

BROOME REGIONAL RESOURCE RECOVERY

PARK

TERRESTRIAL FAUNA ASSESSMENT

PREPARED FOR: TALIS CONSULTANTS | SHIRE
OF BROOME



**Spectrum
ECOLOGY**



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EXECUTIVE SUMMARY

The Shire of Broome is investigating two sites ('D2' and 'G1' – the Study Areas) for the placement of a new community recycling centre and landfill. The D2 Study Area is 122 ha and located approximately 10 km north of Broome. The G1 Study Area is 98 ha and located approximately 33 km north-east of Broome. As part of the site investigations, a range of hydrogeological and geotechnical works are required which will involve the removal of native vegetation (approximately 2.5 ha for D2 and 3.0 ha for G1).

Talis Consultants, on behalf of the Broome Shire, commissioned Spectrum Ecology (Spectrum) to undertake a terrestrial fauna assessment for the Broome Regional Resource Recovery Park (RRRP) Project. A single phase Level 2 terrestrial fauna survey was completed during the 15th – 24th of April 2020.

Systematic trapping and opportunistic foraging identified a total of 31 vertebrate fauna species within the D2 Study Area

- Ten bird species
- Four non-volant mammal species (three introduced)
- Three bat species (with a further three possible species)
- Fourteen reptile species.

Systematic trapping and opportunistic foraging identified a total of 38 vertebrate fauna species within the G1 Study Area:

- Seventeen bird species
- Three non-volant mammal species (two introduced)
- Two bat species (with a further three possible species)
- Sixteen reptile species.

The DBCA Priority 1 listed Northern Coastal Free-tailed Bat (*Ozimops cobourgius*) was detected multiple times via ultrasonic recorder from both the D2 and G1 Study Areas.

Four invertebrate specimens (two species) belonging to potential SRE taxa were collected from dry pitfall traps during the systematic trapping survey, one from D2 and three from G1. Genetic sequencing and morphological analysis identified the specimens as previously undescribed species *Lychas* 'BSCO048' and *Aname* 'BMYG165' that have not been collected previously.

Of the 33 species of conservation significance potentially occurring at the study areas, 15 species have a medium to high likelihood to occur. Due to the consistent habitat found at each of the Study Area and the close proximity of the areas to each other, the likelihood of occurrence of conservation significant species is consistent between the two Study Areas.

The Pindan shrubland habitat that occurs in the study areas is homogenous and the microhabitats present are not thought likely to support short range endemic invertebrate species. Overall, the Pindan Shrubland habitat recorded from within the study areas occurs across a large continuous extend across the Dampier Peninsula, which indicates that there is a low likelihood that the habitat within the study area supports any taxa with a distribution restricted to either study area.

1. INTRODUCTION

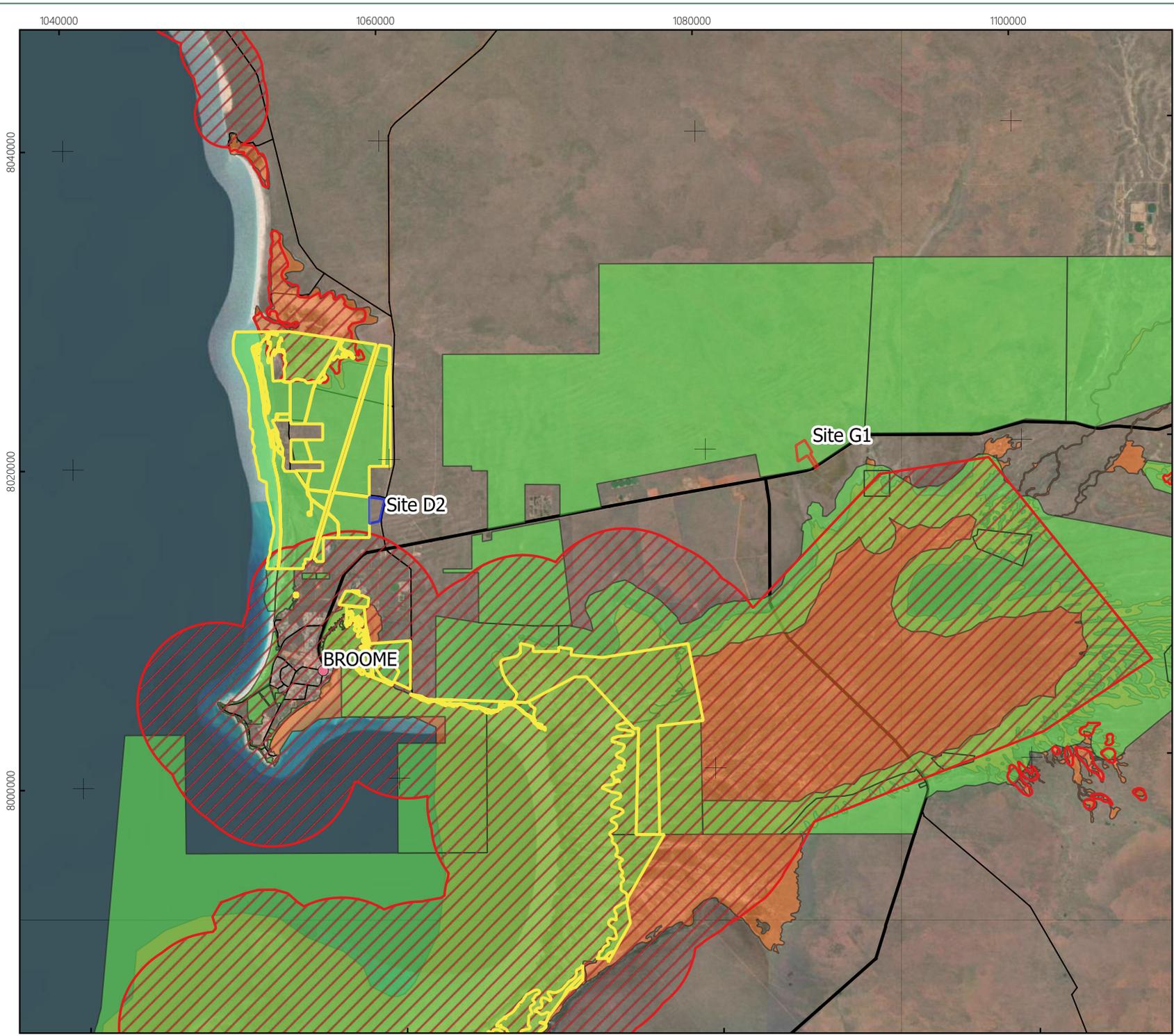
1.1. Project Background

The Shire of Broome is investigating two sites ('D2' and 'G1') for the placement of a new community recycling centre and landfill. The D2 Study Area is 122 ha and located approximately 10 km north of Broome. The G1 Study Area is 98 ha and located approximately 33 km north-east of Broome. As part of the site investigations, a range of hydrogeological and geotechnical works are required which will involve the removal of native vegetation (approximately 2.5 ha for D2 and 3.0 ha for G1). The disturbance to vegetation will include access tracks, boreholes, and trial pits. . To allow such works to occur, a Native Vegetation Clearing Permit (NVCP) will be necessary and, as such, flora and fauna surveys are required to be undertaken in support of the NVCP application. Flora and Fauna surveys have previously been conducted at the G1 prior to the movement of the site boundary to its current location.

1.2. Objectives

Talis Consultants, on behalf of the Broome Shire, commissioned Spectrum Ecology (Spectrum) to undertake a Level 2 terrestrial fauna assessment for the Broome RRRP Project. Spectrum Ecology previously conducted a reconnaissance flora and level 1 fauna survey at the D2 and G1 Study Areas in December 2019 to determine the environmental values present at the sites (Map 1.1) and provide support to the relevant applications to undertake initial hydrogeological and geotechnical investigations for the development of the RRRP project.

The following is a brief technical report and survey data that satisfies the relevant regulatory guidance statements and documents the results, findings, and limitations of the survey.

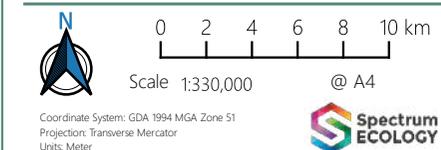


Legend

- D2 Study Area
- G1 Study Area
- CAPAD Protected Areas
- Environmentally Sensitive Areas (ESA)
- Yawuru Indigenous Protected Area
- Directory of Important Wetlands

Roads

- Principal Road
- Minor Road



Author: CS

Date: 19-06-2020

Location of Study Area & Significant Lands

Broome Regional Resource Recovery Park

Prepared for
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Map
1.1

1.3. Bioregion & Climate

The Interim Biogeographic Regionalisation for Australia (IBRA) classifies Australia into regions based on dominant landscape, climate, lithology, geology, landform, and vegetation (Thackway & Cresswell, 1995).

The Study Area is located in the Pindanland (DAL02) IBRA subregion within the larger Dampierland (DAL) region (Figure 1.1). The Pindanland subregion comprises the western half of Dampierland, including the sandplains of the Dampier Peninsula, extending south along the hinterland of Eighty Mile Beach and north to include the paleodelta of the Fitzroy River (Graham, 2002). It is further described as having a fine-textured sand-sheet with low dunes covered by pindan vegetation, being the coastal, semi-arid, north-western margin of the Canning Basin (Graham, 2002). Inland vegetation typically consists of *Triodia* spp. (spinifex) or *Chrysopogon* spp. (ribbon grass) grasslands under *Acacia* spp. open shrub with low open woodlands of *Eucalyptus* species.

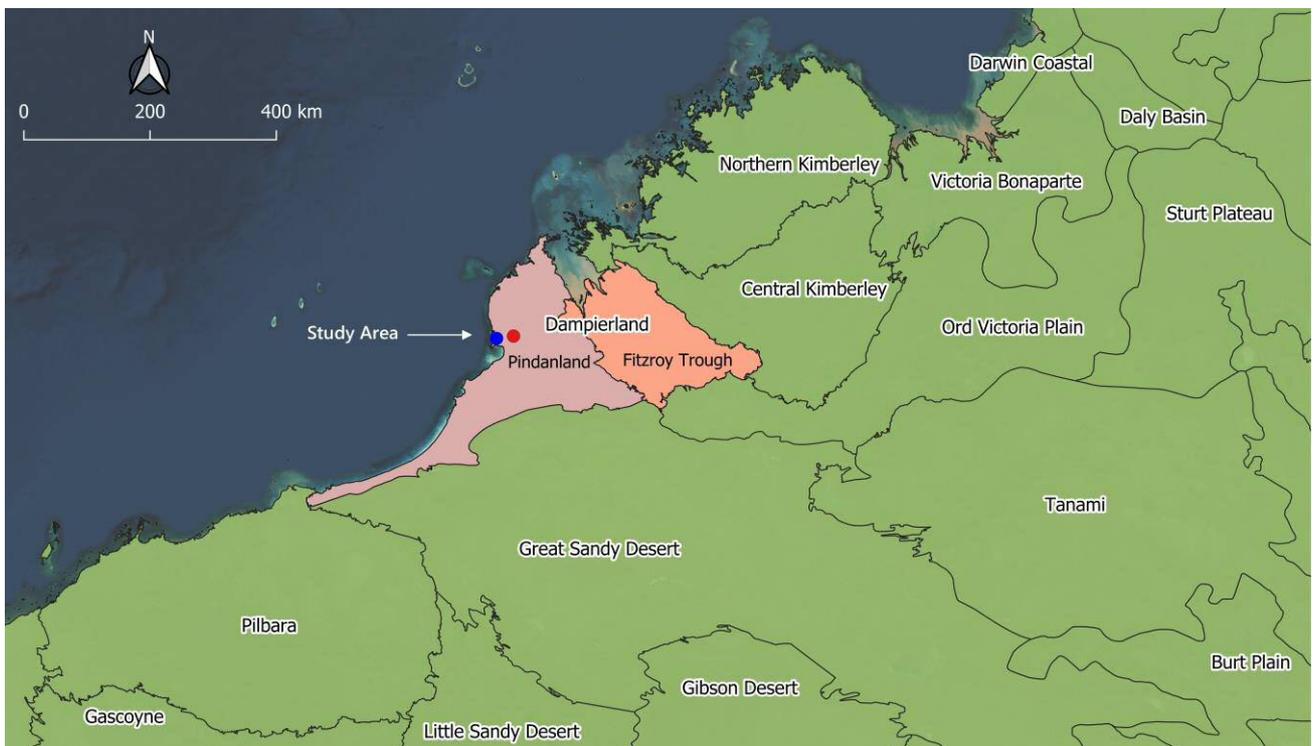


Figure 1.1: IBRA Classification of the Study Areas

The climate near Broome is dry, hot, and tropical and divided into a dry and wet season. The dry season runs from April to November, with very little rain and daily temperatures around 30°C. During the wet season, from December to March, average temperatures are several degrees higher along with erratic, often heavy rainfall, high humidity, and the possibility of tropical cyclones. The median annual rainfall is 561 mm, however the range of recorded annual rainfall is highly variable, from 132 mm to 1599 mm (Bureau of Meteorology, 2019).

1.4. Disturbance History

The dominant land uses for the Pindanland subregion include grazing on native pastures, unallocated crown land, and crown reserves. At the time of survey, the most recent fire within the Study Area and surrounds occurred in 2019.

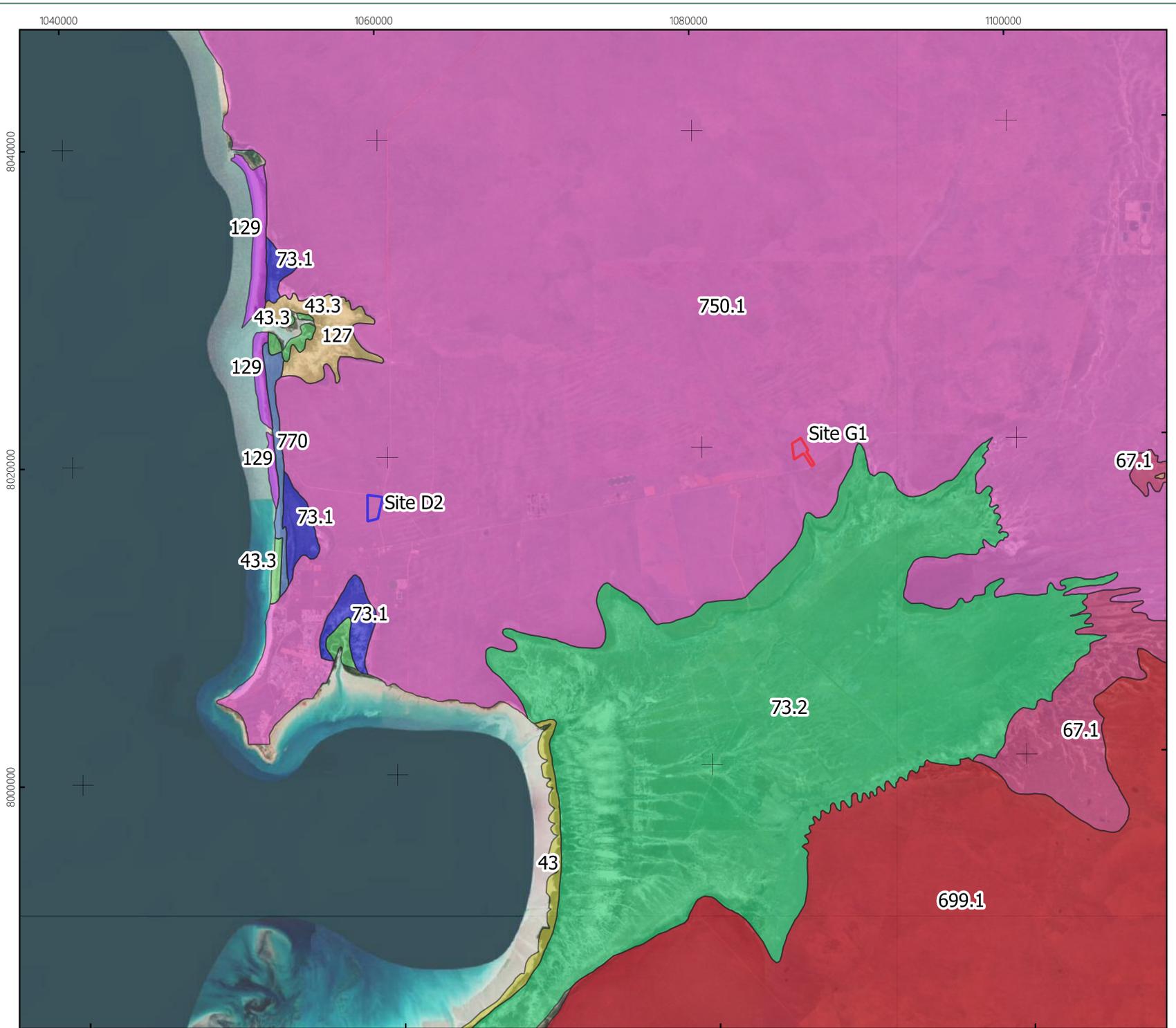
1.5. Beard Vegetation

Pre-European vegetation mapping was originally undertaken by J. S. Beard at various scales across the state and has since been updated to be consistent with the National Vegetation Information System (NVIS) descriptions at a scale of 1:250,000 (DPIRD 2020). State-wide vegetation statistics are available for these units, listing pre-European extent, current extent, and area in DBCA managed lands, are a useful tool to determine if a vegetation unit is rare or otherwise significant (WAGov, 2019). The unit mapped at the Study Areas has more than 99.7% of its pre-European extent remaining.

Both Study Areas occur entirely within one vegetation sub-association (750.1). This sub-association is restricted to the Dampierland IBRA region but is the second largest sub-association within the region and widespread. The vegetation classification is listed in Table 1.1 and presented in Map 1.2.

Table 1.1: Beard Vegetation

Sub-association	NVIS Level VI Vegetation Description	Area in Study (ha)	% of Study Area	Pre-European Whole State (ha)	Current Extent State (ha)	% Remaining	% of Current Extent in DBCA Land
750.1	<i>Corymbia polycarpa</i> , <i>Corymbia papuana</i> and <i>Corymbia setosa</i> woodland, over <i>Acacia eriopoda</i> , <i>Acacia holosericea</i> and <i>Dolichandrone occidentalis</i> tall shrubland, over <i>Chrysopogon</i> sp. open tussock grassland	D2 – 122 G1 – 98	D2 – 100% G1 – 100%	1,221,911.2	1,218,020.5	99.7	2.7

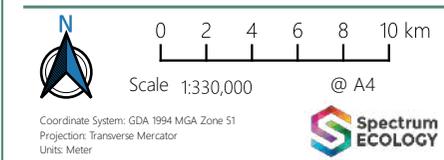


Legend

- D2 Study Area
- G1 Study Area

Beard Vegetation Units

- 43.0
- 43.3
- 67.1
- 73.1
- 73.2
- 125.0
- 127.0
- 129.0
- 699.1
- 750.1
- 770.0



Author: CS Date: 19-06-2020

Beard Vegetation

Broome Regional Resource
Recovery Park

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Map
1.2

1.6. Geology

The geology of Western Australia (WA) has been mapped at a scale of 1:50,000, 1:100,000, 1:250,000, and 1:500,000. The township of Broome has been mapped to the finer scale 1:50,000 (Map 1.3), the surrounding region limited to a 1:250,000 and 1:500,000 scales.

Both study areas are located over the Broome, Mowla and Melligo Sandstones (K-bm-st) 1:500,000 geological unit, the total extent of this geological unit is 2,260,980 ha in WA and 1,980,210 ha in the Dampierland IBRA. The K-bm-st geological unit mapped at the Study Areas is widespread across WA and the Dampierland IBRA. The unit has less than 0.001% of its total occurrence within the Study Areas.

The D2 Study Area occurs within the Sm10 (1:50k) and Qz (1:250k) geological units. Both units are described as homogenous fine-grained red sands. The G1 Study Area is located over the Qs (1:250k) geological unit which is comprised of sand and silt and occurs extensively in the surrounding region. Extrapolating from the 1:50,000 geological units, the G1 site likely falls within the Sm10 (1:50k) geological unit (Table 1.2; Map 1.3). The geological units are listed in Table 1.2 and mapped at 1:50,000 in Map 1.3.

Table 1.2: Geological Units

Scale	Code	Description	Area in Study Area (ha)	% of Study Area
D2 Study Area				
1:50k	Sm10	Silky sand: red, fine-grained, sub-rounded quartz, variable silt content, homogeneous	122	100%
1:250k	Qz	Red sand, fine to medium; minor silt; aeolian	122	100%
1:500k	K-bm-st	Fine- to coarse-grained sandstone; minor mudstone and conglomerate	122	100%
G1 Study Area				
1:50k*	Sm10	Silty sand: red, fine-grained, sub-rounded quartz, variable silt content, homogeneous	98	100%
1:250k	Qs	Sand, silt; minor gravel: mixed alluvial and aeolian	98	100%
1:500k	K-bm-st	Fine- to coarse-grained sandstone; minor mudstone and conglomerate	98	100%

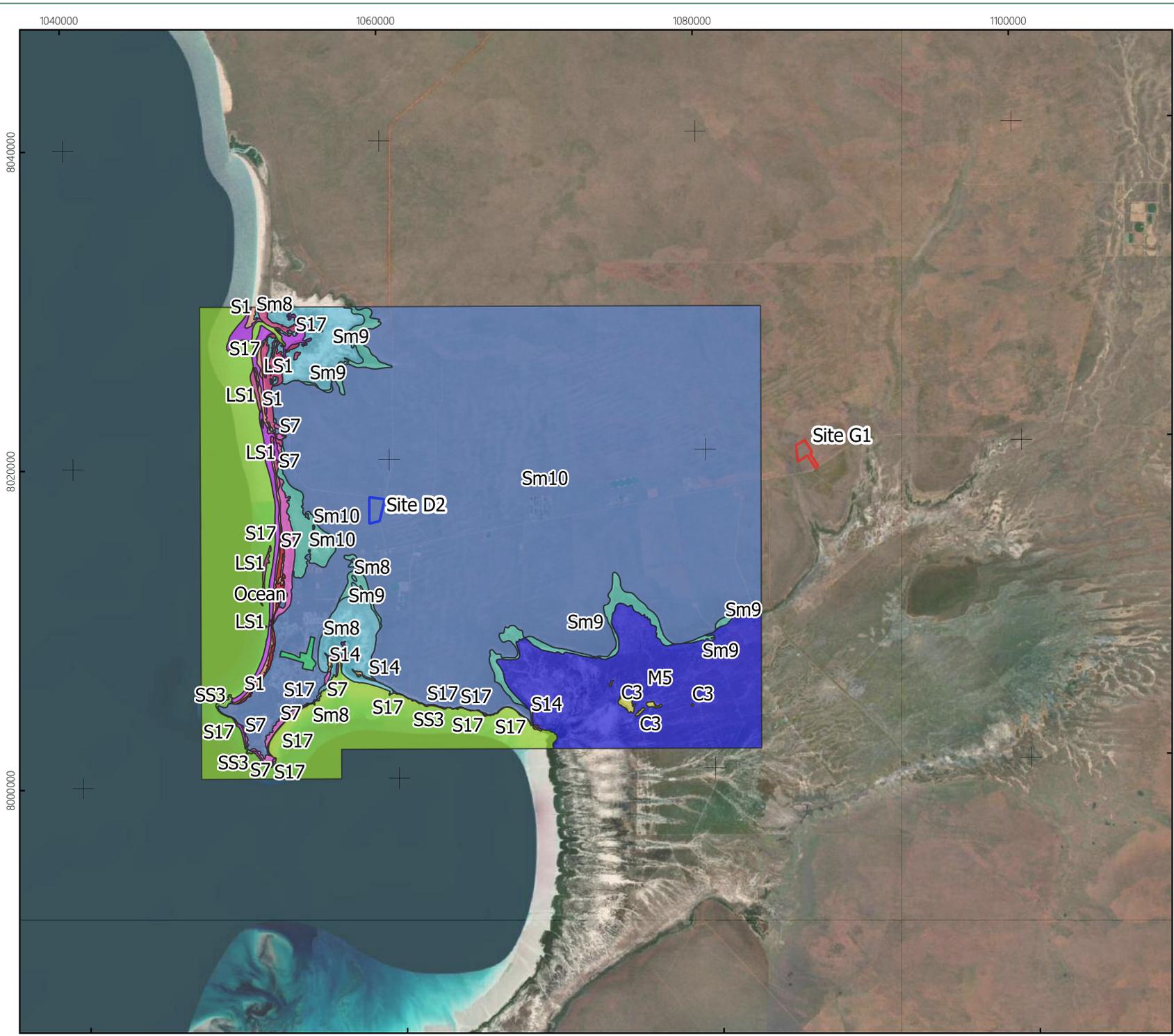
*Estimate based on 1:50,000 and 1:250,000 geological units.

1.7. Land Systems

Both Study Areas are on the boundary between Yeeda and Wanganut land systems (Schoknecht & Payne, 2011). The Yeeda land system is dominated by red sandplains supporting pindan vegetation with dense *Acacia* shrubs, scattered bloodwood and grey box trees and curly spinifex and ribbon grass. The Wanganut land system is dominated by low-lying sandplain and dunefields with through-going drainage (Schoknecht & Payne, 2011). The land systems associated with the Study Areas are presented in Table 1.3 and Map 1.4.

Table 1.3: Land Systems

Land System	Description	Area in Project (ha)	Total Extent (ha)	Location & Description of Occurrence
Yeeda	Sandplain, deep red and yellow sands, pindan and tall woodlands.	D2 – 24 G1 – 95	2,130,800	Widespread across the Dampierland IBRA region. Predominantly found on the Pindanland IBRA subregion.
Wanganut	Low-lying sandplain and dunefields with through-going drainage, pindan.	D2 – 98 G1 – 3	697,300	Located in the northern half of the Dampierland IBRA region. Found evenly across both the Pindanland and Fitzroy Trough IBRA subregions.



Legend

- D2 Study Area
- G1 Study Area

Geological Units 1:50,000

- C3
- Gsb1
- LS1
- M5
- Made grd
- S1
- S14
- S17
- S2
- S7
- Sm10
- Sm8
- Sm9
- SS3
- Ocean



Author: CS

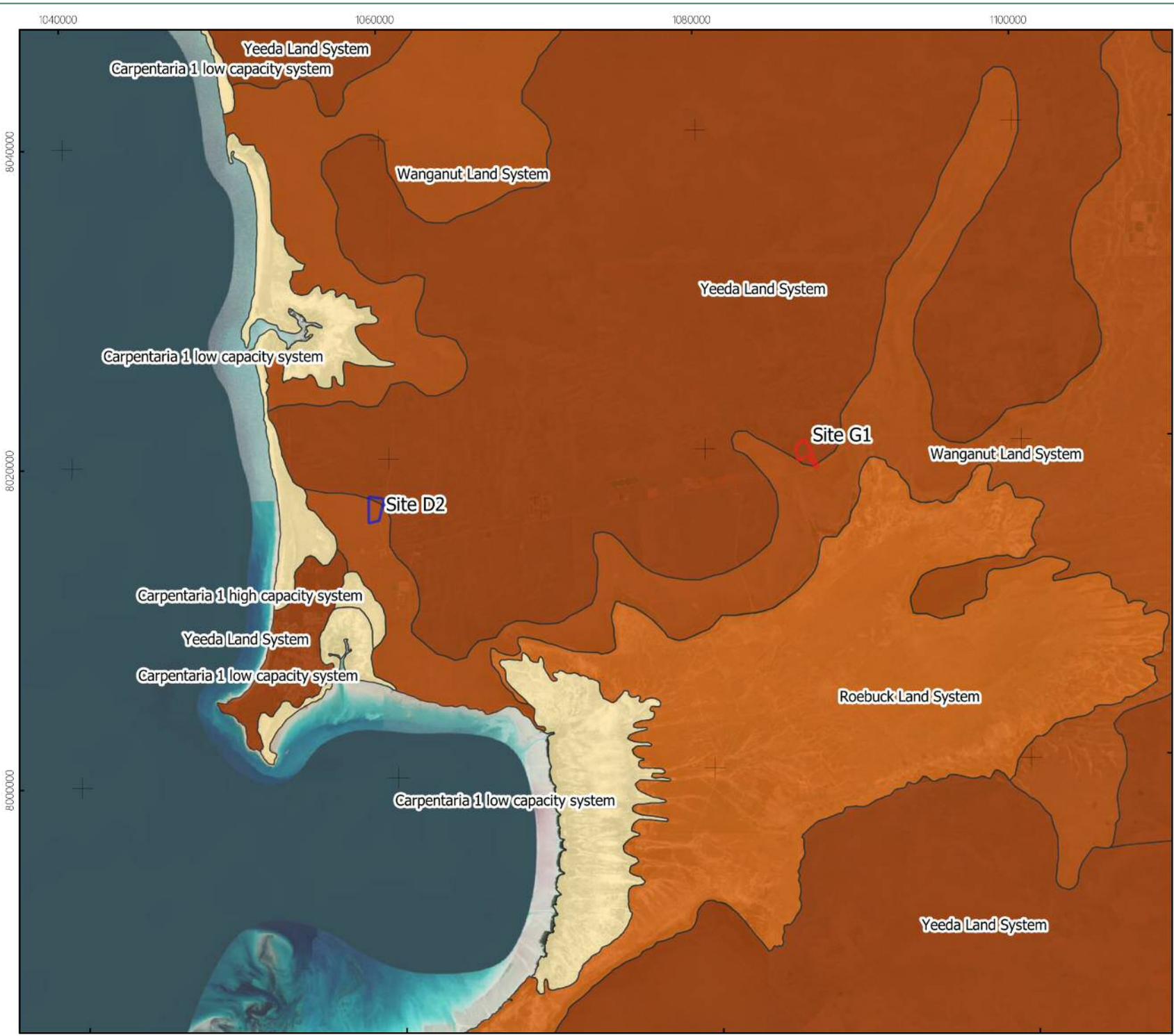
Date: 19-06-2020

Geology (1:50,000)

Broome Regional Resource
Recovery Park

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Map
1.3



Legend

- D2 Study Area
- G1 Study Area

Land Systems

- Carpentaria 1 high capacity system
- Carpentaria 1 low capacity system
- Roebuck Land System
- Wanganut Land System
- Yeeda Land System



Author: CS

Date: 19-06-2020

Land Systems

Broome Regional Resource
Recovery Park

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Map
1.4

1.8. Significant Lands

1.8.1. Environmentally Sensitive Lands

Environmentally Sensitive Areas (ESA) that are associated with flora and vegetation are areas that are defined by the Department of Water and Environmental Regulation (2019) as:

- A defined wetland and the area within 50 m of a wetland;
- The area covered by vegetation within 50 m of Threatened flora, to the extent to which the vegetation is continuous with the vegetation in which the Threatened flora is located;
- The area covered by a TEC;
- A Bush Forever site;
- Areas covered by the Gngangara Mound Crown Land Policy and Western Swamp Tortoise Policy; and
- Areas covered by lakes, wetlands and fringing vegetation of the Swan Coastal Plain Lakes Policy, including South West Agricultural Zone Wetlands Policy and Swan and Canning Rivers Policy.

No ESAs were mapped within the Project. Both Study Areas are located to the north of a large ESA that comprises the Roebuck Bay and associated Roebuck Plain areas (Map 1.1).

1.8.2. Australian Wetlands Database

The Australian Wetlands Database includes nationally significant wetlands (as listed in the directory of important wetlands), wetlands listed under the Ramsar convention, wetlands that are representative, rare or unique, or wetlands that are considered of international importance (DoEE, 2019).

No nationally significant wetlands, including Ramsar wetlands, were mapped within the Project (Map 1.1).

1.8.3. Conservation Estate

A search of the Collaborative Australian Protected Area Database (CAPAD), identified several protected areas located within 50 km of the Study Areas. These protected areas and their approximate distance from the Study Areas are listed in Table 1.4.

The G1 Study Area is located within the Yawuru Indigenous Protected Area (IPA). The combined area of the 5(1)(h) Reserves listed in Table 1.4 make up a small portion of the greater Yawuru IPA. The D2 Study Area is not located within any protected areas though is immediately east of the Yawuru Birragun Conservation Reserve. Conservation Estate, ESAs, nationally significant wetlands, and the extent of the Yawuru IPA are displayed on Map 1.1.

Table 1.4: Significant Lands Within 50 km of the Study Areas

Reserve Name (Protected Area ID)	Relevant to the Study Area		Jurisdiction/ Size
	Distance	Direction	
RAMSAR Wetland			
Roebuck Bay (RAMSAR ID – 33)	D2 – 12.2 km G1 – 20.6 km	Southeast Southwest	Western Australia, 34,141 (ha)
Significant Wetlands			
Roebuck Bay (DIW ID – 20)	D2 – 4.6 km G1 – 13.6 km	South Southwest	Western Australia, 65,203 (ha)
Roebuck Plains System (DIW ID – 21)	D2 – 20.5 km G1 – 2.4 km	Southeast South	Western Australia, 53,715 (ha)
Willie Creek Wetlands (DIW ID – 22)	D2 – 7.1 km G1 – 25.9 km	North West	Western Australia, 3769 (ha)
5(1)(h) Reserves			
Broome Bird Observatory (WA_41066)	D2 – 13.8 km G1 – 23.9 km	Southeast Southwest	Western Australia, 2.7 ha
Broome Wildlife Centre (WA_47964)	D2 – 6.5 km G1 – 32.3 km	Southwest West southwest	Western Australia, 5.0 ha
Unnamed (WA_51105)	D2 – 11.9 km G1 – 26.6 km	South Southwest	Western Australia, 317.0 ha
Yawuru Conservation Estate (WA_51162)	D2 – 5.5 km G1 – 30.5 km	West West	Western Australia, 2,515.6 ha
Unnamed (WA_51497)	D2 – 4.6 km G1 – 28 km	South Southwest	Western Australia, 716.5 ha
Unnamed (WA_51583)	D2 – 11.9 km G1 – 13.3 km	Southeast Southwest	Western Australia, 4,896.0 ha
Unnamed (WA_51617)	D2 – 13.6 km G1 – 24.9 km	Southeast Southwest	Western Australia, 5.7 ha
Unnamed (WA_51932)	D2 – 19.4 km G1 – 20.8 km	Southeast Southwest	Western Australia, 5,778.5 ha
Yawuru Birragun Conservation Park (WA_52354)	D2 – Directly adjacent G1 – 25km	West West	Western Australia, 7,223.8 ha
Indigenous Protected Areas			
Yawuru (CWTH_IPA75)	D2 – Directly adjacent G1 – Located within IPA	West Within	Commonwealth of Australia, 210,763.7 ha

2. METHODS

2.1. Desktop Assessment

2.1.1. Database Searches

The following databases were accessed to provide information to support the current assessment. Details of the completed database searches are listed in Table 2.1.

Table 2.1: Details of Database Searches

Data Source	Custodian	Details
Commonwealth Protected Matters Search Tool (PMST)	Department of the Environment and Energy (DoEE)	Date: 13/11/19 Buffer: 40 km
NatureMap	Department of Parks and Wildlife / Western Australian Museum	Date: 13/11/19 Centre point: 17°54'10"S, 122°20'17"E Buffer: 40 km
Threatened Fauna Database	Department of Biodiversity, Conservation and Attractions (DBCAs)	Date: 13/11/19 Buffer: 10 km around D2; 15 km around G1
Invertebrate Fauna Databases	Western Australian Museum	Arachnids & Myriapods, Crustacea and Mollusca. Results provided for Dampier Peninsula
EPBC Protected Matters report (PMST)	Department of the Environment and Energy (DoEE)	Date: 23/03/20, Buffer: 50 km

2.1.2. Literature Review

A desktop review of all relevant and available literature was undertaken prior to the field assessment. The following previous survey reports were searched to determine which species of conservation significance may occur in the Study Area and to develop a regional potential species list (Appendix D). Details regarding vegetation and major fauna habitat types and extents were also assessed for relevance. The details of each survey are summarised in Table 2.2.

Table 2.2: Terrestrial Fauna Report Details

Report	Survey Type	Distance to Study Areas
Mamabulanjin orchard flora and fauna survey (GHD, 2019b)	Level 1 Fauna	D2- immediately north G1- 26 km west
Broome Asparagus Farm (AECOM, 2017)	Level 1 Fauna	D2- 17 km east G1- 2 km west
James Price Point Terrestrial Fauna Survey: Wet Season 2009 (Biota 2010)	Level 2 vertebrate and SRE invertebrate fauna.	D2- 28 km north G1- 40 km northwest
James Price Point Supplementary Terrestrial Fauna and Habitat Assessment (AECOM, 2010)	Level 1 and targeted vertebrate and SRE invertebrate fauna.	D2- 28 km north G1-40 km northwest
James Price Point: Light Industrial Area, Workers Accommodation and Southern Pipeline Terrestrial Vertebrate Fauna Assessment (ecologia Environment, 2012a)	Level 2 vertebrate fauna.	D2- 28 km north G1-40 km northwest

Report	Survey Type	Distance to Study Areas
Orange Flat (Biota 2013a)	Level 1 vertebrate fauna.	D2- 75 km east G1-48 km east
Nyamba Buru Yawuru Flora and Fauna Survey (Ecoscape 2017)	Level 2 vertebrate and SRE invertebrate fauna.	D2- 48 km southeast G1-31 km south southeast
Thunderbird Dampier Peninsula Project: Level 1 Fauna Assessment (ecologia Environment, 2012b)	Level 1 vertebrate fauna.	D2- 80 km northeast G1- 58 km northeast
Thunderbird Project Terrestrial and Subterranean Fauna Assessment (ecologia Environment, 2016b)	Level 2 vertebrate and SRE invertebrate fauna.	
Thunderbird Haul Road & Accommodation Camp Fauna (ecologia Environment, 2016a)	Level 1 vertebrate fauna.	
Beagle Bay Big Tree Country Tropical Timber Plantation Project (ecologia Environment, 2004)	Level 2 vertebrate fauna.	D2- 100 km north northeast G1- 90 km north
Ungani Study Area Flora and Fauna Assessment (Biota 2013b)	Level 1 vertebrate fauna.	D2- 101 km southeast G1- 81 km southeast
Rey Resources Duchess Paradise Study Area, West Kimberley: Baseline Fauna Surveys (Western Wildlife, 2011)	Level 2 vertebrate fauna.	D2- 244 km east G1-217 km east

2.2. Determination of Survey Design

The level of existing fauna and fauna habitat knowledge was assessed for the Pindanland IBRA sub-region within which the two Study Areas are located. This and other factors that may influence survey design are detailed in Table 2.3.

Table 2.3: Factors that may Influence Survey Design

Factor	Relevance
Bioregion – level of existing survey knowledge of the region and associated ability to predict accurately.	Multiple Level 2 fauna and SRE surveys have been completed within the Pindanland IBRA sub-region, the data from which was readily available.
Landform species characteristics/ specific fauna/ specific context of the landform characteristics and their distribution and rarity in the region.	The landforms associated with Pindanland sub-region are common and not typically restricted. Previous surveys sampled landforms similar to those found within the Study Areas.
Lifeforms, life cycles, types of assemblages and seasonality (e.g. migration) of species likely to be present.	Previous surveys completed within the Pindanland sub-region were completed at optimal times to detect local fauna. Within the Northern Botanical Province this is typically during and immediately after the wet season. The current survey was also completed post wet season.
Level of existing knowledge and results of previous regional sampling (e.g. species accumulation curves, species/area curves).	Multiple Level 1, Level 2 fauna and SRE surveys have been completed. Regional knowledge is available including that related to significant species.
Number of different habitat or degree of similarity between habitats within a survey area.	Pindan Shrubland is the dominant habitat type within the Pindanland sub-region and Study Areas. Multiple previous surveys have sampled this habitat type.

Factor	Relevance
Climatic restrictions (e.g. temperature or rainfall that preclude certain sampling methods).	Previous surveys have been completed at appropriate times following significant wet season rainfall and while temperatures are high enough to ensure reptile species are detectable. The current survey was planned to both take advantage of suitably moist and warm temperatures while avoiding the risk of extreme weather events.
Sensitivity of the environment to the proposed activities.	The Study Areas contain a single major fauna habitat type that is extensive and has been previously sampled within the region.
Size, shape, and location of the proposed activities.	The D2 and G1 Study Areas are small parcels of land located within continuous Pindan Shrubland habitat. The survey was designed to ensure adequate coverage.
Scale and impact of the proposal.	The impact of the proposal was not known and did not influence the survey design.

2.3. Survey Methods

2.3.1. Survey Timing

The field survey was completed during the 15th – 24th of April 2020. The Study Areas fall within the Northern Botanical Province as described by Beard 1980. The Technical Guidance (EPA 2016b) recommends terrestrial fauna surveys in this region be completed during the wet season (December – March), the period of highest vertebrate activity. Though the survey timing fell outside of the peak period of activity, the Technical Guidance also states that some compromise in timing may be required from a logistical or animal welfare perspective (risk of extreme weather e.g. flooding, high temperatures, cyclones). Completing the field survey in April is an effective compromise ensuring both adequate terrestrial fauna activity and a decreased risk of extreme weather events.

2.3.2. Systematic Trapping

Systematic trapping is an effective method of sampling small to medium sized vertebrate fauna as well as some ground dwelling potential SRE taxa. The trapping grids used in the Level 2 survey include the following:

- 20 L bucket and 50 cm PVC pipe traps: these are dug into the ground and act as pitfall traps. A 10 m long, 30 cm high fence is passed across the top of the pit to direct fauna into it.
- Fraser-type funnel traps: similar to yabbie traps, these are placed at the ends of each fence to capture fauna that do not readily fall into pit traps (two per fence line). All funnel traps are covered with shades to reduce the likelihood of animals suffering from overheating.
- Elliott traps: aluminium box traps baited with 'universal bait' to attract and capture smaller mammals (one per fence line) and re-baited daily. All Elliott traps are placed in naturally shaded positions and/or covered by hessian shades to reduce the likelihood of animals suffering from overheating.
- Cage traps: larger wire-frame box traps, also baited with 'universal bait', to capture medium-sized mammals (2 per trapping grid). All cage traps are covered by Hessian shades to reduce the likelihood of animals suffering from overheating.

The layout of each site is detailed diagrammatically in Figure 2.1. Trapping grids were installed in each major fauna habitat.

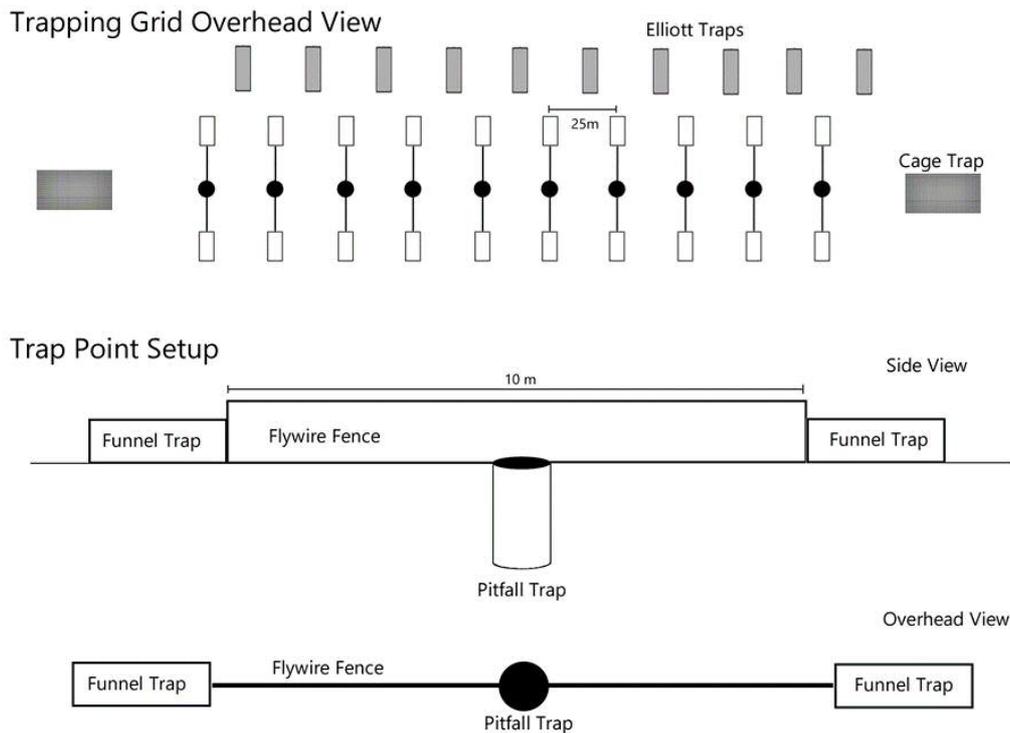


Figure 2.1: Diagram Detailing Systematic Trapping Grid Layout

2.3.3. Supplementary Systematic and Opportunistic Sampling

Trapping surveys typically only target small to medium terrestrial species. Spectrum Ecology compliments the systematic trapping survey with a suite of opportunistic sampling techniques that target specific species and habitats not normally covered by standard trapping (e.g. arboreal species). To increase survey efficiency, foraging for reptiles, amphibians, mammals and potential SRE invertebrates was completed concurrently within the 2 ha Greater Bilby sign plot survey areas. Each 2 ha area was searched by two zoologists for one hour.

Active survey techniques used are listed below:

- **Reptiles and Amphibians:** A minimum of 20-minutes was spent surveying each 2 ha opportunistic site by two experienced herpetologists. Microhabitats favoured by reptiles and amphibians were searched using a variety of methods including the raking of leaf litter, turning of surface debris, searching tree hollows and under bark and spotlighting for nocturnal species.
- **Birds:** A total of two hours of bird survey (in 30-minute blocks) was completed within each of the Study Areas by an experienced ornithologist during optimal periods of the day (early morning and late afternoon). An opportunistic observation list was also maintained for species observed while traversing the Study Areas.
- **Mammals:** Tracks, scats and other mammal traces were recorded within each 2 ha opportunistic site as well as while traversing the Study Areas. Wildlife Acoustics SM4Bat ultrasonic recorders were also deployed at each trapping site to identify bat species utilising the area.
- **Invertebrates:** Microhabitats and habitat isolates favoured by SRE taxa were targeted for foraging. Methods included the raking of deep litter beds, turning embedded surface debris, scanning sheltered areas for Trapdoor Spider (infraorder Mygalomorphae) burrows and searching under bark.

2.3.4. Conservation Significant Fauna

2.3.4.1. Greater Bilby (*Macrotis lagotis*)

Targeted surveys for Greater Bilby were conducted in conjunction with the Level 2 survey. Methods were consistent with standardized Guidelines and DBCA survey methods using sign-based protocols (DBCA 2017; DSEWPaC 2011). Two-hectare plots were searched for evidence of Greater Bilby presence (unambiguous track and gait characteristics, diggings, scats, burrows) in areas of suitable habitat. Sign plots were searched for a total of two person hours (one hour by two zoologists).

Two-hectare sign plots and motion camera trapping were also completed by experienced Nyamba Buru Yawuru Country Managers within the D2 and G1 Study Areas, working independently of Spectrum Ecology Zoologists.

2.3.5. Survey Effort

The terrestrial fauna survey was consistent with a Level 2 survey as described in *Technical Guidance: Terrestrial Fauna Surveys* (EPA 2016a) and *Technical Guidance: Sampling Methods for Terrestrial Vertebrate Fauna* (EPA 2016b). Systematic trapping was conducted over seven nights at both the D2 and G1 Study Areas. A summary of the survey effort undertaken at each Study Area is detailed in Table 2.4. The survey site locations for each of the Study Areas is displayed in Map 2.1 and Map 2.2 and also listed with coordinates in Appendix B.

Table 2.4: Summary of Survey Effort for each Study Area

Site	Pit Traps (trap nights)	Funnels (trap nights)	Elliotts (trap nights)	Cages (trap nights)	Bird Survey (min)	Diurnal Opp. Search (min)	Bat Recording (hours)	Nocturnal Opp. Search (min)	Camera Trapping (nights)
D2 Study Area									
RRRP D2 TRAP	56	112	56	14	120	0	36	0	0
Opportunistic	0	0	0	0	180	540	0	60	24
Subtotal	56	112	56	14	300	540	36	60	24
G1 Study Area									
RRRP G1 TRAP	56	112	56	14	120	0	36	0	0
Opportunistic	0	0	0	0	420	1180	0	60	14
Subtotal	56	112	56	14	540	1180	36	60	14
Total	112	224	112	28	840	1,720	72	120	38

420000 430000 440000 450000 460000

8040000
8030000
8020000
8010000



Legend

DBCA Database Search Results

- Endangered (BC/ EPBC Act)
- Vulnerable (BC/ EPBC Act)
- Migratory (BC/ EPBC Act)
- Other Specially Protected Fauna (BC Act)
- Priority 1 (DBCA)
- Priority 3 (DBCA)
- Priority 4 (DBCA)
- D2 Study Area
- G1 Study Area

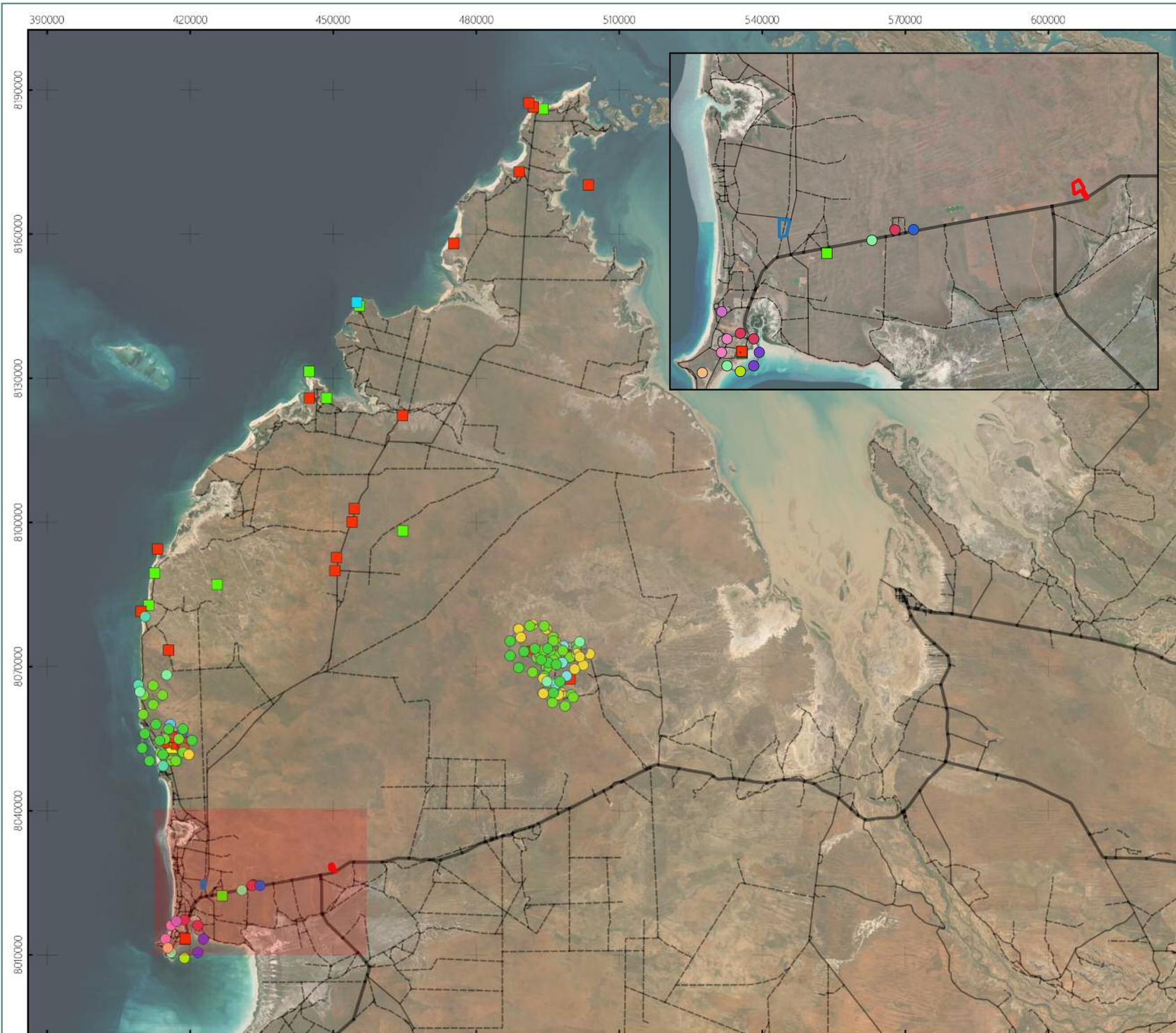



0 2 4 6 8 km
 Scale 1:252951 @ A4
Coordinate System: GDA 1994 MGA Zone 51
 Projection: Transverse Mercator
 Units: Meter


Author: JV Approved: DC Date: 08-06-2020

DBCA Database Search Results

Broome Regional Resource Recovery Park Assessment



Legend

WAM Arachnida

- Aname `MYG231?`
- Aname `MYG284`
- Aname `MYG388`
- Beierolpium `sp. indet.`
- Conothele `MYG543`
- Conothele `MYG613`
- Conothele `MYG614`
- Conothele `MYG615`
- Conothele `MYG616`
- Conothele `MYG617`
- Isometrus maculatus
- Kwonkan `MYG285`
- Lychas `JPP`
- Synothele `MYG179`
- Urodacus `fossor?`
- Urodacus `kraepelini`

WAM Mollusca

- Quistrachia leptogramma
- Rhagada bulgana
- Rhagada cf. bulgana

WAM Crustacea

- ▲ Buddelundia `sp.43`
- D2 Study Area
- G1 Study Area



0 9 18 27 36 km

Scale 1:1101805

@ A4

Coordinate System: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Units: Meter



Author: JV Approved: DC Date: 08-06-2020

Invertebrate Database Search Results

Broome Regional Resource Recovery
Park Assessment

Prepared for
Talis Consultants | Shire of
Broome

Map

3.2

2.3.6. Animal Ethics

The survey followed the DBCA Standard Operating Procedures (SOPs) listed below:

- Aluminium Box Traps for Capture of Terrestrial Vertebrates
- Cage Traps for Live Capture of Terrestrial Vertebrates
- Dry Pitfall Trapping for Vertebrates
- Funnel Trapping for Terrestrial Fauna
- Animal Handling and Restraint using Soft Containment
- Hand Capture of Wildlife
- Hand Restraint of Wildlife
- Transport and Temporary Holding of Wildlife

Survey timing is also a significant factor when considering animal welfare. The survey must be completed at a time when the target faunal groups are active and detectable but not during a time of year when extreme weather events are likely. High temperatures and flooding can lead directly to fauna stress and/ or death or indirectly by restricting access to trapping sites. A compromise in timing was reached for the field survey (April) to ensure fauna detectability without significantly compromising animal welfare.

2.3.7. Survey Team and Licenses

Spectrum Ecology staff involved with this assessment are listed in Table 2.5, along with their role, years of experience and relevant licenses.

Table 2.5: Survey Team and Licenses

Staff	Role	Experience	Licences
Jordan Vos (Zoologist)	Field Assessment, Reporting, Data Analysis	10 years	Fauna: BA27000234
Marcus Cosentino (Zoologist)	Field Assessment	10 years	Fauna: BA27000234
Lauren Buttery (Field Assistant)	Field Assessment (fauna site installation)	-	Fauna: BA27000234
Geoffrey Schoonakker (Field Assistant)	Field Assessment (fauna site installation)	-	Fauna: BA27000234

2.3.8. Survey Limitations

Potential survey limitations are addressed in Table 2.6. No significant limitations were experienced.

Table 2.6: Survey limitations

Limitation	Constraint	Comment
Competency/experience of the consultant carrying out the survey.	No	Zoologists had relevant fauna experience within the Dampierland region and experience with local significant species.
Scope (what faunal groups were sampled and were some sampling methods not able to be employed because of constraints such as weather conditions).	Partial	Amphibians were not sampled during the field survey due to lack of rainfall. This outcome was expected and is not unique to this survey or region. All other faunal groups were sampled.
Proportion of fauna identified, recorded and/or collected.	No	All vertebrate fauna species encountered were identified in the field. Bat call recordings and potential SRE invertebrate specimens were sent to specialists for identification.

Limitation	Constraint	Comment
Sources of information.	No	Database searches and previous survey reports provided a significant level of information, adequate to guide field survey design and effort.
The proportion of the task achieved and further work which might be needed.	No	All components of a Level 2 fauna survey were completed.
Timing/weather/season/cycle.	No	The field survey was completed immediately post wet season as recommended by the EPA Technical Guidance. Rainfall prior to the survey was above the median average for the region.
Disturbances (e.g. fire, flood, accidental human intervention) which affected results of survey.	Partial	The northern part of the D2 Study Area was partially burned prior to the field survey. Trapping was completed in similar unburned habitat south of the fire scar though still within the Study Area boundary. The G1 Study Area had also been recently burned (<1 year) though trapping results do not appear to have been negatively affected when compared with the D2 trapping results.
Intensity (in retrospect, was the intensity adequate).	No	The Level 2 field assessment was adequate to identify the majority of fauna species present within the Study Areas. Opportunistic surveys were also completed targeting significant species and those not likely to be sampled by systematic trapping.
Completeness (was the relevant area fully surveyed).	No	All major fauna habitat types were surveyed. Habitat types that may host significant species were surveyed.
Resources (degree of expertise available in animal identification to taxon level).	No	Resources were adequate to complete the survey and did not compromise the outcome of the survey.
Remoteness and/or access problems.	No	No access problems were experienced.
Availability of contextual (e.g. biogeographic) information on the region.	No	Background information about the region was available and sufficient.

2.4. Likelihood of Occurrence of Significant Species

The following information was collated for each significant fauna taxon identified during the desktop assessment:

- Conservation status (EPBC Act, WC Act, DBCA listing);
- Description of habitat requirements and presence within the Study Areas;
- Source of record (DBCA, previous report etc.); and
- Distance of record to the Study Areas.

A likelihood of occurrence assessment was then conducted using the criteria listed in Table 2.7. This included assessing the distance of the record from the Study Areas (historical database records considered not accurate were excluded if required), presence of appropriate habitats within the Study Areas (using land systems, geology, vegetation mapping, and/or aerial imagery), and the age of the record.

Table 2.7: Likelihood of Occurrence Assessment Criteria

Likelihood	Criteria
Recorded	Species recorded within the Study Area within the previous ten years.
High	Species recorded within or in proximity to the Study Area within the previous 20 years. Suitable habitat occurs in the Study Area.
Medium	Species recorded within or in proximity to the Study Area more than 20 years ago. Species recorded outside the Study Area but within 40 km. Suitable habitat occurs in the Study Area.
Low	Species rarely or not recorded within 40 km of the Study Area. Suitable habitat does not occur within or in proximity to the Study Area.
Very Low	Species not recorded within 40 km despite multiple recent surveys. Suitable habitat does not occur within the Study Area. Species considered locally extinct.

2.5. Determination of SRE Status

The Short-Range Endemic (SRE) status of invertebrates is based on categories which were developed by the Western Australian Museum (WAM). The classifications listed in Table 2.8 are based on known information of the species group such as distribution, representation of records in collections, and distinct morphological features. Information gaps lead to classing certain taxon as potential SREs which is a requirement under the precautionary principle.

Table 2.8: Western Australian Museum SRE Categories (2013)

Distribution	Taxonomic Certainty	Taxonomic Uncertainty
Distribution <10,000km ²	<ul style="list-style-type: none"> • Known distribution of <10,000km² • Taxonomy is well known • Group is well represented in collections and /or via comprehensive sampling <p style="text-align: center;"><u>Confirmed SRE</u></p>	<ul style="list-style-type: none"> • Patchy sampling has resulted in incomplete knowledge of the geographic distribution of the group • There is incomplete taxonomic knowledge • The group is not well represented in collections
Distribution >10,000km ²	<ul style="list-style-type: none"> • Known distribution of >10,000km² • Taxonomy is well known • Group is well represented in collections and /or via comprehensive sampling <p style="text-align: center;"><u>Widespread (not SRE)</u></p>	<p style="text-align: center;">This category is most applicable to situations where there are gaps in knowledge of the taxon</p> <p style="text-align: center;"><u>Potential SRE</u></p>

2.6. Fauna Habitat Mapping

Fauna habitat mapping identifies areas of vegetation and land features that are distinguishable from other areas. Typically, each fauna habitat supports a characteristic fauna assemblage that is adapted to the features of the fauna habitat. Fauna habitat types are identified and mapped based on the following information:

- General vegetation type (Shepherd, Beeston, & Hopkins, 2001);
- Vegetation units mapped within the Study Areas;
- Vegetation structure;
- Landforms;
- Geological units;
- Soil substrate;
- Aerial imagery;
- Fauna assemblage; and
- Field observations.

Fauna habitat assessments were completed at each survey site, opportunistically while traversing the survey areas on foot, and when travelling between sites.

2.7. Survey Adequacy

Survey adequacy, in part, can be assessed by estimating species richness from sample data. Extrapolating Species Accumulation Curves (SACs), fitting parametric models or relative abundance and using non parametric estimators (Bunge & Fitzpatrick, 1993; Colwell & Coddington, 1994; Gaston, 1996) are three generally accepted methods that achieve this. Species Accumulation Curves graphically illustrate the accumulation of species along a timeline and this method was used to analyse the data from the field survey. At the point the horizontal asymptote is reached it is estimated that no new species are present. In an effort to eliminate the impact of random or periodic temporal variation, the sample order was randomised 1000 times using EstimateS (version 9.0, Colwell, 2016). A Michaelis-Menten enzyme kinetic curve was calculated to estimate the theoretical maximum number of species present at each Study Area as a stopping rule technique.

Only systematically collected data can be analysed using these methods due to the need for a standardised sampling effort. As such, only systematically collected mammal and reptile trapping data was used.

2.8. Taxonomy and Nomenclature

Nomenclature for mammals, birds, reptiles and amphibians followed the Western Australian Museum Checklist of the Vertebrates of Western Australia (April 2020). Fauna species identifications were completed based on information provided in references listed in Table 2.9. Nomenclature for SRE invertebrates is based on data provided by WA Museum and relevant experts. Bat call analysis was completed by Dr Kyle Armstrong of Specialised Zoological. The report is included in its entirety as Appendix E.

Table 2.9: Species Identification References

Fauna	Survey Technique
Mammals	Churchill (2009), Menkhorst and Knight (2001), Van Dyck and Strahan (2008)
Birds	Menkhorst et. al. (2019)
Reptiles & Amphibians	Wilson and Swan (2017), Cogger (2014), Tyler and Doughty (2009)

3. RESULTS

3.1. Desktop Assessment

3.1.1. Terrestrial Vertebrate Fauna

The literature review and database search identified 15 amphibians, 316 birds, 46 native mammals, ten introduced mammals and 92 reptile species that could occur in the region surrounding the Study Areas (Table 3.1, Appendix D). The two Study Areas do not include any marine or wetland habitats and a total of 60 waterbird species and four reptile species that have been recorded in the wider region are excluded from this assessment (highlighted in grey Appendix D). Due to the small size of the Study Areas, only a small fraction of the identified species would utilise them on an ongoing basis, although all species could potentially occur at some point in time. Marine mammals have also been excluded from the potential species list and this assessment. In addition, one species of reptile (*Spotted Ctenotus C. uber johnstonei*) was recorded during two previous surveys. However, the species' distribution is known to be limited to a small area near Balgo (Wilson & Swan, 2017). The species' taxonomic status is currently unresolved, and several records have been made from the Pilbara and the Kimberley region that have not been confirmed.

Table 3.1: Summary of Species Recorded During Previous Surveys

Report Title	Amphibians	Birds	Mammals (Native/introduced)	Reptiles
Mamabulanjin Orchard (GHD, 2019a).	0	19	2/3	5
Broome Asparagus Farm (AECOM, 2017).	0	34	4/1	6
James Price Point (AECOM, 2010)	0	103	4/4	17
James Price Point - Wet Season 2009 (Biota 2010)	4	67	9/2	40
James Price Point (Ecologia 2012a)	2	82	10/1	33
Thunderbird Project Lv1 (Ecologia 2012b)	1	71	5/3	7
Thunderbird Project Lv2 (Ecologia 2016b)	8	106	4/4	41
Thunderbird Haul Road (Ecologia 2016a)	1	63	10/3	3
Beagle Bay (Ecologia 2004)	4	65	5/2	27
Duchess Paradise (Western Wildlife, 2011)	11	131	18/6	48
Ungani (Biota 2013b)	0	27	2/1	6
Orange Flat (Biota 2013a)	0	5	0	0
Pivot Project NBY (Ecoscape 2017)	3	39	8/3	25
NatureMap	11	299	33/6	78
Total	15	316	46/10	92

3.1.2. SRE Invertebrate Fauna

The Western Australian Museum SRE invertebrate database search identified 19 potential Short-range Endemic taxa:

- 16 Arachnids (11 trapdoor spiders, one pseudoscorpion and four scorpions)
- One Crustacean (an Isopod or woodlouse)
- Two Molluscs (both snails).

The Lesser Brown Scorpion (*Isometrus maculatus*) was included in the WAM database results (Map 3.2) however, the species has been excluded from the results and likelihood of occurrence assessment due to its widespread distribution both within Australia and internationally.

The database results, information relating to the record and the likelihood of occurrence assessment for each species are shown in Table 3.2 and the locations displayed in Map 3.2.

Table 3.2: WAM Invertebrate Database Records

Species	Previous Records	Likelihood of Occurrence
Arachnida		
Anamidae		
<i>Aname</i> 'MYG231'	Three records from James Price Point region. All records located along the coast in dense coastal vegetation.	Low Dense coastal habitats were not recorded from the Study Areas.
<i>Aname</i> 'MYG284'	Twenty-nine records from James Price Point (11) and the Sheffield Resources Thunderbird project (18). Locations occur over 80 km apart, with individuals from James Price Point located within 5 km of the coast and Thunderbird individuals associated with the Fraser River Drainage system. Habitat described as Pindan Shrubland.	Medium Nearest record located 28 km north of the D2 Study Area. Microhabitats in the Study Areas expected to be similar to those found in the James Price Point and Thunderbird projects.
<i>Aname</i> 'MYG388'	Five records from James Price Point (1) and the Sheffield Resources Thunderbird project (4). Locations occur over 80 km apart, with individuals from James Price Point located within 2 km of the coast and Thunderbird individuals associated with the Fraser River Drainage system.	Medium Nearest record located 29 km north of the D2 Study Area. Microhabitats in the Study Areas could be similar to those found in the James Price Point and Thunderbird projects.
<i>Kwonkan</i> 'MYG285'	Seventeen records from James Price Point (1) and the Sheffield Resources Thunderbird project (16). Locations occur over 80 km apart, with individuals from James Price Point located within 5 km of the coast and Thunderbird individuals associated with the Fraser River Drainage system. Habitat described as Pindan Shrubland.	Medium Nearest record located 29 km north of the D2 Study Area. Microhabitats in the Study Areas expected to be similar to those found in the James Price Point and Thunderbird projects.
Barychelidae		
<i>Synothele</i> 'MYG179'	One record from James Price Point region and located along the coast in a small patch of dense vegetation located within 2 km of the coast.	Low Dense coastal habitats were not recorded from the Study Areas.
Halonoproctidae		
<i>Conothele</i> 'MYG543'	One record from James Price Point region and located along the coast in a small patch of dense vegetation located within 2 km of the coast.	Low Dense coastal habitats were not recorded from the Study Areas.
<i>Conothele</i> 'MYG613'	One record from within the Broome town site. No habitat description available.	Medium Habitat unknown however within 10 km of the D2 Study Area.
<i>Conothele</i> 'MYG614'	One record from within the Broome town site in remnant rainforest habitat.	Low Remnant rainforest habitat were not recorded from the Study Areas.

Species	Previous Records	Likelihood of Occurrence
<i>Conothele</i> 'MYG615'	One record from within the Broome town site; recorded from within a house.	Medium Habitat unknown however within 10 km of the D2 Study Area.
<i>Conothele</i> 'MYG616'	Three records from within the Broome town site; recorded from within a house.	Medium Habitat unknown however within 10 km of the D2 Study Area.
<i>Conothele</i> 'MYG617'	One record from within the Broome town site. No habitat description available.	Medium Habitat unknown however within 10 km of the D2 Study Area.
Olpiidae		
<i>Beierolpium</i> 'sp. indet. (juvenile 3/1) small'	One record from James Price Point region and located along the coast in a small patch of dense vegetation located within 2 km of the coast.	Low Dense coastal habitats were not recorded from the Study Areas.
Buthidae		
<i>Lychas</i> 'JPP'	Twenty-one records from James Price Point (9) and the Sheffield Resources Thunderbird project (12). Locations occur over 80 km apart, with individuals from James Price Point located within 5 km of the coast and Thunderbird individuals associated with the Fraser River Drainage system.	Medium Nearest record located 29 km north of the D2 Study Area. Microhabitats in the Study Areas could be similar to those found in the James Price Point and Thunderbird Project areas.
Urodacidae		
<i>Urodacus</i> 'fossor?'	One record from Great Northern Hwy approximately 11 km east of D2 (14 km west of G1). No habitat description available.	High Microhabitats in the Study Areas are expected to be similar to those found near the location of the record.
<i>Urodacus</i> 'kraepelini'	Six records from the Dampier Peninsula including one from Broome (Liquorama Store) and one from approximately 8 km east of D2 (18 km west of G1). Habitat described as Pindan Shrubland and Open Woodland.	High Microhabitats in the Study Areas are expected to be similar to those found near the location of the record.
Crustacea		
Armadillidae		
<i>Buddelundia</i> '43'	Three records from the James Price Point region in Pindan Shrubland habitat.	High Microhabitats in the Study Areas are expected to be similar to those found near the location of the record.
Mollusca		
Camaenidae		
<i>Quistrachia leptogramma</i>	Twenty-five records from the Dampier Peninsula including one from 4 km east southeast of D2. Available habitats described include leaf litter under Ironwood trees (<i>Erythrophleum chlorostachys</i>).	High Microhabitats in the Study Areas are expected to be similar to those found near the location of the record.
<i>Rhagada bulgana</i>	Thirty-three records from the Dampier Peninsula including one from Broome, 11 km south southwest of D2. Associated habitats described include Eucalypt Woodland and leaf litter under Ironwood trees (<i>Erythrophleum chlorostachys</i>).	High Microhabitats in the Study Areas are expected to be similar to those found near the location of the record.

3.2. Terrestrial Fauna

3.2.1. Fauna Habitats

Both the D2 and G1 Study Areas are dominated by Pindan Shrubland habitats which consist of open to sparse *Acacia* sp. shrubland over tussock grassland, which is mostly homogenous with a natural patchiness in tree, shrub and grass density. Pindan Shrubland habitat was consistent across both Study Areas and the surrounding region. The fire age across both Study Areas varied from recently burned to approximately five years. The habitat is characterised by a low-density of *Corymbia* spp., *Eucalyptus* spp. and *Lysiphyllum cunninghamii* trees over medium to high density *Acacia eriopoda* and *A platycarpa* shrubland. The grass layer varies from low to high density *Sorghum plumosoman*, *Chrysopogon fallax* and *Triodia* spp. on a flat plain of orange sand. Leaf litter and wood litter is generally sparse and accumulates only under trees and shrubs. Images showing habitat typical of the D2 and G1 Study Areas can be found in Plate 3.1 and Plate 3.2.



Plate 3.1: Pindan Shrubland habitat from the D2 Study Area



Plate 3.2: Pindan Shrubland habitat from the G1 Study Area

3.2.2. Vertebrate Fauna

3.2.2.1. D2 Study Area

Systematic trapping and opportunistic foraging identified a total of 31 vertebrate fauna species within the D2 Study Area (Appendix C):

- Ten bird species
- Four non-volant mammal species (three introduced)
- Three bat species (with a further three possible species)
- Fourteen reptile species.

No amphibians were recorded, likely due to the dry conditions experienced during the field survey. Secondary evidence of both introduced European Cattle (*Bos taurus*) and Dogs/ Dingoes (*Canis familiaris dingo*) was regularly encountered while traversing the Study Area. The status of Dingoes in Australia as a native or exotic species is currently a topic of debate. The Western Australian Museum's *Checklist of the Mammals of Western Australia* currently lists the species as a naturalised exotic.

Three bat species were confidently identified from ultrasonic recordings with a further three species potentially occurring within the Study Area. Calls with a characteristic frequency of 35-40 kHz could have been derived from the Hoary Wattled Bat (*Chalinolobus nigrogriseus*), Little Broad-nosed Bat (*Scotorepens*

greyii) or Northern Broad-nosed Bat (*Scotorepens sanborni*). Unambiguous identification of these species is not possible with call analysis alone.

The DBCA Priority 1 listed Northern Coastal Free-tailed Bat (*Ozimops cobourgianus*) was detected multiple times via ultrasonic recorder at systematic trapping site RRRP D2 TRAP. The Northern Coastal Free-tailed Bat was formerly known as *Mormopterus cobourgianus* and is currently referred to as such by the DBCA. No other conservation significant vertebrate fauna species were recorded.

3.2.2.2. G1 Study Area

Systematic trapping and opportunistic foraging identified a total of 38 vertebrate fauna species within the G1 Study Area:

- Seventeen bird species
- Three non-volant mammal species (two introduced)
- Two bat species (with a further three possible species)
- Sixteen reptile species.

No amphibians were recorded, likely due to the dry conditions experienced during the field survey. Secondary evidence of both introduced European Cattle (*Bos taurus*) and Dogs/ Dingoes (*Canis familiaris dingo*) was regularly encountered while traversing the Study Area. The status of Dingoes in Australia as a native or exotic species is a topic of debate. The Western Australian Museum's *Checklist of the Mammals of Western Australia* currently lists the species as a naturalised exotic.

Two bat species were confidently identified from ultrasonic recordings with a further three species potentially occurring within the Study Area. Calls with a characteristic frequency of 35-40 kHz could have been derived from the Hoary Wattled Bat (*Chalinolobus nigrogriseus*), Little Broad-nosed Bat (*Scotorepens greyii*) or Northern Broad-nosed Bat (*Scotorepens sanborni*). Unambiguous identification of these species is not possible with call analysis alone.

The DBCA Priority 1 listed Northern Coastal Free-tailed Bat (*Ozimops cobourgianus*) was detected multiple times via ultrasonic recorder at systematic trapping site RRRP G1 TRAP. The Northern Coastal Free-tailed Bat was previously known as *Mormopterus cobourgianus* and is currently referred to as such by the DBCA. No other conservation significant vertebrate fauna species were recorded.



Plate 3.3: Collett's Ctenotus (*Ctenotus colletti*) and Western Two-toed Slider (*Lerista bipes*) from the G1 Study Area

3.2.3. SRE Fauna

Four invertebrate specimens (two species) belonging to potential SRE taxa were collected from dry pitfall traps during the systematic trapping survey, one from D2 and three from G1 (Table 3.3). Genetic sequencing and morphological analysis, completed by Bennelongia Environmental Consultants (BEC), confirmed that *Lychas* 'BSCO048' and *Aname* 'BMYG165' are new species that have not been collected previously.

Lychas 'BSCO048' shows a genetic divergence of 13.4 - 17.7% from other closely related species. *Aname* 'BMYG165' presents divergences of 12.2% from its closest relatives, whereas typical intraspecific divergences in the genus are up to 5.2% at a maximum. The BEC report is included in its entirety as Appendix F.

Table 3.3: SRE Invertebrate Fauna Recorded at the Study Areas

Species	Type	Voucher No.	Notes
D2 Study Area			
<i>Lychas</i> 'BSCO048'	Scorpion	BSCO0120	New species, confirmed with genetic analysis
G1 Study Area			
<i>Aname</i> 'BMYG165'	Trapdoor Spider	BMYG0105	New species, confirmed with genetic analysis
<i>Lychas</i> 'BSCO048'	Scorpion	BSCO0121	New species, confirmed with genetic analysis

3.2.4. Survey Adequacy

Systematically obtained trapping data was analysed as a measure of survey adequacy. Data for fauna groups sampled using the same systematic technique (amphibians, mammals and reptiles) was combined for analysis as "terrestrial vertebrates". Opportunistic records are not included in the analysis.

Analysis of the terrestrial vertebrate trapping fauna data produced a flattening species accumulation curve approaching the horizontal asymptote. The graph displays two data sets; species observed during the survey (*S*(est)) and the Michaelis-Menten curve (MMMeans) that serves as an estimator of total species richness (Figure 3.1). Comparison of the two results shows that approximately 74.27% of the estimated total number of species were sampled during the field survey over 14 trap nights. These results indicate that with further trapping effort an additional 6 species may be detected.

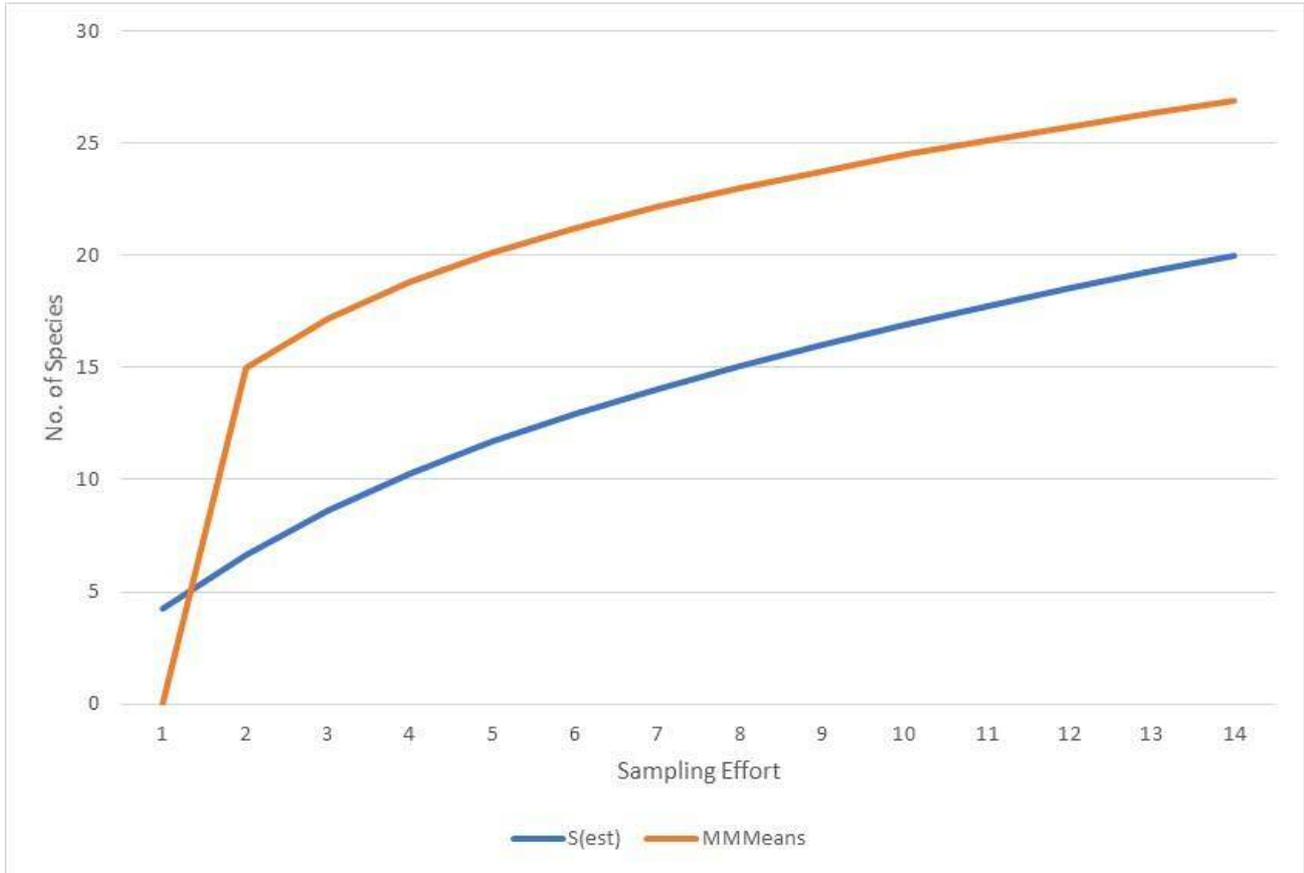
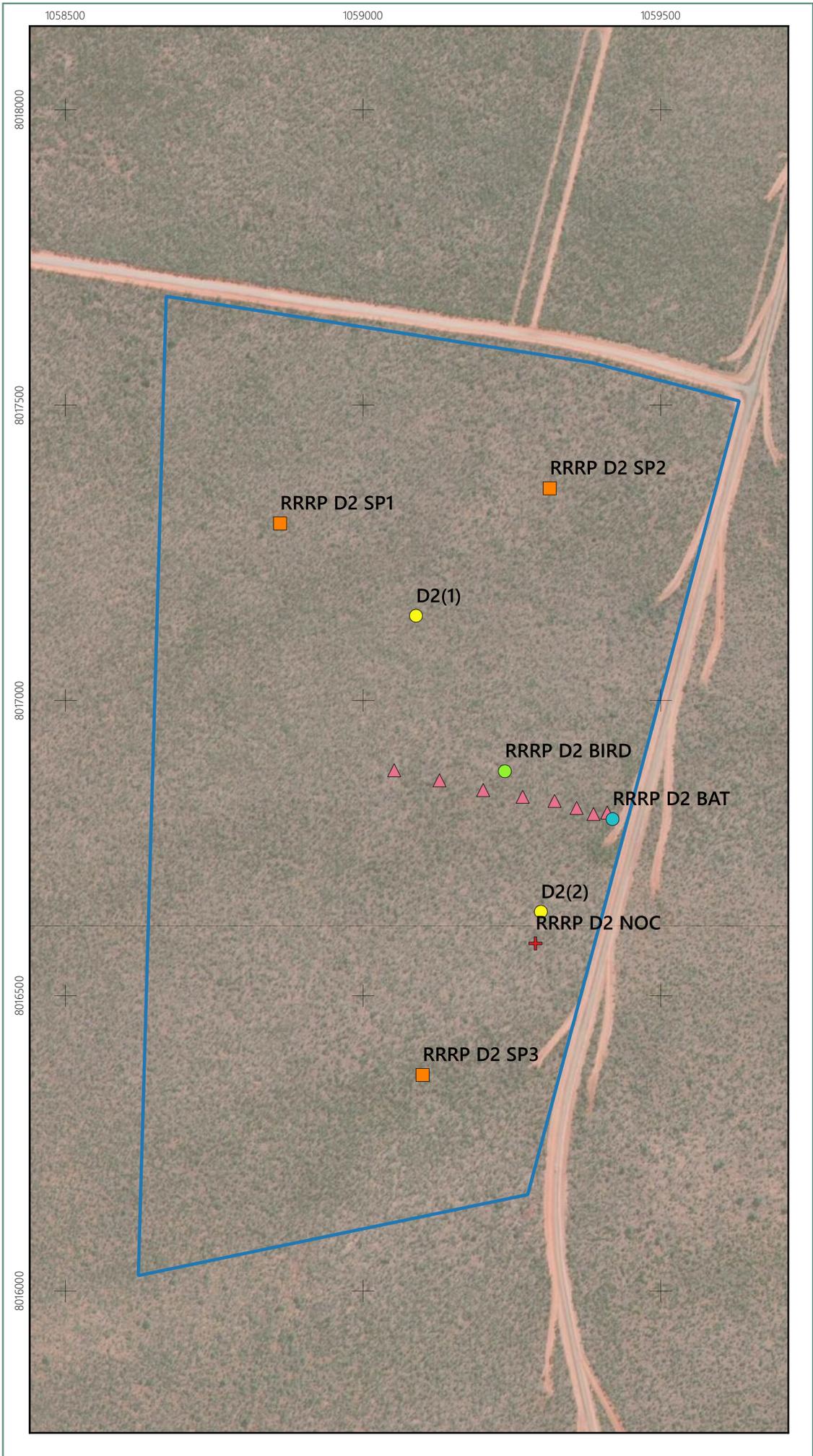


Figure 3.1: Species Accumulation Curve Illustrating Species Observed and Predicted Species Richness

Legend

Fauna Survey Sites

- ▲ Systematic Trapping Array
- Sign Plot and Forage Site
- Bird Survey Site
- Bat Recorder Site
- ✚ Nocturnal Survey Site
- Country Manager Sign Plot
- D2 Study Area



Date: 08-06-2020
 Author: JV Approved: DC



Coordinate System: GDA 1994 MGA Zone 51
 Projection: Transverse Mercator
 Units: Meter



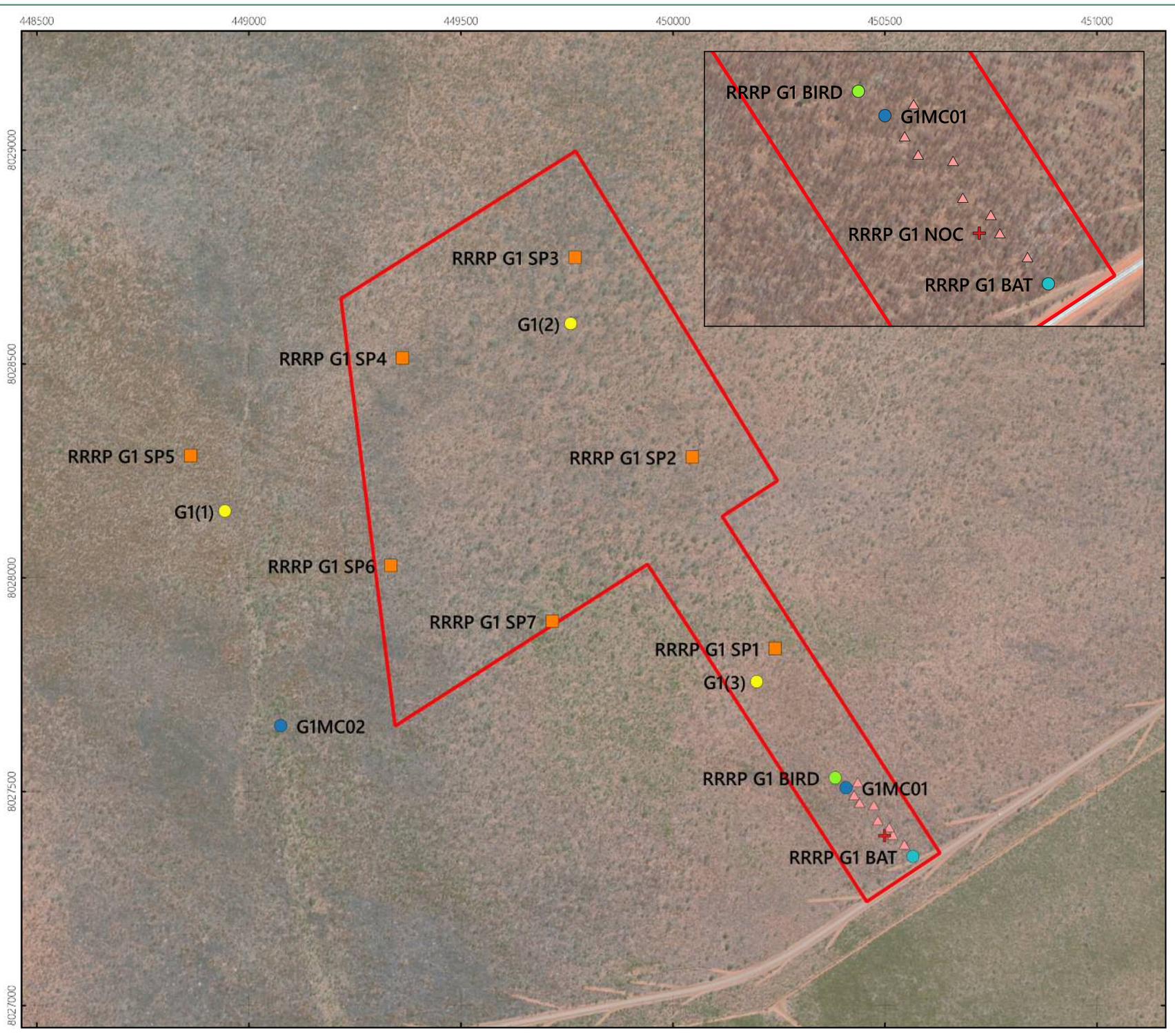
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D2 Study Area Survey Sites
 Broome Regional Resource Recovery Park Assessment

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Map

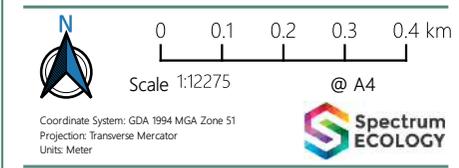
3.3



Legend

Fauna Survey Sites

- ▲ Systematic Trapping Array
- Sign Plot and Forage Site
- Bird Survey Site
- Bat Recorder Site
- + Nocturnal Survey Site
- Country Manager Sign Plot
- Country Manager Motion Camera Site
- G1 Study Area



Author: JV Approved: DC Date: 08-06-2020

G1 Study Area Survey Sites

Broome Regional Resource Recovery Park Assessment

4. DISCUSSION

4.1. Desktop Assessment

4.1.1. Terrestrial Vertebrate Fauna

During the desktop assessment, a total of 46 native mammal, ten introduced mammal, 316 bird, 92 reptile and 15 amphibian species were recorded from the region surrounding the study areas. A large number of species were recorded from NatureMap which includes a variety of sources of records (Threatened Fauna Database, WAM, survey reports and incidental sightings). In particular the number of bird species recorded by NatureMap (299 species) exceeded the average of those recorded during previous surveys (5-131 species) (Table 3.1). The data reported by NatureMap provides a good indication of regional fauna assemblages as the data is accumulated over time, as compared to survey data which is limited to the field sampling period. Large numbers of shorebirds, waterbirds or species associated with oceanic waters were also identified in the NatureMap database search. These are typically not recorded from the mainland and survey areas further inland such as the previous and current survey locations.

Whilst most vertebrate fauna species recorded from the desktop assessment have the potential to occur in the study areas, the fauna assemblage that typically utilise the habitats found within the study areas form a much smaller subset of species. Variations in population distributions and availability of microhabitats within each area also limit the species that would utilise the habitat in each study area. The vertebrate fauna assemblages that are expected to occur in the study areas and habitat preferences are discussed in more detail below.

4.1.2. SRE Invertebrate Fauna

The SRE invertebrate fauna desktop assessment identified a total of 15 arachnids, one crustacean and two mollusc species as potentially occurring at the study areas. None of them were recorded during the current survey. This is likely due to the relatively dry conditions on site during the field survey. In addition, SRE invertebrate species can have a patchy distribution. In addition, the low taxonomic resolution on SRE invertebrate fauna species is often due to a lack of males sampled, the fact that the group is historically understudied, and in many cases formal descriptions are lacking. An extensive, reliable taxonomic evaluation of these species has begun only relatively recently and thus the availability of literature relevant to SREs is relatively scarce. This can result in a large number of taxa potentially occurring (based on database searches) which in fact comprises several synonyms or widespread species.

4.2. Terrestrial Fauna

4.2.1. Fauna Habitats

Both study areas are dominated by Pindan shrubland habitats. This habitat type is the most common habitat across the local region and has been recorded across the Dampier Peninsula from several previous surveys (ecologia 2012b, 2012a, 2016a; Ecoscape 2017).

The fauna assemblage of the Pindan shrubland includes mammal species such as the Northern Brown Bandicoot (*I. macrourus*), Agile Wallaby (*Macropus agilis*), Stripe-faced Dunnart (*Sminthopsis macroura*), and Delicate Mouse (*Pseudomys delicatulus*). Bat species such as the Gould's Wattled Bat (*Chalinolobus gouldii*) and Northern Freetail Bat (*Chaerophon jobensis*) often forage insects from between the shrubs and trees.

A wide variety of bird species are associated with this habitat and occur in different seasons and at varying densities depending on local conditions and resource availability. Common species (Singing Honeyeater, Brown Honeyeater, Rufous-throated Honeyeater, Grey-crowned Babbler, Rufous Whistler, Crested Bellbird, Jacky Winter and Zebra Finch) forage amongst the sparse canopy of the *Corymbia* spp., *Eucalyptus* spp. Ground foraging species (Emu, Crested Pigeon, Brown Quail, Bar-shouldered Dove, Peaceful Dove and Diamond Dove) utilise fallen seed and annual herb resources which can result in large fluctuations in response to rainfall and associated increased plant growth. Predatory raptor species (Brahminy Kite, Whistling Kite, Black Kite, Nankeen Kestrel, Brown Goshawk and Square-tailed kite) are also frequently seen hunting across this landscape.

Reptile species associated with the Pindan shrubland include ground-dwelling goannas (*Varanus brevicauda* and *V. gouldii*), dragons (*Diporiphora pindan*, *Pogona minor*, *Chlamydosaurus kingii*, and *Amphibolurus gilberti*), legless lizards (*Lialis burtoni*, *Pygopus steelescotti* and *Delma tinctoria*), ground-dwelling geckos such as *Lucasium stenodactylum*, and arboreal geckos such as *Strophurus ciliaris* which utilise the *Acacia* shrubs. A number of skinks are also found in the Pindan shrubland, including (*Carlia munda*, *Eremiascincus isolepis*, *Lerista griffini*, *Morethia storri*, *Proablepharus tenuis*, *Tiliqua scincoides*).

This habitat is also suitable for a range of conservation significant fauna species, including ground-dwelling species that forage in the grassland such as the Greater Bilby (*Macrotis lagotis*), Golden Bandicoot (*Isodon auratus auratus*), Dampier Peninsula Goanna (*Varanus sparnus*) and Spectacled Hare-wallaby (*Lagorchestes conspicillatus leichardti*), and species foraging between the foliage of trees and shrubs such as the Bare-rumped Sheath-tail Bat (*Saccolaimus saccolaimus nudiclunatus*).

4.2.2. Conservation Significant Fauna

Results of the literature review identified 33 conservation significant fauna species (12 mammal, 15 bird and 6 reptile species). An additional 61 conservation significant bird species and two mammal species that are associated with marine, shoreline and wetland environments were also identified however due to the location of the survey area and a lack of water bodies associated with the survey area, these species have been excluded from the assessment and are shown in grey in the potential species list Appendix D.

Of the 33 species of conservation significance potentially occurring at the study areas, 15 species have a medium to high likelihood to occur. The remaining 19 species have a low or very low likelihood to utilise the habitats within the study areas. Details of each species are listed in Table 4.1. Species with medium to high likelihood to occur are discussed in further detail in the below sections 4.2.2.1 - 4.2.2.3.

Due to the consistent habitat found at each of the Study Area and the close proximity of the areas to each other, the likelihood of occurrence of conservation significant species is consistent between the two Study Areas. The detailed description in sections 4.2.2.1 - 4.2.2.3 apply to both D2 and G1.

Table 4.1: Conservation Significant Fauna Species Likelihood of Occurrence Assessment

Species	Conservation Status			Preferred Habitats	Previous Records	Likelihood of Occurrence
	EPBC Act	BC Act	DBCA			
Mammals						
Northern Quoll <i>Dasyurus hallucatus</i>	EN	EN	-	Dissected rocky escarpments, gorges and granite boulder piles with access to surface water. Also utilise surrounding eucalypt forest/woodland and drainage lines.	NatureMap (one record in Broome).	Very Low Only one regional record and no suitable habitat exists in the Study Areas.
Kimberley Brush-tailed Phascogale <i>Phascogale tapoatafa kimberleyensis</i>	VU	VU	-	Tall open forest/woodland dominated by <i>Eucalyptus</i> and <i>Corymbia</i> spp. with suitable tree hollows. Typically drier habitats and not rainforest.	NatureMap (one historical record 30 km south).	Very Low Only one historical (written) record although habitat in the Study Areas could be considered suitable. The record is located on Roebuck Plains where no suitable habitat exists which suggests the information associated with this record is incorrect.
Greater Bilby <i>Macrotis lagotis</i>	VU	VU	-	Variety of habitats with suitable soil substrates and availability of food resource plants species. Habitats can include hummock grassland, acacia shrubland, open woodland and cracking clays.	High number of Greater Bilby records from, NatureMap, DBCA and several other surveys in the region.	High Commonly recorded across the region with recent records from adjacent to the D2 Study Area. A dead specimen was also recorded from approx. 4km west of G1. Species is mobile and may move into the Study Areas.
Golden Bandicoot <i>Isodon auratus auratus</i>	VU	VU		Margins of rainforests lined with sandstone in the Northern Kimberley. Eucalypt woodlands in the Yampi Peninsula. Recorded from spinifex and tussock grasslands in arid deserts, as well as tropical forests and woodlands in semi-arid areas.	Naturemap, one historical (written) record from approx. 18 km south of G1. A 2014 record also exists from 47 km east of G1.	Medium The 2014 record is from a motion camera capture in "open grassland savanna" habitat. Similar habitat occurs within both Study Areas though no further contemporary records exist further west.
Bare-rumped Sheath-tail Bat <i>Saccolaimus saccolaimus nudicluniatu</i>	VU	-	P3	Distribution appears to be coastal. Lowland areas, typically in a range of woodland, forest and open environments. One recent record from Pinnacle Creek in the central Kimberley.	PMST, potential habitat may be present within the area. SPRAT profile habitat mapping.	High Historic record 25 km north of the study area. Has been previously recorded from pindan habitat in close vicinity on the Dampier Peninsula (McKenzie <i>et. al.</i> 2018). Suitable foraging and roosting habitat is present.

Species	Conservation Status			Preferred Habitats	Previous Records	Likelihood of Occurrence
	EPBC Act	BC Act	DBCA			
Northern Brushtail Possum <i>Trichosurus vulpecula arnhemensis</i>	-	VU	-	Dry forest/woodland dominated by <i>Eucalyptus</i> and <i>Corymbia</i> spp. with suitably large trees, hollows and developed understorey. Low fire frequency is often associated with suitable habitat.	NatureMap, DBCA (numerous records in Broome and inland), also recorded on one other survey in the region (Western Wildlife; Duchess Paradise 2011).	Medium Several records nearby and suitable habitat occurs within the Study Areas.
Northern Coastal Free-tailed Bat <i>Ozimops (Mormopterus) cobourgianus</i>	-	-	P1	Western Australian populations are associated with mangrove communities with roosts only recorded from <i>Avicennia marina</i> , however Northern Territory populations also utilise woodland habitats.	DBCA (two records in 2016).	Recorded The species was recorded from both Study Areas during the survey. Previous records also exist from the D2 Study Area (2016).
Yellow-lipped Cave Bat <i>Vespadelus douglasorum</i>	-	-	P2	Tropical woodlands, often along streams lined with Melaleuca and Pandanus. Utilises sandstone and limestone caves, usually near water.	Recorded during the Beagle Bay survey (ecologia 2005)	Very Low Nearest records over 100 km north, no suitable habitat in the Study Areas.
Spectacled Hare-wallaby <i>Lagorchestes conspicillatus leichardti</i>	-	-	P4	Inhabits grasslands, open forests, open woodlands and tall shrublands and shelters during the day under grass tussocks. Long unburnt areas considered most suitable.	NatureMap (many records further inland), Potential scats recorded from a recent survey in the region.	Medium Previously recorded from the region to the east and south-east. Suitable habitat occurs in both Study Areas though no secondary evidence was recorded during the field survey.
Scaly-tailed Possum <i>Wyulda squamicaudata</i>	-	-	P4	Structurally complex, rocky landscapes with deep crevices for shelter and open woodland, closed forest and rainforest pockets which supply a variety of fruiting trees.	NatureMap (one record from 1970 in Broome).	Very Low Only one historical record within 40km, distribution typically restricted to north of the Dampier Peninsula. No suitable habitat.
Short-tailed Mouse <i>Leggadina lakedownensis</i>	-	-	P4	Acacia shrubland, samphire, woodlands, and stony ranges. Also Spinifex and tussock grassland on cracking clays in the Pilbara region.	Thunderbird (ecologia 2016b), Duchess Paradise (Western Wildlife 2011).	Medium Although suitable habitat exists within the Study Areas, the nearest records are over 80km away
Golden-backed Tree-rat <i>Mesembriomys macrurus</i>	-	-	P4	Recorded from a variety of habitats including Eucalypt open forests with tussock grass understorey, rainforest patches on a variety of landforms and soils, eucalypt woodlands with hummock grass understorey, rugged sandstone screes, beaches, and blacksoil plains with pandanus.	Naturemap, DBCA. One historical (written) record from Waterbank, accuracy 50 km.	Very Low One historic record within 40km. No other records on the Dampier Peninsula. Current distribution typically restricted to north and east of Derby.

Species	Conservation Status			Preferred Habitats	Previous Records	Likelihood of Occurrence
	EPBC Act	BC Act	DBCA			
Birds						
Gouldian Finch <i>Erythrura gouldiae</i>	EN	-	P4	Wooded rocky hills with adjoining flat country. Key habitat attribute is annual spear grasses or perennial sorghum in the understorey during the dry season.	PMST, NatureMap. Recorded from the Broome Bird Observatory (2016).	Medium Has been recorded from the region but typically recorded from northern half of the Dampier Peninsula and further north into the Kimberley. Nesting habitat typically includes water sources which are absent from the Study Areas. Records from 2016 were lodged by the Broome Bird Observatory through Atlas of Living Australia.
Red Goshawk <i>Erythrotriorchis radiatus</i>	VU	VU	-	Coastal and sub-coastal areas in wooded/forested lands and riverine forests of tropical and warm-temperate Australia. Vegetation types include eucalypt woodland, open forest, tall open forest, gallery rainforest, swamp sclerophyll forest, and rainforest margins.	PMST, NatureMap	Low One historic record from Waterbank (1976), distribution typically restricted to north of the Dampier Peninsula.
Princess Parrot <i>Polytelis alexandrae</i>	VU	-	P4	Sand dunes and sand flats in the arid zone with open savanna woodlands and shrublands that usually consist of scattered stands of <i>Eucalyptus</i> , <i>Casuarina</i> or <i>Allocasuarina</i> trees; an understorey of shrubs such as <i>Acacia</i> (especially <i>A. aneura</i>), <i>Cassia</i> , <i>Eremophila</i> , <i>Grevillea</i> , <i>Hakea</i> and <i>Senna</i> ; and a ground cover dominated by <i>Triodia</i> species. Also riverine or littoral areas	PMST, NatureMap	Low One old record from Broome (1999), no suitable habitat in the Study Areas.
Masked Owl (Northern) <i>Tyto novaehollandiae kimberli</i>	VU	-	P1	Riparian forest, rainforest, open forest, Melaleuca swamps and the edges of mangroves. Require tall trees with suitable hollows for nesting and roosting and adjacent areas for foraging as they remain in territory all year.	PMST, NatureMap	Low No records of this subspecies exist on the Dampier Peninsula. No suitable habitat in the Study Areas.
Oriental Pratincole <i>Glareola maldivarum</i>	MI	MI	-	Typically uses inland ephemeral wetland habitat types when present. Can also be found foraging in adjacent open grassland habitats	PMST, NatureMap, DBCA (39 records).	High Non-breeding visitor. Multiple records along Roebuck Plain and surrounds, may seasonally utilise Study Areas for foraging.

Species	Conservation Status			Preferred Habitats	Previous Records	Likelihood of Occurrence
	EPBC Act	BC Act	DBCA			
Red-rumped Swallow <i>Cecropis daurica</i>	MI	MI	-	Vagrant species occurs across Europe, Africa and Asia. Typical swallow behavior hawking insects over a variety of habitats.	PMST, NatureMap.	Low This vagrant is only rarely recorded in northern WA.
Fork-tailed Swift <i>Apus pacificus</i>	MI	MI	-	Nomadic, almost entirely aerial lifestyle over a variety of habitats; associated with storm fronts.	PMST, NatureMap, DBCA (19 records).	High Non-breeding visitor during wet season. Many records during previous surveys, however almost entirely aerial lifestyle.
Oriental Cuckoo <i>Cuculus optatus</i>	MI	MI	-	Regular migrant to Australia over the non-breeding season (Sept-May) in coastal regions, rivers and mangroves.	PMST, NatureMap.	Medium Non-breeding visitor. Several records nearby and suitable habitat occurs within the Study Areas. Species has the potential to utilise the Study Areas for foraging during non-breeding season.
Barn Swallow <i>Hirundo rustica</i>	MI	MI	-	Barn Swallows are a cosmopolitan species, breeding throughout most of the northern hemisphere. Small numbers are regular non-breeding migrants to northern Australia, with vagrants further south. Open country in coastal lowlands, often near freshwater wetlands, paperbark Melaleuca woodland, mesophyll shrub thickets and tussock grassland. Also recorded from urban areas perched on overhead wires.	PMST, NatureMap, DBCA (19 records).	Medium Non-breeding visitor. Several records nearby and suitable habitat occurs within the Study Areas. Species has the potential to utilise the Study Areas for foraging during non-breeding season.
White-throated Needletail <i>Hirundapus caudacutus</i>	MI	MI		Nomadic, almost entirely aerial lifestyle over a variety of habitats; although most often over wooded areas and shrublands.	NatureMap. One record from Broome Bird Observatory (2000).	Low Vagrant. Few records from the region.
Grey Wagtail <i>Motacilla cinerea</i>	MI	MI	-	Occurs across Eurasia in a variety of habitats associated with moving water (rivers, streams). Some individuals migrate as far south as northern Australia.	PMST, NatureMap (recent records from northern edge of Roebuck Plain).	Low Vagrant. Few records from Roebuck Plain, no suitable habitat present within Study Areas.
Yellow Wagtail <i>Motacilla flava</i>	MI	MI	-	Occurs across Europe, Western Asia and Africa. Occurs across a variety of damp or wet habitats with low vegetation, such as damp meadows, marshes, waterside pastures etc.	PMST, NatureMap (one record from Broome).	Low Vagrant. One record from Broome, no suitable habitat present.

Species	Conservation Status			Preferred Habitats	Previous Records	Likelihood of Occurrence
	EPBC Act	BC Act	DBCA			
Grey Falcon <i>Falco hypoleucos</i>	-	VU	-	Generally open inland plains and woodland habitats.	NatureMap, DBCA (two historical records).	Medium Several records (historical up to 1999) from near Broome and Roebuck Plain. Some suitable foraging habitat occurs within the Study Areas.
Peregrine Falcon <i>Falco peregrinus</i>	-	OS	-	Widespread; coastal cliffs, riverine gorges and wooded watercourses.	DBCA (nine records), NatureMap	Medium Many records within 40km, in particular along the coast and Roebuck Plain. No suitable breeding habitat occurs though Study Areas though they may be utilised for foraging.
Letter-winged Kite <i>Elanus scriptus</i>	-	-	P4	Open country and grasslands in arid and semi-arid Australia, where there are tree-lined streams or water courses.	NatureMap, DBCA (1).	Low Two older records from 1994 from Broome, species recorded sporadically along the coast.
Reptiles						
Great Desert Skink <i>Liopholis kintorei</i>	VU	VU		Generally associated with red sandplains and sand ridges. In WA also associated with <i>Triodia basedowii</i> and <i>T. schinzii</i> with some <i>Eremophila leucophylla</i> shrubs. Also gravelly undulating plain with scattered Black Gidgee (<i>Acacia pruinocarpa</i>) or Mulga over <i>Triodia basedowii</i> and low shrubs.	NatureMap. One historical (written) record from Great Sandy Desert.	Low Only one historic record within 40km. Current distribution typically restricted to Central Desert regions.
Spotted Ctenotus <i>Ctenotus uber johnstonei</i>			P2	Chenopod shrubland at the base of a sandstone hill (near Balgo).	Recorded from two previous surveys	Very Low Subspecies is not known to occur in the vicinity of the study areas. Isolated records from previous surveys may belong to a different subspecies.
Dampierland Peninsula Goanna <i>Varanus sparnus</i>	-	-	P1	Recently described species, with current records from Pindan Shrubland habitats located across the Dampier Peninsula.	NatureMap. Records from approx. 26 km south of G1 (2017).	Medium Previous records nearby and suitable habitat occurs within the Study Areas. Previous records from 26 km south of G1, from the Thunderbird Project and also from the mid-western coast of Dampier Peninsula.

Species	Conservation Status			Preferred Habitats	Previous Records	Likelihood of Occurrence
	EPBC Act	BC Act	DBCA			
Dampierland Plain Slider <i>Lerista separanda</i>	-	-	P2	Recorded from coastal dunes and inland sand dunes south to the northern Pilbara.	NatureMap (records from Broome)	Low Coastal species which is very rarely found inland of Broome. No suitable habitat within the Study Areas.
Dampierland Burrowing Snake <i>Simoselaps minimus</i>	-	-	P2	Limited habitat information available. Previously recorded from coastal dunes on the Dampier Peninsula.	NatureMap, one record from Broome.	Low Coastal species, previous records are from Broome and coastal areas further north on Dampier Peninsula.
Northwestern Coastal Ctenotus <i>Ctenotus angusticeps</i>	-	-	P3	Landward fringe of salt marsh communities in samphire shrubland or marine couch grassland (Maryan et al. 2013) in the intertidal zone along mangrove margins.	NatureMap, DBCA (19 recent records in dunes/mangrove areas),	Very Low Records from the coast, no suitable habitat within the Study Areas.

4.2.2.1. Mammals

Greater Bilby (*Macrotis lagotis*)

Conservation Status: EPBC Act Vulnerable & BC Act Vulnerable

Distribution, Habitat and Ecology: The Greater Bilby (*Macrotis lagotis*) is currently listed as Vulnerable under both the EPBC Act and the BC Act, following the IUCN common assessment method. Although once widespread across arid and semi-arid Australia, the Greater Bilby is now primarily restricted to sandy inland deserts in the north-west of the continent. It can be found in a range of habitats with moderately open ground-level vegetation, from cracking clays to desert sandplains and dune fields with spinifex hummock grasslands and Acacia shrubland. On the Dampier Peninsula, it usually prefers open woodland or forest pindan habitat, with less preference for pindan shrubland and other vegetation communities (Southgate, 2012). The Greater Bilby also prefers mixed shrublands dominated by Acacia and Grevillea along paleo-drainage systems (Southgate & Carthew, 2006). These habitat preferences align closely with the habitat found throughout the Study Areas.

Likelihood of Occurrence - High: The Greater Bilby was not recorded during the survey. Approximately 160 previous records have also been recorded from within 40 km, and several recent surveys on the Dampier Peninsula have identified signs of Greater Bilby presence (Appendix D). Home ranges are usually temporary and may suddenly shift when food availability changes (A. A. Burbidge & Johnson, 2008). Due to the temporary nature of Greater Bilby presence, a visual check of the area to be cleared should be completed immediately prior to the clearing activity to ensure no active burrows have been created since the field survey. Avoidance and monitoring of occupied burrows until the individual relocates of its own accord is preferred, though this is not always possible. Where avoidance is not possible, displacement methods may be utilised. Displacement involves monitoring burrows until the occupying animal departs then collapsing the burrow, forcing the animal to move into suitable habitat adjacent to the area to be cleared. Further details regarding pre-clearance survey and displacement protocols can be found in *The conservation and management of the bilby (Macrotis lagotis) in the Pilbara* (Dziminski & Carpenter, 2018).

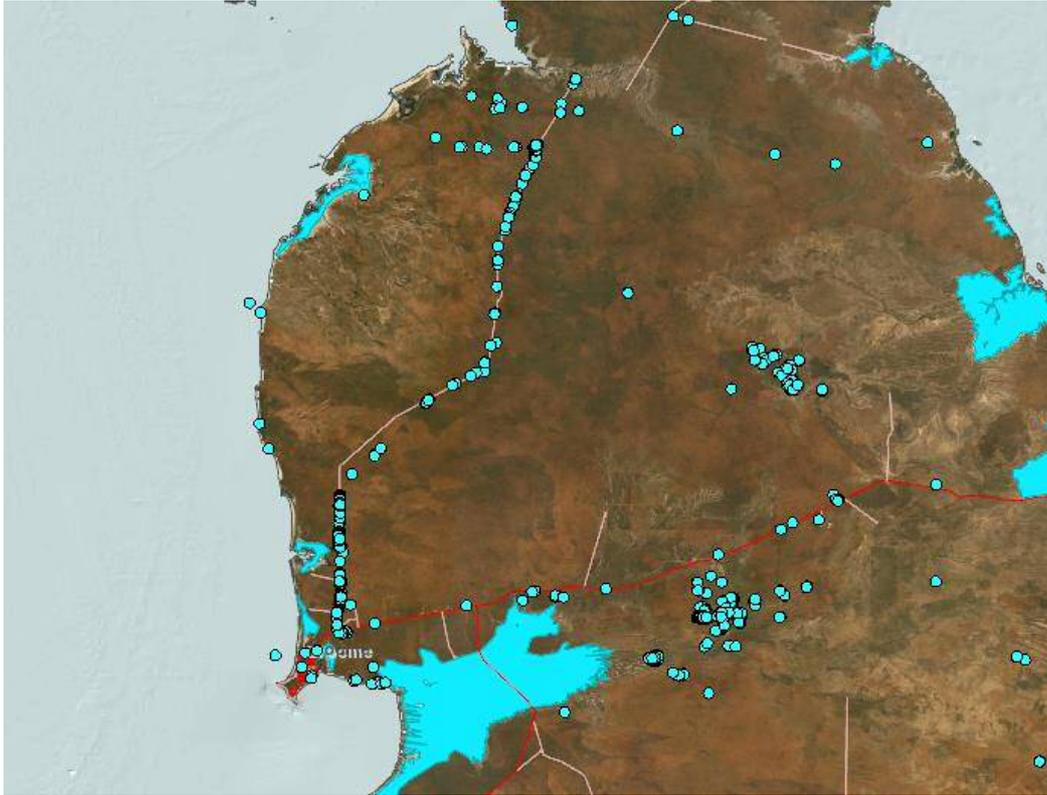


Figure 4.1: Regional Records of the Greater Bilby (NatureMap 2020)

Golden Bandicoot (*Isodon auratus auratus*)

Conservation Status: EPBC Act Vulnerable & BC Act Vulnerable

Distribution, Habitat and Ecology: The Golden Bandicoot was originally widely distributed throughout northern and central Australia until the 1930. Now it is restricted to rocky sandstone spinifex habitats and vine thickets in the northern Kimberley, and several offshore islands. The Golden Bandicoots feed on ants and termites, moths, turtle eggs, small reptiles and plant material. It forages between spinifex clumps and other grasses (Van Dyck & Strahan, 2008).

Likelihood of Occurrence - Medium: The Golden Bandicoot has been recorded from 18 km south of the study areas. The record is historical (written) but has been confirmed (trapped or caught). Another record was made in 2014 on a motion camera from an area of “open grassland savanna” habitat approx. 48 km east of the study areas (NatureMap 2020). The habitat present at the study areas is similar to that of the record and the species has a potential to occur at the study areas.

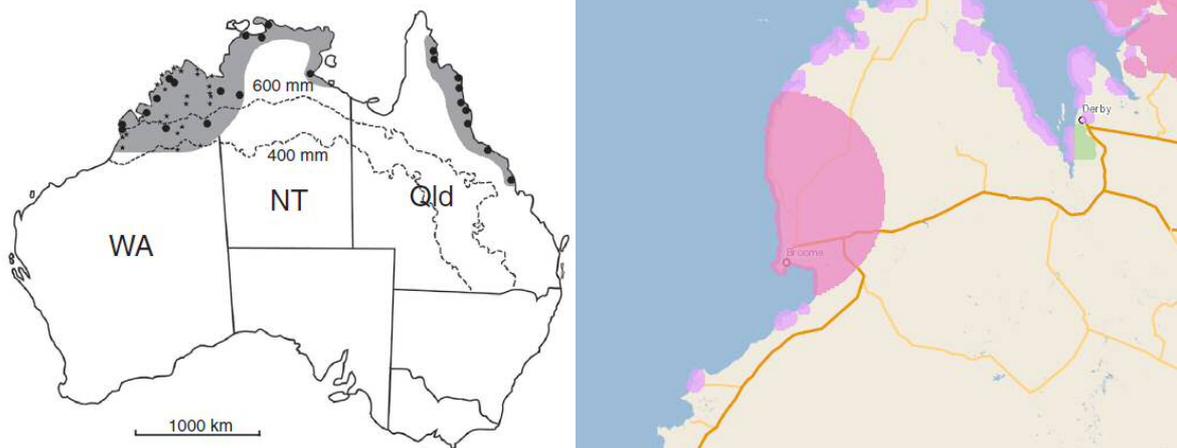
Bare-rumped Sheath-tail Bat (*Saccolaimus saccolaimus nudicluniatus*)

Conservation Status: EPBC Act Vulnerable & DBCA Priority 3

Distribution, Habitat and Ecology: Based on current distributional information, there are two geographically separated populations of the Bare-rumped Sheathtail Bat: the north-eastern Queensland and Northern Territory population (Churchill, 2009; P. W. Menkhorst & Knight, 2001). However, the taxonomy is still unclear. The two populations may possibly represent two different subspecies or species (Australian Government 2020). There is relatively little known about the ecology of this species due to the small number of sightings of this species. The species is likely sociable and roosts in small groups in tree hollows of Poplar Gum, Darwin Woollybutt (*Eucalyptus miniata*) and Darwin Stringybark (Aepartment of the Environment, 2020). Recent studies have also shown that the Bare-rumped Sheathtail Bat in Western Australia has been historically misidentified as *S. flaviventris* because of the lack of the bare rump and characteristic spots that can be found in the Queensland population of *S. saccolaimus* (N. L. McKenzie, Bullen, Cowan, & Milne, 2018). Museum specimens have then be reviewed and additional surveys were able to record and confirm the call sequence of the species (N. L. . McKenzie & Bullen, 2018; N. L. McKenzie et al., 2018).

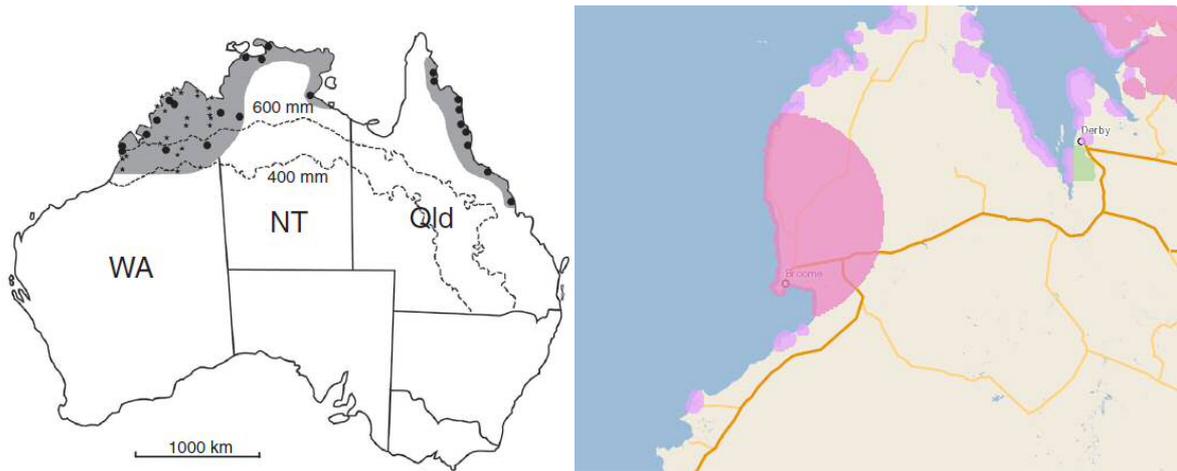
Likelihood of Occurrence – High: The distribution of the Bare-rumped Sheathtail Bat has been originally be indicative (Aepartment of the Environment, 2020; DEWHA 2010) with further clarifications in 2018 when additional surveys were undertaken and specimens were recorded and confirmed (call sequences), Museum specimens were reviewed and additional specimens were vouchered. It should be noted that the taxonomic status of the two populations is still unclear. The species has been recorded from the immediate surrounding of the study areas (N. L. McKenzie et al., 2018).

Bat recordings from the study areas were scanned for calls recorded from this species in the Northern Territory which is a reliable technique to record the species if present (Armstrong et al., 2020) (Appendix E). The study areas are of relatively small size and each area was sampled using echolocation recorders. Some suitable trees are present at the study areas providing tree hollows for roosting. The species has also been seen foraging in a variety of airspace from open to cluttered. Based on the close proximity of records, the unknown taxonomic status and the presence of suitable roosting and foraging habitat, the Bare-rumped Sheathtail Bat has a potential to occur at the study areas



Source: McKenzie and Bullen (2018) (Left) and DotE (2020) (Right)

Figure 4.2) (N. L. . McKenzie & Bullen, 2018; N. L. McKenzie et al., 2018).



Source: McKenzie and Bullen (2018) (Left) and DotE (2020) (Right)

Figure 4.2: Distribution of the Bare-rumped Sheathtail Bat (Australian Government 2020)

Northern Brushtail Possum (*Trichosurus vulpecula arnhemensis*)

Conservation Status: BC Act Vulnerable

Distribution, Habitat and Ecology: The Northern Brushtail Possum is a small subspecies of the common Brushtail Possum. They can be found in woodlands and other tropical habitats that are more stable and predictable than of the larger Common Brushtail Possum (Kerle & Howe, 1992). This enables the species to breed continuously throughout the year.

Likelihood of Occurrence - Medium: The Northern Brushtail Possum has been recorded from across Broome with very few records from the remainder of the Dampier Peninsula. The species was also recorded during the Duchess Paradise survey (Appendix D). There is some suitable habitat present within the Study Areas and it may be present; however, no signs were recorded during the survey.

Northern Coastal Free-tailed Bat (*Ozimops (Mormopterus) cobourgianus*)

Conservation Status: DBCA Priority 1

Distribution, Habitat and Ecology: The taxonomy of the molossid bats is relatively unsure and has been described as 'chaotic' (A. . Burbidge, Harrison, & Woinarsky, 2014). The Northern Coastal Free-tailed Bat is also known as *Mormopterus (loriae) cobourgiana*. It has an extensive distribution, occurring in coastal areas from Exmouth to Broome, and in the Northern Territory and Queensland (Churchill, 2009). Roosting takes place in small spouts and dead upper branches of mangroves from where they disperse to forage around mangroves, waterways and deciduous vine thickets (A. . Burbidge et al., 2014).

Likelihood of Occurrence - Recorded: The Northern Coastal Free-tailed Bat was recorded from all the study areas during the survey. Previously, the species was known from two locations, Cable Beach and Motorplex, where it was recorded in 2016. The Northern Coastal Free-tailed Bat typically inhabits mangroves and is more commonly found along the coast. The three study areas are located in proximity to coastal habitats, whoever it is likely that the species overflies or forages within the habits of the study area.

Spectacled Hare-wallaby (*Lagorchestes conspicillatus leichardti*)

Conservation Status: DBCA Priority P4

Distribution, Habitat and Ecology: The Spectacled Hare-wallaby (*Lagorchestes conspicillatus leichardti*) is listed as Priority 4 by the DBCA due to the limited knowledge about the species' distribution and ecology. In some areas, the species was presumably extinct (East Pilbara and East Kimberley region) until recently when specimens were recorded as roadkill. The Spectacled Hare-wallaby is an elusive species that is rarely recorded, and if so it is mostly found through only secondary evidence (scats). It inhabits grasslands, open forests and tall shrubland where it shelters during the day in *Triodia* tussock grasses. In the Kimberley region it often shelters underneath *Chrysopogon* tussock grasses. The Spectacled hare-wallaby lives a solitary lifestyle with a large home range (of up to 177 ha in QLD), and it is well adapted to the arid habitats. It rarely requires water with the water turnover is far less than in other mammals (A. A. Burbidge & Johnson, 2008).

Likelihood of Occurrence - Medium: Recent records have been made from within 35 km south-east of the study areas during a previous survey in 2017 (Ecoscape 2017) and multiple records are known from further (NatureMap). The movements patterns and occurrence of the species on a local level is not fully understood at the moment but it is likely that the species is a resident in the local area. Due to the large home range of the species, it is unknown how frequent the Spectacled Hare-wallaby would visit the study areas; however, the habitat provides suitable conditions.

Due to the highly mobile nature of Spectacled Hare-wallaby and the high noise and vibrations associated with clearing activity any individuals present with the clearance area are expected to flee the area immediately prior to clearing.

Short-tailed Mouse (*Leggadina lakedownensis*)

Conservation Status: DBCA Priority P4

Distribution, Habitat and Ecology: The Short-tailed Mouse occurs across northern Australia in a variety of habitats, ranging from spinifex and tussock grasslands, samphire and sedgeland, *Acacia* shrubland, tropical eucalypt and *Melaleuca* woodlands and stony ranges (Van Dyck & Strahan, 2008). Most of the time the species is however found in seasonally inundated habitats. Population often fluctuate in response to rainfall.

Likelihood of Occurrence - Medium: The species was recorded during two previous surveys on the Dampier Peninsula (Ecologia 2016b; Western Wildlife, 2011). The species is more frequently recorded from further inland and nearby populations expand depending on seasonal food availabilities. The Short-tailed Mouse is likely to occasionally occur at the study areas when food resources are plentiful.

4.2.2.2. Birds**Oriental Pratincole (*Glareola maldivarum*)**

Conservation Status: EPBC Act Migratory & BC Act Migratory

Distribution, Habitat and Ecology: The Oriental Pratincole is a non-breeding migrant to Australia. It breeds in Mongolia, Siberia, China, Sri Lanka and Thailand. The winters in the northern hemisphere (late October to May) are spent in northern Australia where they are found on open plains, bare grounds around swamps and claypans (Simpson & Day, 2017).

Likelihood of Occurrence - Medium: The species has been recorded from multiple locations across the Roebuck Plain and the coastal areas south of the study areas. Habitat within the study areas is suitable when low grasslands and bare areas are present post fire or after tall grasses die off in the dry season.

Grey Falcon (*Falco hypoleucos*)

Conservation Status: BC Act Vulnerable

Distribution, Habitat and Ecology: The Grey Falcon is a nomadic species with a sparse distribution across much of arid and semi-arid Australia. It inhabits a variety of habitats from woodland, open acacia woodland, swamps, wooded drainage lines, to spinifex covered plains. The Grey Falcon primarily preys on birds but also feeds reptiles and mammals. Breeding takes place on cliffs, large trees or repeater towers. Due to the scarce distribution of the species, sightings are rare (Garnett, Szabo, & Dutson, 2011).

Likelihood of Occurrence - Medium: Several records (historical up to 1999) exist from near Broome and the Roebuck Plain. Some suitable foraging habitat occurs within the study areas, however, breeding habitat is not present. The study areas may be used occasionally for as hunting ground or when travelling between surrounding habitats.

Peregrine Falcon (*Falco peregrinus*)

Conservation Status: BC Act OS

Distribution, Habitat and Ecology: The Peregrine Falcon is a nomadic and sedentary species that is widespread throughout Australia, but uncommon in the Kimberley, Hamersley and Darling Ranges. It occurs most commonly on cliffs and along ranges and coastal habitats, river and at wooded water courses and lakes.

Likelihood of Occurrence - Medium: Several records exist from Broome and the Roebuck Plain. One record was made from 2 km east of option 1 study area (DBCA Threatened Database), likely whilst travelling or hunting. Some suitable foraging habitat occurs within the study area, however, typical watercourses that are used for hunting are absent. The species has been recorded from James Price Point during previous surveys (Appendix D). Breeding habitat is not present and foraging habitat is limited. However, the species is likely to be using adjacent habitats and may also utilised the study areas whilst travelling between the surrounding habitats.

Oriental Cuckoo (*Cuculus optatus*)

Conservation Status: EPBC Act Migratory & BC Act Migratory

Distribution, Habitat and Ecology: The Oriental Cuckoo is a non-breeding visitor to Australia and does not breed here. It is mainly seen in northern Australia. They inhabit open country, river margins, mangroves, wet eucalypt forests and monsoon forests.

Likelihood of Occurrence - Medium: Several records were made nearby and suitable habitat occurs within the study areas. Species has the potential to utilise the study area for foraging during non-breeding season. The Oriental Cuckoo has been recorded occasionally from the Roebuck Plains and more coastal areas around Broome (NatureMap).

Barn Swallow (*Hirundo rustica*)

Conservation Status: EPBC Act Migratory & BC Act Migratory

Distribution, Habitat and Ecology: The Barn Swallow occurs across northern Australia, on Cocos Island and Christmas Island, patchily across the Pilbara and Queensland. It migrates from Europe, North America and Asia to spend the boreal winter in the southern hemisphere. The Barn Swallow forages in open country near the coast, often near water, towns and cities. Individuals can be seen perched on overhead wires, in freshwater wetlands, paperbark woodland, mesophyll shrub thickets and tussock grassland (DoE 2020).

Likelihood of Occurrence: The Barn Swallow is a non-breeding visitor to Australia that is regularly recorded from the Roebuck Plain and urban environments around Broome (NatureMap, DBCA threatened fauna database). Several records nearby exist and suitable habitat occurs within the study areas. The species has the potential to utilise the study areas for foraging during the non-breeding season.

Fork-tailed Swift (*Apus pacificus*)

Conservation Status: EPBC Act Migratory & BC Act Migratory

Distribution, Habitat and Ecology: The Fork-tailed Swift breeds in north-east and mi-east Asia and visits Australia and New Guinea during the winter in the northern hemisphere. It is a common trans-equatorial migrant from October to April throughout Australia which arrives in the Kimberley region in late September (Simpson & Day, 2017). The Fork-tailed Swift is a nomadic species that response to broad-scale weather pattern changes. It is associated with thunderstorms where it can be seen in large flocks of up to 2,000 individuals. In Australia, the species is almost entirely aerial and rarely lands.

Likelihood of Occurrence - High: The Fork-tailed Swift is a non-breeding visitor over the Australian wet season (October to April). Several records were made nearby during previous surveys (Appendix D). The DBCA threatened fauna database lists several records from the northern edge of the Roebuck Plain (Map 3.1). Species is likely to overfly the Study Area during the wet season whilst foraging though is unlikely to be negatively affected by development or ground disturbance.

4.2.2.3. Reptiles

Dampier Peninsula Goanna (*Varanus sparnus*)

Conservation Status: DBCA Priority 1

Distribution, Habitat and Ecology: The Dampier Peninsula Goanna was originally collected in 2009 at Coloumb Point, approx. 50 km north of the Study Areas (Doughty, Kealley, & Donnellan, 2014). It has been found to inhabit *Triodia* and tussock grasses as well as Pindan vegetation on sandy substrate. The species is closely related to the common Short-tailed Pygmy Monitor *Varanus brevicauda* and is restricted to the Dampier Peninsula.

Likelihood of Occurrence - Medium: Habitat is suitable for the Dampier Peninsula Goanna at both Study Areas. Individuals were trapped during the surveys to the north-east and north of D2 and G1 though no individuals were recorded during the field survey.

4.2.3. SRE Invertebrate Fauna

SRE invertebrate fauna database searches identified a total of 15 arachnids, one crustacean and two snails from the surrounding region (Table 3.2). During the survey, two undescribed species (*Lychas* 'BSCO048' and *Aname* 'BMYG165') belonging to potential SRE taxa were collected from dry pitfall traps during the systematic trapping survey, one individual from D2 and three individuals from G1 (Table 3.3). The Pindan shrubland habitat that occurs in the study areas is homogenous and the microhabitats present are not thought likely to support short range endemic invertebrate species. SRE invertebrate species are typically found in restricted habitats that provide a higher level of moisture than the surrounding habitats. In addition, many SREs are considered to be relict taxa that are confined to certain habitats such as rocky gorges, BIF ranges or creeklines (Harvey, 2002; Main, 1996, 1999). Overall, the Pindan Shrubland habitat recorded from within the study areas occurs across a large continuous extend across the Dampier Peninsula, which was recorded from previous surveys (AECOM, 2010; Biota 2010; Ecologia 2012a, Ecologia 2016b; Ecoscape 2017). This would also indicate a low likelihood that the habitat within the study area supports any taxa with a distribution restricted to either study area.

4.3. Principles for Clearing Native Vegetation

An assessment on how the proposed vegetation clearing applies to the fauna native vegetation clearing principles is present below in Table 4.2. All native vegetation clearing principles are provided in the Broome Regional Resource Recovery Park Detailed Flora & Vegetation Assessment report by Spectrum Ecology (2020).

Table 4.2: Native Vegetation Clearing Principles

Principle Number	Principle	Assessment	Outcome
(a)	It comprises a high level of biological diversity.	<p>There was one vegetation type identified from the Study Areas derived from flat Pindan Plains. There were 127 taxa from 39 families and 93 genera were recorded during the survey. The proportion of flora collected was consistent with expectations for this type of survey and survey timing in the context of other surveys of a similar level and seasonality.</p> <p>Both Study Areas fall in the 750.1 Pre-European Vegetation mapping classification. This vegetation unit covers more than 1.2 million hectares, of which, approximately 99% is undisturbed.</p> <p>There were 31 and 38 vertebrate fauna species found within the D2 and G1 Study Areas, respectively.</p> <p>Given the species count, vegetation types, literature review and the Pre-European vegetation units, the vegetation at the Study Areas is not considered to have a high level of biological diversity.</p>	The Proposal at the Study Areas is not likely to be at variance to this Principle.
(b)	It comprises the whole or a part of, or is necessary for the maintenance of, a significant habitat for fauna indigenous to Western Australia.	The Pindan shrubland habitat that occurs in the Study Areas is homogenous and the microhabitats present are not thought likely to support short range endemic invertebrate species. Overall, the Pindan Shrubland habitat recorded from within the Study Areas occurs across a large continuous extend across the Dampier Peninsula, which indicates that there is a low likelihood that the habitat within the Study Areas supports any taxa with a distribution restricted to either Study Area.	The Proposal at the Study Areas is not likely to be at variance to this Principle.

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Appendix A: Conservation Codes



EPBC Act 1999 Categories for Flora and Fauna

Code	Definition (EPBC Act)
Extinct	A native species is eligible to be included in the extinct category at a particular time if, at that time, there is no reasonable doubt that the last member of the species has died.
Extinct in the wild	A native species is eligible to be included in the extinct in the wild category at a particular time if, at that time: <ul style="list-style-type: none"> (a) it is known only to survive in cultivation, in captivity or as a naturalised population well outside its past range; or (b) it has not been recorded in its known and/or expected habitat, at appropriate seasons, anywhere in its past range, despite exhaustive surveys over a time frame appropriate to its life cycle and form.
Critically Endangered (CE)	A native species is eligible to be included in the critically endangered category at a particular time if, at that time, it is facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with the prescribed criteria.
Endangered (EN)	A native species is eligible to be included in the endangered category at a particular time if, at that time: <ul style="list-style-type: none"> (a) it is not critically endangered; and (b) it is facing a very high risk of extinction in the wild in the near future, as determined in accordance with the prescribed criteria.
Vulnerable (VU)	A native species is eligible to be included in the vulnerable category at a particular time if, at that time: <ul style="list-style-type: none"> (a) it is not critically endangered or endangered; and (b) it is facing a high risk of extinction in the wild in the medium term future, as determined in accordance with the prescribed criteria.
Conservation Dependent (CD)	A native species is eligible to be included in the conservation dependent category at a particular time if, at that time: <ul style="list-style-type: none"> (a) the species is the focus of a specific conservation program the cessation of which would result in the species becoming vulnerable, endangered or critically endangered; or (b) the following subparagraphs are satisfied: <ul style="list-style-type: none"> (i) the species is a species of fish; (ii) the species is the focus of a plan of management that provides for management actions necessary to stop the decline of, and support the recovery of, the species so that its chances of long term survival in nature are maximised; (iii) the plan of management is in force under a law of the Commonwealth or of a State or Territory; (iv) cessation of the plan of management would adversely affect the conservation status of the species.

Conservation Codes for Western Australian Flora and Fauna (DBCA 2019)

Code	Definition (BC Act)
<p>Threatened Species (T)</p> <p>Listed by order of the Minister as Threatened in the category of critically endangered, endangered or vulnerable under section 19(1), or is a rediscovered species to be regarded as threatened species under section 26(2) of the Biodiversity Conservation Act 2016 (BC Act).</p> <p>Threatened fauna is that subset of 'Specially Protected Fauna' listed under schedules 1 to 3 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018 for Threatened Fauna.</p> <p>Threatened flora is that subset of 'Rare Flora' listed under schedules 1 to 3 of the Wildlife Conservation (Rare Flora) Notice 2018 for Threatened Flora.</p> <p>The assessment of the conservation status of these species is based on their national extent and ranked according to their level of threat using IUCN Red List categories and criteria as detailed below.</p>	
<p>Critically Endangered (CR)</p>	<p>Threatened species considered to be “facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with criteria set out in the ministerial guidelines”.</p> <p>Listed as critically endangered under section 19(1)(a) of the BC Act in accordance with the criteria set out in section 20 and the ministerial guidelines. Published under schedule 1 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018 for critically endangered fauna or the Wildlife Conservation (Rare Flora) Notice 2018 for critically endangered flora.</p>
<p>Endangered (EN)</p>	<p>Threatened species considered to be “facing a very high risk of extinction in the wild in the near future, as determined in accordance with criteria set out in the ministerial guidelines”.</p> <p>Listed as endangered under section 19(1)(b) of the BC Act in accordance with the criteria set out in section 21 and the ministerial guidelines. Published under schedule 2 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018 for endangered fauna or the Wildlife Conservation (Rare Flora) Notice 2018 for endangered flora.</p>
<p>Vulnerable (VU)</p>	<p>Threatened species considered to be “facing a high risk of extinction in the wild in the medium-term future, as determined in accordance with criteria set out in the ministerial guidelines”.</p> <p>Listed as vulnerable under section 19(1)(c) of the BC Act in accordance with the criteria set out in section 22 and the ministerial guidelines. Published under schedule 3 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018 for vulnerable fauna or the Wildlife Conservation (Rare Flora) Notice 2018 for vulnerable flora.</p>
<p>Extinct species</p> <p>Listed by order of the Minister as extinct under section 23(1) of the BC Act as extinct or extinct in the wild.</p>	
<p>Extinct species (EX)</p>	<p>Species where “there is no reasonable doubt that the last member of the species has died”, and listing is otherwise in accordance with the ministerial guidelines (section 24 of the BC Act).</p> <p>Published as presumed extinct under schedule 4 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018 for extinct fauna or the Wildlife Conservation (Rare Flora) Notice 2018 for extinct flora.</p>

Code	Definition (BC Act)
Extinct in the wild species (EW)	<p>Species that “is known only to survive in cultivation, in captivity or as a naturalised population well outside its past range; and it has not been recorded in its known habitat or expected habitat, at appropriate seasons, anywhere in its past range, despite surveys over a time frame appropriate to its life cycle and form”, and listing is otherwise in accordance with the ministerial guidelines (section 25 of the BC Act).</p> <p>Currently there are no threatened fauna or threatened flora species listed as extinct in the wild. If listing of a species as extinct in the wild occurs, then a schedule will be added to the applicable notice.</p>
<p>Specially protected species</p> <p>Listed by order of the Minister as specially protected under section 13(1) of the BC Act. Meeting one or more of the following categories: species of special conservation interest; migratory species; cetaceans; species subject to international agreement; or species otherwise in need of special protection.</p> <p>Species that are listed as threatened species (critically endangered, endangered or vulnerable) or extinct species under the BC Act cannot also be listed as Specially Protected species.</p>	
Migratory species (MI)	<p>Fauna that periodically or occasionally visit Australia or an external Territory or the exclusive economic zone; or the species is subject of an international agreement that relates to the protection of migratory species and that binds the Commonwealth; and listing is otherwise in accordance with the ministerial guidelines (section 15 of the BC Act).</p> <p>Includes birds that are subject to an agreement between the government of Australia and the governments of Japan (JAMBA), China (CAMBA) and The Republic of Korea (ROKAMBA), and fauna subject to the Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention), an environmental treaty under the United Nations Environment Program. Migratory species listed under the BC Act are a subset of the migratory animals, that are known to visit Western Australia, protected under the international agreements or treaties, excluding species that are listed as Threatened species.</p> <p>Published as migratory birds protected under an international agreement under schedule 5 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018.</p>
Conservation Dependent (CD)	<p>Fauna of special conservation need being species dependent on ongoing conservation intervention to prevent it becoming eligible for listing as threatened, and listing is otherwise in accordance with the ministerial guidelines (section 14 of the BC Act).</p> <p>Published as conservation dependent fauna under schedule 6 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018</p>
Other specially protected fauna (OS)	<p>Fauna otherwise in need of special protection to ensure their conservation, and listing is otherwise in accordance with the ministerial guidelines (section 18 of the BC Act).</p> <p>Published as other specially protected fauna under schedule 7 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018</p>

Code	Definition (BC Act)
<p>Priority species (P)</p> <p>Possibly threatened species that do not meet survey criteria, or are otherwise data deficient, are added to the Priority Fauna or Priority Flora Lists under Priorities 1, 2 or 3. These three categories are ranked in order of priority for survey and evaluation of conservation status so that consideration can be given to their declaration as threatened fauna or flora.</p> <p>Species that are adequately known, are rare but not threatened, or meet criteria for near threatened, or that have been recently removed from the threatened species or other specially protected fauna lists for other than taxonomic reasons, are placed in Priority 4. These species require regular monitoring.</p> <p>Assessment of Priority codes is based on the Western Australian distribution of the species, unless the distribution in WA is part of a contiguous population extending into adjacent States, as defined by the known spread of locations.</p>	
<p>Priority 1: Poorly-known species (P1)</p>	<p>Species that are known from one or a few locations (generally five or less) which are potentially at risk. All occurrences are either: very small; or on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, road and rail reserves, gravel reserves and active mineral leases; or otherwise under threat of habitat destruction or degradation. Species may be included if they are comparatively well known from one or more locations but do not meet adequacy of survey requirements and appear to be under immediate threat from known threatening processes. Such species are in urgent need of further survey.</p>
<p>Priority 2: Poorly-known species (P2)</p>	<p>Species that are known from one or a few locations (generally five or less), some of which are on lands managed primarily for nature conservation, e.g. national parks, conservation parks, nature reserves and other lands with secure tenure being managed for conservation. Species may be included if they are comparatively well known from one or more locations but do not meet adequacy of survey requirements and appear to be under threat from known threatening processes. Such species are in urgent need of further survey.</p>
<p>Priority 3: Poorly-known species (P3)</p>	<p>Species that are known from several locations, and the species does not appear to be under imminent threat, or from few but widespread locations with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat. Species may be included if they are comparatively well known from several locations but do not meet adequacy of survey requirements and known threatening processes exist that could affect them. Such species are in need of further survey.</p>
<p>Priority 4: Rare, Near Threatened and other species in need of monitoring (P4)</p>	<p>(a) Rare. Species that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection but could be if present circumstances change. These species are usually represented on conservation lands.</p> <p>(b) Near Threatened. Species that are considered to have been adequately surveyed and that are close to qualifying for vulnerable but are not listed as Conservation Dependent.</p> <p>(c) Species that have been removed from the list of threatened species during the past five years for reasons other than taxonomy.</p>

¹ The definition of flora includes algae, fungi and lichens; ² Species includes all taxa (plural of taxon - a classificatory group of any taxonomic rank, e.g. a family, genus, species or any infraspecific category i.e. subspecies or variety, or a distinct population).

Appendix B: Site Locations



Site Locations

Site Name	Trap Type	Easting	Northing
D2 Study Area			
D2 Trap Site	Level 2 Trapping site		
	D2T1	423106	8024575
	D2T2	423083	8024572
	D2T3	423055	8024582
	D2T4	423017	8024592
	D2T5	422964	8024597
	D2T6	422897	8024607
	D2T7	422824	8024621
	D2T8	422747	8024635
RRRP D2 BAT	Bat Recorder Site	423115	8024565
RRRP D2 BIRD	Bird Survey Site	422932	8024640
RRRP D2 NOC	Nocturnal Survey Site	422993	8024351
RRRP D2 SP1	Sign Plot and Forage Site	422543	8025045
RRRP D2 SP2	Sign Plot and Forage Site	422992	8025119
RRRP D2 SP3	Sign Plot and Forage Site	422811	8024123
D2(1)	Country Manager Sign Plot	422780	8024893
D2(2)	Country Manager Sign Plot	423008	802440
D2MC01	Motion Camera	422568	8025231
D2MC02	Motion Camera	422911	8024105
D2MC03	Motion Camera	423051	8024804
G1 Study Area			
G1 Trap Site	Level 2 Trapping site		
	G1T1	450545	8027373
	G1T2	450518	8027395
	G1T3	450510	8027413
	G1T4	450483	8027429
	G1T5	450473	8027465
	G1T6	450440	8027470
	G1T7	450427	8027488
	G1T8	450435	8027519
RRRP G1 BAT	Bat Recorder Site	450565	8027349
RRRP G1 BIRD	Bird Survey Site	450382	8027533
RRRP G1 NOC	Nocturnal Survey Site	450499	8027397
RRRP G1 SP1	Sign Plot and Forage Site	450240	8027835
RRRP G1 SP2	Sign Plot and Forage Site	450045	8028283
RRRP G1 SP7	Sign Plot and Forage Site	449715	8027899
RRRP G1 SP3	Sign Plot and Forage Site	449768	8028750
RRRP G1 SP4	Sign Plot and Forage Site	449362	8028515
RRRP G1 SP5	Sign Plot and Forage Site	448862	8028286
RRRP G1 SP6	Sign Plot and Forage Site	449334	8028029

Appendix C: Vertebrate Fauna Survey Results



Species	Common Name	Conservation Status						Survey Sites					
		EPBC Act	BC Act	DBCA	RRRP D2 TRAP	RRRP G1 TRAP	RRRP D2 BIRD	RRRP G1 BIRD	RRRP D2 NOC	RRRP G1 NOC	RRRP D2 SP1	D2MC01	D2MC02
BIRDS													
Accipitridae													
<i>Milvus migrans</i>	Black Kite							X					
Columbidae													
<i>Geopelia striata</i>	Peaceful Dove						X						
Meropidae													
<i>Merops ornatus</i>	Rainbow Bee-eater							X					
Cacatuidae													
<i>Calyptorhynchus banksii</i>	Northern Red-tailed Black Cockatoo							X					
Psittacidae													
<i>Trichoglossus moluccanus</i>	Rainbow Lorikeet							X					
<i>Aprosmictus erythropterus</i>	Red-winged Parrot						X	X					
Maluridae													
<i>Malurus melanocephalus</i>	Red-backed Fairy-wren						X	X			X		
Meliphagidae													
<i>Lichmera indistincta</i>	Brown Honeyeater						X	X			X		
Pardalotidae													
<i>Pardalotus striatus</i>	Striated Pardalote						X						
Pomatostomidae													
<i>Pomatostomus temporalis</i>	Grey-crowned Babbler							X			X		
Artamidae													
<i>Artamus cinereus</i>	Black-faced Woodswallow							X					
Cracticidae													
<i>Cracticus nigrogularis</i>	Pied Butcherbird							X					
<i>Cracticus tibicen</i>	Australian Magpie							X					
Campephagidae													
<i>Coracina novaehollandiae</i>	Black-faced Cuckoo-shrike						X						
<i>Lalage tricolor</i>	White-winged Triller							X					
Pachycephalidae													
<i>Pachycephala rufiventris</i>	Rufous Whistler						X				X		
<i>Colluricincla harmonica</i>	Grey Shrike-thrush							X					
Rhipiduridae													
<i>Rhipidura leucophrys</i>	Willie Wagtail						X	X					
Monarchidae													

Species	Common Name	Conservation Status						Survey Sites					
		EPBC Act	BC Act	DBCA	RRRP D2 TRAP	RRRP G1 TRAP	RRRP D2 BIRD	RRRP G1 BIRD	RRRP D2 NOC	RRRP G1 NOC	RRRP D2 SP1	D2MC01	D2MC02
<i>Myiagra inquieta</i>	Paperbark Flycatcher							X					
Corvidae													
<i>Corvus orru</i>	Torresian Crow							X					
Dicaeidae													
<i>Dicaeum hirundinaceum</i>	Mistletoebird						X						
Estrildidae													
<i>Poephila acuticauda</i>	Long-tailed Finch							X					
MAMMALS													
Macropodidae													
<i>Notamacropus agilis</i>	Agile Wallaby									1		1	
Muridae													
<i>Pseudomys delicatulus</i>	Delicate Mouse					1							
Emballonuridae													
<i>Saccolaimus flaviventris</i>	Yellow-bellied Sheath-tailed Bat				R								
Molossidae													
<i>Chaerephon jobensis</i>	Greater Northern Free-tailed Bat					R							
<i>Ozimops (Mormopterus) cobourgianus</i>	Northern Coastal Free-tailed Bat			P1	R	R							
Vespertilionidae													
<i>Chalinolobus nigrogriseus</i>	Hoary Wattled Bat				NC	NC							
<i>Pipistrellus westralis</i>	Northern Pipistrelle				R								
<i>Scotorepens greyii</i>	Little Broad-nosed Bat				NC	NC							
<i>Scotorepens sanborni</i>	Northern Broad-nosed Bat				NC	NC							
INTRODUCED MAMMALS													
Canidae													
<i>Canis familiaris</i>	Dog				1	1							
Equidae													
<i>Equus caballus</i>	Horse										2		
Bovidae													
<i>Bos taurus</i>	European Cattle				1	1							
REPTILES													
Diplodactylidae													
<i>Strophurus ciliaris</i>	Northern Spiny-tailed Gecko									1			
<i>Diplodactylus laevis</i>	Desert Fat-tailed Gecko				2	2							

Species	Common Name	Conservation Status				Survey Sites							
		EPBC Act	BC Act	DBCA	RRRP D2 TRAP	RRRP G1 TRAP	RRRP D2 BIRD	RRRP G1 BIRD	RRRP D2 NOC	RRRP G1 NOC	RRRP D2 SP1	D2MC01	D2MC02
Gekkonidae													
<i>Gehyra kimberleyi</i>	Robust Termitaria Gecko				1								
Pygopodidae													
<i>Delma tincta</i>	Black-necked Delma				1	1							
<i>Pygopus nigriceps</i>	Western Hooded Scaly-foot					1							
Agamidae													
<i>Chlamydosaurus kingii</i>	Frill-necked Lizard								1				
<i>Diporiphora pindan</i>	Pindan Dragon				1	1							
Scincidae													
<i>Carlia munda</i>	Striped Rainbow Skink				1								
<i>Ctenotus colletti</i>	Collett's Ctenotus					2							
<i>Ctenotus inornatus</i>	Plain Ctenotus				3	1							
<i>Ctenotus pantherinus</i>	Leopard Ctenotus					1							
<i>Ctenotus robustus</i>	Robust Ctenotus				12								
<i>Ctenotus saxatilis</i>	Rock Ctenotus				13	1							
<i>Ctenotus serventyi</i>	North-western Sandy-loam Ctenotus				3	3							
<i>Eremiascincus isolepis</i>	Northern Bar-lipped Skink				1	1							
<i>Lerista bipes</i>	Western Two-toed Slider					3							
<i>Lerista griffini</i>	Stout Sand-slider				20	15							
<i>Morethia storri</i>	Northern Fire-tailed Skink					1							
Varanidae													
<i>Varanus panoptes</i>	Yellow-spotted Monitor										1		
Typhlopidae													
<i>Anilius diversus</i>	Northern Blind Snake				1								
<i>Anilius grypus</i>	Northern Beaked Blind Snake					1							
Elapidae													
<i>Brachyuropsis roperi</i>	Northern Shovel-nosed Snake					2							

R- Recorded via ultrasonic bat recorder

NC- Not confirmed. Ambiguous identification, call could belong to multiple species

Appendix D: Fauna Recorded from the Region



Mammals

Family and Species	Common name	Conservation Status																			
		EPBC Act	BC Act	DBCA	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	
TACHYGLOSSIDAE																					
<i>Tachyglossus aculeatus</i>	Echidna					P	S					S	S		P			S	P		
DASYURIDAE																					
<i>Dasyurus hallucatus</i>	Northern Quoll	EN	EN																P		
<i>Phascogale tapoatafa subsp. kimberleyensis</i>	Kimberley Brush-tailed Phascogale	VU	VU																P		
<i>Planigale ingrami</i>	Long-tailed Planigale																		P		
<i>Planigale maculata</i>	Common Planigale																		P		
<i>Sminthopsis macroura</i>	Stripe-faced Dunnart													P							
<i>Sminthopsis youngsoni</i>	Lesser Hairy-footed Dunnart								P		P								P		
PERAMELIDAE																					
<i>Isoodon auratus subsp. auratus</i>	Golden Bandicoot (mainland)	VU	VU																P		
<i>Isoodon macrourus</i>	Northern Brown Bandicoot																				
THYLACOMYIDAE																					
<i>Macrotis lagotis</i>	Greater Bilby	VU	VU		P	P	S		P		P	S							P	P	P
MACROPODIDAE																					
<i>Lagorchestes conspicillatus leichardti</i>	Spectacled Hare-wallaby (mainland)			P4														P	P		
<i>Notamacropus agilis</i>	Agile Wallaby				P	P	P	P	S		P	P		P	P			P	P		
<i>Osphranter robustus</i>	Euro					P				P	P								P		
<i>Osphranter rufus</i>	Red Kangaroo													P	P						
<i>Onychogalea unguifera</i>	Northern Nailtail Wallaby													P					P		
PHALANGERIDAE																					
<i>Trichosurus vulpecula arnhemensis</i>	Northern Brushtail Possum (Kimberley)		VU											P					P	P	

Family and Species	Common name	Conservation Status			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
		EPBC Act	BC Act	DBCA																
<i>Wyulda squamicaudata</i>	Scaly-tailed Possum			P4														P		
PTEROPODIDAE																				
<i>Pteropus alecto</i>	Black Flying-fox												P					P		
<i>Pteropus scapulatus</i>	Litte Red Flying-fox												P					P		
EMBALLONURIDAE																				
<i>Saccolaimus flaviventris</i>	Yellow-bellied Sheathtail Bat						P	P		P	P		P				P	P		
<i>Saccolaimus saccolaimus</i>	Bare-rumped Sheathtail Bat																	P		
<i>Saccolaimus saccolaimus nudicluniatus</i>	Bare-rumped Sheathtail Bat	VU		P3																P
<i>Taphozous georgianus</i>	Common Sheathtail Bat												P							
VESPERTILIONIDAE																				
<i>Chalinolobus gouldii</i>	Gould's Wattled Bat						P	P	P	P	P		P					P		
<i>Chalinolobus nigrogriseus</i>	Hoary Wattled Bat						P	P	P	P	P	P					Δ	P		
<i>Miniopterus schreibersii</i>	Common Bent-wing Bat									P			P					P		
<i>Myotis macropus</i>	Large-footed Myotis									P										
<i>Nyctophilus arnhemensis</i>	Arnhem Land Long-eared Bat						P											P		
<i>Nyctophilus daedalus</i>	Northwestern Long-eared Bat																	P		
<i>Nyctophilus geoffroyi</i>	Lesser Long-eared Bat							P		P	P							P		
<i>Pipistrellus westralis</i>	Northern Pipistrelle												P					P		
<i>Scotorepens greyii</i>	Little Broad-nosed Bat						P	P	P	P	P	P					Δ			
<i>Scotorepens sanborni</i>	Northern Broad-nosed Bat						P											P		
<i>Vespadelus douglasorum</i>	Yellow-lipped Cave Bat			P2									P							
MOLOSSIDAE																				
<i>Chaerophon jobensis</i>	Northern Freetail Bat						P	P	P	P	P		P				P	P		
<i>Mormopterus loriae</i>	Little Northern Freetail Bat																	P		
<i>Mormopterus cobourgiensis</i>	North-western Free-tailed Bat			P1															P	

Family and Species	Common name	Conservation Status														K	L	M	N	O	P
		EPBC Act	BC Act	DBCA	A	B	C	D	E	F	G	H	I	J							
MURIDAE																					
<i>Leggadina lakedownensis</i>	Short-tailed Mouse			P4								P			P						
<i>Notomys alexis</i>	Spinifex Hopping-mouse																				
<i>Pseudomys delicatulus</i>	Delicate Mouse						S	P	P		P	P	P	P			P	P			
<i>Pseudomys desertor</i>	Desert Mouse													P							
<i>Pseudomys hermannsburgensis</i>	Sandy Inland Mouse																		P		
<i>Pseudomys nanus</i>	Western Chestnut Mouse										P		P	P					P		
<i>Hydromys chrysogaster</i>	Water-rat			P4															P		
<i>Mesembriomys macrurus</i>	Golden-backed Tree-rat			P4															P	P	
<i>Xeromys myoides</i>	Water Mouse	VU																			P
INTRODUCED MAMMALS																					
<i>Mus musculus</i>	House Mouse							P			P			P					P		P
<i>Rattus rattus</i>	Black Rat						P												P		P
<i>Canis lupus</i>	Dog/Dingo				P	P	P	P	P	P	P	P	P	P			P				P
<i>Felis catus</i>	Cat				P		P			P	P	P	P	P			P	P			P
<i>Vulpes vulpes</i>	Red Fox																				P
<i>Equus asinus</i>	Donkey												P	P							P
<i>Equus caballus</i>	Horse																		P		P
<i>Camelus dromedarius</i>	Camel																		P		P
<i>Sus scrofa</i>	Pig													P							P
<i>Bos taurus</i>	Cow				P		P			P	P	P		P	P		P	P			

Birds

Family and Species	Common name	Conservation Status			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
		EPBC Act	BC Act	DBCA																
CASUARIIDAE																				
<i>Dromaius novaehollandiae</i>	Emu													P					P	
PHASIANIDAE																				
<i>Cortunix pectoralis</i>	Stubble Quail																		P	
<i>Coturnix ypsilophora</i>	Brown Quail					P	P	P	P		P			P	P				P	
PHASIANIDAE																				
<i>Pavo cristatus</i>	Common Peafowl																		P	
ANSERANATIDAE																				
<i>Anseranas semipalmata</i>	Magpie Goose										P								P	
ANATIDAE																				
<i>Dendrocygna arcuata</i>	Spotted Whistling-Duck										P			P					P	
<i>Dendrocygna eytoni</i>	Plumed Whistling-Duck										P			P					P	
<i>Stictonetta naevosa</i>	Freckled Duck										P								P	
<i>Cygnus atratus</i>	Black Swan																		P	
<i>Tadorna tadornoides</i>	Australian Shelduck																		P	
<i>Tadorna radjah</i>	Radjah Shelduck																		P	
<i>Chenonetta jubata</i>	Australian Wood Duck										P								P	
<i>Malacorhynchus membranaceus</i>	Pink-eared Duck										P								P	
<i>Nettapus pulchellus</i>	Green Pygmy-Goose										P								P	
<i>Anas rhynchotis</i>	Australasian Shoveler																		P	
<i>Anas gracilis</i>	Grey Teal									P	P								P	
<i>Anas castanea</i>	Chestnut Teal																		P	
<i>Anas querquedula</i>	Garganey	MI	MI																P	

Family and Species	Common name	Conservation Status			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
		EPBC Act	BC Act	DBCA																
<i>Anas superciliosa</i>	Pacific Black Duck									P	P			P				P		
<i>Aythya australis</i>	Hardhead										P							P		
PODICIPEDIDAE																				
<i>Tachybaptus novaehollandiae</i>	Australasian Grebe										P			P				P		
<i>Tachybaptus ruficollis</i>	Little Grebe																	P		
<i>Poliiocephalus poliocephalus</i>	Hoary-headed Grebe																	P		
<i>Podiceps cristatus</i>	Great Crested Grebe																	P		
COLUMBIDAE																				
* <i>Columba livia</i>	Rock Dove																	P		P
<i>Ptilinopus regina</i>	Rose-crowned Fruit-dove																	P		
<i>Phaps chalcoptera</i>	Common Bronzewing					P												P		
<i>Phaps histrionica</i>	Flock Bronzewing							P						P				P		
<i>Ocyphaps lophotes</i>	Crested Pigeon					P	P	P		P	P	P	P	P	P			P	P	
<i>Geopelia cuneata</i>	Diamond Dove				P	P		P	P	P	P	P	P					P	P	
<i>Geopelia striata</i>	Peaceful Dove					P	P	P	P	P	P	P	P	P	P	P	O	P		
<i>Geopelia humeralis</i>	Bar-shouldered Dove					P	P	P	P				P	P				P		
<i>Geophaps plumifera</i>	Spinifex Pigeon																	P		
<i>Ducula bicolor</i>	Pied Imperial-Pigeon																	P		
PODARGIDAE																				
<i>Podargus strigoides</i>	Tawny Frogmouth						P	P	P		P	P	P	P				O	P	
EUROSTOPODIDAE																				
<i>Eurostopus argus</i>	Spotted Nightjar						P				P	P		P				P		
AEGOTHELIDAE																				
<i>Aegotheles cristatus</i>	Australian Owlet-nightjar						P		P		P		P	P				P		

Family and Species	Common name	Conservation Status			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
		EPBC Act	BC Act	DBCA																
APODIDAE																				
<i>Apus pacificus</i>	Fork-tailed Swift	MI	MI				P		P		P		P	P				P	P	P
<i>Hirundapus caudacutus</i>	White-throated Needletail	MI	MI															P	P	
STERCORARIIDAE																				
<i>Stercorarius parasiticus</i>	Arctic Jaeger	MI	MI															P		
OCEANITIDAE																				
<i>Oceanites oceanicus</i>	Wilson's Storm-Petrel	MI	MI															P	P	
PROCELLARIIDAE																				
<i>Ardenna tenuirostris</i>	Short-tailed Shearwater	MI	MI															P		
<i>Ardenna huttoni</i>	Hutton's Shearwater	EN																P		
<i>Ardenna pacifica</i>	Wedge-tailed Shearwater	MI	MI															P		
<i>Pelecanoides urinatrix subsp. Exsul</i>	Common Diving Petrel																	P		
<i>Calonectris leucomelas</i>	Streaked Shearwater	MI	MI															P	P	P
<i>Bulweria bulwerii</i>	Bulwer's Petrel	MI	MI															P		
<i>Macronectes halli</i>	Northern Giant Petrel	VU, MI	MI															P		
FREGATIDAE																				
<i>Fregata ariel</i>	Lesser Frigatebird	MI	MI				P	P	P									P	P	P
<i>Fregata minor</i>	Great Frigatebird	MI	MI															P		P
SULIDAE																				
<i>Sula leucogaster</i>	Brown Booby								P									P	P	
ANHINGIDAE																				
<i>Anhinga novaehollandiae</i>	Australasian Darter													P				P		
PHALACROCORACIDAE																				

Family and Species	Common name	Conservation Status			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
		EPBC Act	BC Act	DBCA																
<i>Microcarbo melanoleucos</i>	Little Pied Cormorant									P	P			P				P		
<i>Phalacrocorax carbo</i>	Great Cormorant																	P		
<i>Phalacrocorax sulcirostris</i>	Little Black Cormorant													P				P		
<i>Phalacrocorax varius</i>	Pied Cormorant						P							P				P		
PELECANIDAE																				
<i>Pelecanus conspicillatus</i>	Australian Pelican						P		P		P							P		
CICONIIDAE																				
<i>Ephippiorhynchus asiaticus</i>	Black-necked Stork													P				P		
ARDEIDAE																				
<i>Ixobrychus flavicollis</i>	Black Bittern			P2														P		
<i>Ixobrychus flavicollis</i>	Australian Little Bittern			P4														P		
<i>Ardea pacifica</i>	White-necked Heron								P	P	P			P			O	P		
<i>Ardea modesta</i>	Eastern Great Egret													P				P		
<i>Ardea intermedia</i>	Intermediate Egret													P				P		
<i>Ardea ibis</i>	Cattle Egret																	P		
<i>Ardea sumatrana</i>	Great-billed Heron																	P		
<i>Butorides striatus</i>	Striated Heron																	P		
<i>Egretta novaehollandiae</i>	White-faced Heron						P			P	P			P				P		
<i>Egretta garzetta</i>	Little Egret													P				P		
<i>Egretta sacra</i>	Eastern Reef Egret																	P		
<i>Nycticorax caledonicus</i>	Nankeen Night-Heron						P							P				P		
THRESKIORNITHIDAE																				
<i>Plegadis falcinellus</i>	Glossy Ibis	MI	MI											P				P	P	
<i>Threskiornis molucca</i>	Australian White Ibis													P						

Family and Species	Common name	Conservation Status			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
		EPBC Act	BC Act	DBCA																
<i>Threskiornis spinicollis</i>	Straw-necked Ibis						P			P	P	P		P				P		
<i>Platalea regia</i>	Royal Spoonbill										P			P					P	
<i>Platalea flavipes</i>	Yellow-billed Spoonbill																		P	
ACCIPITRIDAE																				
<i>Pandion cristatus</i>	Eastern Osprey	MI	MI				P	P										P	P	P
<i>Aviceda subcristata</i>	Pacific Baza																		P	
<i>Elanus axillaris</i>	Black-shouldered Kite						P							P					P	
<i>Elanus scriptus</i>	Letter-winged Kite			P4															P	
<i>Lophoictinia isura</i>	Square-tailed Kite				P			P	P				P		P					P
<i>Hamirostra melanosternon</i>	Black-breasted Buzzard								P			P		P			P	P		
<i>Haliaeetus leucogaster</i>	White-bellied Sea-Eagle						P	P	P					P					P	
<i>Haliastur sphenurus</i>	Whistling Kite				P	P	P			P	P	P		P					P	
<i>Haliastur indus</i>	Brahminy Kite						P		P										P	
<i>Milvus migrans</i>	Black Kite					P	P		P	P	P	P	P				O	P		
<i>Accipiter cirrocephalus</i>	Collared Sparrowhawk										P		P	P					P	
<i>Accipiter fasciatus</i>	Brown Goshawk						P	P	P	P	P		P	P			P	P		
<i>Accipiter novaehollandiae</i>	Grey Goshawk																		P	
<i>Erythrotriorchis radiatus</i>	Red Goshawk	VU	VU																P	P
<i>Circus assimilis</i>	Spotted Harrier										P			P					P	
<i>Circus approximans</i>	Swamp Harrier																		P	
<i>Aquila audax</i>	Wedge-tailed Eagle								P	P	P		P	P					P	
<i>Hieraaetus morphnoides</i>	Little Eagle							P					P						P	
FALCONIDAE																				
<i>Falco cenchroides</i>	Nankeen Kestrel						P	P	P	P	P	P	P				P	P		

Family and Species	Common name	Conservation Status			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
		EPBC Act	BC Act	DBCA																
<i>Falco berigora</i>	Brown Falcon					P	P	P	P	P	P	P	P	P			P	P		
<i>Falco longipennis</i>	Australian Hobby						P				P	P						P		
<i>Falco hypoleucos</i>	Grey Falcon		VU															P	P	
<i>Falco subniger</i>	Black Falcon																	P		
<i>Falco peregrinus</i>	Peregrine Falcon		OS				P	P										P	P	
GRUIDAE																				
<i>Grus rubicunda</i>	Brolga								P				P	P				P		
RALLIDAE																				
<i>Porphyrio porphyrio</i>	Purple Swamphen																	P		
<i>Gallirallus philippensis</i>	Buff-banded Rail																	P		
<i>Rallina fasciata</i>	Red-legged Crake																	P		
<i>Porzana pusilla</i>	Baillon's Crake																	P		
<i>Porzana fluminea</i>	Australian Spotted Crake																	P		
<i>Porzana tabuensis</i>	Spotless Crake																	P		
<i>Tribonyx ventralis</i>	Black-tailed Native-hen																	P		
<i>Fulica atra</i>	Eurasian Coot										P							P		
OTIDIDAE																				
<i>Ardeotis australis</i>	Australian Bustard					P			P	P	P	P	P	P			P	P		
BURHINIDAE																				
<i>Burhinus grallarius</i>	Bush Stone-curlew						P		P	P	P	P	P	P				P		
<i>Esacus magnirostris</i>	Beach Stone-curlew						P											P		
HAEMATOPODIDAE																				
<i>Haematopus longirostris</i>	Australian Pied Oystercatcher						P	P	P									P		
<i>Haematopus fuliginosus</i>	Sooty Oystercatcher						P		P									P		

Family and Species	Common name	Conservation Status			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
		EPBC Act	BC Act	DBCA																
RECURVIROSTRIDAE																				
<i>Himantopus himantopus</i>	Black-winged Stilt										P			P				P		
<i>Recurvirostra novaehollandiae</i>	Red-necked Avocet																	P		
<i>Cladorhynchus leucocephalus</i>	Banded Stilt																	P		
CHARADRIIDAE																				
<i>Anous stolidus</i>	Common Noddy	MI	MI															P		P
<i>Pluvialis fulva</i>	Pacific Golden Plover	MI	MI															P	P	P
<i>Pluvialis squatarola</i>	Grey Plover	MI	MI															P	P	P
<i>Charadrius bicinctus</i>	Double-banded Plover	MI	MI																	P
<i>Charadrius dubius</i>	Little Ringed Plover																	P		
<i>Charadrius ruficapillus</i>	Red-capped Plover							P										P		
<i>Charadrius mongolus</i>	Lesser Sand Plover	EN, MI	EN				P											P	P	P
<i>Charadrius leschenaultii</i>	Greater Sand Plover	VU, MI	VU				P											P	P	P
<i>Charadrius veredus</i>	Oriental Plover	MI	MI										P					P	P	P
<i>Euseyonis melanops</i>	Black-fronted Dotterel						P		P	P			P					P		
<i>Erythrogonys cinctus</i>	Red-kneed Dotterel									P			P					P		
<i>Vanellus miles</i>	Masked Lapwing						P		P	P			P					P		
<i>Vanellus tricolor</i>	Banded Lapwing																	P		
JACANIDAE																				
<i>Irediparra gallinacea</i>	Comb-crested Jacana									P								P		
ROSTRATULIDAE																				
<i>Rostratula australis</i>	Australian Painted Snipe	EN	EN															P	P	P

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		EPBC Act	BC Act	DBCA																
GALLINAGONIAE																				
<i>Gallinago megala</i>	Swinhoe's Snipe	MI	MI															P	P	P
<i>Gallinago stenura</i>	Pin-tailed Snipe	MI	MI															P	P	P
SCOLOPACIDAE																				
<i>Limosa limosa</i>	Black-tailed Godwit	MI	MI															P	P	P
<i>Limosa lapponica</i>	Bar-tailed Godwit	MI	MI			P												P	P	P
<i>Limnodromus semipalmatus</i>	Asian Dowitcher	MI	MI															P	P	P
<i>Numenius minutus</i>	Little Curlew	MI	MI															P	P	P
<i>Numenius phaeopus</i>	Whimbrel	MI	MI			P												P	P	P
<i>Numenius madagascariensis</i>	Eastern Curlew	CR, MI	CR			P												P	P	P
<i>Phalaropus lobatus</i>	Red-necked Phalarope	MI	MI															P	P	
<i>Xenus cinereus</i>	Terek Sandpiper	MI	MI															P	P	P
<i>Actitis hypoleucos</i>	Common Sandpiper	MI	MI				P						P					P	P	P
<i>Tringa brevipes</i>	Grey-tailed Tattler	MI	MI	P4		P												P		P
<i>Tringa nebularia</i>	Common Greenshank	MI	MI			P					P		P					P	P	
<i>Tringa stagnatilis</i>	Marsh Sandpiper	MI	MI															P	P	P
<i>Tringa totanus</i>	Common Redshank	MI	MI															P		P
<i>Tringa glareola</i>	Wood Sandpiper	MI	MI			P				P								P	P	P
<i>Arenaria interpres</i>	Ruddy Turnstone	MI	MI			P												P		P
<i>Calidris tenuirostris</i>	Great Knot	CR, MI	CR															P	P	P
<i>Calidris canutus</i>	Red Knot	EN, MI	EN															P		P
<i>Calidris alba</i>	Sanderling	MI	MI			P												P		P

Family and Species	Common name	Conservation Status			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
		EPBC Act	BC Act	DBCA																
<i>Calidris ruficollis</i>	Red-necked Stint	MI	MI				P											P		P
<i>Calidris minuta</i>	Little Stint																	P		
<i>Calidris subminuta</i>	Long-toed Stint	MI	MI															P	P	
<i>Calidris melanotos</i>	Pectoral Sandpiper	MI	MI															P	P	P
<i>Calidris acuminata</i>	Sharp-tailed Sandpiper	MI	MI				P											P	P	P
<i>Calidris ferruginea</i>	Curlew Sandpiper	CR, MI	CR															P	P	P
<i>Limicola falcinellus</i>	Broad-billed Sandpiper	MI	MI															P	P	P
<i>Philomachus pugnax</i>	Ruff	MI	MI															P		
TURNICIDAE																				
<i>Turnix maculosus</i>	Red-backed Button-quail																	P		
<i>Turnix castanotus</i>	Chestnut-backed Button-quail						P											P		
<i>Turnix pyrrhotorax</i>	Red-chested Button-quail						P	P		P			P					P		
<i>Turnix velox</i>	Little Button-quail							P	P	P		P	P				P	P		
GLAREOLIDAE																				
<i>Glareola maldivarum</i>	Oriental Pratincole	MI	MI															P	P	P
<i>Stiltia isabella</i>	Australian Pratincole												P					P		
LARIDAE																				
<i>Onychoprion fuscata</i>	Sooty Tern																	P		
<i>Sternula albifrons</i>	Little Tern	MI	MI				P											P	P	P
<i>Sternula nereis nereis</i>	Australian Fairy Tern	VU	VU																	P
<i>Gelochelidon nilotica</i>	Gull-billed Tern	MI	MI				P											P	P	
<i>Hydroprogne caspia</i>	Caspian Tern	MI	MI															P	P	
<i>Chlidonias hybrida</i>	Whiskered Tern												P					P		

Family and Species	Common name	Conservation Status			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
		EPBC Act	BC Act	DBCA																
<i>Onychoprion anaethetus</i>	Bridled Tern	MI	MI															P		
<i>Chlidonias leucopterus</i>	White-winged Black Tern	MI	MI											P				P	P	
<i>Sterna dougallii</i>	Roseate Tern	MI	MI															P	P	
<i>Sterna hirundo</i>	Common Tern	MI	MI				P		P									P	P	
<i>Sterna sumatrana</i>	Black-naped Tern	MI	MI																	P
<i>Thalasseus bengalensis</i>	Lesser Crested Tern						P		P									P		
<i>Thalasseus bergii</i>	Crested Tern	MI	MI				P		P									P	P	
<i>Larus fuscus</i>	Lesser Black-backed Gull																	P		
<i>Larus novaehollandiae</i>	Silver Gull						P											P		
CACATUIDAE																				
<i>Calyptorhynchus banksii</i>	Northern Red-tailed Black-Cockatoo					P	P		P	P	P	P	P	P	P	P		P		
<i>Cacatua roseicapillus</i>	Galah					P				P	P	P	P	P			P	P		
<i>Cacatua sanguinea</i>	Little Corella						P			P	P	P		P	P			P		
<i>Cacatua galerita</i>	Sulphur-crested Cockatoo																	P		
<i>Nymphicus hollandicus</i>	Cockatiel								P	P	P	P		P				P		
PSITTACIDAE																				
<i>Trichoglossus haematodus</i>	Rainbow Lorikeet						P	P					P		P			O	P	
<i>Trichoglossus haematodus rubritorquis</i>	Red-collared Lorikeet						P			P	P	P		P				P		
<i>Psitteuteles versicolor</i>	Varied Lorikeet						P	P	P	P	P	P	P							
<i>Aprosmictus erythropterus</i>	Red-winged Parrot					P	P	P	P	P		P	P	P	P			O	P	
<i>Polytelis anthopeplus</i>	Regent Parrot										P									
<i>Polytelis alexandrae</i>	Princess Parrot	VU		P4														P		P
<i>Melopsittacus undulatus</i>	Budgerigar									P	P	P		P	P			P	P	

Family and Species	Common name	Conservation Status			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
		EPBC Act	BC Act	DBCA																
CUCULIDAE																				
<i>Centropus phasianinus</i>	Pheasant Coucal						P	P	P	P	P		P	P				P		
<i>Scythrops novaehollandiae</i>	Channel-billed Cuckoo						P											P		
<i>Chalcites basalis</i>	Horsfield's Bronze-Cuckoo					P	P	P	P	P			P	P	P		P	P		
<i>Chalcites osculans</i>	Black-eared Cuckoo						P	P					P					P		
<i>Chalcites minutillus</i>	Little Bronze-Cuckoo							P		P			P					P		
<i>Cacomantis pallidus</i>	Pallid Cuckoo						P		P	P			P	P				P		
<i>Cacomantis variolosus</i>	Brush Cuckoo						P	P			P		P	P				P		
<i>Cuculus optatus</i>	Oriental Cuckoo	MI	MI				P											P	P	P
STRIGIDAE																				
<i>Ninox connivens</i>	Barking Owl													P				P	P	
<i>Ninox novaeseelandiae</i>	Southern Boobook							P	P	P			P	P				P		
TYTONIDAE																				
<i>Tyto novaehollandiae kimberli</i>	Masked Owl (Northern)	VU		P1														P		P
<i>Tyto javanica</i>	Eastern Barn Owl													P				P		
<i>Tyto longimembris</i>	Eastern Grass Owl																	P		
HALCYONIDAE																				
<i>Dacelo leachii</i>	Blue-winged Kookaburra				P		P	P	P	P	P	P	P	P				P		
<i>Todiramphus pyrrhopygius</i>	Red-backed Kingfisher						P	P			P			P			P	P		
<i>Todiramphus sanctus</i>	Sacred Kingfisher						P	P	P		P		P	P	P			P		
<i>Todiramphus chloris</i>	Collared Kingfisher																	P		
MEROPIDAE																				
<i>Merops ornatus</i>	Rainbow Bee-eater				P	P	P	P	P	P	P	P	P	P				P	P	
CORACIIDAE																				

Family and Species	Common name	Conservation Status			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
		EPBC Act	BC Act	DBCA																
<i>Eurystomus orientalis</i>	Dollarbird						P	P	P		P			P				P		
CLIMACTERIDAE																				
<i>Climacteris melanura</i>	Black-tailed Treecreeper									P	P	P	P	P						
PTILONORHYNCHIDAE																				
<i>Ptilonorhynchus nuchalis</i>	Great Bowerbird					P	P	P	P	P	P		P	P				P		
MALURIDAE																				
<i>Malurus melanocephalus</i>	Red-backed Fairy-wren						P	P	P	P	P	P	P				P	P		
<i>Malurus elegans</i>	Red-winged Fairy-wren																	P		
<i>Malurus lamberti</i>	Variegated Fairy-wren				P	P	P	P	P		P	P		P			P	P		
ACANTHIZIDAE																				
<i>Acanthiza apicalis</i>	Inland Thornbill																		P	
<i>Smicronis brevirostris</i>	Weebill						P	P	P	P	P	P	P					P		
<i>Gerygone levigaster</i>	Mangrove Gerygone						P											P		
<i>Gerygone fusca</i>	Western Gerygone																	P		
<i>Gerygone tenebrosa</i>	Dusky Gerygone																	P		
<i>Gerygone albogularis</i>	White-throated Gerygone				P	P	P	P	P	P	P	P	P				P	P		
PARDALOTIDAE																				
<i>Pardalotus rubricatus</i>	Red-browed Pardalote						P	P		P	P	P		P				P		
<i>Pardalotus striatus</i>	Striated Pardalote					P		P	P	P	P	P	P	P			P	P		
MELIPHAGIDAE																				
<i>Certhionyx variegatus</i>	Pied Honeyeater													P					P	
<i>Lichenostomus virescens</i>	Singing Honeyeater				P	P	P	P	P	P	P	P	P				P	P		
<i>Lichenostomus unicolor</i>	White-gaped Honeyeater						P		P					P				P		
<i>Lichenostomus flavescens</i>	Yellow-tinted Honeyeater						P	P	P	P	P	P	P					P		

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		EPBC Act	BC Act	DBCA																
<i>Lichenostomus penicillatus</i>	White-plumed Honeyeater						P	P						P						
<i>Manorina flavigula</i>	Yellow-throated Miner					P								P					P	
<i>Acanthagenys rufogularis</i>	Spiny-cheeked Honeyeater																		P	
<i>Conopophila rufogularis</i>	Rufous-throated Honeyeater						P	P	P		P		P	P					P	
<i>Epthianura crocea</i>	Yellow Chat																		P	
<i>Epthianura aurifrons</i>	Orange Chat																		P	
<i>Epthianura tricolor</i>	Crimson Chat																		P	
<i>Sugomel niger</i>	Black Honeyeater									P	P			P						
<i>Myzomela erythrocephala</i>	Red-headed Honeyeater						P												P	
<i>Lichenostomus plumulus</i>	Grey-fronted Honeyeater							P												
<i>Cissomela pectoralis</i>	Banded Honeyeater								P		P		P	P					P	
<i>Lichmera indistincta</i>	Brown Honeyeater				P	P	P	P	P	P	P	P	P	P	P		P	P		
<i>Melithreptus gularis</i>	Black-chinned Honeyeater						P	P	P	P	P	P	P						P	
<i>Melithreptus albogularis</i>	White-throated Honeyeater						P		P		P		P						P	
<i>Purnella albifrons</i>	White-fronted Honeyeater																		P	
<i>Philemon argenteiceps</i>	Silver-crowned Friarbird						P								P				P	
<i>Philemon citreogularis</i>	Little Friarbird				P		P	P	P	P	P		P	P	P				P	
POMATOSTOMIDAE																				
<i>Pomatostomus temporalis</i>	Grey-crowned Babbler				P	P	P	P	P	P	P	P	P	P	P	P	P	P		
NEOSITTIDAE																				
<i>Daphoenositta chrysoptera</i>	Varied Sittella						P	P	P	P	P	P	P						P	
CAMPEPHAGIDAE																				
<i>Coracina novaehollandiae</i>	Black-faced Cuckoo-shrike				P	P	P	P	P	P	P	P	P	P			P	P		
<i>Coracina papuensis</i>	White-bellied Cuckoo-shrike											P		P					P	

Family and Species	Common name	Conservation Status			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
		EPBC Act	BC Act	DBCA																
<i>Lalage sueurii</i>	White-winged Triller						P		P	P	P	P	P				P	P		
PACHYCEPHALIDAE																				
<i>Pachycephala melanura</i>	Mangrove Golden Whistler																	P		
<i>Pachycephala rufiventris</i>	Rufous Whistler				P	P	P	P	P	P	P	P	P				P	P		
<i>Pachycephala lanioides</i>	White-breasted Whistler																	P		
<i>Colluricincla harmonica</i>	Grey Shrike-thrush				P		P	P	P	P	P	P	P				P	P		
<i>Oreoica gutturalis</i>	Crested Bellbird																	P		
ORIOLIDAE																				
<i>Oriolus sagittatus</i>	Olive-backed Oriole						P		P	P	P	P	P					P		
ARTAMIDAE																				
<i>Artamus leucorhynchus</i>	White-breasted Woodswallow						P	P			P	P						P		
<i>Artamus personatus</i>	Masked Woodswallow					P			P	P	P		P					P		
<i>Artamus superciliosus</i>	White-browed Woodswallow							P										P		
<i>Artamus cinereus</i>	Black-faced Woodswallow					P	P	P	P	P	P	P	P				P	P		
<i>Artamus cyanopterus</i>	Dusky Woodswallow													P						
<i>Artamus minor</i>	Little Woodswallow						P	P	P	P	P	P	P					P		
<i>Cecropis daurica</i>	Red-rumped Swallow	MI	MI															P	P	P
<i>Cracticus torquatus</i>	Grey Butcherbird						P											P		
<i>Cracticus nigrogularis</i>	Pied Butcherbird				P	P	P	P	P	P	P	P	P	P			P	P		
<i>Cracticus tibicen</i>	Australian Magpie										P		P				P	P		
RHIPIDURIDAE																				
<i>Rhipidura albiscapa</i>	Grey Fantail									P		P						P		
<i>Rhipidura phasiana</i>	Mangrove Grey Fantail																	P		

Family and Species	Common name	Conservation Status			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
		EPBC Act	BC Act	DBCA																
<i>Rhipidura rufiventris</i>	Northern Fantail						P	P	P									P		
<i>Rhipidura leucophrys</i>	Willie Wagtail					P	P	P	P	P	P	P	P	P	P		P	P		
CORVIDAE																				
<i>Corvus bennetti</i>	Little Crow					P							P	P				P		
<i>Corvus orru</i>	Torresian Crow					P	P	P	P	P	P	P	P	P	P	P	P	P		
MONARCHIDAE																				
<i>Myiagra rubecula</i>	Leaden Flycatcher						P	P	P				P					P		
<i>Myiagra inquieta</i>	Restless Flycatcher						P	P	P	P			P	P				P		
<i>Myiagra nana</i>	Paperbark Flycatcher										P	P		P						
<i>Myiagra ruficollis</i>	Broad-billed Flycatcher																	P		
<i>Cyanoptila cyanomelana</i>	Blue and White Flycatcher																	P		
<i>Grallina cyanoleuca</i>	Magpie-lark					P	P			P	P	P	P	P			P	P		
PETROICIDAE																				
<i>Microeca fascinans</i>	Jacky Winter						P	P	P	P	P	P	P					P		
<i>Microeca flavigaster</i>	Lemon-bellied Flycatcher																	P		
<i>Petroica goodenovii</i>	Red-capped Robin																	P		
<i>Melanodryas cucullata</i>	Hooded Robin										P	P	P					P		
ALAUDIDAE																				
<i>Mirafrja javanica</i>	Horsfield's Bushlark													P				P		
CISTICOLIDAE																				
<i>Cisticola exilis</i>	Golden-headed Cisticola							P						P				P		
ACROCEPHALIDAE																				
<i>Acrocephalus australis</i>	Australian Reed-Warbler																	P		
MEGALURIDAE																				

Family and Species	Common name	Conservation Status			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
		EPBC Act	BC Act	DBCA																
<i>Megalurus timoriensis</i>	Tawny Grassbird				P													P		
<i>Megalurus gamineus</i>	Little Grassbird																	P		
<i>Cincloramphus mathewsi</i>	Rufous Songlark							P	P	P				P						
<i>Cincloramphus cruralis</i>	Brown Songlark							P						P						
<i>Eremiornis carteri</i>	Spinifexbird													P						
ZOSTEROPIDAE																				
<i>Zosterops luteus</i>	Yellow White-eye						P											P		
<i>Zosterops lateralis</i>	Grey-breasted White-eye																	P		
HIRUNDINIDAE																				
<i>Hirundo rustica</i>	Barn Swallow	MI	MI															P	P	P
<i>Hirundo neoxena</i>	Welcome Swallow																	P		
<i>Cheramoeca leucosterna</i>	White-backed Swallow																	P		
<i>Petrochelidon ariel</i>	Fairy Martin							P	P					P				P		
<i>Petrochelidon nigricans</i>	Tree Martin				P		P	P	P	P	P	P	P					P		
STURNIDAE																				
<i>Sturnus vulgaris</i>	Common Starling																	P		
NECTARINIIDAE																				
<i>Dicaeum hirundinaceum</i>	Mistletoebird						P	P	P	P	P	P	P	P			O	P		
PASSERIDAE																				
<i>Passer montanus</i>	Eurasian Tree Sparrow																	P		
PITTIDAE																				
<i>Pitta moluccensis</i>	Blue-winged Pitta																	P		
ESTRILDIDAE																				
<i>Taeniopygia guttata</i>	Zebra Finch						P		P	P	P			P	P	P	P	P		

Family and Species	Common name	Conservation Status			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
		EPBC Act	BC Act	DBCA																
<i>Taeniopygia bichenovii</i>	Double-barred Finch				P	P		P	P					P				P		
<i>Poephila acuticauda</i>	Long-tailed Finch					P	P	P	P		P	P	P				P	P		
<i>Neochmia phaeton</i>	Crimson Finch													P				P		
<i>Neochmia ruficauda</i>	Star Finch													P				P		
<i>Emblema pictum</i>	Painted Finch													P				P		
<i>Erythrura gouldiae</i>	Gouldian Finch	EN		P4														P		P
<i>Lonchura castaneothorax</i>	Chestnut-breasted Mannikin																	P		
<i>Heteromunia pectoralis</i>	Pictorella Mannikin													P				P		
MOTACILLIDAE																				
<i>Anthus novaeseelandiae</i>	Australasian Pipit						P	P						P						
<i>Anthus cervinus</i>	Red-throated Pipit																	P		
<i>Motacilla alba</i>	White Wagtail																	P		
<i>Motacilla cinerea</i>	Grey Wagtail	MI	MI								P							P	P	P
<i>Motacilla flava</i>	Yellow Wagtail	MI	MI															P		P
<i>Motacilla tschutschensis</i>	Eastern Yellow Wagtail										P									

Reptiles

Family and Species	Common name	Conservation Status																		
		EPBC Act	BC Act	DBCA	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
CHELIIDAE																				
<i>Chelodina burrungandjii</i>	Northern Long-necked Turtle																		P	
CHELOINIIDAE																				
<i>Chelonia mydas</i>	Green Turtle	VU & MI	VU																P	
<i>Eretmochelys imbricata subsp. bisssa</i>	Hawksbill Turtle	VU & MI	VU																P	
<i>Lepidochelys olivacea</i>	Olive Ridley Turtle	EN & MI	EN																P	
<i>Natator depressus</i>	Flatback Turtle	VU & MI	VU																P	
AGAMIDAE																				
<i>Amphibolurus gilberti</i>							P	P	P		P				P				P	
<i>Chlamydosaurus kingii</i>	Frill-necked Lizard						P	P	P				P		P		P	P		
<i>Ctenophorus caudicinctus</i>	Ring-tailed Dragon																		P	
<i>Ctenophorus isolepis</i>	Central Military Dragon													P					P	
<i>Ctenophorus nuchalis</i>	Central Netted Dragon													P						
<i>Diporiphora bennettii</i>														P						
<i>Diporiphora lalliae</i>														P	P					
<i>Diporiphora magna</i>											P		P	P						
<i>Diporiphora pindan</i>	Pindan Dragon				P	P	P	P	P		P		P	P	P		P	P		
<i>Pogona minor</i>	Dwarf Bearded Dragon					P	P	P	P	P	P		P	P			P	P		
DIPLODACTYLIDAE																				
<i>Crenadactylus ocellatus</i>	Clawless Gecko																		P	
<i>Diplodactylus conspicillatus</i>	Fat-tailed Gecko						P	P	P		P						P	P		

Family and Species	Common name	Conservation Status																		
		EPBC Act	BC Act	DBCA	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
<i>Lucasium stenodactylum</i>							P	P		P		P	P					P		
<i>Oedura rhombifer</i>						P												P		
<i>Rhynchoedura ornata</i>	Beaked Gecko												P					P		
<i>Strophurus ciliaris</i>						P	P	P		P		P	P				P	P		
GEKKONIDAE																				
<i>Gehyra australis</i>								P					P					P		
<i>Gehyra kimberleyi</i>					P													P		
<i>Gehyra nana</i>										P			P							
<i>Gehyra pilbara</i>							P	P	P	P			P	P				P		
<i>Gehyra punctata</i>							P							P						
<i>Gehyra purpurascens</i>																			P	
<i>Gehyra variegata</i>						P								P			P	P		
<i>Heteronotia binoei</i>	Bynoe's Gecko				P	P		P	P		P		P	P				P		
PYGOPODIDAE																				
<i>Delma borea</i>														P						
<i>Delma desmosa</i>																			P	
<i>Delma tincta</i>							P			P			P			P	P			
<i>Lialis burtonis</i>						P	P	P		P				P			P	P		
<i>Pygopus nigriceps</i>													P						P	
<i>Pygopus steelescotti</i>							P			P										
SCINCIDAE																				
<i>Carlia amax</i>																			P	
<i>Carlia munda</i>								P	P	P			P	P					P	
<i>Carlia rufilatus</i>					P		P	P		P									P	
<i>Carlia triacantha</i>													P						P	

Family and Species	Common name	Conservation Status																		
		EPBC Act	BC Act	DBCA	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
<i>Cryptoblepharus metallicus</i>								P	P	P	P							P		
<i>Cryptoblepharus ruber</i>							P	P	P	P			P					P		
<i>Cryptoblepharus tythos</i>																		P		
<i>Ctenotus angusticeps</i>	Airlie Island Ctenotus	VU		P3														P	P	
<i>Ctenotus colletti</i>	Buff-tailed Finesnout Ctenotus										P							P	P	
<i>Ctenotus sp. (leonhardii group)</i>																		P		
<i>Ctenotus pantherinus</i>	Leopard Ctenotus								P		P			P				P	P	
<i>Ctenotus robustus</i>											P			P					P	
<i>Ctenotus inornatus (former C. saxatilis)</i>	Bar-shouldered Ctenotus					P	P	P	P	P	P	P	P	P				P	P	
<i>Ctenotus saxatilis</i>	Rock Ctenotus																		P	
<i>Ctenotus serventyi</i>							P	P		P			P						P	
<i>Ctenotus uber johnstonei</i>	Spotted Ctenotus			P2				P										P		
<i>Cyclodomorphus melanops</i>	Slender Blue-tongue																	P		
<i>Eremiascincus isolepis</i>	Northern Bar-lipped Skink						P	P	P		P		P	P				P	P	
<i>Lerista apoda</i>								P	P	P	P								P	
<i>Lerista bipes</i>	North-western Sandslider							P	P		P			P				P	P	
<i>Lerista greeri</i>											P									
<i>Lerista griffini</i>					P			P	P					P					P	
<i>Lerista labialis</i>																			P	
<i>Lerista separanda</i>				P2				P											P	
<i>Liopholis kintorei</i>	Great Desert Skink	VU	VU																P	
<i>Menetia greyii</i>	Common Dwarf Skink							P										P	P	
<i>Menetia maini</i>	Northern Dwarf Skink										P							P	P	
<i>Morethia ruficauda</i>							P												P	

Family and Species	Common name	Conservation Status																		
		EPBC Act	BC Act	DBCA	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
<i>Morethia storri</i>	Top End Fire-tailed Skink						P	P	P	P			P				P	P		
<i>Notoscincus ornatus</i>	Ornate Soil-crevice Skink													P			P	P		
<i>Proablepharus tenuis</i>							P			P				P				P		
<i>Tiliqua multifasciata</i>	Central Blue-tongue						P							P				P		
<i>Tiliqua scincoides</i>	Eastern Blue-tongue					P	P	P		P		P	P	P			P	P		
VARANIDAE																				
<i>Varanus acanthurus</i>	Spiny-tailed Monitor					P				P				P				P		
<i>Varanus brevicauda</i>	Short-tailed Pygmy Monitor						P	P		P				P				P		
<i>Varanus eremius</i>	Pygmy Desert Monitor													P				P		
<i>Varanus gouldii</i>	Sand Monitor					P	P	P		P	P	P	P	P			O	P		
<i>Varanus panoptes</i>	Yellow-spotted Monitor					P	P							P				P		
<i>Varanus scalaris</i>	Spotted Tree Monitor												P	P						
<i>Varanus sparnus</i>	Dampier Peninsula goanna			P1						P							P	P		
<i>Varanus tristis</i>	Racehorse Monitor					P	P	P		P								P		
TYPHLOPIDAE																				
<i>Anilius diversus</i>	Northern Blind Snake						P	P					P	P			P	P		
<i>Anilius grypus</i>	Beaked Blind Snake													P				P		
BOIDAE																				
<i>Antaresia childreni</i>	Children's Python																	P		
<i>Antaresia stimsoni</i>	Stimson's Python					P	P			P			P	P				P		
<i>Aspidites melanocephalus</i>	Black-headed Python							P					P	P				P		
ELAPIDAE																				
<i>Acanthophis pyrrhus</i>	Desert Death Adder																			
<i>Brachyurophis roperi</i>	Northern Shovel-nosed Snake						P	P		P			P	P			P	P		
<i>Demansia angusticeps</i>	Narrow-headed Whipsnake						P	P		P				P			P	P		

Family and Species	Common name	Conservation Status																		
		EPBC Act	BC Act	DBCA	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
<i>Ephalophis greyae</i>	Mangrove Sea Snake																		P	
<i>Fordonia leucobalia</i>	White-bellied Mangrove Snake																		P	
<i>Furina ornata</i>	Moon Snake							P	P		P		P	P					P	
<i>Pseudechis australis</i>	Mulga Snake							P	P		P	P		P					P	
<i>Pseudonaja mengdeni</i>	Western Brown Snake							P	P		P		P	P				P	P	
<i>Simoselaps anomalus</i>	Desert Banded Snake																		P	
<i>Simoselaps minimus</i>	Dampierland Burrowing Snake			P2				P											P	
<i>Suta punctata</i>	Spotted Snake							P			P			P					P	

Amphibians

Family and Species	Common name	Conservation Status																		
		EPBC Act	BC Act	DBCA	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
HYLIDAE																				
<i>Cyclorana australis</i>	Giant Frog							P			P		P	P					P	
<i>Cyclorana cryptotis</i>	Hidden-ear Frog													P						
<i>Cyclorana longipes</i>	Long-footed Frog							P			P								P	
<i>Cyclorana vagitus</i>	Wailing Frog													P						
<i>Litoria caerulea</i>	Green Tree Frog							P	P		P			P	P			P	P	
<i>Litoria inermis</i>	Bumpy Rocket Frog														P					
<i>Litoria nasuta</i>	Striped Rocket Frog																		P	
<i>Litoria pallida</i>	Pale Rocket Frog														P					
<i>Litoria rothii</i>	Northern Laughing Tree Frog										P	P			P				P	
<i>Litoria rubella</i>	Little Red Tree Frog										P			P	P				P	
LIMNODYNASTIDAE																				
<i>Notaden nicholli</i>	Desert Spadefoot										P				P			P	P	
<i>Opisthodon ornatus</i>	Ornate Burrowing Frog							P	P		P								P	
MYOBATRACHIDAE																				
<i>Uperoleia aspera</i>	Derby Toadlet																		P	
<i>Uperoleia mjobergii</i>	Mjoberg's Toadlet														P			P	P	
<i>Uperoleia talpa</i>	Ratcheting Toadlet										P			P					P	

Appendix E: Bat Call Analysis Report



Acoustic analysis and bat call identification from Broome, Western Australia

Prepared for **Spectrum Ecology Pty Ltd**

Version **19 May 2020**

SZ project reference **SZ533**

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This report should be included as an appendix in any larger submission to Government, and cited as:

Specialised Zoological (2020). Acoustic analysis and bat call identification from Broome, Western Australia. Unpublished report by Specialised Zoological for Spectrum Ecology Pty Ltd, 19 May 2020, project reference SZ533.

Summary

Bat identifications from acoustic recordings are provided from near Broome, in the Kimberley region of Western Australia. The identification of bat species from full spectrum WAV-format recordings of their echolocation calls was based on measurements of characteristic frequency, observation of pulse shape, and the pattern of harmonics. At least six species of bat were identified as being present (**Tables 1** and **2**). The Bare-rumped Sheath-tailed Bat *Saccolaimus saccolaimus* was considered as a possibility (based on McKenzie et al. 2018), but was not detected. An assessment for evidence of the presence of *S. saccolaimus* was made in the context of seven criteria that can be helpful in separating several northern Australian bat species that emit calls with a relatively low characteristic frequency (25 kHz and lower; **Tables 3**). Representative echolocation calls for each identification are illustrated (**Figure 1**), as recommended by the Australasian Bat Society (ABS 2006). Further details are available should verification be required.

Methods

The data provided were recorded in full spectrum WAV format with Wildlife Acoustics Song Meter SM2BAT bat detectors (sampling rate 384 kHz, set to turn on automatically at sunset and off at sunrise).

A multi-step acoustic analysis procedure developed to process large full spectrum echolocation recording datasets from insectivorous bats (Armstrong and Aplin 2014; Armstrong et al. 2016) was applied to the recordings made on the survey. Firstly, the WAV files were scanned for bat echolocation calls using several parameter sets in the software SCAN'R version 1.8.3 (Binary Acoustic Technology), which also provides measurements (SCAN'R parameters) from each putative bat pulse. The outputs were then used to determine if putative bat pulses measured in SCAN'R could be identified to species. This was done using a custom [R] language script that performed three tasks: 1. undertook a Discriminant Function Analysis on training data from representative calls from northern Australia; 2. from the measurements of each putative bat pulse from SCAN'R, calculated values for the first two Discriminant Functions that could separate the echolocation call types derived from the analysis of training data, and plotted these resulting coordinates over confidence regions for the defined call types; and 3. facilitated an inspection in a spectrogram of multiple examples of each call type for each recording night by opening the original WAV files containing pulses of interest in Adobe Audition CS6 version 5.0.2.

Species were identified based on information in Churchill (2008), McKenzie and Bullen (2012), and the author's own unpublished material; and nomenclature follows Jackson and Groves (2015).

Comments on ambiguous identifications

Most species were identified unambiguously, but some call types have more than one possibility for their source. Calls with a characteristic frequency of c. 35–40 kHz could have been derived from the Hoary Wattled Bat *Chalinolobus nigrogriseus*, Little Broad-nosed Bat *Scotorepens greyii* or the Northern Broad-nosed Bat *Scotorepens sanborni*. Calls with a characteristic frequency of 40–44 kHz might have derived from *S. sanborni*.

Limitations

The identifications presented in this report have been made within the following context:

1. The identifications made herein were based on the ultrasonic acoustic data recorded and provided by a 'third party' (the client named on the front of this report).
2. The scope of this report extended to providing information on the identification of bat species in bulk ultrasonic recordings. Further comment on these species and the possible impacts of a planned project on bat species were not part of the scope.
3. In the case of the present report, the recording equipment was not set up and supplied by Specialised Zoological. The equipment was operated by the third party during the survey.
4. Other than the general location of the study area, Specialised Zoological has not been provided with detailed information of the survey area, has not made a visit to observe the habitats available for bats, nor have we visited the specific project areas on a previous occasion.
5. Specialised Zoological has had no input into the overall design and timing of this bat survey, recording site placement, nor the degree of recording site replication.
6. While Specialised Zoological has made identifications to the best of our ability given the available materials, and reserves the right to re-examine the data and revise any identification following a query, it is the client's and / or proponent's responsibility to provide supporting evidence for any identification, which might require follow-up trapping effort or non-invasive methods such as video recordings. Specialised Zoological bears no liability for any follow-up work that may be required to support an identification based initially on the analysis of acoustic recordings undertaken and reported on here.
7. There are a variety of factors that affect the 'detectability' of each bat species, given the frequency, power and shape characteristics of their calls. Further information on the analysis and the various factors that can impinge on the reliability of identifications can be provided upon request.
8. The analysis of ultrasonic recordings is one of several methods that can be used to survey for bats, and comprehensive surveys typically employ more than one method. If an identification in the present report is ambiguous or in question, a trapping programme would help to resolve the presence of the possibilities in the project area.

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Table 1. Species identified in the present survey from all sites combined.

EMBALLONURIDAE	
Yellow-bellied Sheath-tailed Bat	<i>Saccolaimus flaviventris</i>
VESPERTILIONIDAE	
Gould's Wattled Bat	<i>Chalinolobus gouldii</i>
Northern Pipistrelle	<i>Pipistrellus westralis</i>
<i>Ambiguous identifications</i>	
Hoary Wattled Bat /	<i>Chalinolobus nigrogriseus</i> /
and/or Little Broad-nosed Bat /	and/or <i>Scotorepens greyii</i> /
and/or Northern Broad-nosed Bat	and/or <i>Scotorepens sanborni</i>
MOLOSSIDAE	
Greater Northern Free-tailed Bat	<i>Chaerephon jobensis</i>
Northern Coastal Free-tailed Bat	<i>Ozimops cobourgianus</i>

Table 2. Species identifications, with the degree of confidence indicated by a code. Date and recording unit number correlates with site; see *Table 1* for full species names.

		<i>C. gouldii</i>	<i>C. jobensis</i>	<i>C. nigrogriseus</i> / <i>S. greyii</i> / <i>S. sanborni</i>	<i>O. cobourgius</i>	<i>P. westralis</i>	<i>S. sanborni?</i>	<i>S. flaviventris</i>
SM2BAT 6174	RRRP D2							
18/04/2020		—		NC	◆	—	◆	—
19/04/2020		—	—	NC	◆	◆	◆	◆
20/04/2020		—	—	NC	◆	—	◆	—
SM2BAT 6269	DoJ Option 2							
18/04/2020		◆	—	NC	◆	—	◆	◆
19/04/2020		◆	◆	NC	◆	—	—	—
20/04/2020		◆	—	NC	◆	◆	◆	◆
SM2BAT 6269	DoJ Option 3							
21/04/2020		◆	—	NC	◆	—	◆	◆
22/04/2020		◆	◆	NC	◆	—	◆	◆
23/04/2020		—	—	NC	◆	—	◆	◆
SM2BAT 6272	DoJ Option 1							
18/04/2020		—	—	NC	◆	—	◆	◆
19/04/2020		—	—	NC	◆	—	◆	—
20/04/2020		—	—	NC	◆	—	◆	—
SM2BAT 6272	RRRP G1							
21/04/2020		—	—	NC	◆	—	—	—
22/04/2020		—	◆	NC	◆	—	◆	—
23/04/2020		—	—	NC	—	—	◆	—

Definition of confidence level codes

— Not detected.

◆ Unambiguous identification of the species at the site based on measured call characteristics and comparison with available reference material. Greater confidence in this ID would come only after capture and supported by morphological measurements or a DNA sequence.

NC Needs Confirmation. Either call quality was poor, or the species cannot be distinguished reliably from another that makes similar calls. Alternative identifications are indicated in the *Comments on identifications* section of this report. If this is a species of conservation significance, further survey work might be required to confirm the record.

Table 3. Criteria used to attribute call types to the Bare-rumped Sheath-tailed Bat *Saccolaimus saccolaimus*. A tick or a cross indicates whether an observation consistent with that particular criterion was observed in the recordings from the present survey.

	Indicative of a species of <i>Saccolaimus</i>
✓	1. Characteristic frequency of the second (loudest, based on microphone sensitivity) harmonic between c. 20 and 25 kHz (Milne et al. 2009; K.N. Armstrong unpublished data; evident in AnaBat or full spectrum format data). This feature is indicative of, but not exclusively characteristic of <i>Saccolaimus</i> .
✓	2. In multi-harmonic representations available from full spectrum recordings, the characteristic frequency of the fundamental at around 10–12 kHz, and of the third harmonic around 30–35 kHz (K.N. Armstrong unpublished data; evident sometimes in AnaBat or more usually full spectrum format data; see examples of harmonic fragments in the AnaBat-recorded calls presented by Milne et al. 2009). This feature is indicative of, but not always exclusively characteristic of <i>Saccolaimus</i> , as one species of <i>Taphozous</i> can produce calls with a characteristic frequency slightly below 24 kHz.
✓	3. A pulse shape that is either curvilinear or serpentine (a typical curvilinear chirp with a terminal droop) (Milne et al. 2009; K.N. Armstrong unpublished data; evident in AnaBat or full spectrum format data). Pulses meeting this criterion are indicative of, but not exclusively characteristic of <i>Saccolaimus</i> .
✗	4. Measurements from pulses that fall within the confidence region of <i>S. saccolaimus</i> in an ordination plot constructed from the Discriminant Function Analysis of a range of low frequency emitting bats from northern Australia (K.N. Armstrong manuscript in prep.). Pulses meeting this criterion are indicative of, but not exclusively characteristic of <i>S. saccolaimus</i> . Note that there is often variation from other low frequency emitting species and other non-mammalian signals that can fall close to the cluster centroid of <i>S. saccolaimus</i> , so points falling within the confidence region of this species are not absolutely diagnostic. The original WAV files represented by points in the confidence region for <i>S. saccolaimus</i> were checked in a spectrogram.
✗	5. Feeding buzz shape differing from that of the Yellow-bellied Sheath-tailed Bat <i>S. flaviventris</i> (an example from the project recordings in Figure 2) as described by Corben (2010, 2011), which is diagnostic in the absence of the Papuan Sheath-tailed Bat <i>S. mixtus</i> (K.N. Armstrong unpublished data; evident in AnaBat or full spectrum format data). Attack phase calls also have strongly drooped terminating portions.
	Diagnostic of the species <i>Saccolaimus saccolaimus</i> (given criteria 1–5) in sympatry with <i>S. mixtus</i>.
✗	6. Alternation of high and low characteristic frequency in successive pulses within the band 20–25 kHz (Milne et al. 2009; evident in AnaBat or full spectrum format data).
✗	7. Repeated triplet or doublet pulse sequences as described by Coles et al. (2012, 2014) and Meutstege et al. (2014) (evident in full spectrum format data only).

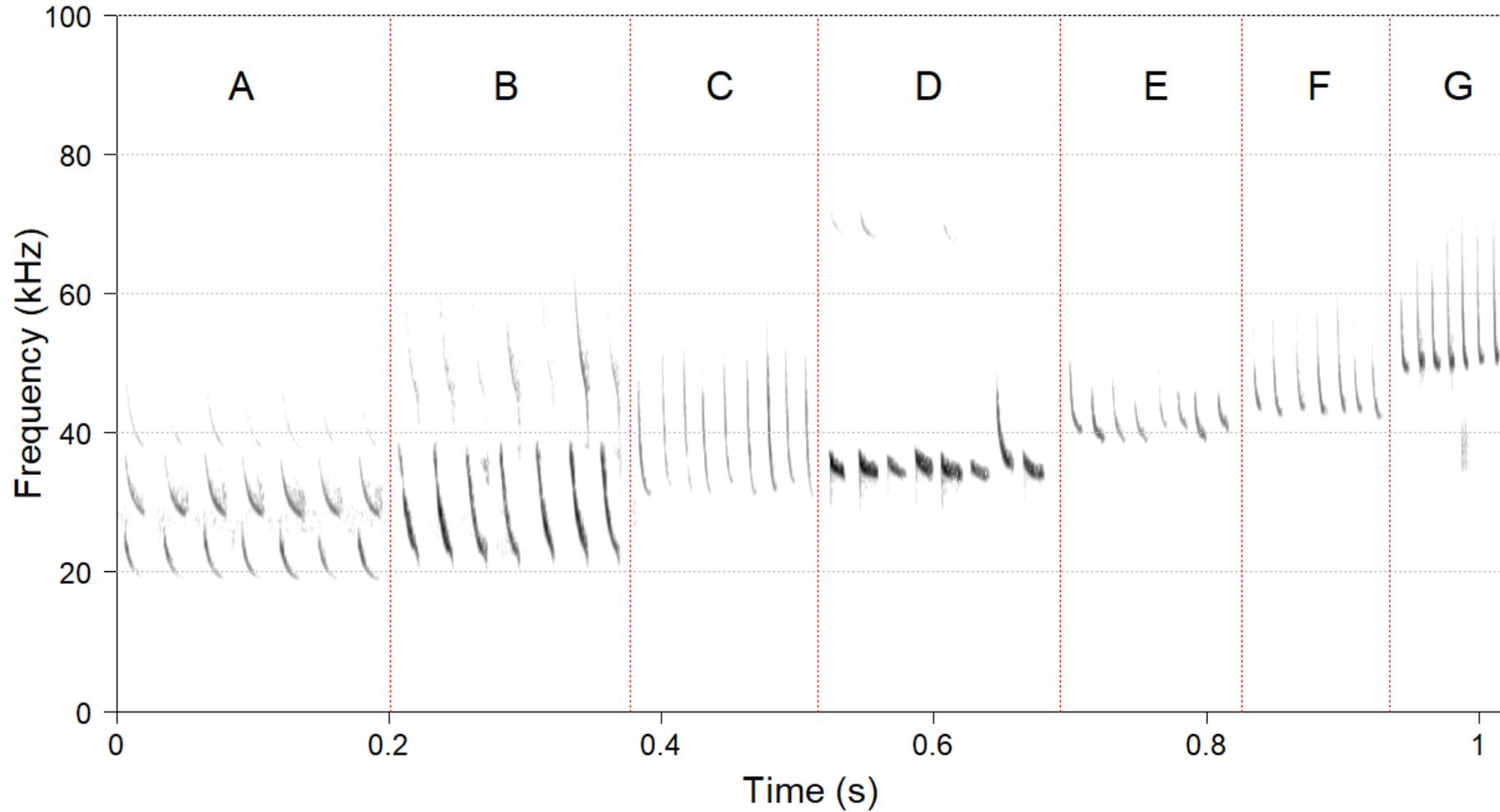


Figure 1. Representative echolocation call sequence portions of the species identified (**A:** *Saccolaimus flaviventris*; **B:** *Chaerephon jobensis*; **C:** *Chalinolobus gouldii*; **D:** *Ozimops cobourgianus*; **E:** *Chalinolobus nigrogriseus* / *Scotorepens greyii* / *Scotorepens sanborni*; **F:** *Scotorepens sanborni*?; **G:** *Pipistrellus westralis*; time between pulses has been compressed).

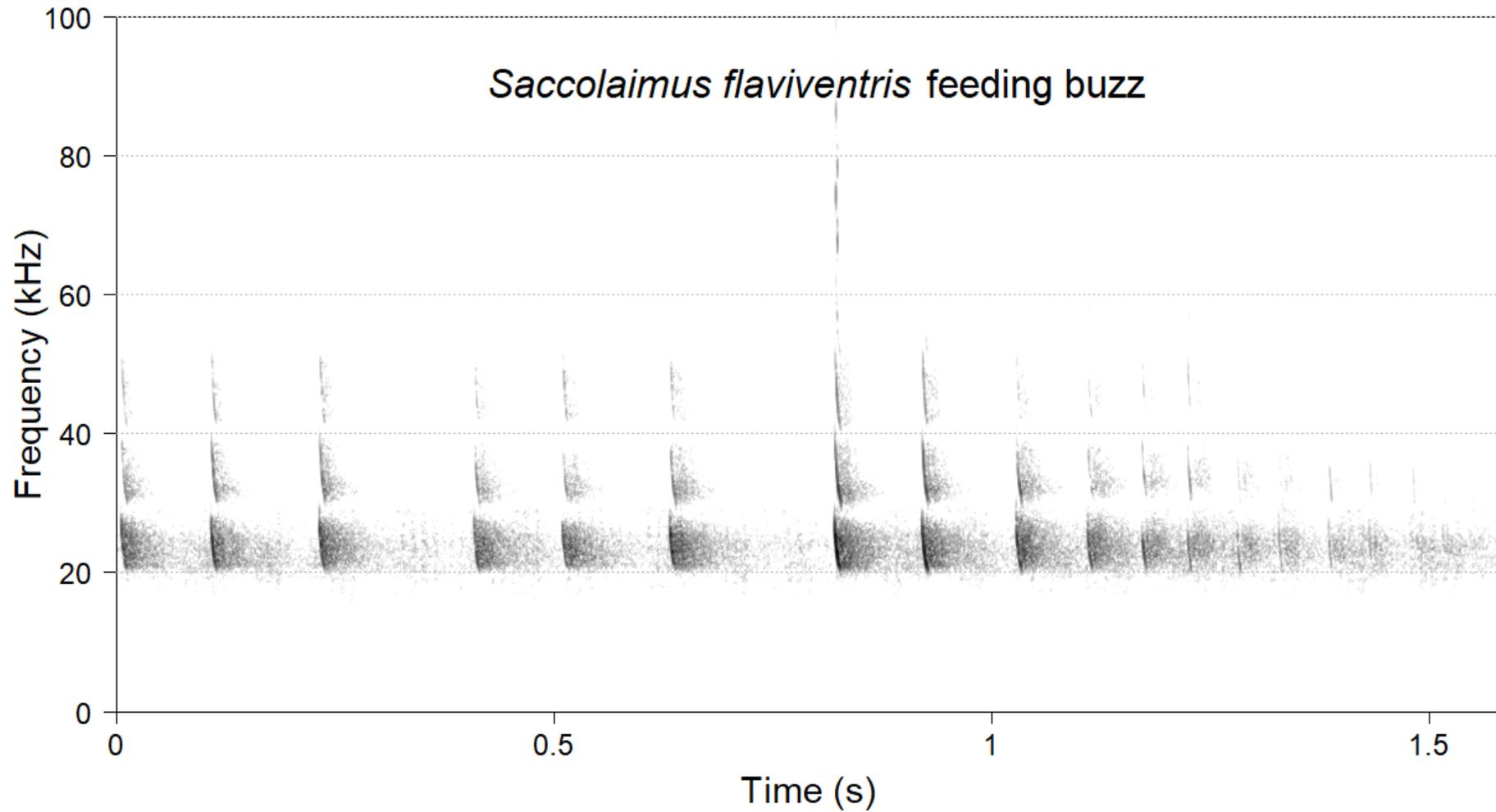


Figure 2. Confirmation of *Saccolaimus flaviventris* based on the slightly curvilinear shape of the approach calls and beginning of a feeding buzz (cf. serpentine shape in *S. saccolaimus*; Corben 2010, 2011).

Appendix F: SRE Genetic Sequencing Report





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15th June 2020

Broome Waste Storage Facility Short-range Endemic Genetics Results

This memo presents data from genetics work carried out on SRE species collected from the proposed Broome Regional Resource Recovery Park (RRRP). The Shire of Broome is investigating two locations for the placement of the Broome Regional Resource Recovery Park (RRRP). The two prospective sites are 'D2', which is located 9 km north of the Broome township on the south side of the Mcguigan and Broome – Cape Leveque road intersection; and 'G1', which is located 32 km northeast of the township on the north side of the Great Northern Highway. As a part of planning for this project, environmental surveys including a Short-Range Endemic (SRE) have been conducted.

Bennelongia Environmental Consultants (BEC) were commissioned to identify SRE specimens collected at the Broome RRRP proposed sites. The specimens were processed in conjunction with specimens collected from another project in close proximity. A total of 5 animals were collected during on site surveys, including two spider specimens and three scorpions. Morphological identifications were conducted and genetic analysis was performed to support and confirm the morphological identifications. The results of the genetical analysis are presented below.

Spiders

The two spiders collected are males of a new species of *Aname*, a genus of trap-door spiders from the family Nemesiidae. This family has been relatively well studied through recent phylogenetic work, along with the description of a new genus and four new species of *Aname* (Castalanelli *et al.* 2017; Harvey *et al.* 2012), providing a good taxonomic framework. The genus *Aname* is endemic to Australia, currently with 37 valid species (Atlas of Living Australia), out of which 11 were first collected in Western Australia. These spiders inhabit inland dry open country, and four of them have been recorded in the Pilbara before: *A. aragog*, *A. ellenae*, *A. marae* and *A. mellosa*. However, the individuals collected by Spectrum Ecology are not morphologically consistent with any of these valid species, or to any of the additional six undescribed species previously collected by BEC. Therefore, the specimens received the morphospecies name *Aname* sp. BMYG165. To confirm the status of *A.* sp. BMYG165 as a new species, DNA sequences from the two specimens were obtained for the MT-CO1 gene, amplified with the primers LCO1490 (forward) and HCO2198 (reverse) as per Folmer *et al.* (1994). Sequences were then edited and aligned in Geneious (Kearse *et al.* 2012) with the MUSCLE algorithm using default parameters. Interestingly, the two specimens of BMYG165 were genetically identical, although the sequences obtained differed in length (606 base pairs for *A.* sp. BMYG165A and 490 base pairs for *A.* sp. BMYG165B). Taken together with the morphology, this is strong evidence that males collected are conspecifics.



In order to have a framework for assessing intra and interspecific variation, as well as to investigate the genetic affinity of *Aname* sp. BMYG165 with other species of *Aname*, 90 additional sequences were obtained from: (a) GenBank, via a BLAST search using the consensus of both sequences of *A. sp.* BMYG165; and (b) from the taxonomic literature, including all sequences found for *Aname* spp. and *Ummidia picea* (family Halonoproctidae), used as the outgroup. The full set of 92 sequences were included in a phylogenetic analysis estimated using neighbour-joining in Geneious Tree Builder and the Tamura-Nei genetic distance model. The consensus tree was obtained with 1,000 bootstraps and a clade support threshold of 50%.

The phylogenetic analysis based on MT-CO1 (Figure 1) retrieved the monophyly of several species of *Aname* and revealed the relationship between some of these species. Regarding *A. sp.* BMYG165, the analysis indicates that this species is separate from all other species in the sample, but failed to reveal its sister species. The table of pairwise genetic divergences (% different base pairs) however indicates that *A. sp.* BMYG165 is a new species and presents divergences of at least 12.2 % from its closest relatives, whereas typical intraspecific divergences in the genus are up to 5.2 % at a maximum (Table 1).

Table 1: Intra (bold) and interspecific genetic divergences (% different base pairs) in sequences of mt-CO1 from species of *Aname* included in the phylogenetic analysis presented in figure 1. For brevity, we only show the five closest species (based on least divergence) to *A. sp.* BMYG165, along with its new sequences (highlighted in green).

Species (number of sequences)	<i>Aname ellenae</i>	<i>Aname</i> sp. MYG331	<i>Aname</i> sp. BMYG165	<i>Aname</i> sp. B11
<i>Aname ellenae</i> (5)	0.2 – 5.2			
<i>Aname</i> sp. MYG331 (3)	12.3 – 13.1	0.2 – 0.3		
<i>Aname</i> sp. BMYG165 (2)	12.2 – 14.5	13.5 – 14.7	0	
<i>Aname</i> sp. B11 (1)	13.7 – 14.3	13.2	14.3 - 14.4	-
<i>A. sp.</i> MYG288-DNA (1)	10 - 11.2	8.1	14.5-14.7	13.1

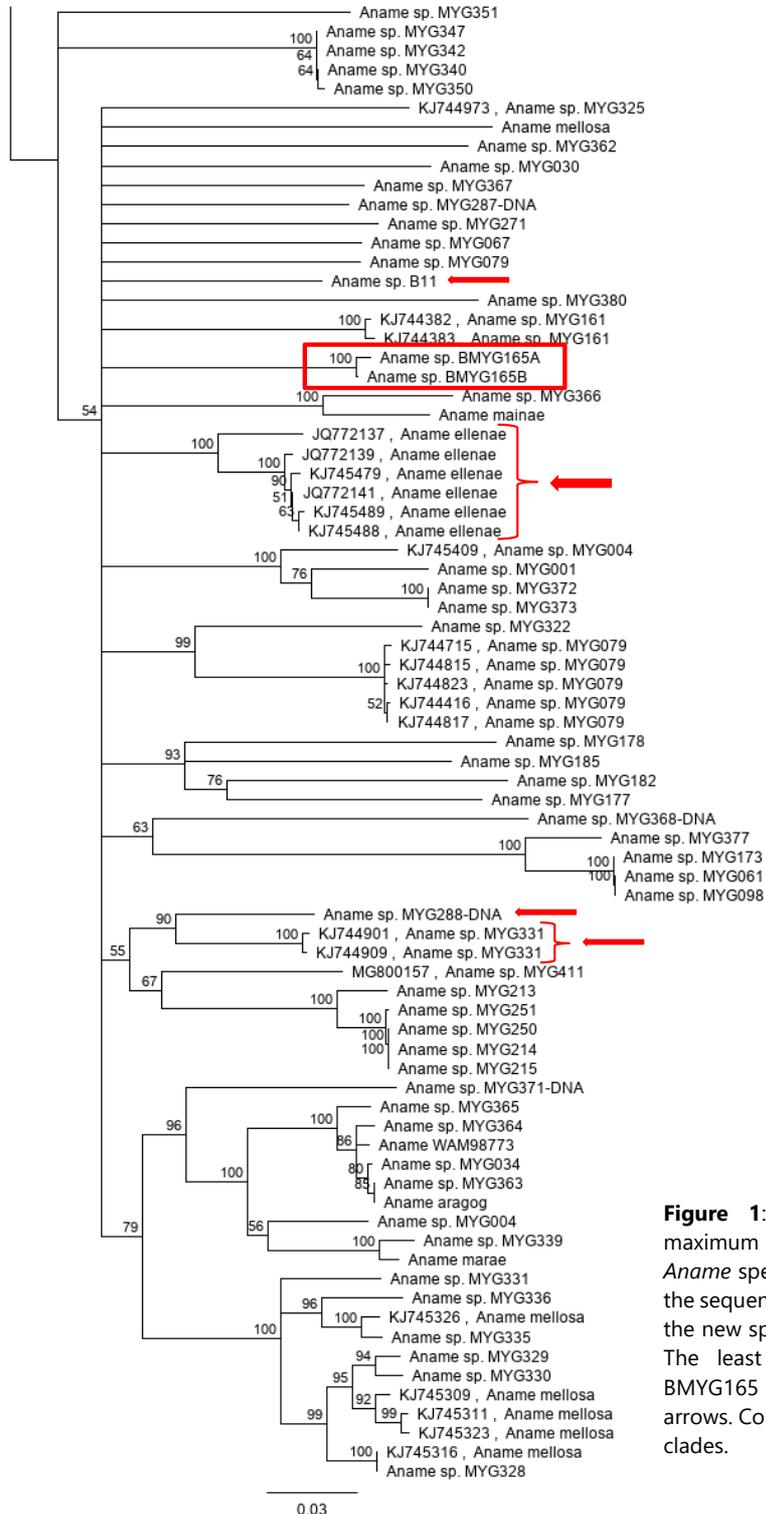


Figure 1: Consensus tree estimated via maximum likelihood showing the ingroup (all *Aname* species) and indicating the position of the sequences obtained from the specimens of the new species *A. sp. BMYG165* in a red box. The least divergent sequences to *A. sp. BMYG165* (**Table 1**) are indicated with red arrows. Consensus support (%) is shown for all clades.



Scorpions

The three specimens of scorpions collected are from the genus *Lychas*, one of the five genera of Buthidae that occur in Australia (along with *Australobuthus*, *Hemilychas*, *Isometroides* and *Isometrus*). *Lychas* currently contains five valid species in Australia (*L. buchari*, *L. jonesae*, *L. marmoreus*, *L. mjobergi*, *L. variatus*), four of which have been collected from the Pilbara; the exception is *L. marmoreus*, which is widespread throughout Australia. Unfortunately however, the majority of *Lychas* species in Australia are yet to be described (Volschenk *et al.* 2010), and we found an additional 24 species of that genus in the grey literature and in the database of BEC. Nonetheless, the specimens collected by Spectrum Ecology are not morphologically consistent with any of these previously collected species. Two of them were morphologically indistinguishable from each other (individuals collected from G1:SPEC21 and D2:SPEC20 [Field code : Site code]), and therefore received the morphospecies name *Lychas* sp. BSCO048, whereas the third individual (Option1:SPEC19) received the morphospecies name *Lychas* sp. BSCO047.

To further investigate the new species status and their genetic affinities, DNA sequences were obtained for the MT-CO1 gene in the same way and using the same primers as described for the spiders. Given that Australian *Lychas* are yet to be studied in a phylogenetic context, we used a recent phylogeny of species of the family Buthidae from India (Suranse *et al.* 2017) to provide a framework for our molecular analysis. We also obtained 100 additional sequences from GenBank, via a BLAST search using the consensus of all three sequences obtained from the specimens. This search returned: (a) 10 sequences from at least three other species of *Lychas*; (b) 88 sequences from six other genera of Buthidae – *Hottentotta* (1 species), *Mesobuthus* (2 species), *Heteroctenus* (3 species), *Centruroides* (18 species), *Isometrus* (2 species) and *Zabius* (2 species); and (c) two sequences of *Brachistosternus ehrenbergii* (family Bothriuridae), used as an outgroup. All 103 sequences were included in a phylogenetic analysis estimated using neighbour-joining in Geneious Tree Builder and the Tamura-Nei genetic distance model. The consensus tree was obtained with 1,000 bootstraps and 50% clade support threshold.

The phylogenetic analysis (Figure 2) retrieved the monophyly of Buthidae and several of its genera, and revealed some relationships between them. The monophyly of *Lychas* was not supported, but the analysis corroborates the placement of the three new specimens in two new species (*L.* sp. BSCO047 and *L.* sp. BSCO048). Table 2 further indicates that these new species are divergent from all others at 12.4%–17.1%, which is more consistent to interspecific (9.7%–17.2%), rather than intraspecific divergence (7.4% or less) in the Buthidae. Finally, the two individuals of BSCO048 are only 4.1% divergent from each other, whereas *L.* sp. BSCO047 and *L.* sp. BSCO048 diverge in 11.2%. These intra and interspecific divergences are consistent with a previous study on Buthidae (Suranse *et al.* 2017).



Table 2: Intra (**bold**) and interspecific genetic divergences (% different base pairs) in sequences of mt-CO1 from species of *Lychas* and related buthid genera included in the phylogenetic analysis presented in figure 2. For brevity, we only show the five closest species (based on least divergence) to *L. sp.* BSCO047 and *L. sp.* BSCO048, along with their new sequences (highlighted in green).

	<i>Heteroctenus</i>		<i>Lychas</i>			
	<i>abudi</i>	<i>junceus</i>	<i>mucronatus</i>	sp.	<i>tricarinatus</i>	BSCO048
<i>Heteroctenus abudi</i>	0 – 1.8					
<i>Heteroctenus junceus</i>	9.7 – 11.7	0.7 – 5.2				
<i>Lychas mucronatus</i>	15.6 – 15.8	15.3 – 16.2	-			
<i>Lychas sp.</i> (MN436716, MN436720)	16 - 17	16.3 – 17.2	14.7 – 15.1	1.5		
<i>Lychas tricarinatus</i>	15.9 – 15.7	14.3 – 16.1	15.5 – 16.2	14.3 – 15.9	0 - 7.4	
<i>Lychas sp.</i> BSCO048	15.4 - 16	14.9 – 16.1	14.1 – 14.4	13.4 – 14.7	14.4 – 17.7	4.1
<i>Lychas sp.</i> BSCO047	16.9 – 17.1	15.7 – 16.8	14.2	12.4 – 13.1	14.8 – 15.3	11.2

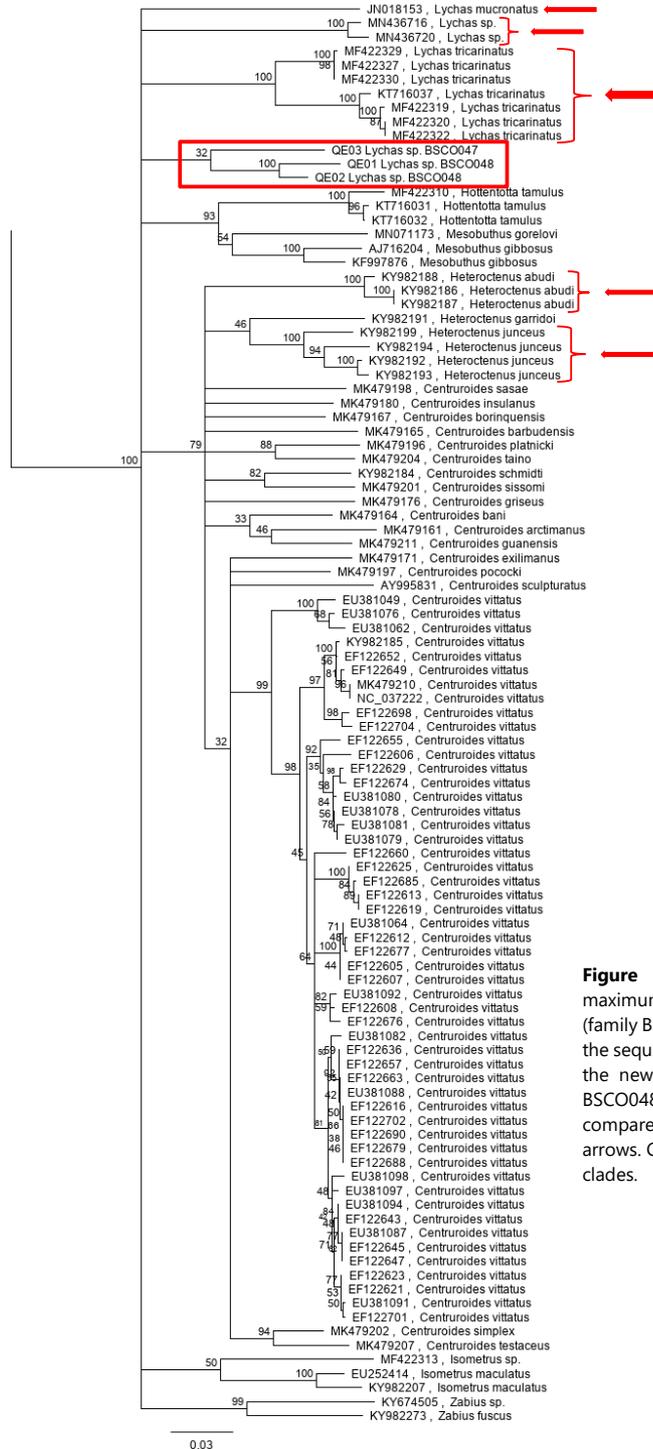


Figure 2: Consensus tree showing the estimated maximum likelihood showing the ingroup (family Butthidae) and indicating the position of the sequences obtained from the specimens of the new species *L. sp. BSCO047* and *L. sp. BSCO048* in a red box. The sequences compared in **Table 1** are indicated with red arrows. Consensus support (%) is shown for all clades.



Conclusions

Genetic sequencing confirmed the morphological identifications conducted by BEC, confirming that the two specimens of *Aname* spiders are representatives of the same species. It also confirmed that this is a new species that has not been collected previously. Assigned the name *Aname*. sp. BMYG165, this new species presents divergences of at least 12.2 % from its closest relatives, whereas typical intraspecific divergences in the genus are up to 5.2 % at a maximum.

Morphological identifications indicated that the three specimens of scorpion collected from the Broome RRRP were representatives of two species. Genetic analysis confirmed this, and the species have been assigned the morphospecies names *Lychas* sp. BSCO048, and *Lychas* sp. BSCO047. Genetic analysis also confirmed that these are distinct species that have not been previously collected as they have 12.4%–17.1% divergence from other closely known species.

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