	-23.118	118.624	Cave- CWAN-04	4
Total- ultrasonic nights- targeted survey					**24**
Baseline survey					
VRT-WA05	Dep-J and MtEE	-23.220	118.771	Hilltop, Hillslope, Ridge or Cliff	3
VRT-WA06	Dep-J and MtEE	-23.238	118.761	Minor Drainage	3
VRT-WA07	Dep-J and MtEE	-23.231	118.715	Hilltop, Hillslope, Ridge or Cliff	2
VRT-WA10	Dep-F	-23.174	118.851	Gorge or Gully	1
VRT-WA11	WH	-23.121	118.603	Gorge or Gully	6
VRT-WA13	Dep-J and MtEE	-23.220	118.766	Hilltop, Hillslope, Ridge or Cliff	6
VRT-WA14	Dep-J and MtEE	-23.211	118.803	Hilltop, Hillslope, Ridge or Cliff	2
VRT-WA16	Dep-H	-23.120	118.869	Gorge or Gully	4
VRT-WA17	Dep-H	-23.134	118.855	Hilltop, Hillslope, Ridge or Cliff	4
VRT-WA22	WH	-23.117	118.625	Hilltop, Hillslope, Ridge or Cliff	2
VRT-WA23	Dep-J and MtEE	-23.210	118.756	Hilltop, Hillslope, Ridge or Cliff	1
VRT-WA24	Dep-J and MtEE	-23.216	118.820	Hilltop, Hillslope, Ridge or Cliff	2
VRT-WA33	WH	-23.117	118.585	Hilltop, Hillslope, Ridge or Cliff	5
VRT-WA35	WH	-23.108	118.658	Footslope and Plain	5
VRT-WA39	Dep-F	-23.174	118.838	Hilltop, Hillslope, Ridge or Cliff	1
VRT-WA42	WH	-23.118	118.624	Gorge or Gully	2
VRT-WA44	WH	-23.114	118.611	Hilltop, Hillslope, Ridge or Cliff	2
VWAF-01	Dep-F	-23.184	118.875	Footslope and Plain	2
VWAF-02	Dep-F	-23.177	118.859	Footslope and Plain	2
VWAH-11	Dep-H	-23.124	118.892	Gorge or Gully	2
VWAH-63	Dep-H	-23.129	118.835	Hilltop, Hillslope, Ridge or Cliff	3
VWAJ-75	Dep-J and MtEE	-23.209	118.781	Hilltop, Hillslope, Ridge or Cliff	2
VWAW-81	WH	-23.110	118.653	Hilltop, Hillslope, Ridge or Cliff	2
VWAW-83	WH	-23.107	118.645	Hilltop, Hillslope, Ridge or Cliff	2
VWAW-87	WH	-23.109	118.620	Footslope and Plain	2
Total- ultrasonic nights- baseline survey					**68**
Total- ultrasonic recording nights- baseline and targeted					**92**

2.3.3 Night Parrot

2.3.3.1 Acoustic Recorders

Song Meter 4 Acoustic units (SM4; Wildlife Acoustics, USA) were deployed to passively record Night Parrot calls through the night. Recorders were set in the most suitable roosting and nesting habitat of the Study Area (Mulga Spinifex and Footslope and Plains). The units were set to record between 0-20,000 Hz using a built-in omnidirectional microphone and were deployed off the ground to maximise detection range. Each unit was preconfigured to record each night, an hour before and after sunset and sunrise, respectively.

Phase one of the baseline survey recorded unusual bird calls in Dep-J & MtEE at site VRT-WA08, during phase two ultrasonic recorders were set for a further six nights and it was determined that it was most likely a common species of bird calling faintly in the background. During Phase two unconfirmed calls within the same frequency range of the Night Parrot were recorded at Site WA-SM4A-001 at (VWAW-85) within long-unburnt spinifex plains within Mulga spinifex woodland and Footslope and Plains habitat in the northern section of the Study Area (WH Deposit). As such, the current survey was primarily focussed in this area. Sampling for Night Parrots was undertaken at 39 locations within the WH Deposit, ranging between 2 and 34 nights per sites, for a total of 290 recording nights (Table 2.4). During the baseline survey units were deployed for a total of 30 sampling nights, giving a total of 320 recording nights for the Study Area (Table 2.4). This included units deployed at seven locations (WA-SM4A-001 to WA-SM4A-007) prior to the survey, by Rio Tinto biologist Scott Reiffer, for a period of –14 – 34 days. Four of these locations were within WH tenement, while three sites were located within Karijini National Park, between 2 km and 16 km from the Study Area.

All recordings were analysed by Ornithologist Nigel Jackett using Kaleidoscope Pro software (v5.1.8; Wildlife Acoustics, USA) and publicly available Night Parrot calls (Night Parrot Recovery Team, 2017) and call information (Jackett *et al.*, 2017; Leseberg *et al.*, 2019; Murphy *et al.*, 2017a).

Table 2.4: Acoustic survey locations within the Study Area

Site Name	Deposit	Latitude	Longitude	Habitat	Trap Nights
VWAN-02	WH	-23.101	118.602	Mulga Spinifex Woodland	7
VWAN-03	WH	-23.102	118.609	Mulga Spinifex Woodland	7
VWAN-04	WH	-23.099	118.579	Mulga Spinifex Woodland	6
VWAN-05	WH	-23.099	118.586	Footslope and Plain	6
VWAN-06	WH	-23.108	118.583	Footslope and Plain	6
VWAN-07	WH	-23.102	118.591	Mulga Spinifex Woodland	6
VWAN-08	WH	-23.107	118.591	Mulga Spinifex Woodland	6
VWAN-09	WH	-23.102	118.613	Mulga Spinifex Woodland	6
VWAN-10	WH	-23.102	118.617	Mulga Spinifex Woodland	6
VWAN-11	WH	-23.107	118.596	Mulga Spinifex Woodland	6
VWAN-12	WH	-23.099	118.596	Mulga Spinifex Woodland	6

Site Name	Deposit	Latitude	Longitude	Habitat	Trap Nights
VWAN-13	WH	-23.102	118.625	Mulga Spinifex Woodland	6
VWAN-14	WH	-23.103	118.629	Footslope and Plain	6
VWAN-16	WH	-23.101	118.639	Mulga Spinifex Woodland	7
VWAN-17	WH	-23.106	118.642	Mulga Spinifex Woodland	7
VWAN-18	WH	-23.100	118.648	Mulga Spinifex Woodland	7
VWAN-27	WH	-23.106	118.626	Footslope and Plain	4
VWAN-28	WH	-23.105	118.615	Footslope and Plain	3
VWAN-29	WH	-23.112	118.585	Footslope and Plain	3
VWAN-30	WH	-23.110	118.579	Footslope and Plain	7
VWAN-31	WH	-23.108	118.587	Footslope and Plain	3
VWAN-32	WH	-23.102	118.595	Footslope and Plain	8
VWAN-33	WH	-23.110	118.593	Mulga Spinifex Woodland	3
VWAN-34	WH	-23.104	118.630	Mulga Spinifex Woodland	4
VWAN-35	WH	-23.101	118.644	Mulga Spinifex Woodland	8
VWAN-37	WH	-23.105	118.641	Spinifex Stony Plain	3
VWAN-38	WH	-23.109	118.642	Mulga Spinifex Woodland	3
VWAN-39	WH	-23.107	118.601	Footslope and Plain	6
VWAN-40	WH	-23.110	118.632	Footslope and Plain	3
VWAN-41	WH	-23.101	118.621	Mulga Spinifex Woodland	7
VWAN-42	WH	-23.106	118.609	Footslope and Plain	3
VWAN-44	WH	-23.106	118.620	Mulga Spinifex Woodland	3
WA-SM4A-001 (VWAW-85)	WH	-23.107	118.638	Mulga Spinifex Woodland	34
WA-SM4A-002	WH	-23.100	118.637	Footslope and Plain	14
WA-SM4A-003	WH	-23.100	118.622	Mulga Spinifex Woodland	14
WA-SM4A-004	WH	-23.107	118.594	Footslope and Plain	14
WA-SM4A-005	WH	-23.107	118.563	*Not within study boundary. Located in Karijini National Park	14
WA-SM4A-006	WH	-23.172	118.457	*Not within study boundary. Located in Karijini National Park	14
WA-SM4A-007	WH	-23.167	118.449	*Not within study boundary. Located in Karijini National Park	14
Total- acoustic nights- targeted survey					**290 #**
Baseline survey					
VRT-WA08	Dep-J & MtEE	-23.237	118.726	Drainage Area	4
VRT-WA08	Dep-J & MtEE	-23.237	118.726	Drainage Area	6
VRT-WA15	Dep-J & MtEE	-23.207	118.802	Footslope and Plain	2
VRT-WA26	Dep-J & MtEE	-23.203	118.757	Footslope and Plain	2
VRT-WA40	WH	-23.187	118.879	Drainage Area	2

Site Name	Deposit	Latitude	Longitude	Habitat	Trap Nights
VRT-WA46	Dep-H	-23.179	118.863	Footslope and Plain	1
VWAF-67	Dep-F	-23.175	118.836	Hilltop, Hillslope, Ridge or Cliff- Dep-F	2
VWAH-12	Dep-H	-23.136	118.855	Footslope and Plain	4
VRT-WA29	Dep-F	-23.135	118.584	Footslope and Plain	1
VWAH-13	Dep-F	-23.128	118.912	Hilltop, Hillslope, Ridge or Cliff	2
VRT-WA30	Dep-H	-23.123	118.876	Hilltop, Hillslope, Ridge or Cliff	1
VRT-WA43	Dep-H	-23.110	118.595	Mulga Spinifex Woodland	1
VWAW-85	WH	-23.107	118.639	Mulga Spinifex Woodland	2
Total- acoustic nights- baseline survey					**30**
Total- acoustic nights- baseline and targeted survey					**320**

2.3.3.2 Dusk Surveys

Dusk bird surveys are regarded as a primary method for confirming the Night Parrot (DPaW, 2017). Four nights of dusk bird surveys were conducted at the site where unidentified calls were recorded within the WH Deposit in the Study Area (WA-SM4A-001) and the surrounding area. Peak calling may occur in the two hours after sunset and two hours before sunrise, therefore dusk surveys were conducted from just before sunset until two hours after sunset.

2.3.4 Greater Bilby, Pilbara Olive Python and Northern Brushtail Possum

While traversing the Study Area, the team recorded all vertebrate fauna of conservation significance encountered, either from primary (i.e. direct observation) or secondary (e.g. burrows, scratching's, diggings and scats) evidence. The locations of all fauna of conservation significance were recorded.

Cave searching also provided the opportunity to detect Northern Quolls, Pilbara Olive Python and Northern Brushtail Possums if they were utilising the area. Motion cameras deployed for other species such as Northern quolls in section 2.3.1.1 can also detect species such as the Pilbara Olive Python and Northern Brushtail Possum.

Unexplored suitable habitat for the Greater Bilby was searched on-foot within the northern section of WH, with the team looking for potential burrows and diggings (while setting out Acoustic recorders for Night Parrots).

Table 2.5: Survey design and effort for each targeted conservation significant species

Species	Consideration	Guideline recommendation	Current survey
Ghost Bat	Detectability	Cave searching and scat finding (collecting). Passive recorders as a secondary technique.	• Bat detectors were placed at known caves, new caves or significant habitat areas. • Searching was undertaken for suitable caves. • Caves were inspected for presence of scats and individuals.

Species	Consideration	Guideline recommendation	Current survey
	Timing	Nil	• Surveys were undertaken in June/ July, well before pups are born (~November). • Baseline survey; 25 locations (68 sampling nights).
Pilbara Leaf-nosed Bat	Detectability	Passive acoustic bat detectors are the best non-invasive survey, cave searching for roost site.(DEWHA, 2010)	• Bat detectors were placed at known caves, new caves or significant habitat areas. • Searching was undertaken for suitable caves. • Caves were inspected for presence of scats and individuals
	Timing	Unattended detectors should be left overnight at multiple locations. (DEWHA, 2010)	• Surveys were undertaken in June/ July, well before pups are born (~January). • This survey; 8 locations (24 sampling nights). • Baseline survey; 25 locations (68 sampling nights).
Northern Quoll	Detectability	Where possible, undertake repeat sampling in habitat critical to the survival of the Northern Quoll.	The Study Area has previously been surveyed for the species.
	Timing	Motion cameras can be used at any time of the year but preferably when Northern Quolls are likely to be active and more detectable, i.e. before male die-off.	The survey was conducted in June/ July when populations are typically higher post-weaning, and before male die-off occurs (semelparity).
	Survey design and effort	Transects of ten baited motion sensor cameras spaced at least 100 m intervals for four nights is recommended. Where possible, undertake repeat sampling in habitat critical to the survival of the Northern Quoll. Searching for secondary evidence such as scats and tracks. DoE (2016)	• Baseline cameras; 139 sampling nights. • Motion cameras were used at cave entrances, from where unidentified scats were recorded during the baseline survey; 282 sampling nights. • Two motion camera quoll lines were left out for 145 nights in between baseline surveys; 2,900 sampling nights. • Eight motion camera quoll lines were set during the current survey; 320 sampling nights. • Searches were undertaken for secondary evidence (e.g. scats).
	Animal welfare	Motion cameras should not be baited with food rewards for longer than five consecutive nights to prevent impacts on normal animal behaviour. DoE (2016)	Motion cameras with reward bait were not deployed longer than four nights. Motion cameras deployed for longer than five consecutive nights were baited with a no-reward bait.
	Effective baiting	Traps baited with sardines or a bolus mix of oats and peanut butter (honey optional), chicken wings and/or diced bacon. DoE (2016)	Cameras were baited with “universal bait” (a mixture of oats, sardines and peanut butter).

Species	Consideration	Guideline recommendation	Current survey
	Site coverage	Cameras should cover all habitat types i.e. shelter and foraging and dispersal habitat. DoE (2016)	Motion cameras were set up in the denning/ foraging habitat of the species (Hilltop, Hillslope, Ridge or Cliff, Gorge or Gully habitat).
Night Parrot	Detectability	The most effective survey technique for Night Parrots is passive acoustic surveys. DPaW (2017)	Acoustic recorders were deployed at 39 sites during the current survey. Four dusk bird surveys conducted just before sunset until two hours after sunset.
	Survey design and effort	A survey will need to include at least six nights of recordings that are made under good recording conditions (i.e. little or no wind, rain, or other acoustic disturbances) for each recording device. DPaW (2017)	SM4 recorders were deployed for between three and fourteen nights each for a total of 290 recording nights during the current survey. Conditions during the recording period was generally good, with no rain and low winds recorded.
	Supplementary methods	Motion cameras have proved not to be effective in surveying roosting or feeding areas but could be used as a supplementary technique. No available survey technique can irrefutably demonstrate that Night Parrots are absent from a site. Habitat assessment is therefore critically important. DPaW (2017)	No motion cameras where set up within the habitat areas for Night Parrot.
	Coverage	No specific guidelines.	• Acoustic recorders were deployed at 36 sites within the current survey within the WH Deposit; 248 nights recorded. • Acoustic recorders were deployed at 3 sites within the current survey within the Karijini National Park; 42 nights recorded. • 13 sites (30 nights) were recorded over the baseline survey.
Greater Bilby	Survey design and effort	Survey effort is to be distributed across suitable Greater Bilby habitat, defined as habitat known to be favoured by bilbies in the region. (DBCA, 2017)	Survey effort was concentrated on the most likely habitat within the Study Area, although considered marginal.

Species	Consideration	Guideline recommendation	Current survey
	Techniques	Linear surveys/ searches, 2 ha sign plot technique, and/or combination of both are recommended. (DBCA, 2017) The most efficient and reliable technique to detect Greater Bilbies is the observation of signs by trained and experienced observers. Remote cameras may be useful in detecting and confirming the presence of bilbies in habitats where their sign is not easily detected, determining current presence or activity (*e.g.* at burrows).(DBCA, 2017)	Transects of the most likely suitable habitat within the study area were undertaken in conjunction with setting up Acoustic recorders.
Pilbara Olive Python	Techniques	Night driving roads, through rocky areas that contain permanent water. Also searching rocky ranges close to water. Searches for faecal pellets.	Searches were undertaken through rocky Gorge or Gully and Hilltop, Hillslope, Ridge or Cliff. Motion Cameras set up to detect species such as Northern Quoll, Northern Brushtail Possums may also opportunistically detect Pilbara Olive Pythons.
Northern Brushtail Possum	Techniques	No specific guidelines. Motion cameras may be useful in detecting and confirming the presence of Northern Brushtail Possum in habitats where their sign is not easily detected. Searching for scats, tracks and scratches.	• Baseline motion cameras; 139 sampling nights. • Motion cameras were used at cave entrances, from where unidentified scats were recorded during the baseline survey; 282 sampling nights. • Two motion camera quoll lines were left out for 145 nights in between baseline surveys; 2,900 sampling nights. • Eight motion camera Quoll lines (may also detect Northern Brushtail Possum) were set during the current survey; 320 sampling nights

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Habitat Type

- Cleared
- Drainage Area
- Footslope and Plain
- Gorge or Gully
- Hilltop, Hillslope, Ridge or Cliff
- Minor Drainage
- Mixed Acacia Woodland
- Mulga Spinifex Woodland

Legend

- Study Area
- Karijini National Park

This Survey

- Acoustic Recording
- Ultrasonic Recording
- Motion Camera Transect
- Targeted Searches

Baseline Surveys

- Acoustic Recording
- Ultrasonic Recording
- Motion Camera Transect
- Baseline Targeted Searches

biologic Environmental Survey

N

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0 0.475 0.95 1.9 2.85 3.8 km

RTIO - West Angelas Beyond 2020

Vertebrate Fauna Targeted Survey

Figure 2.2: Vertebrate fauna sampling sites Western Hill Deposit

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

Size A3. Created 26/06/2020

682500 685000 687500 690000 692500 695000 697500

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A1 A2 L2 L3

West Angelas Mine

Habitat Type

- Cleared
- Drainage Area
- Footslope and Plain
- Gorge or Gully
- Hilltop, Hillslope, Ridge or Cliff
- Minor Drainage
- Mixed Acacia Woodland
- Mulga Spinifex Woodland

Legend

- Study Area
- Karijini National Park
- Biologic (2018) Cave Monitoring

This Survey

- Motion Camera Transect
- Targeted Searches
- Targeted Searches

biologic Environmental Survey

N

1:45,000

0 0.35 0.7 1.4 2.1 2.8 km

RTIO - West Angelas Beyond 2020

Vertebrate Fauna Targeted Survey

Figure 2.3: Vertebrate fauna sampling sites Deposit H

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

Size A3. Created 26/06/2020

675000 677500 680000 682500 685000 687500 690000 692500

7435000 7432500 7430000 7427500

AA1

Habitat Type

- Cleared
- Drainage Area
- Footslope and Plain
- Gorge or Gully
- Hilltop, Hillslope, Ridge or Cliff
- Minor Drainage
- Mixed Acacia Woodland
- Mulga Spinifex Woodland

Legend

- Study Area
- Karijini National Park
- Biologic (2018) Cave Monitoring

This Survey

- Ultrasonic Recording
- Motion Camera Transect
- Targeted Searches
- Targeted Searches

biologic Environmental Survey

N

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0 0.4 0.8 1.6 2.4 3.2 km

RTIO - West Angelas Beyond 2020

Vertebrate Fauna Targeted Survey

Figure 2.4: Vertebrate fauna sampling sites Deposit F and Deposit J & MT Ella East

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

Size A3. Created 26/06/2020

3 RESULTS AND DISCUSSION

Results of the targeted surveys undertaken for the seven species of conservation significance at West Angelas are discussed below.

3.1 Northern Quoll

3.1.1 Previous Records

The Northern Quoll has been recorded approximately 71 km from the Western Hill Deposit study boundary within Karijini National Park, which lies immediately of the west of the Study Area (DBCA, 2019a). The species has also been recorded approximately 17 km northeast of the Study Area at Hope Downs 1 Mine, where the species was captured on camera in 2017 and sighted in 2010 (DBCA, 2019a). Generally, there are few contemporary records of this species within the central Hamersley Ranges.

Scat of the Northern Quoll were recorded during the baseline survey in October 2018 at cave CWAN-04, within the WH Deposit (Biologic, 2019a). The scats (approx. 200) were located towards the back of the cave within a small cavity lined with grass, suggesting it may be a possible den.

During the baseline survey, motion cameras were deployed for between two and nine nights at 40 locations within the Study Area, for a total of 139 sampling nights (Phase1 and 2). These deployments targeted the most suitable habitat for the Northern Quoll, such as rocky outcrops and locations containing sources of water. Three additional sites were selected for longer term camera deployments, including cave CWAN-04, where scats of the species were recorded. Two cameras were deployed here (VWAN-62) for 141 nights between the Phase 1 (October 2018) and Phase 2 (March 2019) surveys, resulting in a total of 282 sampling nights. The other two sites (VWAN-63 and VWAN-64) comprised rocky habitat considered likely to support the Northern Quoll, with each site consisting of a line of 10 cameras placed 100 m apart. These cameras were in place for 145 nights between the Phase 1 (October 2018) and Phase 2 (March 2019) surveys, resulting in 2,900 sampling nights. No Northern Quolls were detected on these cameras and no scats were recorded outside of cave CWAN-04.

3.1.2 Current Survey

The current survey recorded no additional Northern Quoll observations from the eight targeted motion camera lines (320 sampling nights) that where set up in the most suitable habitat to detect the species, namely Gorge or Gully habitat or Hilltop, Hillslope, Ridge or Cliff habitats (Figure 3.1). Additionally, no other Northern Quoll evidence was recorded while walking the transects.

Northern Quolls have only been confirmed from the Study Area through the scats that were collected from one cave during the baseline survey. The number recorded suggests long term occupation by a breeding individual that probably resided in the area following a dispersal event after a season of good conditions. The condition of the scat indicates these to be somewhat recent (<12 months) however they are likely to be older than they appear given the stable microclimate within the cave. Based on the work undertaken thus far and the density of records compared to other areas, it is very likely that Northern Quolls are infrequently encountered in the Study Area, and then likely to be dispersing from a permanent population elsewhere.

3.1.3 Habitats Within the Study Area

The Gorge or Gully (157 ha, 1.4% of Study Area) habitat has a high density of potential denning locations and foraging opportunities for the Northern Quoll, and for that reason is considered core habitat and of high significance to the species (DoE, 2016) (Figure 3.1). The Drainage Area (72.1 ha; 0.6%) and the Hilltop, Hillslope, Ridge or Cliff (4,920 ha; 42.5%) habitats provide key dispersal and foraging habitat for the species and are considered to be of moderate significance (Figure 3.1, Figure 3.2, Figure 3.3). The remainder of habitats present are unlikely to provide significant habitat for the species and are considered to be of low significance.

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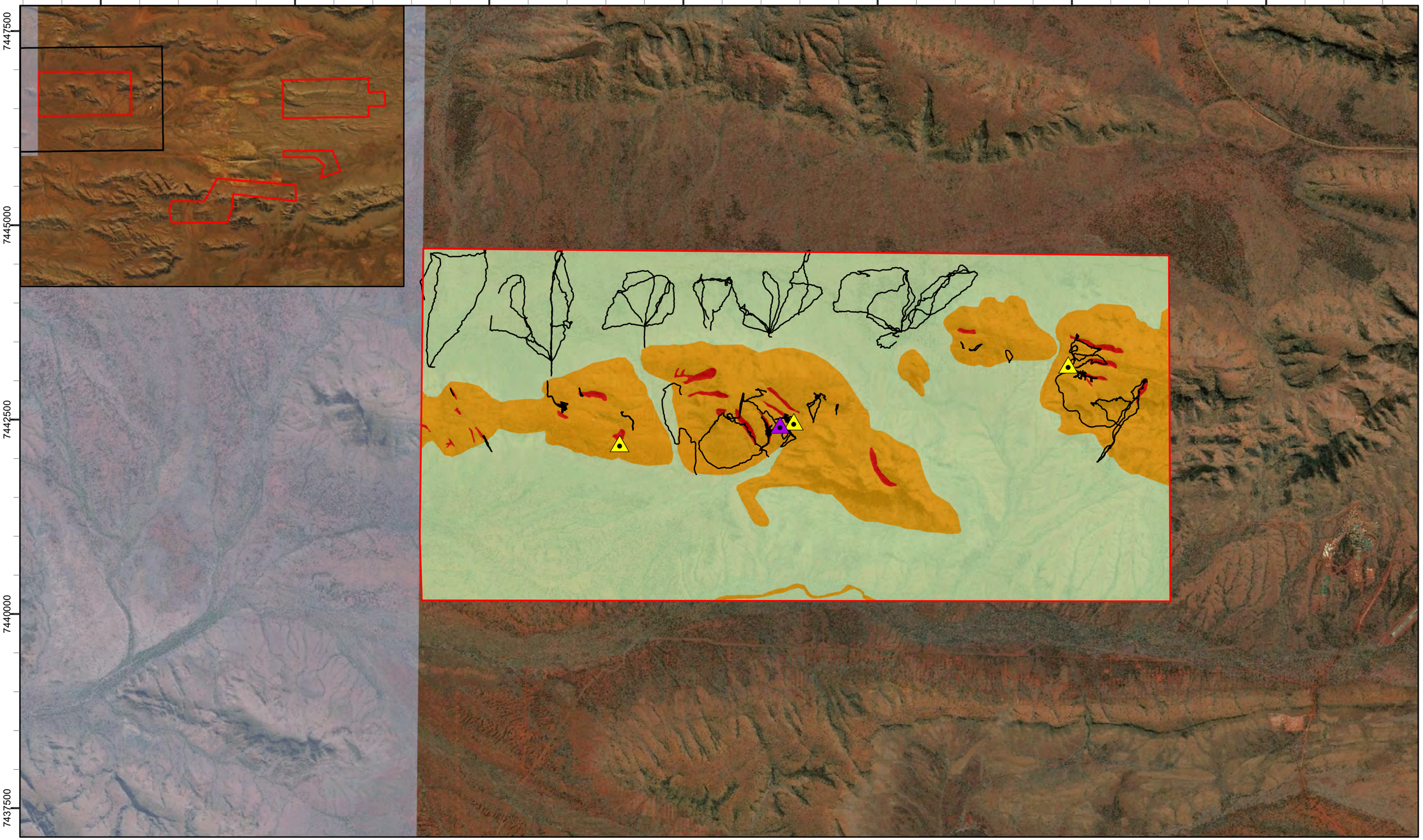

Legend

- Study Area
- Karijini National Park
- Targeted Searches

Northern Quoll Records

- Biologic (2019a) Scat

Null Records

- Motion Camera Transect

Potential Northern Quoll habitat

- Foraging and Dispersal - Drainage Area; Hilltop, Hillslope, Ridge or cliff
- Denning - Gorge or Gully
- Supporting habitat - Cleared; Footslope and Plain; Minor Drainage; Mixed Acacia Woodland; Mulga Spinifex Woodland

biologic Environmental Survey

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0 0.35 0.7 1.4 2.1 2.8 km

RTIO - West Angelas Beyond 2020

Vertebrate Fauna Targeted Survey

Figure 3.1: Potential Northern Quoll habitat within Western Hill Deposit

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

Size A3. Created 26/06/2020

682500 685000 687500 690000 692500 695000 697500

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West Angelas Mine

Legend

- Study Area
- Karijini National Park
- Targeted Searches

Null Records

- Motion Camera Transect

Potential Northern Quoll habitat

- Foraging and Dispersal - Drainage Area; Hilltop, Hillslope, Ridge or cliff
- Denning - Gorge or Gully
- Supporting habitat - Cleared; Footslope and Plain; Minor Drainage; Mixed Acacia Woodland; Mulga Spinifex Woodland

biologic Environmental Survey

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0 0.35 0.7 1.4 2.1 2.8 km

RTIO - West Angelas Beyond 2020

Vertebrate Fauna Targeted Survey

Figure 3.2: Potential Northern Quoll habitat within Deposit H

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

Size A3. Created 26/06/2020

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Legend

- Study Area
- Karijini National Park
- Targeted Searches

Null Records

- Motion Camera Transect

Potential Northern Quoll habitat

- Foraging and Dispersal - Drainage Area; Hilltop, Hillslope, Ridge or cliff
- Denning - Gorge or Gully
- Supporting habitat - Cleared; Footslope and Plain; Minor Drainage; Mixed Acacia Woodland; Mulga Spinifex Woodland

biologic Environmental Survey

N

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0 0.4 0.8 1.6 2.4 3.2 km

RTIO - West Angelas Beyond 2020

Vertebrate Fauna Targeted Survey

Figure 3.3: Potential Northern Quoll habitat within the Deposit F and Deposit J & MT Ella East

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

Size A3. Created 26/06/2020

3.2 Greater Bilby

3.2.1 Previous Records

The Study Area falls within the current distribution of the Greater Bilby, located within the Hamersley subregion in the Pilbara (Southgate, 1990a). The nearest records are located 5 km north of Dep-H (1983); 78 km north of the Study Area (2013) and 99 km northwest of the Study Area (2013) (DBCA, 2019a).

3.2.2 Current Survey

During the current survey, the most likely habitat within the Study Area (although considered marginal) was surveyed while undertaking targeted transects for suitable Night Parrot habitat. No Greater Bilby signs, tracks, scats, diggings or burrows, were recorded from the 15 targeted transects within the Study Area (Figure 3.4).

3.2.3 Habitats within the Study Area

Extant population of the Greater Bilby occur in a variety of habitats, usually on landforms with level to low slope topography and light to medium soils (Southgate, 1990b). Within the Pilbara region, the species is recorded within spinifex sandplains associated with paleo-drainage lines and perched drainage lines where the substrate of sand, soil, sandy clay, or sandy gravel is suitable for burrowing (Dziminski & Carpenter, 2017). Within these sandplain habitats, there is also an association with particular *Acacia* spp. containing root dwelling larvae that the species use for food resources (Dziminski & Carpenter, 2017). Recently burnt habitat (within the last 1-3 years) is also included as a suitable habitat type for Greater Bilby (DBCA, 2017).

The Study Area contains moderately suitable habitat for the species in the form of sandy/ stony flats containing patches of large spinifex hummocks, such as those observed within the Mulga Spinifex Woodland, and Footslope and Plains habitat, as well as Drainage Area and Minor Drainage habitats, making a total area of moderately suitable habitat across the Study Area of 5,832.1 ha (50.35%) (Figure 3.4, Figure 3.5, Figure 3.6). Due to the lack of contemporary records in the vicinity of the Study Area, only moderately suitable habitat and no evidence of tracks, scats and diggings in the area, it is considered Unlikely that the Greater Bilby occurs within the Study Area.

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Legend

- Study Area
- Karijini National Park
- Targeted Searches

Potential Greater Bilby habitat

- Marginal Habitat - Drainage Area; Footslope and Plain; Minor Drainage; Mulga Spinifex Woodland
- Not likely - Mixed Acacia Woodland; Hilltop, Hillslope, Ridge or Cliff; Gorge or Gully; Cleared

biologic Environmental Survey

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1:45,000

0 0.35 0.7 1.4 2.1 2.8 km

RTIO - West Angelas Beyond 2020

Vertebrate Fauna Targeted Survey

Figure 3.4: Potential Greater Bilby habitat within Western Hill Deposit

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

Size A3. Created 26/06/2020

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West Angelas Mine

Legend

- Study Area
- Karijini National Park
- Targeted Searches

Potential Greater Bilby habitat

- Marginal Habitat - Drainage Area; Footslope and Plain; Minor Drainage; Mulga Spinifex Woodland
- Not likely - Mixed Acacia Woodland; Hilltop, Hillslope, Ridge or Cliff; Gorge or Gully; Cleared

biologic Environmental Survey

N

1:45,000

0 0.35 0.7 1.4 2.1 2.8 km

RTIO - West Angelas Beyond 2020

Vertebrate Fauna Targeted Survey

Figure 3.5: Potential Greater Bilby habitat within Deposit H

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

Size A3. Created 26/06/2020

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Legend

- Study Area
- Karijini National Park

Potential Greater Bilby habitat

- Marginal Habitat - Drainage Area; Footslope and Plain; Minor Drainage; Mulga Spinifex Woodland
- Not likely - Mixed Acacia Woodland; Hilltop, Hillslope, Ridge or Cliff; Gorge or Gully; Cleared

biologic Environmental Survey

N

1:50,000

0 0.4 0.8 1.6 2.4 3.2 km

RTIO - West Angelas Beyond 2020

Vertebrate Fauna Targeted Survey

Figure 3.6: Potential Greater Bilby habitat within Deposit F and Deposit J & MT Ella East

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

Size A3. Created 26/06/2020

3.3 Ghost Bat

3.3.1 Previous Records

Ghost Bats have been known to occur within the West Angelas area since 1978 and have been recorded intermittently since this time (Biologic, 2018). Five caves used by the Ghost Bat in the West Angelas area (A1, A2, L2, L3, AA1) have been monitored annually since 2012 (Biologic, 2018). Cave AA1, which represents a maternity roost, is located 1.2 km west of Dep-F and 1.6 km north of Dep-J & MtEE. The remaining four caves (A1, A2, L2 and L3) are located between 2.4 km and 5 km of Dep-F and 10 km from both the WH Deposit and Dep-J & MtEE. A recent targeted fauna assessment of other deposits close to the Study Area (Deposits C, D and G) located 11 caves used by the Ghost Bat, including three (CWAN13, CWAN21 and CWAN23) that may represent maternity roosts, four that are likely to be diurnal roosts (CWAN12, CWAN17, CWAN20, CWAN22) and four that are likely to be night roosts (CWAN09, CWAN10, CWAN11, CWAN16) (Biologic, 2019b). A total of 11 caves were also identified during the baseline surveys, including seven containing Ghost Bat scats (Biologic, 2019a). A Ghost Bat was observed in cave CWAN06 during both phases of the baseline survey, and the remains of a Ghost Bat pup were found in cave CWAN04 (Biologic, 2019a). Approximately 1,500 Ghost Bat scats were also observed in each of these two caves (Biologic, 2019a). Scats of the species were also recorded in five other caves in the Study Area, with the number of scats observed ranging from a single scat to up to 5,000 scats (in the case of CWAN07). Based on these records and the structure of the caves, one was identified as a maternity roost (CWAN04), two as potential maternity roosts (CWAN06, CWAN07), four as potential diurnal roosts (CWAN01, CWAN02, CWAN03, CWAN10), three as night roosts (CWAN08, CWAN09, CWAN11) and one as a potential night roost (CWAN05).

3.3.2 Current Survey

An additional nine caves (CWAN-26- CWAN-34) were recorded during the current survey, each recorded in Gorge or Gully, Hilltop, Hillslope, Ridge or Cliff habitat (Table 3.1). Of the nine caves, two were recorded as potential diurnal roosts (CWAN-29 and CWAN-31) and two night roosts (CWAN-28 and CWAN-32), the remaining five contained no evidence of the species but were recorded as they may represent potential night roosts for the species (CWAN-26, CWAN-27, CWAN-30, CWAN-33 and CWAN-34). Three of the caves contained Ghost Bat scats (CWAN-28, CWAN-29 and CWAN-32) and one contained remains of a Ghost Bat (CWAN-29). Ultrasonic recorders were placed at the entrance of two of these caves (CWAN-29 and CWAN-31), although no calls of the Ghost Bat were recorded. For further detail of the caves recorded during the baseline survey and this survey, refer to Appendix 1.

Three caves (CWAN-04, CWAN-06 and CWAN-07) originally recorded during the baseline work were revisited to further characterise their importance and collect scats from sheets that were deployed over the Ghost Bat middens at each cave during the baseline survey. Additionally, CWAN-03 in WH Deposit and CWAN-08 from Dep-J & MtEE were also revisited and sheeted for the first time (for future sampling). CWAN-04 recorded 100 scats between March and June. One Ghost Bat individual was recorded in cave CWAN-06 during the current survey and one individual had been recorded in the same cave on two occasions during the baseline survey. No other individuals were recorded. Ultrasonic recorders were placed at the entrance of five of these caves to record presence of the species. One

Ghost Bat call was recorded on the 30th June 2019 at 18:41 from Cave CWAN-06 (Site WAN-23). Twenty calls were also recorded from 30 June - 1st July between 18:48 and 23:42 from Cave CWAN-04 (Site WAN-100).

Table 3.1: Caves recorded within the Study Area

Name	Deposit	Cave category	Initial Assessment	Follow up monitoring
Caves found during Baseline surveys, Phase 1 &2 (Biologic, 2019b)				
CWAN-01	WH	• Potential diurnal roost	• 10 Ghost Bat scats	• N/A
CWAN-02	WH	• Potential diurnal roost	• no Ghost Bat scats	• N/A
CWAN-03	WH	• Potential diurnal roost	• no Ghost Bat scats	• Scats recorded targeted search • Sheeted cave and collected scats
CWAN-04	WH	• Confirmed maternity roost	• ~1,500 Ghost Bat scats recorded during Phase 1, sheeted • Dead Ghost Bat pup (Skeleton) found	• ~500 Ghost Bats scats deposited on sheets between Phase 1 and Phase 2 • Between Phase 2 and Targeted 100 Ghost Bat scats deposited on sheets
CWAN-05	WH	• Potential night roost	• no Ghost Bat scats	• N/A
CWAN-06	WH	• Potential maternity roost	• ~1,500 Ghost Bat scats • 1 Ghost Bat individual present during Phase 1 and Phase 2 and Targeted	• Collected 20 scats off sheet
CWAN-07	WH	• Potential maternity roost	• ~5,000 Ghost Bat scats	• Collected 20 scats off sheet
CWAN-08	Dep-J & MtEE	• Night roost	• 30 Ghost Bat scats	• Sheeted in Targeted survey
CWAN-09	Dep-H	• Night roost	• 7 Ghost Bat scats	• N/A
CWAN-10	Dep-J & MtEE	• Potential diurnal roost	• No Ghost Bat scats	• N/A
CWAN-11	Dep-J & MtEE	• Night roost	• 1 Ghost Bat scat	• N/A
New caves found during Targeted surveys				
CWAN-26	WH	• Potential night roost	• No Ghost Bat scats	• N/A
CWAN-27	WH	• Potential night roost	• No Ghost Bat scats	• N/A
CWAN-28	WH	• Night roost	• 5 Ghost Bat scats	• N/A
CWAN-29	WH	• Potential diurnal roost	• 5 Ghost Bat scats • Remains of Ghost Bat found	• N/A
CWAN-30	WH	• Potential night roost	• No Ghost Bat scats	• N/A
CWAN-31	WH	• Potential diurnal roost	• No scats recorded but a good dark cave	• N/A
CWAN-32	WH	• Night Roost	• 5 Ghost Bat scats	• N/A

Name	Deposit	Cave category	Initial Assessment	Follow up monitoring
CWAN-33	WH	• Potential night roost	• No Ghost Bat scats	• N/A
CWAN-34	Dep-J & MtEE	• Potential Night Roost	• No Ghost Bat scats	• N/A

3.3.3 Habitats within the Study Area

Gorge or Gully habitat represents the most important habitat for the Ghost Bat within the Study Area as this is where suitable caves are most likely to be located and can be utilised for both denning and foraging. Additionally, this habitat often contains shallow overhangs and rock ledges that may be used as hanging locations by the species for foraging activities and feeding. This habitat makes up 157 ha (1.4%) of the Study Area. Woodlands in the Study Area, such as those within Drainage Area, Footslope and Plain, Minor Drainage, Mixed Acacia Woodland and Mulga Spinifex Woodland habitats (5,876.1 ha, 50.75%), also provide suitable foraging habitat for Ghost Bats (Figure 3.7, Figure 3.8, Figure 3.9).

The WH Deposit has been thoroughly searched for caves and appears to be a significant area for the species. All caves recorded in WH Deposit and Dep-J & MtEE are recorded within the Brockman Iron Formation, whereas the single cave recorded in Dep-H was recorded within Marra Mamba Iron Formation.

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7445000 7442500 7440000 7437500

CWAN-07 CWAN-06 CWAN-01 CWAN-33 CWAN-30 CWAN-27 CWAN-32 CWAN-05 CWAN-26 CWAN-28 CWAN-29 CWAN-02 CWAN-04 CWAN-03 CWAN-31

CWAN-09 CWAN-10 CWAN-23 CWAN-24 CWAN-11 CWAN-12 CWAN-13 CWAN-22 CWAN-25 CWAN-15 CWAN-14 CWAN-19 CWAN-16 CWAN-21 CWAN-20 CWAN-17 CWAN-18

Caves

Biologic (2019a) Baseline Survey

- Maternity Roost
- Potential Maternity Roost
- Potential Diurnal Roost
- Night Roost
- Potential Night Roost

Biologic (2019b) C, D, and G, Targeted Survey

- Potential Maternity Roost
- Diurnal Roost
- Potential Diurnal Roost
- Night Roost
- Potential Night Roost

This Survey

- Potential Diurnal Roost
- Night Roost
- Potential Night Roost

Legend

- Study Area
- Karijini National Park

Ghost Bat records

- DBCA 2018
- This Survey

Potential Ghost Bat Habitat

- Foraging and dispersal - Drainage Area; Footslope and Plain; Minor Drainage; Mixed Acacia Woodland; Mulga Spinifex Woodland
- Denning - Gorge or Gully
- Supporting habitat - Cleared; Hilltop, Hillslope, Ridge or Cliff

biologic Environmental Survey

N

1:45,000

0 0.35 0.7 1.4 2.1 2.8 km

RTIO - West Angelas Beyond 2020

Vertebrate Fauna Targeted Survey

Figure 3.7: Potential Ghost Bat habitat within Western Hill Deposit

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

Size A3. Created 14/02/2020

682500 685000 687500 690000 692500 695000 697500

7447500 7445000 7442500 7440000 7437500

West Angelas Mine

CWAN-09

Legend

Study Area

Karijini National Park

Ghost Bat records

DBCA 2018

Biologic (2019a) Baseline Survey

Night Roost

Biologic (2018) Monitoring

Maternity Roost

Diurnal Roost

Night Roost

Potential Ghost Bat Habitat

Foraging and dispersal - Drainage Area; Footslope and Plain; Minor Drainage; Mixed Acacia Woodland; Mulga Spinifex Woodland

Denning - Gorge or Gully

Supporting habitat - Cleared; Hilltop, Hillslope, Ridge or Cliff

biologic Environmental Survey

N

1:45,000

0 0.35 0.7 1.4 2.1 2.8 km

RTIO - West Angelas Beyond 2020

Vertebrate Fauna Targeted Survey

Figure 3.8: Potential Ghost bat habitat within Deposit H

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

Size A3. Created 14/02/2020

675000 677500 680000 682500 685000 687500 690000 692500

7437500 7435000 7432500 7430000 7427500

CWAN-08
CWAN-10
CWAN-11
CWAN-34

Caves

Biologic (2018 Monitoring)
- Maternity Roost

Biologic (2019a) Baseline Survey
- Maternity Roost
- Potential Maternity Roost
- Potential Diurnal Roost
- Night Roost
- Potential Night Roost

This Survey
- Potential Diurnal Roost
- Night Roost
- No Usage

Legend

- Study Area
- Karijini National Park

Ghost Bat records
- DBCA 2018

Potential Ghost Bat Habitat
- Foraging and dispersal - Drainage Area; Footslope and Plain; Minor Drainage; Mixed Acacia Woodland; Mulga Spinifex Woodland
- Denning - Gorge or Gully
- Supporting habitat - Cleared; Hilltop, Hillslope, Ridge or Cliff

biologic Environmental Survey

N

1:50,000

0 0.4 0.8 1.6 2.4 3.2 km

RTIO - West Angelas Beyond 2020
Vertebrate Fauna Targeted Survey
Figure 3.9: Potential Ghost Bat habitat within Deposit F and Deposit J & MT Ella East

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

Size A3. Created 14/02/2020

3.4 Pilbara-leaf Nosed Bat

3.4.1 Previous Records

Regional work conducted in the area has recorded this species at 12 locations, comprising 11 by Rio Tinto (December 2016 = 2 locations, April 2017 = 3 locations, and November 2018 = 6 locations) and one location by Biologic (2019a) (Figure 3.10, Figure 3.11, Figure 3.12). The most notable recording was from the southeast corner of Karijini National Park, where 181 calls were recorded at a breakaway above a dry gully. The earliest call from this location was recorded seven minutes after dusk civil twilight (CT; civil twilight representing the time when individuals of the species leave/enter their roost; Bullen, 2013), indicating a roost is in close proximity to this location. Given the sampling was undertaken in the late dry season, when bats are believed to congregate back to the most important and permanent roosts (Armstrong, 2000, 2001), it is likely that the newly discovered roost represents a permanent diurnal roost (as defined by TSSC, 2016b). Based on an indicative location, the Karijini roost, named the Upper Turee Creek Roost, is located approximately 13.5 km to the west of the WH Deposit, a distance that could be covered by a foraging individual.

Within the Study Area, echolocation calls of the Pilbara Leaf-nosed Bat have been recorded at two locations within the WH Deposit; VWAW-87 within Footslope and Plain habitat, where a single call was recorded at 02:00 during Phase 1 of the baseline survey; and cave CWAN-04, within Gorge or Gully habitat where a single call was recorded at 02:26 during Phase 2 of the baseline survey. The timing of calls at these locations is consistent with individuals flying to the Study Area from the Upper Turee Creek Roost. Given the size and structure of the cave and the fact that the species was recorded at its entrance, cave CWAN-04 is likely to represent a nocturnal refuge (as defined by TSSC, 2016b) for the species. Other caves in the Study Area may also be used during nocturnal foraging by the species.

3.4.2 Current Survey

Pilbara Leaf-nosed Bat was recorded during the current survey from two calls on the ultrasonic recorder located at cave CWAN-04 (site VWAN-100) at 19:33 on the 30th June (104 mins after civil twilight) and 19:42 on the 1st July (113 mins after civil twilight).The timing for all the calls is consistent with bats originating from the Upper Turee Roost (*pers. comms.* Bob Bullen). No other calls were recorded from the six other caves sampled and no other observations were recorded during the current survey. However, not all caves in the Study Area have been sampled for this species and therefore it is possible that these other caves represent habitat, such as nocturnal refuges for the species (Table 3.2).

Table 3.2: Caves recorded in the West Angelas Study Area and importance to Pilbara Leaf-nosed Bats

Name	Deposit	Cave category
Baseline Survey (Biologic, 2019a)		
CWAN-01	WH	• Potential Nocturnal Refuge
CWAN-02	WH	• Potential Nocturnal Refuge
CWAN-03	WH	• Potential Nocturnal Refuge
CWAN-04	WH	• Potential Nocturnal Refuge
CWAN-05	WH	• Potential Nocturnal Refuge
CWAN-06	WH	• Potential Nocturnal Refuge
CWAN-07	WH	• Potential Nocturnal Refuge
CWAN-08	Dep-J & MtEE	• Potential Nocturnal Refuge
CWAN-09	Dep-H	• Potential Nocturnal Refuge
CWAN-10	Dep-J & MtEE	• Potential Nocturnal Refuge
CWAN-11	Dep-J & MtEE	• Potential Nocturnal Refuge
This Survey		
CWAN-26	WH	• Potential Nocturnal Refuge
CWAN-27	WH	• Potential Nocturnal Refuge
CWAN-28	WH	• Potential Nocturnal Refuge
CWAN-29	WH	• Potential Nocturnal Refuge
CWAN-30	WH	• Potential Nocturnal Refuge
CWAN-31	WH	• Potential Nocturnal Refuge
CWAN-32	WH	• Potential Nocturnal Refuge
CWAN-33	WH	• Potential Nocturnal Refuge
CWAN-34	Dep-J & MtEE	• Potential Nocturnal Refuge

3.4.3 Habitats within the Study Areas

Significant caves for Pilbara Leaf-nosed Bat are most commonly found within Gorge or Gully (157 ha, 1.4%) habitats. Suitable foraging habitat for this species occurs within the Gorge or Gully, Drainage Area, and Minor Drainage habitats (168 ha, 1.45%). Whilst the Pilbara Leaf-nosed Bat may be recorded in other habitats within the Study Area, as evidenced by the single call recorded within Footslope and Plain habitat, it is these former habitats which the species is most likely to target during foraging. Gorge or Gully habitat has the potential to contain Priority 1 and Priority 2 foraging habitat (as defined by TSSC, 2016b) for the species. These foraging habitats consist of gorges and gullies which can contain water pools that persist for weeks or months. Drainage Area and Minor Drainage habitat contains important dispersal habitat for the Pilbara Leaf-nosed Bat and represents Priority 4 foraging habitat for the species, which includes sandy or gravelly channels of riverbeds and surrounding riparian vegetation. The Footslope and Plan and the Mixed Acacia Woodland habitat represents Priority 5 foraging habitat for the species, which is characterised by open grassland and woodland.

Three water pools were recorded within the Study Area during the baseline survey (Table 3.3), which was conducted in October 2018. It is likely that the water in these pools came from the high rainfall in June 2018, three months prior. Following the lack of rainfall between June and the survey, the pools were drying up, indicating that they provide only temporary sources of water following periods of rain. After rain in March 2019, they had filled again but were nearly completely dry during the current survey. Each of these features may provide a potential drinking and foraging resource for the species. However,

given that no Pilbara Leaf-nosed Bat calls were recorded at any of the water features sampled by recorders, their temporary presence and the fact they are all located >40 km from the Upper Turee Creek Roost, it is unlikely that the species is reliant on such features, and likely to be used on an opportunistic basis only.

Table 3.3: Water features in the Study Area

Name	Location	Latitude	Longitude	Comment
WB-WAJ2	Dep-J & MtEE	-23.216	118.820	Small rock pool in Gorge or Gully habitat
WB-WAJ1	Dep-J & MtEE	-23.217	118.821	Small rock pool in Gorge or Gully habitat
WB-WAH1	Dep-H	-23.120	118.869	Rock pool in Gorge or Gully habitat; within the upper catchment of Pebble Mouse Creek

657500 660000 662500 665000 667500 670000 672500

7445000 7442500 7440000 7437500

CWAN-07 CWAN-02 CWAN-04 CWAN-33 CWAN-03 CWAN-06 CWAN-01 CWAN-32 CWAN-05 CWAN-26 CWAN-31 CWAN-28 CWAN-29 CWAN-30 CWAN-27

CWAN-09 CWAN-10 CWAN-22 CWAN-11 CWAN-23 CWAN-24 CWAN-12 CWAN-14 CWAN-13 CWAN-15 CWAN-25 CWAN-19 CWAN-20 CWAN-16 CWAN-17 CWAN-18 CWAN-21

Caves

Biologic (2019a) Baseline Survey

- Potential Nocturnal Refuge
- Nocturnal Refuge

Biologic (2019b) C, D, and G, Targeted Survey

- Potential Nocturnal Refuge

Copy of Caves Phase 1 & Targeted.csv Events

This Survey

- Potential Nocturnal Refuge

Legend

- Study Area
- Karijini National Park
- Pilbara Leaf-nosed Bat record

Potential Pilbara Leaf-nosed Bat Habitat

- Foraging and dispersal - Drainage Area; Footslope and Plain; Minor Drainage; Mixed Acacia Woodland; Mulga Spinifex Woodland
- Denning - Gorge or Gully
- Supporting habitat - Cleared; Hilltop, Hillslope, Ridge or Cliff

biologic Environmental Survey

N

1:45,000

0 0.35 0.7 1.4 2.1 2.8 km

RTIO - West Angelas Beyond 2020

Vertebrate Fauna Targeted Survey

Figure 3.10: Potential Pilbara Leaf-nosed Bat habitat within Western Hill Deposit

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

Size A3. Created 14/02/2020

682500 685000 687500 690000 692500 695000 697500

7447500 7445000 7442500 7440000 7437500

West Angelas Mine

CWAN-09

Legend

- Study Area
- Karijini National Park
- Water feature

Biologic (2018) Monitoring

- Potential Nocturnal Refuge

Biologic (2019a) Baseline Survey

- Potential Noturnal Refuge

Potential Pilbara Leaf-nosed Bat Habitat

- Foraging and dispersal - Drainage Area; Footslope and Plain; Minor Drainage; Mixed Acacia Woodland; Mulga Spinifex Woodland
- Denning - Gorge or Gully
- Supporting habitat - Cleared; Hilltop, Hillslope, Ridge or Cliff

biologic Environmental Survey

N

1:45,000

0 0.35 0.7 1.4 2.1 2.8 km

RTIO - West Angelas Beyond 2020

Vertebrate Fauna Targeted Survey

Figure 3.11: Potential Pilbara Leaf-nosed Bat habitat within Deposit H

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

Size A3. Created 14/02/2020

675000 677500 680000 682500 685000 687500 690000 692500

7437500 7435000 7432500 7430000 7427500

CWAN-34 CWAN-08 CWAN-10 CWAN-11

Caves

Biologic (2019a) Baseline Survey

Potential Nocturnal Refuge

Biologic (2018) Monitoring

Potential Nocturnal Refuge

This Survey

Potential Nocturnal Refuge

Legend

Study Area

Karijini National Park

Water feature

Ghost Bat records

DBCA 2018

Potential Pilbara Leaf-nosed Bat Habitat

Foraging and dispersal - Drainage Area; Footslope and Plain; Minor Drainage; Mixed Acacia Woodland; Mulga Spinifex Woodland

Denning - Gorge or Gully

Supporting habitat - Cleared; Hilltop, Hillslope, Ridge or Cliff

biologic Environmental Survey

N

1:50,000

0 0.4 0.8 1.6 2.4 3.2 km

RTIO - West Angelas Beyond 2020

Vertebrate Fauna Targeted Survey

Figure 3.12: Potential Pilbara Leaf-nosed Bat habitat within Deposit F adn Deposit J & MT Ella East

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

Size A3. Created 14/02/2020

3.5 Northern Brushtail Possum

3.5.1 Previous Survey

Unidentified scats that were initially tentatively identified as Northern Brushtail Possum were collected from three caves within WH Deposit (CWAN-04, CWAN-06, CWAN-07) during the baseline survey. The scats were initially thought to belong to this species; however, when compared with known Northern Brushtail Possum scats, they appear smaller in size and more elongated in shape. Additionally, the Northern Brushtail Possum was not identified by the desktop assessment as known or potentially occurring in the Study Area. The nearest record of a Northern Brushtail Possum is 230 km north northeast of the Study Area (Mt Webber Mine site) (DBCA, 2019a).

The scats were sent for morphological analysis to two experts in the field of scat identification, Georgeanna Story and Barbara Triggs. A small number of scats were also subject to genetic analysis (Biologic, 2019a). All identifications were inconclusive in their findings; however, the two morphological identifications suggested that the scats belonged to a rodent species. The most likely candidate, based on distribution alone, is the Common Rock Rat (*Zyzomys argurus*), which was recorded in the Study Area on multiple occasions during the current survey. Several hair fragments found in the scats most likely belong to the genus *Zyzomys*; however, it was not possible to identify the hair to species level (B. Triggs, *pers. comm.*) and in both instances, the scats were noted as being substantially larger than known scats of the Common Rock Rat (G. Story, *pers. comm.;* B. Triggs, *pers. comm.*). The scats were described as being more similar in size to those of larger rodents, such as the native Pale Field-rat (*Rattus tunneyi*) or introduced Black Rat (*R. rattus*) (G. Story, *pers. comm.*); however, there are no previous records of these species in the vicinity of the Study Area and both are Highly Unlikely to occur. The Pale Field-rat is only known in the Pilbara from a number of islands, and the closest record of the Black Rat is approximately 230 km northwest of the Study Area (DBCA, 2019a).

The genetic analysis comprised two tests, a general assay to determine the most similar genetic material and another assay specifically testing for a Brushtail Possum species. No genetic material was traced in the Brushtail Possum assay. The general assay indicated that a portion of the genetic material recorded was most similar to a *Zyzomys* sp. (Appendix 4). Given the occurrence of the Common Rock Rat in the Study Area, it is possible that the genetic material detected from this test was derived from a Common Rock Rat coming into contact with the scats rather than the scats belonging to this species (Appendix 4).

Without further genetic testing, it is not possible to confidently assign the scats to a particular species. Given that the scats were recorded from deep caves where they are protected from weathering, it is possible that they are remnant scats from species that are now considered locally extinct from the region, such as the Central Rock-rat (*Z. pedunculatus*) or Lesser Stick-nest Rat (*Leporillus apicalis* (Gibson & McKenzie, 2009). Evidence of the latter species was found in the Study Area in the form of amberat (crystallised urine); however, the scats were reported to be smaller than known scats of this species (G. Story, *pers. comm.*).

3.5.2 Current Survey

Scats, similar to those recorded during the baseline survey (caves CWAN-04, CWAN-06 and CWAN-07) were also recorded at a newly discovered cave during the survey within WH Deposit (CWAN-28). No other evidence was recorded this survey for Northern Brushtail Possum, including no records on the motion cameras and no scratching on trees.

3.5.3 Habitat in the Study Area

Little ecological information is known about the Pilbara population of this species, although it is most often recorded from gorges and major drainage lines that contain large hollow-bearing Eucalypts (DBCA, 2019a). The species is considered Unlikely to occur in the Study Area, although possible denning habitat is present within Gorge or Gully habitat, and marginally suitable foraging habitat is present within Drainage Area habitat.

3.6 Night Parrot

3.6.1 Previous Records

The distribution of the Night Parrot is very poorly understood in Western Australia; however, the Study Area does fall within the possible distribution as mapped by DPaW (2017). There are only two contemporary records of the species within Western Australia, both located approximately 100 km north of the Study Area at Minga Qwirriawirie Well, south of the Cloudbreak mine site (Davis & Metcalf, 2008) and the other from an unnamed location in the East Murchison in early 2017 (Jackett *et al.*, 2017; Night Parrot Recovery Team, 2017) (Table 3.4).

Table 3.4: Table of previous records of Night Parrot within Western Australia

Location	Date of observation	Source	Distance from Study Area	Recorded habitat type	Other comments
Minga Qwirriawirie Well, south of Cloudbreak mine site	12/04/2005	Davis and Metcalf (2008)	~100 km North	Mulga Woodland. No understorey.	Permanent water soak. 3 individuals observed at dusk in a targeted survey
Moojarri Well	~2005 (exact date not noted)	Biota (2005)	~100 km North	Not noted	Unconfirmed Biota record between Fortescue Marsh and FMG Stage B Rail Corridor
Vacant crown land	15/07/1970	DBCA (2019a)	~290 km northeast	Spinifex grassland (Spinifex and scattered gums) Crest/summit.	Four individuals observed.
East Murchison	March 2017	Night Parrot Recovery Team (2017), Jackett *et al.* (2017)	Unknown	Spinifex hummock grassland on sandy substrate, encompassed by mulga woodland and a breakaway, separated from the *Triodia* by an open plain of samphire	Living individuals and an active nest

Sampling was undertaken by Biologic in the West Angelas area during the baseline surveys in October 2018 and March 2019; 13 sites (30 nights) were sampled across the Study Area, resulting in unconfirmed calls of the same frequency as Night Parrot being detected from site WA-SM4A-001 (VWAW-85) within the WH Deposit. A detailed report of Night Parrot sampling and results can be found in Appendix 3.

3.6.2 Current Survey

A total of 39 acoustic sites with 269 nights of recordings were undertaken within the Study Area specifically targeting WH, the area mentioned above where unconfirmed calls (WA-SM4A-001 (VWAW-85)) were recorded during the baseline survey (Biologic, 2019b). Three acoustic recorder units were also deployed in suitable habitat within Karijini National Park. No Night Parrot calls were detected from these 269 acoustic survey nights and 36 non-target bird species were detected during the analysis. Four nights of dusk surveys were also undertaken with no calls heard.

The sampling undertaken during the current survey provided sufficient detail to confirm that the unconfirmed calls were due to movement of nearby tree branches, and/or the subtle movement of the Song Meters or their attachment when fixed to an object (e.g. a tree) caused by high winds. The remaining recordings were deemed adequate given the number of non-target bird species with calls in the same frequency as Night Parrot recorded (and adequately identified). Therefore it can be reasonably surmised that the recording units would have recorded any Night Parrot vocalisations had they occurred (Appendix 3).

Based on the significant amount of targeted sampling effort undertaken within the Study Area for this species, and the lack of records within the region, it is regarded as Unlikely that the species resides or forages in the Study Area.Habitats Within the Study Area

3.6.3 Habitat Within the Study Area

Night Parrots reportedly occur in spinifex grasslands in stony or sandy areas on floodplains or near creeks, shrubby samphire and chenopod vegetation on claypans or at the edges of salt lakes, and in dense, low vegetation around watercourses (Murphy *et al.*, 2017b; Night Parrot Recovery Team, 2017; Pyke & Ehrlich, 2014). Given the ambiguity of the species-specific habitat requirements, it is considered possible that the species can occur in most habitats dominated by *Triodia* hummock grasses. Habitat types in the Study Area considered most likely to support Night Parrot for nesting and foraging are the Mulga Spinifex Woodland or Footslope and Plain habitat (5,592 ha, 48.3%) (Figure 3.13, Figure 3.14, Figure 3.15). The northern portion of the WH Deposit has patches of *Triodia* hummock grasses, comparable in size to confirmed nesting habitat in Western Australia's Murchison region (~0.5 m in height excluding seed heads, Jackett *et al.*, 2017). Vegetation of the remaining habitats was not of suitable size, age or type to be regarded as suitable for the species. As only marginal habitat exists on site and the fact there are few records confirmed within Western Australia, it is considered Unlikely that the species resides in the Study Area or frequents the area for foraging.

657500 660000 662500 665000 667500 670000 672500

7447500 7445000 7442500 7440000 7437500

Legend

- Study Area
- Karijini National Park
- Targeted Searches

Null Records

- Biologic (2019a) Baseline
- This Survey

Potential Night Parrot habitat

- Marginal Nesting and Foraging - Footslope and Plain; Mulga Spinifex Woodland
- Not likely - Mixed Acacia Woodland; Hilltop, Hillslope, Ridge or Cliff; Gorge or Gully; Cleared; Drainage Area; Minor Drainage

biologic Environmental Survey

N

1:45,000

0 0.35 0.7 1.4 2.1 2.8 km

RTIO - West Angelas Beyond 2020

Vertebrate Fauna Targeted Survey

Figure 3.13: Potential Night Parrot habitat within Western Hill Deposit

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

Size A3. Created 26/06/2020

682500 685000 687500 690000 692500 695000 697500

7447500 7445000 7442500 7440000 7437500

West Angelas Mine

Legend

- Study Area
- Karijini National Park
- Targeted Searches

Potential Night Parrot habitat

- Marginal Nesting and Foraging - Footslope and Plain; Mulga Spinifex Woodland
- Not likely - Mixed Acacia Woodland; Hilltop, Hillslope, Ridge or Cliff; Gorge or Gully; Cleared; Drainage Area; Minor Drainage

biologic Environmental Survey

N

1:45,000

0 0.35 0.7 1.4 2.1 2.8 km

RTIO - West Angelas Beyond 2020

Vertebrate Fauna Targeted Survey

Figure 3.14: Potential Night Parrot habitat within Deposit H

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

Size A3. Created 26/06/2020

675000 677500 680000 682500 685000 687500 690000 692500

7437500
7435000
7432500
7430000
7427500

Legend

- Study Area
- Karijini National Park
- Targeted Searches

Potential Night Parrot habitat

- Marginal Nesting and Foraging - Footslope and Plain; Mulga Spinifex Woodland
- Not likely - Mixed Acacia Woodland; Hilltop, Hillslope, Ridge or Cliff; Gorge or Gully; Cleared; Drainage Area; Minor Drainage

biologic Environmental Survey

N

1:50,000

0 0.4 0.8 1.6 2.4 3.2 km

RTIO - West Angelas Beyond 2020

Vertebrate Fauna Targeted Survey

Figure 3.15: Potential Night Parrot habitat within Deposit F and Deposit J & MT Ella East

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

Size A3. Created 26/06/2020

3.7 Pilbara Olive Python

3.7.1 Previous Records

Pilbara Olive Pythons are known to occur across the Pilbara bioregion (Bush & Maryan, 2011). In the Hamersley subregion they most often encountered in the vicinity of permanent waterholes in rocky ranges or among riverine vegetation (DSEWPaC, 2011b; Pearson, 1993). Pilbara Olive Pythons were previously recorded from an old record (1962) on the edge of Dep-H and, more recently, 11 km northwest of WH Deposit (2013) within Karijini National Park (DBCA, 2019b).

During the baseline survey, three water features were recorded (Table 3.3) and a Pilbara Olive Python was recorded on a motion camera at VRT-WA16 in Dep-H, within Gorge or Gully habitat. The camera had been pointed to water pool WB-WAH1, from which the individual emerged to investigate a macropod that had come to the water to drink. Scats of the Pilbara Olive Python were also found in cave CWAN-04, which is in Hilltop, Hillslope, Ridge or Cliff habitat within the WH Deposit.

Plate 3.1 Pilbara Olive Python investigating macropod during the baseline survey

3.7.2 Current Survey

No observations of the Pilbara Olive Python were recorded during the current survey.

3.7.3 Habitats within the Study Area

Gorge or Gully habitat (157 ha, 0.6%) is the most significant habitat for the Pilbara Olive Python in the Study Area as it contains important denning and foraging habitat in the form of caves, crevices and water features. Also providing important dispersal and foraging habitat for the species are the Drainage Area and Minor Drainage Line habitats (240.1 ha, 2.05%) (Figure 3.17, Figure 3.18). Any water features represent particularly important foraging locations as the species utilises water pools during hunting, as observed at VRT-WA16. The Pilbara Olive Python is expected to occur throughout the Study Area in these habitats. The Hilltop and Hillslope habitat also provides denning and foraging opportunities for the species; however, these areas are not considered as significant as those discussed above and as classified as supporting habitat.

657500 660000 662500 665000 667500 670000 672500

7447500 7445000 7442500 7440000 7437500

Legend

- Study Area
- Karijini National Park

Records

- Biologic (2019a) Scat

Potential Pilbara Olive Python Habitat

- High Quality Denning and Foraging - Gorge or Gully
- Moderate Quality Denning and Foraging - Hilltop, Hillslope, Ridge or Cliff
- Dispersal and Foraging - Drainage Area; Minor Drainage
- Supporting habitat - Cleared; Footslope and Plain; Mixed Acacia Woodland; Mulga Spinifex Woodland

biologic Environmental Survey

N

1:45,000

0 0.35 0.7 1.4 2.1 2.8 km

RTIO - West Angelas Beyond 2020

Vertebrate Fauna Targeted Survey

Figure 3.16: Potential Pilbara Olive Python within Western Hill Deposit

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

Size A3. Created 18/02/2020

682500 685000 687500 690000 692500 695000 697500

7447500 7445000 7442500 7440000 7437500

West Angelas Mine

Legend

- Study Area
- Karijini National Park
- Water feature

Records

- Motion camera

Potential Pilbara Olive Python Habitat

- High Quality Denning and Foraging - Gorge or Gully
- Moderate Quality Denning and Foraging - Hilltop, Hillslope, Ridge or Cliff
- Dispersal and Foraging - Drainage Area; Minor Drainage
- Supporting habitat - Cleared; Footslope and Plain; Mixed Acacia Woodland; Mulga Spinifex Woodland

biologic Environmental Survey

N

1:45,000

0 0.35 0.7 1.4 2.1 2.8 km

RTIO - West Angelas Beyond 2020

Vertebrate Fauna Targeted Survey

Figure 3.17: Potential Pilbara Olive Python habitat within Deposit H

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

Size A3. Created 18/02/2020

675000 677500 680000 682500 685000 687500 690000 692500

7437500 7435000 7432500 7430000 7427500

Legend

- Study Area
- Karijini National Park
- Water feature

Potential Pilbara Olive Python Habitat

- High Quality Denning and Foraging - Gorge or Gully
- Moderate Quality Denning and Foraging - Hilltop, Hillslope, Ridge or Cliff
- Dispersal and Foraging - Drainage Area; Minor Drainage
- Supporting habitat - Cleared; Footslope and Plain; Mixed Acacia Woodland; Mulga Spinifex Woodland

biologic Environmental Survey

N

1:50,000

0 0.4 0.8 1.6 2.4 3.2 km

RTIO - West Angelas Beyond 2020

Vertebrate Fauna Targeted Survey

Figure 3.18: Potential Pilbara Olive Python habitat within Deposit F and Deposit J & MT Ella East

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

Size A3. Created 18/02/2020

3.8 Constraints and Limitations

The EPA (2016b) outlines several potential limitations to vertebrate fauna surveys. These aspects are assessed and discussed in Table 3.5 below.

Table 3.5: Survey constraints and limitations

Potential limitation or constraint	Constraint	Applicability to this survey
Experience of personnel	No	The field personnel involved in the survey each have more than 10 years of fauna survey experience within the Pilbara and with the targeted species. Technical personnel (Nigel Jackett) assisting in the identification of Night Parrot calls were considered ornithological experts. Bob Bullen was the technical expert that analysed all bat calls. Barbara Triggs and Georgeanna Story both experienced with scat analysis assisted in possible Northern Brushtail Possum scats.
Scope (faunal groups sampled and whether any constraints affect this)	No	The scope was a targeted fauna survey and was conducted within that framework (EPA, 2016b).
		Northern Quoll – The species has now been sampled across multiple seasons. The species was sampled following survey guidelines in relation to survey design and effort, site coverage, and detectability (DoE, 2016).
		Greater Bilby – The survey guidelines were followed, which recommends either linear transect searches, 2 ha plot searches or a combination of both (DBCA, 2017a). Targeted sampling for the Greater Bilby within the Study Area was conducted by walking transects through the most suitable habitat within the Study Area, which was considered marginal habitat. No Greater Bilby signs were recorded; therefore no 2 ha plots were conducted.
		Ghost Bat- The species has been sampled through the baseline survey and targeted survey, including sampling at the West Angelas Deposits C, D &G (Biologic, 2019c), Rio Tinto sampling and Ecologia (2014). Caves have been searched for scats and sheeted for follow up monitoring.
		Pilbara Leaf-nosed Bat- The species has been sampled through the baseline survey and targeted survey, including sampling at the West Angelas Deposits C, D &G (Biologic, 2019c), Rio Tinto sampling and Ecologia (2014). Not all caves located have been sampled by SM recorder.
		Northern Brushtail Possum- Motion cameras were placed at caves where unidentified scats were recorded, potential habitat areas were searched for scats and scratching signs.
		Night Parrot – Sampling has been conducted throughout the Study Area and had adequate spatial coverage (39 sites). The acoustic detectors range is only ~300 metres (DPaW, 2017), but due to the large number of sites within the area, it is considered adequate coverage.
		Pilbara Olive Python- Potential habitat areas were searched for individuals, scats and water features.

Potential limitation or constraint	Constraint	Applicability to this survey
Proportion of fauna identified	Partial	All fauna recorded via motion camera were able to be accurately identified. Unidentified calls with similar characteristic to the Night Parrot were recorded within the baseline survey, and this was followed up with increased sampling across the Study Area during the current survey, which included dusk bird surveys, resolving the identity of the "calls" recorded.
		Unknown scats were found within various caves and have not been able to be positively identified, even with scat ID experts and DNA sampling. These scats are not believed to belong to any species of interest to this survey and most likely a locally extinct species
Sources of information (recent or historic) and availability of contextual information	No	This is the third fauna survey conducted by Biologic within the Study Area in consecutive years (Biologic, 2017, 2019a), while targeted Ghost Bat monitoring has occurred within the West Angelas area since 2012 and further targeted work has been conducted at West Angelas Deposits C, D &G (Biologic, 2019c). A significant amount of survey work has been undertaken in the wider local area and the surrounding region, and the majority of these previous survey results were available for review. DBCA has also undertaken the Pilbara Biological Survey, which provided information on regional distribution of selected species. These reports were available at the time of reporting.
Proportion of the task achieved	No	A targeted fauna survey of the Study Area was completed and related to the results of surveys in the broader area.
Disturbances (e.g. fire or flood)	No	No temporary disturbance impinged on the results of the current survey.
Intensity of survey	No	A targeted survey was undertaken across the Study Area to assist with decisions on future environmental approvals. The survey intensity was high and focussed on the species of interest.
Completeness of survey	No	The survey was adequately completed to meet the requirements of a targeted survey.
Resources (e.g. degree of expertise available)	No	All resources required to complete the survey were available. Experts were consulted for Night Parrot- Nigel Jackett and for Bats- Bob Bullen. Barbara Triggs and Georgeanna Story both experienced with scat analysis assisted in possible Northern Brushtail Possum scats
Remoteness or access issues	No	The majority of the Study Area was accessible either by vehicle or on foot, thus the sampling techniques used during this survey were unconstrained by accessibility or remoteness.

4 CONCLUSION

The overarching objective of this assessment was to fill knowledge gaps surrounding the occurrence of species of conservation significance within the Study Area. The targeted fauna species for the current survey comprised the Northern Quoll, Night Parrot, Ghost Bat, Pilbara Leaf-nosed Bat, Greater Bilby, Pilbara Olive Python and Northern Brushtail Possum. This survey follows the baseline Level 2 vertebrate fauna survey conducted by (Biologic, 2019a). Ghost Bats, Pilbara Leaf-nosed Bats and Pilbara Olive Pythons are all confirmed within the Study Area. Northern Quolls have also been confirmed due to scats in the Study Area at one location within WH Deposit but are considered to occur as transient or in very low densities. It is considered Unlikely for the Night Parrot, Greater Bilby or Northern Brushtail Possum to occur within the Study Area.

4.1 Northern Quoll

Northern Quoll scats were recorded in cave CWAN-04 within WH Deposit in the baseline survey in October 2018. Numerous Northern Quoll camera transects have been set up within the Study Area with no further records.

Considering the level of survey effort, and the low numbers of previous recent records, Northern Quolls are expected to be infrequent visitors to the area, and therefore it is regarded as not likely that a resident population occurs in the area. Based on the occurrence of suitable Gorge or Gully habitats within the Study Area, it is possible that the Northern Quoll could occur during dispersal events. Nevertheless, owing to the rarity of this species within the central Hamersley Ranges and the low number of records within the Study Area, despite the high level of survey effort, it is likely that records in the Study Area represent individuals dispersing from a permanent population outside of the Study Area.

4.2 Greater Bilby

The Study Area falls within the current distribution of the Greater Bilby, located within the Hamersley subregion in the Pilbara. Based on habitat assessments during the baseline survey and a lack of recent records, it is considered Unlikely for the Greater Bilby to occur within the Study Area.

The current survey did not record the species despite targeted sampling (transects) within the most suitable habitat. Due to the lack of contemporary records in the vicinity of the Study Area, only moderately suitable habitat being present and no evidence of tracks, scats and diggings in the area, it is considered Unlikely that the Greater Bilby occurs within the Study Area.

4.3 Ghost Bat

A total of 20 caves have been recorded in the Study Area, ten of these containing evidence of occupation by the Ghost Bat. Of these 20, 15 have been recorded within the WH Deposit (one is considered a confirmed maternity, two potential maternity roosts, five potential diurnal roosts, two night roosts, and five potential night roosts), three caves were recorded at Dep-J & MtEE (one potential diurnal roost, two night roosts and one potential night roost) and one cave recorded in Dep-H (one night roost). Five caves are currently sheeted for monitoring, four in the WH Deposit (CWAN-03, CWAN-04, CWAN-06 and CWAN-07) and one in Dep-J & MtEE (CWAN-08).

Gorge or Gully habitat represents the most important habitat for the Ghost Bat within the Study Area as this is where suitable caves are most likely to be located and can be utilised for both roosting and foraging. Woodlands in the Study Area, such as those within Drainage Area, Mulga Spinifex Woodland and Mixed Acacia Woodland habitats, also provide suitable foraging habitat for Ghost Bats. Given the lack of known maternity caves in the Hamersley Ranges, CWAN-04, CWAN-06 and CWAN-07 should be considered of regional importance. The WH Deposit has been thoroughly searched for caves and appears to be a significant area for the species. All caves recorded in WH Deposit and Dep-J & MtEE are recorded within the Brockman Iron Formation.

4.4 Pilbara Leaf-nosed Bat

Within the Study Area, echolocation calls of the Pilbara Leaf-nosed Bat were recorded at two locations within the WH Deposit during the baseline survey, and a further two calls during the targeted survey. The timing of calls at these locations is consistent with individuals flying to the Study Area from the Upper Turee Creek Roost. Pilbara Leaf-nosed Bats are likely to forage permanently within the Study Area, especially after good rains, utilising significant caves within Gorge or Gully and Hilltop, Hillslope, Ridge or Cliff habitats.

4.5 Northern Brushtail Possum

Previous records of the species come from gorges and major drainage lines with eucalypt woodland (DBCA, 2019a). Ridges containing gullies and, presumably, caves occur frequently in the surrounding region, and there are other creek lines with mature eucalypts (DBCA, 2019a).

Due to a scarcity of records from the region, and that the species was not detected in the desktop assessment as potentially occurring in the Study Area, the species is considered Highly Unlikely to occur in the Study Area. Analysis of the scats was inconclusive, and it is possible these scats are potential locally extinct rodent scats but Unlikely to be from the Northern Brushtail Possum.

4.6 Night Parrot

Previous sampling during the baseline surveys recorded unconfirmed calls within the frequency of known Night Parrot calls at two locations. However, there was insufficient information to conclude these were attributable to any particular species. The potential calls were always faint and were recorded on single nights (i.e. not during any subsequent nights at the same locations). Significantly, the sounds were associated with periods of wind gusts. Further targeted sampling in May – July 2019 was conducted to verify the source of these noises. This additional sampling provided sufficient detail to confirm that these calls were a result of wind gusts in combination with the movement of nearby tree branches, and/or the subtle movement of the Song Meters or their attachment, when fixed to an object (e.g. a tree). Based on the significant amount of targeted sampling effort undertaken within the Study Area for this species, and the lack of records within the region, it is regarded as Unlikely that the species forages in the Study Area.

The Study Area contains marginally suitable habitat for the species in the form of sandy and stony flats containing patches of large spinifex hummocks, such as those observed within the Mulga Spinifex

Woodland habitat, as well as the Footslope and Plain habitats. As only marginal habitat exists on site and the species is generally rare, it is still considered Unlikely for the species to occur in the Study Area, and then more Likely as a transient visitor.

4.7 Pilbara Olive Python

With two records of the Pilbara Olive Python recorded during the baseline survey in Dep-H and WH Deposit, it is regarded as highly likely that the species permanently resides within suitable habitat in the Study Area.

Gorge or Gully habitat is the most significant habitat for the Pilbara Olive Python in the Study Area as it contains important denning and foraging habitat in the form of caves, crevices and water features. Also providing important foraging habitat for the species are the Drainage Area and Minor Drainage. Any water features represent particularly important foraging locations as the species utilises water pools during hunting, as observed at VRT-WA16. Drainage Area habitat also represents suitable dispersal habitat for the species. The Hilltop and Hillslope habitat also provides denning and foraging opportunities for the species; however, these areas are not considered as significant as those discussed above and as classified as supporting habitat.

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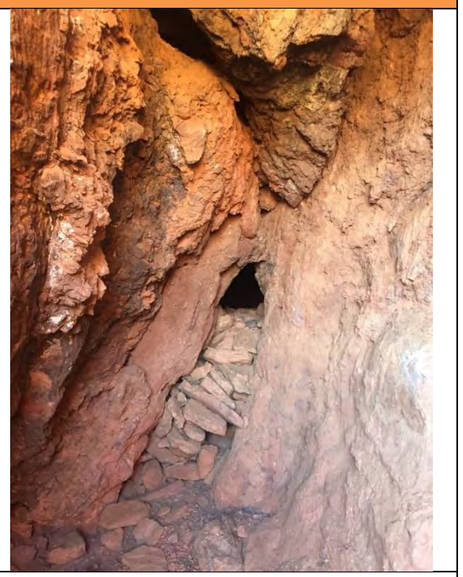
6 APPENDICES

Appendix 1. Cave details of the West Angelas Study Area

Cave ID/ Deposit	Coordinates	Date Assessed	Roost Type GB	Cave Position	Floor Slope	Aspect	Cave Exposure	Entrance Type	Entrance Shape	Entrance Width (m)	Entrance Height (m)	Cave Depth (m)	No Cham	Cham Height (m)	Water Present	Number of Ghost Bat Scats	Scat Count or Scat Estimate	Scat Age	Bats in cave	
CWAN-01 WH Deposit	-23.11719067 118.6252856	18/10/2018	Potential Ghost Bat diurnal roost	Upper Slope	Incline	North	Semi Exposed	Overhang	Round/ Oval	3	2	10	2	2.5	None	10	Count	Recent (1 to 6mths)	Nil	
CWAN-02 WH Deposit	-23.1175515 118.623311	19/10/2018	Potential Ghost Bat diurnal roost	Upper Slope	Flat	North/ West	Exposed	Cavern	Round/ Oval	6	2	10	2	2.5	None				Nil	
CWAN-03 WH Deposit	-23.1176952 118.6240202	19/10/2018	Potential Ghost Bat diurnal roost	Lower Slope	Incline	South/ West	Sheltered	Overhang	Horizontal	6.5	1.5	25	2	4	None				*Taphozous georgianus*	
CWAN-04 WH Deposit	-23.1181643 118.6242662	19/10/2018	Ghost Bat maternity roost	Mid Slope	Incline	North/ East	Semi Exposed	Overhang	Round/Oval	2	1.5	15	2	3.5	None	1500	Estimate	Fresh (<1mth)	*Taphozous georgianus*	

Cave ID/ Deposit	Coordinates	Date Assessed	Roost Type GB	Cave Position	Floor Slope	Aspect	Cave Exposure	Entrance Type	Entrance Shape	Entrance Width (m)	Entrance Height (m)	Cave Depth (m)	No Cham	Cham Height (m)	Water Present	Number of Ghost Bat Scats	Scat Count or Scat Estimate	Scat Age	Bats in cave	
CWAN-05 WH Deposit	-23.1199321 118.5947551	19/10/2018	Potential Ghost Bat night roost	Mid Slope	Incline	East	Exposed	Overhang	Round/ Oval	12	4	10	1	4	None				*Vespadelus finlaysoni*, *Taphozous georgianus*	
CWAN-06 WH Deposit	-23.11517803 118.6125083	20/10/2018	Potential Ghost Bat maternity roost	Mid Slope	Incline	West	Exposed	Cavity	Horizontal	4	1	30	1	4	None	1500	Estimate	Fresh (<1mth)	*Vespadelus finlaysoni*, *Taphozous georgianus*, *Macroderma gigas*	
CWAN-07 WH Deposit	-23.1123807 118.6111788	20/10/2018	Potential Ghost Bat maternity roost	Mid Slope	Incline	South/ East	Semi Exposed	Overhang	Round/ Oval	3	2	35	3	3	None	5000	Estimate	Fresh (<1mth)	*Vespadelus finlaysoni*, *Taphozous georgianus*	
CWAN-08 Dep-J	-23.2118291 118.7850553	20/10/2018	Ghost Bat night roost	Mid Slope	Incline	North/ East	Exposed	Overhang	Horizontal	11	2.5	30	1	4	None	30	Count	Recent (1 to 6mths)	*Vespadelus finlaysoni*, *Taphozous georgianus*	

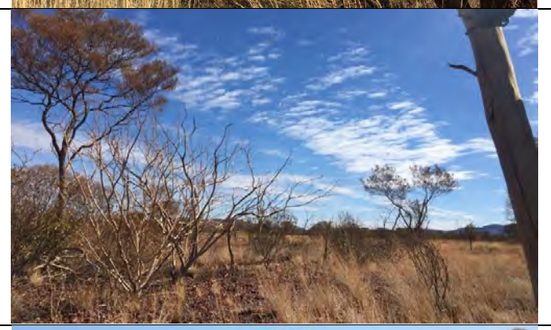
Cave ID/ Deposit	Coordinates	Date Assessed	Roost Type GB	Cave Position	Floor Slope	Aspect	Cave Exposure	Entrance Type	Entrance Shape	Entrance Width (m)	Entrance Height (m)	Cave Depth (m)	No Cham	Cham Height (m)	Water Present	Number of Ghost Bat Scats	Scat Count or Scat Estimate	Scat Age	Bats in cave	
CWAN-09 Dep-H	-23.1283326 118.860471	20/10/2018	Ghost Bat night roost	Upper Slope	Incline	South	Semi Exposed	Overhang	Round/ Oval	6	3	30	1	3	None	7	Count	Recent (1 to 6mths)	*Vespadelus finlaysoni*	
CWAN-10 Dep-J	-23.2175484 118.7649055	20/10/2018	Potential Ghost Bat diurnal roost	Upper Slope	Incline	South/ East	Semi Exposed	Cavity	Horizontal	3	1	20	2	3	None	None	-	-	*Taphozous georgianus*	
CWAN-11 Dep-J	-23.2168183 118.8250839	20/10/2018	Ghost Bat night roost	Upper Slope	Flat	North/ West	Exposed	Cavity	Round/ Oval	3	1.5	15	1	2	None	1	Count	Old (6mths to 3yrs)	Nil	
CWAN-26 WH Deposit	-23.1199936, 118.6034164	28/06/2019	Potential Ghost Bat night roost	Upper Slope	Incline	North	Semi Exposed	Cavern	Round/ Oval	5	4	15	2	3	None	0	Count	-	*Taphozous georgianus*	

Cave ID/ Deposit	Coordinates	Date Assessed	Roost Type GB	Cave Position	Floor Slope	Aspect	Cave Exposure	Entrance Type	Entrance Shape	Entrance Width (m)	Entrance Height (m)	Cave Depth (m)	No Cham	Cham Height (m)	Water Present	Number of Ghost Bat Scats	Scat Count or Scat Estimate	Scat Age	Bats in cave	
CWAN-27 WH Deposit	-23.112292, 118.6608178	29/06/2019	Potential Ghost Bat night roost	Upper Slope		North/ West	Semi Exposed	Cavity	Round/ Oval	0.5	0.5	-	-	-	None	0	Count	-	Nil	
CWAN-28 WH Deposit	-23.1121013, 118.6614533	29/06/2019	Night Roost	Upper Slope	Incline	South	Semi Exposed	Overhang	Round/Oval	5	2	12	2	2.5	None	5	Count	Recent (1 to 6mths)	Nil	
CWAN-29 WH Deposit	-23.1121928, 118.6613898	29/06/2019	Potential diurnal roost	Mid Slope	Incline	South/ West	Sheltered	Cavern	Round/Oval	3	1.5	15	1	3.5	None	5	Count	Recent (1 to 6mths)	*Taphozous georgianus*	

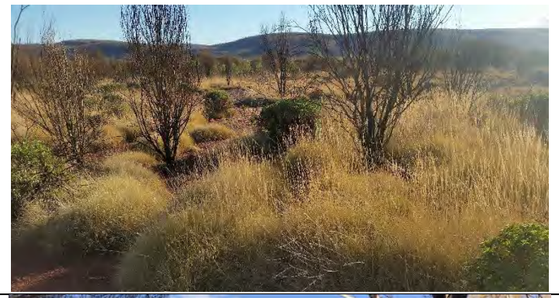
Cave ID/ Deposit	Coordinates	Date Assessed	Roost Type GB	Cave Position	Floor Slope	Aspect	Cave Exposure	Entrance Type	Entrance Shape	Entrance Width (m)	Entrance Height (m)	Cave Depth (m)	No Cham	Cham Height (m)	Water Present	Number of Ghost Bat Scats	Scat Count or Scat Estimate	Scat Age	Bats in cave	
CWAN-30 WH Deposit	-23.1094329, 118.6635019	29/06/2019	Potential Ghost Bat night roost	Mid Slope	Flat	North	Semi Exposed	Cavity	Round/Oval	2	1	40	2	1.2	None	0	Count	-	Taphozous georgianus	
CWAN-31 WH Deposit	-23.1197353, 118.6221545	29/06/2019	Potential Day Roost	Lower Slope	Flat	North/ East	Sheltered	Cavern	Round/Oval	0.7	0.7	8	1	2.5	None	0	Count	-	Taphozous georgianus	
CWAN-32 WH Deposit	-23.1189969, 118.6220438	29/06/2019	Night Roost	Upper Slope	Incline	South/ West	Exposed	Overhang	Round/Oval	5	4	12	1	4.5	None	5	Count	Fresh (<1mth)	Taphozous georgianus	
CWAN-33 WH Deposit	-23.1151078, 118.6279905	30/06/2019	Potential Ghost Bat night roost	Upper Slope	Incline	South/ East	Semi Exposed	Cavern	Round/Oval	2.5	1.2	8	2	1.2	None	0	Count	-	Nil	

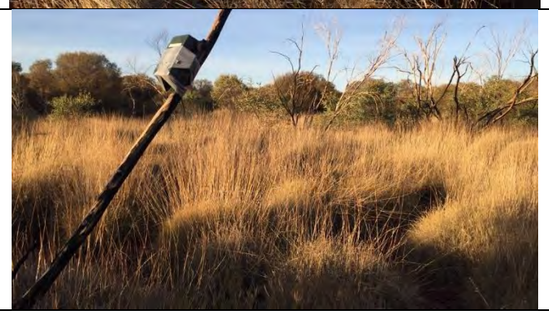
Cave ID/ Deposit	Coordinates	Date Assessed	Roost Type GB	Cave Position	Floor Slope	Aspect	Cave Exposure	Entrance Type	Entrance Shape	Entrance Width (m)	Entrance Height (m)	Cave Depth (m)	No Cham	Cham Height (m)	Water Present	Number of Ghost Bat Scats	Scat Count or Scat Estimate	Scat Age	Bats in cave	
CWAN-34 WH Deposit	-23.2115702, 118.7841587	05/072019	Potential Night Roost	Upper Slope	Incline	West	Semi Exposed	Overhang	Round/Oval	10	5	20	1	3	None	0	Count	-	Taphozous georgianus	

Appendix 2. Targeted acoustic sites located within the WH Deposit within the Study Area

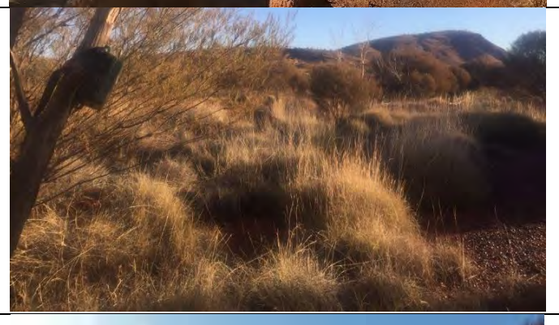
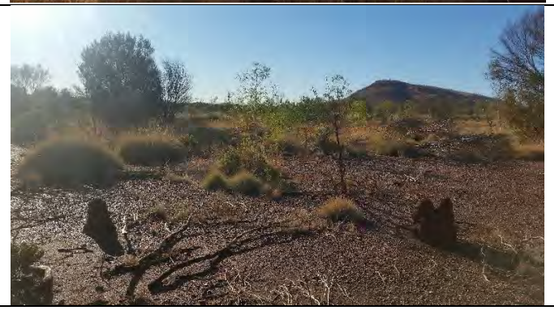
Site ID	Latitude	Latitude	Date Deployed	Date Retrieved	Habitat	Trap Nights	Photo
VWAN-02	-23.101	118.602	27/06/2019	04/07/2019	Mulga Woodland	7	
VWAN-03	-23.102	118.609	27/06/2019	04/07/2019	Mulga Woodland	7	
VWAN-04	-23.099	118.579	27/06/2019	03/07/2019	Mulga Woodland	6	
VWAN-05	-23.099	118.586	27/06/2019	03/07/2019	Mulga Woodland	6	

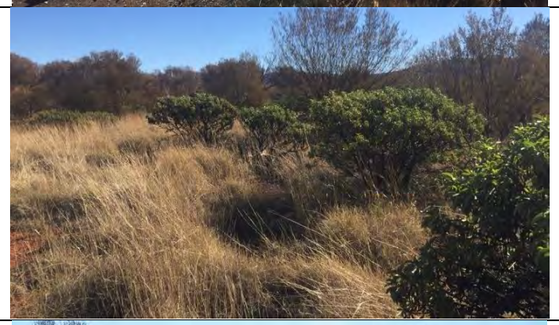
Site ID	Latitude	Latitude	Date Deployed	Date Retrieved	Habitat	Trap Nights	Photo
VWAN-06	-23.108	118.583	27/06/2019	03/07/2019	Mulga Woodland	6	
VWAN-07	-23.102	118.591	27/06/2019	03/07/2019	Mulga Woodland	6	
VWAN-08	-23.107	118.591	27/06/2019	03/07/2019	Mulga Woodland	6	
VWAN-09	-23.102	118.613	27/06/2019	03/07/2019	Mulga Woodland	6	

Site ID	Latitude	Latitude	Date Deployed	Date Retrieved	Habitat	Trap Nights	Photo
VWAN-10	-23.102	118.617	27/06/2019	03/07/2019	Mulga Woodland	6	
VWAN-11	-23.107	118.596	27/06/2019	03/07/2019	Spinifex Stony Plain	6	
VWAN-12	-23.099	118.596	27/06/2019	03/07/2019	Mulga Woodland	6	
VWAN-13	-23.102	118.625	27/06/2019	03/07/2019	Mulga Woodland	6	

Site ID	Latitude	Latitude	Date Deployed	Date Retrieved	Habitat	Trap Nights	Photo
VWAN-14	-23.103	118.629	27/06/2019	03/07/2019	Mulga Woodland	6	
VWAN-16	-23.101	118.639	27/06/2019	04/07/2019	Mulga Woodland	7	
VWAN-17	-23.106	118.642	27/06/2019	04/07/2019	Mulga Woodland	7	
VWAN-18	-23.100	118.648	27/06/2019	04/07/2019	Mulga Woodland	7	

Site ID	Latitude	Latitude	Date Deployed	Date Retrieved	Habitat	Trap Nights	Photo
VWAN-27	-23.106	118.626	03/07/2019	07/07/2019	Spinifex Stony Plain	4	
VWAN-28	-23.105	118.615	03/07/2019	06/07/2019	Mulga Woodland	3	
VWAN-29	-23.112	118.585	03/07/2019	06/07/2019	Spinifex Stony Plain	3	
VWAN-30	-23.110	118.579	03/07/2019	10/07/2019	Spinifex Stony Plain	7	

Site ID	Latitude	Latitude	Date Deployed	Date Retrieved	Habitat	Trap Nights	Photo
VWAN-31	-23.108	118.587	03/07/2019	06/07/2019	Spinifex Stony Plain	3	
VWAN-32	-23.102	118.595	03/07/2019	11/07/2019	Spinifex Stony Plain	8	
VWAN-33	-23.110	118.593	03/07/2019	06/07/2019	Spinifex Stony Plain	3	
VWAN-34	-23.104	118.630	04/07/2019	08/07/2019	Mulga Woodland	4	

Site ID	Latitude	Latitude	Date Deployed	Date Retrieved	Habitat	Trap Nights	Photo
VWAN-35	-23.101	118.644	04/07/2019	12/07/2019	Spinifex Stony Plain	8	
VWAN-37	-23.105	118.641	04/07/2019	07/07/2019	Spinifex Stony Plain	3	
VWAN-38	-23.109	118.642	04/07/2019	07/07/2019	Mulga Woodland	3	
VWAN-39	-23.107	118.601	04/07/2019	10/07/2019	Spinifex Stony Plain	6	

Site ID	Latitude	Latitude	Date Deployed	Date Retrieved	Habitat	Trap Nights	Photo
VWAN-40	-23.110	118.632	04/07/2019	07/07/2019	Mulga Woodland	3	
VWAN-41	-23.101	118.621	04/07/2019	11/07/2019	Spinifex Stony Plain	7	
VWAN-42	-23.106	118.609	04/07/2019	07/07/2019	Spinifex Stony Plain	3	
VWAN-44	-23.106	118.620	04/07/2019	07/07/2019	Spinifex Stony Plain	3	

Site ID	Latitude	Latitude	Date Deployed	Date Retrieved	Habitat	Trap Nights	Photo
WA-SM4A-001 Site where unusual calls were recorded	-23.107	118.638	29/05/2019 21/06/2019	12/06/2019 11/07/2019	Mulga Spinifex Woodland	14 20	
WA-SM4A-002	-23.100	118.637	29/05/2019	12/06/2019	Footslope and plain	14	
WA-SM4A-003	-23.100	118.622	29/05/2019	12/06/2019	Mulga Spinifex Woodland	14	
WA-SM4A-004	-23.107	118.594	29/05/2019	12/06/2019	Mulga Spinifex Woodland	14	

Site ID	Latitude	Latitude	Date Deployed	Date Retrieved	Habitat	Trap Nights	Photo
WA-SM4A-005	-23.107	118.563	29/05/2019	12/06/2019	Mulga Spinifex Woodland	14	
WA-SM4A-006	-23.172	118.457	29/05/2019	12/06/2019	Mulga Spinifex Woodland	14	
WA-SM4A-007	-23.167	118.449	29/05/2019	12/06/2019	Mulga Spinifex Woodland	14	

Appendix 3. Night Parrot report

Nigel Jackett
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01 August 2019

Chris Knuckey
Senior Zoologist
Biologic Environmental Survey

Ref: 1876 West Angelas Targeted Fauna

Dear Chris,

Please find below the results of Biologic Environmental Survey's bioacoustic surveys targeting the Night Parrot between May and July 2019.

Survey summary

Biologic Environmental Survey conducted targeted sampling for the Night Parrot (*Pezoporus occidentalis*) across two surveys: in May/June and June/July 2019. Wildlife Acoustic Song Meter 4 and Song Meter 2 bioacoustic recording units were deployed across twenty-seven sites, and recorded a combined total of 191 nights of data (Table 1).

Table 1. Bioacoustic recordings analysed from the May/June and June/July 2019 surveys.

Site name	Recording start date (PM)	Recording end date (AM)	Total recording nights
WA-SM4A-001	29/05/2019	11/06/2019	13
WA-SM4A-002	29/05/2019	12/06/2019	14
WA-SM4A-003	29/05/2019	12/06/2019	14
WA-SM4A-004	29/05/2019	12/06/2019	14
WA-SM4A-005	29/05/2019	12/06/2019	14
WA-SM4A-006	29/05/2019	12/06/2019	14
WA-SM4A-007	29/05/2019	12/06/2019	14
VWAN-07	27/06/2019	03/07/2019	6
VWAN-08	27/06/2019	03/07/2019	6
VWAN-09	27/06/2019	03/07/2019	6
VWAN-10	27/06/2019	03/07/2019	6
VWAN-12	27/06/2019	03/07/2019	6
VWAN-13	27/06/2019	03/07/2019	6
VWAN-14	27/06/2019	03/07/2019	6
VWAN-16*	27/06/2019	04/07/2019	7
VWAN-17	27/06/2019	04/07/2019	7
VWAN-18	27/06/2019	04/07/2019	7
VWAN-27	03/07/2019	07/07/2019	4
VWAN-28	03/07/2019	06/07/2019	3

Site name	Recording start date (PM)	Recording end date (AM)	Total recording nights
VWAN-29	03/07/2019	06/07/2019	3
VWAN-31	03/07/2019	06/07/2019	3
VWAN-33	03/07/2019	06/07/2019	3
VWAN-37	04/07/2019	07/07/2019	3
VWAN-38*	04/07/2019	07/07/2019	3
VWAN-40	04/07/2019	07/07/2019	3
VWAN-42	04/07/2019	07/07/2019	3
VWAN-44	04/07/2019	07/07/2019	3
Total recording nights			**191**

*sampling rate: 384 kHz

Results

The analysis targeted the frequency band of 1000 – 4000 Hz for which all known calls of the Night Parrot are distributed within (Jackett *et al.* 2017; Murphy *et al.* 2017; Leseberg *et al.* 2019). All call detections within this band were manually assessed for Night Parrot vocalisations.

No calls attributable to Night Parrots were detected during the analysis.

Twenty-eight non-target bird species were detected during the analysis and are listed in Appendix 1.

Analysis remarks

The surveys produced a very large dataset of nocturnal recordings, which provided high confidence in the results from the analysis. The quality of recordings was generally good, with constant insect noise and some wind gusts being the only noise interference. As a result, a minimum of four (non-target) bird species were detected at all sites, except for the two sites where the sampling rate was set at a higher sampling rate than at other sites and no bird species were detected.

Previous sampling by Biologic in the West Angelas area (i.e. in October 2018 and March 2019) resulted in *Night Parrot-like* calls being detected. However, these calls were associated with nights where wind gusts were present, which added some doubt as to their origin.

The sampling during the May – July 2019 surveys provided sufficient detail to confirm that the Night Parrot-like calls were a result of wind gusts, and were produced by the movement of nearby tree branches, and/or the subtle movement of the Song Meters, or their attachment, when fixed to an object (e.g. a tree).

The call frequency range of most of the non-target bird species listed in Appendix 1 overlap with the known frequency range of Night Parrot calls. It can therefore be expected that the recording units would have recorded any Night Parrot vocalisations had they occurred.

If you have any questions or comments relating to the analysis, don't hesitate to be in touch.

Sincerely,

Nigel Jackett

2

Selected references

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

Leseberg, N.P, Murphy, S.A., Jackett, N.A., Greatwich, B.R., Brown, J., Hamilton, N., Joseph, L. & Watson, J. (2019). Descriptions of known vocalisations of the Night Parrot *Pezoporus occidentalis*. *Australian Field Ornithology*, **36**, 79-88.

Murphy, S.A., Austin, J.A., Murphy, R.K., Silcock, J., Joseph, L., Garnett, S.T., Leseberg, N.P., Watson, J.E.M. & Burbidge, A.H. (2017a). Observations on breeding Night Parrots (*Pezoporus occidentalis*) in western Queensland. *Emu* **117**, 107-113.

Appendix 1 – Species detected during the analysis

Species	Site WA-SM4A-0							Site VWAN-																		
	01	02	03	04	05	06	07	07	08	09	10	12	13	14	16	17	18	27	28	29	31	33	37	38	40	42	44
Crested Pigeon		•	•			•				•	•		•														
Horsfield's Bronze-Cuckoo	•	•	•	•						•	•	•		•		•	•	•	•	•	•		•		•	•	•
Black-eared Cuckoo					•		•																				
Pallid Cuckoo	•	•	•			•		•				•						•		•	•	•				•	
Australian Owlet-nightjar	•	•	•		•	•				•	•		•			•				•			•		•	•	•
Bush Stone-curlew										•	•																
Eastern Barn Owl						•				•	•					•	•										
Rainbow Bee-eater					•																						
Little Corella																										•	
Australian Ringneck		•	•	•		•	•									•							•				
White-winged Fairy-wren		•				•																			•		
Purple-backed Fairy-wren																•											
Fairy-wren sp.								•			•																
Yellow-throated Miner		•	•		•								•														
Spiny-cheeked Honeyeater		•																									
Singing Honeyeater	•	•	•	•	•		•	•	•	•	•		•	•		•	•	•	•	•	•	•	•		•	•	•
Redthroat							•																				
Grey-crowned Babbler		•																									
Black-faced Woodswallow		•	•																	•							•
Masked Woodswallow	•	•																									
Grey Butcherbird	•		•	•	•	•	•		•	•	•	•	•	•		•	•	•	•	•			•		•	•	•
Pied Butcherbird	•		•	•				•		•			•	•		•	•		•			•	•		•		•
Grey Shrike-thrush	•		•								•																
Crested Bellbird																						•					
Grey Fantail			•																								
Willie Wagtail									•				•			•	•		•								

Species	Site WA-SM4A-0							Site VWAN-																			
	01	02	03	04	05	06	07	07	08	09	10	12	13	14	16	17	18	27	28	29	31	33	37	38	40	42	44
Torresian Crow		•	•					•	•			•									•						
Crow sp.					•																						
Spinifexbird		•		•				•		•	•	•	•	•		•		•	•	•			•		•	•	•
Zebra Finch		•	•							•											•						
Total	8	16	14	6	7	7	5	6	4	10	10	5	8	5	0	10	6	5	6	7	5	4	7	0	7	7	7

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29 January 2020

Amy Hutchison
Graduate Zoologist
Biologic Environmental Survey

Ref: 1876

Dear Amy,

Please find below the results of Biologic's survey targeting the Night Parrot in June and July 2019 for Project 1876.

Survey summary

Biologic Environmental Survey conducted sampling for the Night Parrot (*Pezoporus occidentalis*) in June and July 2019. Wildlife Acoustic Song Meter 4 bioacoustic recording units were deployed across 13 sites, and recorded a combined total of 98 nights of data (Table 1). Each unit recorded continuously for a minimum of 12 hours per night.

Table 1. Bioacoustic recordings analysed from the June and July 2019 surveys.

Site name	Recording start date (PM)	Recording end date (AM)	Total recording nights
VWAN-01	21/06/2019	11/07/2019	20
VWAN-02	27/06/2019	04/07/2019	7
VWAN-03	27/06/2019	04/07/2019	7
VWAN-04	27/06/2019	03/07/2019	6
VWAN-05	27/06/2019	03/07/2019	6
VWAN-06	27/06/2019	03/07/2019	6
VWAN-11	27/06/2019	03/07/2019	6
VWAN-30	03/07/2019	10/07/2019	7
VWAN-32	03/07/2019	11/07/2019	8
VWAN-34	04/07/2019	08/07/2019	4
VWAN-35	04/07/2019	12/07/2019	8
VWAN-39	04/07/2019	10/07/2019	6
VWAN-41	04/07/2019	11/07/2019	7
		Total	98

Results

The analysis was undertaken using the software Kaleidoscope Pro v5.1.8, targeting the frequency range of 1000 – 4000 Hz for which all known calls of the Night Parrot are distributed within (Jackett *et al.* 2017; Murphy *et al.* 2017; Leseberg *et al.* 2019). Searching for calls over a large frequency range such as this is likely to produce a high number of false-positive results due to many other bird species calling at similar frequencies. A total of 24,389 Kaleidoscope detections were manually assessed for Night Parrot vocalisations, and as expected, a high percentage (100% of all calls in this analysis) were false-positives.

No calls attributable to Night Parrots were detected during the analysis.

Twenty-seven non-target bird species were detected during the analysis and are listed in Appendix 1.

Analysis remarks

The recordings were all of good quality, with minimal noise interference, except for occasional low wind gusts, and some insect noise at higher frequencies (i.e. >3200 Hz). The majority of detected vocalisations of non-target bird species were visually clear on the spectrogram, and audible.

The frequency range of many of the non-target bird species detected overlaps with the calls of the Night Parrot, and it can therefore be expected that the deployed Song Meter 4 units would have recorded any Night Parrot vocalisations had they occurred within a reasonable distance of a unit.

If you have any questions or comments relating to the analysis, don't hesitate to be in touch.

Sincerely,

Nigel Jackett

Selected references

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Appendix 1 – Species detected during the analysis

Species	Site VWAN-												
	01	02	03	04	05	06	11	30	32	34	35	39	41
Crested Pigeon		•	•		•		•		•	•		•	
Horsfield's Bronze-Cuckoo	•	•	•	•	•	•	•	•	•	•		•	•
Black-eared Cuckoo												•	
Pallid Cuckoo	•			•				•	•	•	•		
Spotted Nightjar											•		
Australian Owlet-nightjar	•	•	•	•	•	•	•	•	•		•	•	•
Bush Stone-curlew			•										
Eastern Barn Owl	•												
Australian Ringneck	•			•			•	•					
Purple-backed Fairy-wren	•		•			•							•
Inland Thornbill	•												
Singing Honeyeater	•	•	•	•	•	•	•	•	•	•	•	•	•
Grey-headed Honeyeater			•			•							
White-browed Babbler	•	•								•	•		
Grey-crowned Babbler			•	•	•	•						•	
Black-faced Woodswallow	•				•			•	•		•	•	•
Grey Butcherbird	•	•	•	•	•	•	•	•	•	•	•	•	•
Pied Butcherbird	•		•	•				•			•		•
Australian Magpie	•		•		•		•	•	•	•			•
Ground Cuckoo-shrike		•					•						
Grey Shrike-thrush	•		•										•
Crested Bellbird	•							•	•			•	
Grey Fantail			•										
Willie Wagtail			•			•		•					
Torresian Crow	•	•	•	•	•	•	•	•	•			•	•
Western Bowerbird				•									
Spinifexbird	•	•	•			•		•	•				
Total	17	9	16	10	9	10	9	13	11	7	8	10	10

Appendix 4. Unidentified Scats DNA report

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Species Identification Results Report

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07/05/2019

Attention: Chris Knuckey
Senior Zoologist | Manager Vertebrate Zoology
Biologic Environmental

Results Report

Species Identification from faecal samples

Background

Faecal samples were submitted for species identification. Biologic environmental is interested to determine whether the samples may have originated from a northern brush tail possum (*Trichosurus arnhemensis*) or any other mammal. Faecal samples consisted of multiple elongated droppings, about 1cm long. Supplied samples are listed in table 1.

Table 1. List of samples supplied for species identification.

ID	Type of sample	Species	Comments
Sample 1	Scats	Unknown	Western Hill (WA07), Hamersley Ranges. WA07.20181028 Sticknest-rat/possum scats CK, BD 1 of 2.
Sample 2	Scats	Unknown	Western Hill (WA07), Hamersley Ranges. Cave WA07 28/10/2018 possible possum scats 2 of 2
Sample 3	Scats	Unknown	Hamersley Ranges.

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Methodology

The above three samples were divided into seven DNA extractions based on the number of individual droppings per sample. Therefore, sample 1 and sample 3 were divided into two and four extractions respectively. Due to the limited number and the brittle condition of sample 2, it was represented by a single sample.

Total genomic DNA was extracted using commercially available kits and following the manufacturer's instructions. Species identification was attempted by the amplification of a 390 base pair (bp) segment of the mitochondrial gene Cytochrome b (cytb) by polymerase chain reaction using previously published primers[1]. Subsequent amplification attempts also involved the amplification of a larger segment of the same region 460 (bp) using an alternative forward primer [2]. Since samples were suspected to belong to northern brush tail possum, amplification of a small cytb region were also carried out, using two independent sets of possum specific primers [2]. Efforts to obtain a positive result also involved performing the above reactions with a variety of template concentrations.

Resulting sequences were checked manually, trimmed in Geneious v.10.2.6 (Biomatters) and compared to publicly available sequences available in Genebank.

Results

Positive PCR products were obtained from most extractions except from sample 2. A total of 18 PCR products were sequenced and 14 sequences resulted in the detection of a single target. A query against publicly available sequences in Genebank showed that of these 14 sequences, 11 were highly similar to human with a nucleotide identity ranging from 99.7% to 100%. The remaining three high quality sequences were amplified from sample 3 and were most similar to *Zyzomys argurus* (common rock rat) with a nucleotide identity of 97%. Further analyses were carried out to determine the nucleotide identity among species of *Zyzomys* along the amplified region. The alignment included sequences representing *Z. argurus, Z. maini, Z. palatalis and Z. woodwardi*. The nucleotide identity between species of this group ranged between 88.7% and 98%.

Of the four low quality sequences, two were discarded from analysis and the remaining two appeared to represent the amplification of mixed templates. Manual analysis suggested that both samples contained DNA from *Zyzomys sp* and the second contributing template in one of the samples is likely human and results were inconclusive for the second sample.

All extractions showed a negative result for the possum specific assays.

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Interpretation of results

Amplification of human DNA from the scats indicates the likely cross contamination of the samples together with a low number of cells of the target species or poor binding between the primer set and target DNA. The primers employed here bind to a large variety of vertebrates and therefore in cases of low number of cells from the target species, the primers may preferentially amplify the available human DNA, even if it is present in very low quantities. Development of group specific primers (e.g marsupials, rodents, etc) can increase the specificity of species identification from environmental samples as they would be designed to avoid binding to human DNA, and if present, amplify DNA from the target group.

Nucleotide identity to available sequences and the levels of identity within *Zyzomys*, suggest the presence of *Zyzomys*- like DNA in the scats, particularly in sample 3. These results must be used in conjunction with additional evidence to reach an overall conclusion that can explain the presence of this species' DNA in the scats. Even though, the possum specific assays showed negative results, this is not enough evidence to discard that the scats may be of possum origin.

References

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