Biota Environmental Sciences

Asian Renewable Energy Hub Terrestrial Fauna and SRE Fauna Survey

Prepared for NW Interconnected Power

November 2018

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Project No.: 1290C

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Document Quality Checking History

Version:	1	Peer review:	S. Schmidt, P. Brooshooft
	Rev 0	Director review:	G. Humphreys
	Rev 0	Format review:	G. Humphreys
		Approved for issue:	G. Humphreys

Asian Renewable Energy Hub Level 2 Terrestrial Fauna and SRE Fauna Survey

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1.1 Project Background

NW Interconnected Power Pty Ltd is seeking to develop the Asian Renewable Energy Hub. The proposal is to construct and operate a large-scale wind and solar hybrid renewable energy project (hereafter 'the project') at a site approximately 220 km east of Port Hedland and 270 km southwest of Broome, in the northwest of Western Australia. The project will be constructed within a 660,686 ha development envelope (hereafter 'the study area').

Biota was commissioned to conduct a Level 2 terrestrial fauna survey and targeted sampling for conservation significant fauna and short-range endemic (SRE) fauna. The first phase of the terrestrial fauna survey was carried out from 24th August – 5th September 2017. The second sampling phase of the survey was undertaken from 13th – 21st March 2018, following summer rainfall.

All surveys were completed as far as practicable in accordance with relevant State and Commonwealth policy, with key policy and guidelines that were considered including:

- Environmental Factor Guideline: Terrestrial Fauna (EPA 2016a);
- Technical Guide - Terrestrial Fauna Surveys (EPA 2016b); and
- Technical Guide - Sampling of Short Range Endemic Invertebrates (EPA 2016c).

1.2 Methods

A total of 22 fauna trapping sites were installed across the study area, representatively sampling the range of habitat types present. Sixteen sites comprised a systematic trapping regime of 10 pitfall traps and four funnel traps and were sampled during both phases for up to eight consecutive nights. The remainder of the trapping sites comprised Elliott, cage and funnel traps as appropriate to habitat and fauna being targeted. Birds were sampled via dedicated censuses at the trapping sites as well as in other areas of favourable habitat identified during the course of the survey. Additional bird census work was conducted outside of the two phases of the terrestrial fauna survey during a separate study (also conducted by Biota 2018a), which targeted migratory shorebird species in relation to the proposal. This latter study also incorporated the long-term deployment of automated acoustic recorders for birdcalls, which were scanned for Night Parrot calls and any other birds recorded were also noted. All records of terrestrial birds, including those recorded from the study area during the migratory shorebird study, have been included in this report, while all survey effort relating primarily to shorebirds, and results of that survey from outside of the current study area, are reported separately (Biota 2018a).

In addition to systematic sampling, passive sampling methods such as remote cameras and ultrasonic bat call recorders, were placed at locations identified as having the potential to support conservation significant fauna.

Sampling of potential SRE invertebrate fauna was also undertaken using a combination of dry pitfall trapping and hand searching at a range of sites considered to comprise prospective habitat for groups supporting SRE species, utilising method consistent with those identified in EPA (2016c).

1.3 Vertebrate Fauna

A total of 177 vertebrate fauna species were recorded from the study area during the seasonal survey. While the study area is situated on the boundary of the Pilbara and Kimberley, the faunal assemblage showed a strong association with the Pilbara bioregion and very few species with typical Kimberley distributions were recorded. The locality has been subject to little previous fauna survey effort and the records of a number of species represented northerly extensions to their previously known distributions.

1.3.1 Mammals

Thirty-one mammal species were recorded comprising 18 native non-volant (ground-dwelling) species, nine bats species and five introduced species. The native non-volant mammal fauna consisted of four macropods, seven dasyurid marsupials, one notorcytid marsupial, one thylacomyid marsupial, four murid rodents and one canid. The introduced mammal species recorded were the House Mouse, Camel, Fox, Dog and Feral Cat.

The most abundant native mammals recorded from the study area were the Long-tailed Planigale (*Planigale ingrami),* the Spinifex Hopping-mouse (*Notomys alexis)* and the Sandy Inland Mouse (*Pseudomys hermannsburgensis*). Seven mammal species of conservation significance were recorded during the survey: Black-footed Rock-wallaby (*Petrogale lateralis lateralis* - Schedule 2; Endangered), Northern Quoll (*Dasyurus hallucatus* - Schedule 2; Endangered), Bilby (*Macrotis lagotis* - Schedule 3; Vulnerable), Western Pebble-mound Mouse (*Pseudomys chapmani* - Priority 4), Brush-tailed Mulgara (*Dasycercus blythi* - Priority 4), Spectacled Hare-wallaby (*Lagorchestes conspicillatus* - Priority 4) and the Northern Marsupial Mole (*Notoryctes caurinus* - Priority 4).

Nine bat species were identified from ultrasonic call recordings, comprising two from the family Emballonuridae, three from the family Molossidae and four from the family Vespertilionidae. The most frequently recorded species were the Common Sheath-tailed Bat (*Taphozous georgianus*) and Gould's Wattled Bat (*Chalinolobus gouldii*). None of the bat species recorded during the survey were of elevated conservation significance.

1.3.2 Birds

Sixty-eight bird species from 26 families were recorded. The most species-rich families recorded were the Accipitridae (all diurnal raptors except falcons and kestrels), with eight species, and the Meliphagidae (honeyeaters and chats), with seven species. The most abundant bird species were the Singing Honeyeater (*Lichenostomus virescens*) and the Crimson Chat (*Epthianura tricolor*), which accounted for 26% and 18% respectively of all individual bird records from the study area (1,889 individuals). One species of elevated conservation significance, the Oriental Pratincole (*Glareola maldivarum* - Schedule 5; Migratory), was recorded opportunistically during the migratory shorebird study (Biota 2018a), but was recorded within terrestrial habitat feeding over spinifex.

1.3.3 Reptiles

The recorded reptile assemblage consisted of 73 species inclusive of one turtle species, 16 species of gecko, five legless lizards, nine dragons, 24 skinks, six goannas, three blind snakes, two pythons and seven elapid snake species. Two conservation significant reptiles were recorded: the Flatback Turtle (*Natator depressus* - Schedule 3; Vulnerable, Marine, Migratory), which was only recorded from a body hole on Eighty Mile Beach at the northernmost limit of the study area, and the Dampier Plain Slider (*Lerista separanda* - Priority 2).

1.3.4 Amphibians

Four frog species were recorded across the two phases of survey. The most commonly recorded species was the Desert Spadefoot (*Notaden nichollsi*). No frogs of conservation significance were recorded or have distributions overlapping the study area.

1.4 Vertebrate Fauna of Conservation Significance

Eleven vertebrate species of conservation significance were recorded in the study area during the survey, comprising:

- Bilby (*Macrotis lagotis*) – Schedule 3; Vulnerable;
- Black-footed Rock-wallaby (*Petrogale lateralis lateralis*) – Schedule 2; Endangered;

- Northern Quoll (*Dasyurus hallucatus*) – Schedule 2; Endangered;
- Flatback Turtle (*Natator depressus*) – Schedule 3; Vulnerable, Marine, Migratory;
- Oriental Pratincole (*Glareola maldivarum*) - Schedule 5; Migratory;
- Rainbow Bee-eater (*Merops ornatus*) - Marine
- Dampierland Plain Slider (*Lerista separanda*) – Priority 2;
- Spectacled Hare-wallaby *Lagorchestes conspicillatus* – Priority 3;
- Brush-tailed Mulgara (*Dasycercus blythi*) – Priority 4;
- Northern Marsupial Mole (*Notoryctes caurinus*) – Priority 4; and
- Western Pebble-mound Mouse (*Pseudomys chapmani*) – Priority 4.

Previous records and habitat availability indicate a further five conservation significant species are likely to occur, but no evidence of any of these was recorded during the seasonal survey.

1.5 Invertebrate Fauna

In total, 63 invertebrate fauna samples were collected from a combination of dry pitfall trapping and targeted searching of microhabitats likely to support potential SRE fauna.

The collected specimens comprised 29 mygalomorph spiders from 10 sampling locations, 10 scorpions from four sampling locations, and 24 land snails from four sampling locations. None of the land snail or scorpion specimens represented SRE taxa.

Three potential SRE taxa, all trapdoor spiders, were recorded from the study area, but they are likely to be more widespread, considering all three came from widely-connected sandplain habitats with no barriers to dispersal, within the very widespread Nita and Little Sandy land systems.

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2.0 Introduction

2.1 Project Background

NW Interconnected Power Pty Ltd is seeking to develop the Asian Renewable Energy Hub. The proposal is to construct and operate a large-scale wind and solar hybrid renewable energy project (hereafter 'the project') at a site approximately 220 km east of Port Hedland and 270 km southwest of Broome, in the northwest of Western Australia (Figure 2.1). The project will be constructed within a 660,686 ha development envelope (hereafter 'the study area').

The onshore components of the project will comprise a series of linear arrays of wind turbines and solar panels, with a transmission cable corridor to the coast. The offshore component of the proposal comprises two inert subsea power cables, with the marine component of the current proposal only extending to the limit of State Waters (Commonwealth Waters and any international permitting required will be the subject of a separate assessment).

2.2 Study Objectives and Scope

Biota Environmental Sciences (Biota) was commissioned to conduct a Level 2 terrestrial vertebrate fauna survey with targeted sampling for conservation significant fauna species, and sampling for potential short-range endemic (SRE) invertebrate fauna within the study area.

A comprehensive survey for migratory shorebirds and waterbirds has also been undertaken for the project and is reported separately (Biota 2018a). Separate studies conducted by BMT Global (2018) have assessed the potential for the project to impact the marine environment, including marine fauna. Given the scope of those concurrent studies, only fauna likely to utilise the terrestrial habitats of the study area are addressed here.

This study is intended for use as a supporting document for the environmental impact assessment of the proposal, which has been referred under Section 38 of the *Environmental Protection Act 1986* (EP Act). The project is also being assessed as controlled action under the terms of the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), and the document provides technical support and data to inform that assessment.

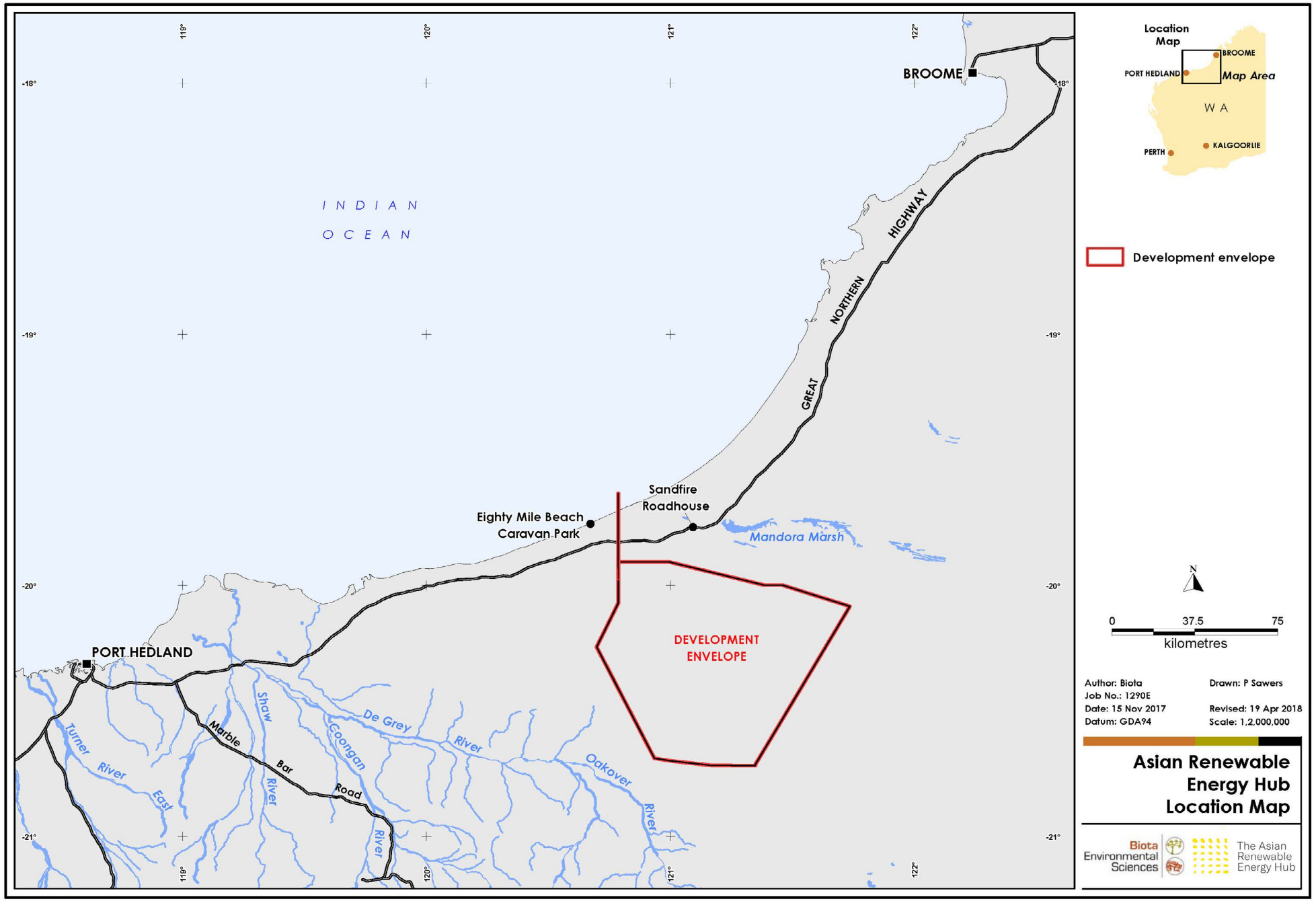


Figure 2.1: Location of the study area.

3.0 Existing Environment

3.1 IBRA Bioregions and Subregions

The Interim Biogegographic Regionalisation of Australia (IBRA) identifies 85 bioregions across Australia (Environment Australia 2000). The study area is located within the Dampierland and Great Sandy Desert IBRA bioregions, and includes sections of three subregions within these:

- The Dampierland bioregion is divided into two subregions, with the Pindanland subregion relevant to the western part of the study area.
- The Great Sandy Desert bioregion is divided into six subregions, two of which are relevant: McLarty and Mackay dominate the inland sections of the study area (Figure 3.1).

These subregions are summarised as follows:

- The Pindanland subregion (5,198,904 ha) "comprises sandplains of the Dampier Peninsula and western part of Dampier Land, including the hinterland of the Eighty Mile Beach. It is a fine-textured sand-sheet with subdued dunes and includes the paleodelta of the Fitzroy River. This is the coastal, semi-arid, northwestern margin of the Canning Basin. The climate is described as dry hot tropical and semi-arid with summer rainfall. The average annual rainfall is between 450 – 700 mm, slightly lower than the Fitzroy Trough subregion" (Graham 2003a). The vegetation is described primarily as pindan, but includes *Melaleuca alsophila* low forests on coastal plains, and *Spinifex* spp. – *Crotalaria* spp. strand communities (Graham 2003a).
- The McLarty subregion (13,173,266 ha) "includes the Mandora paleoriver system and red-brown dunefields with finer texture than further south. It also includes gravelly surfaces of Anketell Ridge along its northern margin. The subregion is arid tropical with summer rain and is influenced by monsoonal activity. Morning fogs are recorded during the dry season. The vegetation is mainly tree steppe grading to shrub steppe in the south; comprising open hummock grassland of *Triodia pungens* and *Triodia schinzii* with scattered trees of *Owenia reticulata* and Bloodwoods (*Corymbia* spp.), and shrubs of *Acacia* spp., *Grevillea wickhamii* and *G. refracta*, on Quaternary red longitudinal sand dune fields overlying Jurassic and Cretaceous sandstones of the Canning and Armadeus Basins. Gently undulating lateritised uplands support shrub steppe" (Graham 2003b). Wetland features in the subregion include isolated mound springs supporting *Melaleuca leucadendra* closed forests, and *Melaleuca glomerata - M. lasiandra* shrublands around salt lakes (Graham 2003b).
- The Mackay subregion (18,636,695 ha) comprises the "tropical inland 'red-centre' desert, and includes the 'Percival' and 'Auld' palaeoriver systems. The climate is arid tropical with summer rainfall, and monsoonal influences are apparent in the northwestern sector of this region" (Kendrick 2003). Vegetation is similar to the McLarty subregion.

3.2 Conservation Reserves

The nearest conservation reserves to the study area comprise the following (all distances are from the closest point of the study area):

- **Eighty Mile Beach Marine Park** – a small section at the northern end of the transmission cable corridor extends into this park, which incorporates the Kujungurru-Warrarn Nature Reserve on its inland margin.
- **Walyarta Conservation Park (Mandora Marsh)** – the southwestern corner of this park abuts the northeastern boundary of the study area.
- **Ex-Meentheena Station Conservation Reserve** – 50 km southwest of the study area (Figure 3.1).

In addition, the main study area lies entirely within the western section of the Nyangumarta Warrarn Indigenous Protected Area (IPA). The transmission cable corridor follows a cleared track along the eastern edge of Wallal Downs Station, at its boundary with Mandora Station

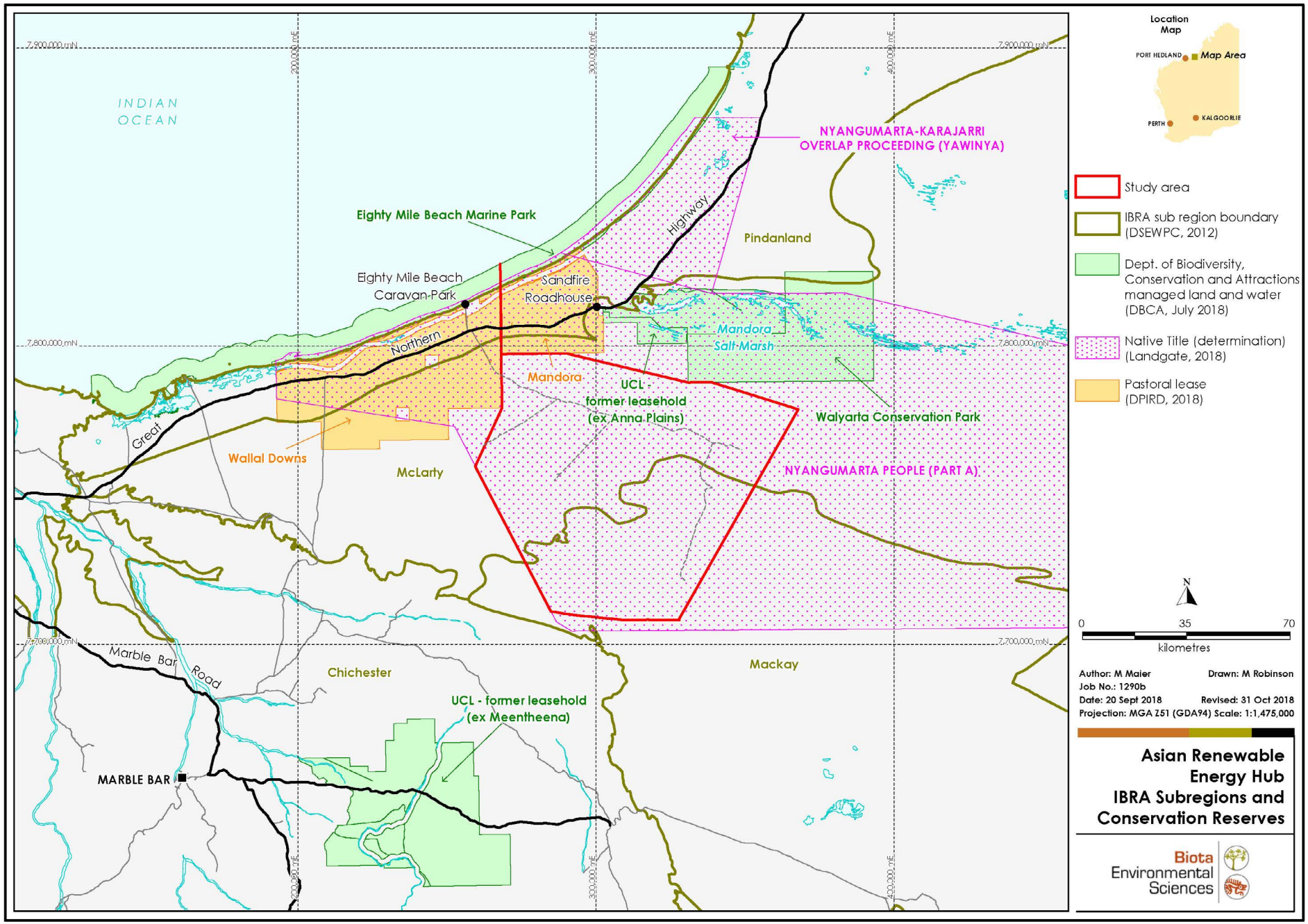


Figure 3.1: IBRA sub-regions and conservation reserves in proximity to the study area.

3.3 Land Systems

The then Department of Agriculture Western Australia mapped land systems for the Rangelands regions of WA, including much of the study area (van Vreeswyk et al. 2004). This classification divides the region into broad units (land systems), each consisting of a series of "land units" that occur on characteristic physiographic types within the land system. The study area intersects eight land systems; Anna, Buckshot, Callawa, Eighty Mile, Little Sandy, Mannerie, Nita and Robertson (Table 3.1 and Figure 3.2). Assessment of the regional extent of these land systems is complicated by a lack of mapping for large areas of the Great Sandy Desert, mostly south and east of the study area (van Vreeswyk et al. 2004, Payne and Schoknecht 2011). This included a portion of the study area, and the eastern margin of the study area was therefore extrapolated from surrounding land systems based on aerial imagery. The extent of some land systems in the broader locality may therefore be greater than is indicated by the available data.

The study area is dominated by two land systems; the Nita land system occupying the northwestern half (55.1%) and the Little Sandy land system occupying most of the southeast (38.4%). These land systems both feature sandy substrates with vegetation dominated by hummock grasses, the most significant difference between the two being the significant east-west dune systems dominating the Little Sandy land system. The Buckshot (1.1%) and Callawa (5.4%) land systems contain most of the low stony rise and rocky habitats in the study area and tend to occur in close geographic association. Most of the remaining land system mapping represents coastal or near-coastal habitats: the Anna, Eighty Mile and Mannerie land systems together comprise 0.006% of the study area and are only intersected by the transmission cable corridor. A small portion of the final land system, Robertson (0.03% of the study area), is intersected along the southern edge of the study area.

The study area encompasses a small proportion of the total mapped extent of the Anna, Eighty Mile, Mannerie and Robertson land systems across the McLarty, Mackay and Pindanland subregions, but contains substantial proportions of the Buckshot, Callawa, Little Sandy and Nita land systems, including 88.1% of Buckshot. The Buckshot land system does also exist outside of the McLarty, Mackay and Pindanland subregions, with the majority of its extent occurring to the south within the Trainor subregion of the Little Sandy Desert. The Buckshot land system has a total mapped extent of 279,157 ha when all subregions are included; approximately 2.5% of this total mapped extent occurs within the study area. The Little Sandy land system similarly has a broad distribution further south within the Trainor subregion, and the extent within the current study area represents 18.6% of the total 1,359,914.4 ha mapped across all subregions. In contrast, the distribution of the Callawa and Nita land systems is centred on the McLarty, Mackay and Pindanland subregions, meaning that the substantial proportions within the current study area are realistic.

3.4 Beard's Regional Vegetation Mapping

Broad-scale vegetation mapping for the locality has been prepared at the 1:1,000,000 scale based on the work of J.S. Beard for the Pilbara (Beard 1975) and Great Sandy Desert (Beard 1968). The study area includes 11 of Beard's "vegetation system associations", however as some of these are essentially the same unit mapped in adjacent areas, the study area actually contains only seven broad vegetation types (see Table 3.2 and Figure 3.3). The majority of the study area was mapped by Beard as hummock grasslands with sparse to open shrublands.

The pre-European and current extents of Beard's vegetation system associations have been calculated using interpretation of imagery to determine areas that have been cleared (see Shepherd et al. 2002, and Government of Western Australia 2018). According to this, none of Beard's vegetation system associations have been substantially cleared, and the study area contains substantial proportions of three broad system associations: 51.8% of 80.1, 34.3% of 101.1 and 25.5% of 117.1 (see Table 3.2 and Figure 3.3).

Table 3.1: Description and extent of land systems in the study area.

Land System	Area within Study Area (ha)	% of Study Area	Extent within McLarty, Mackay and Pindanland Subregions (ha)	% of Subregional Extent Within Study Area	Description
Nita	364,535.00	55.2%	1,429,175.4	25.5	Sandplains supporting shrubby spinifex grasslands with occasional trees.
Little Sandy	253,483.60	38.4%	676,256.8	37.5	Sandplains with linear and reticulate dunes supporting shrubby hard and soft spinifex grasslands.
Callawa	35,539.80	5.4%	97,792.8	36.3	Highly dissected low hills, mesas and gravelly plains of sandstone and conglomerate supporting soft and hard spinifex grasslands.
Buckshot	6,995.90	1.1%	7,943.9	88.1	Gravelly sandplains and occasional sand dunes supporting hard spinifex grasslands.
Robertson	177.5	0.03%	3,361.2	5.3	Hills and ranges of sedimentary rocks supporting hard spinifex grasslands.
Anna	25.1	<0.01%	149,250.5	0.02	Paleo-tidal coastal plains with saline soils supporting tussock grasslands and halophytic low shrublands
Eighty Mile	7.6	<0.01%	42,259.1	0.02	Beach foredunes, longitudinal coastal dunes and sandy plains with tussock grasslands and spinifex grasslands.
Mannerie	9.5	<0.01%	61,304.8	0.02	Seepage areas on inland margins of paleo-tidal plains (adjacent to sand plain land systems) supporting melaleuca thickets and halophytic low shrublands.

Table 3.2: Description and extent of Beard's broad vegetation units in the study area (Source: Department of Primary Industries and Regional Development).

Beard's Vegetation Unit	Association Code	Area (ha)	% of Study Area	Description
Mandora Coastal Plain 73	73.2	28.4	<0.01	Grasslands, short bunch grass savanna, grass; salt water grassland (*Sporobolus virginicus*)
Mandora Coastal Plain 41	41.3	15.7	<0.01	Shrublands; teatree scrub
Pindan 32	32.1	41.8	<0.01	Shrublands, pindan; Acacia shrubland with scattered low trees over Triodia spp.
Mandora - East 80	80.1	152,538.8	23.1	Hummock grasslands, low tree steppe; desert walnut over soft spinifex between sandridges
Mandora - East 117	117.1	30,209.4	4.6	Hummock grasslands, grass steppe; soft spinifex
Mandora - West 117	117.1	29,866.4	4.5	
Great Sandy Desert 117	117.0	1,098.1	0.2	
Mandora - East 101	101.1	117,960.2	17.9	Hummock grasslands, shrub steppe; *Acacia pachycarpa* over soft spinifex
Mandora - West 101	101.1	77,356.6	11.7	
Great Sandy Desert 101	101.2	8,874.9	1.3	
Great Sandy Desert 134	134.1	242,642.9	36.7	Mosaic: Hummock grasslands, open low tree steppe; desert bloodwood and feathertop spinifex on sandhills / Hummock grasslands, shrub steppe; mixed shrubs over spinifex between sandhills

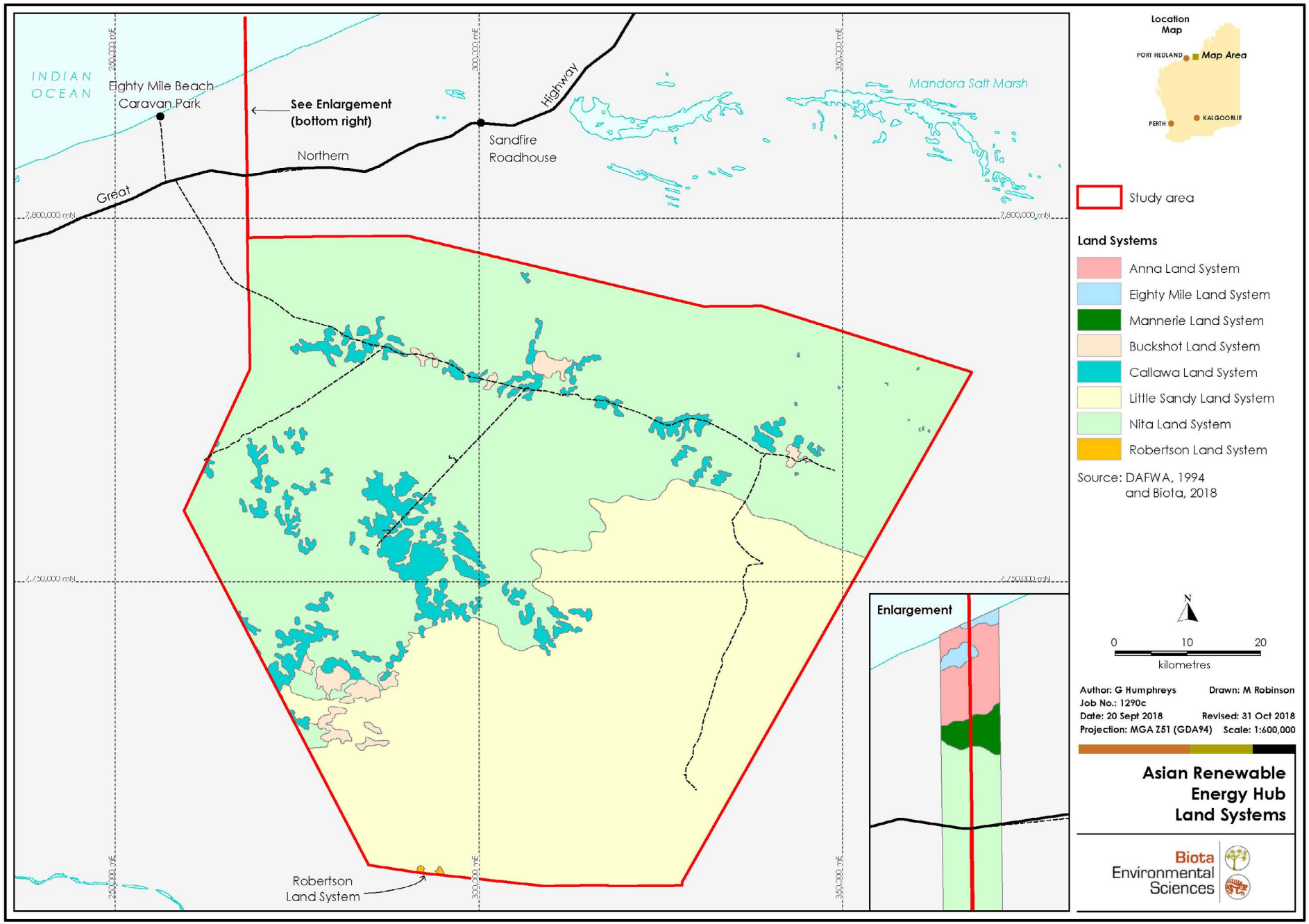


Figure 3.2: Land systems of the study area.

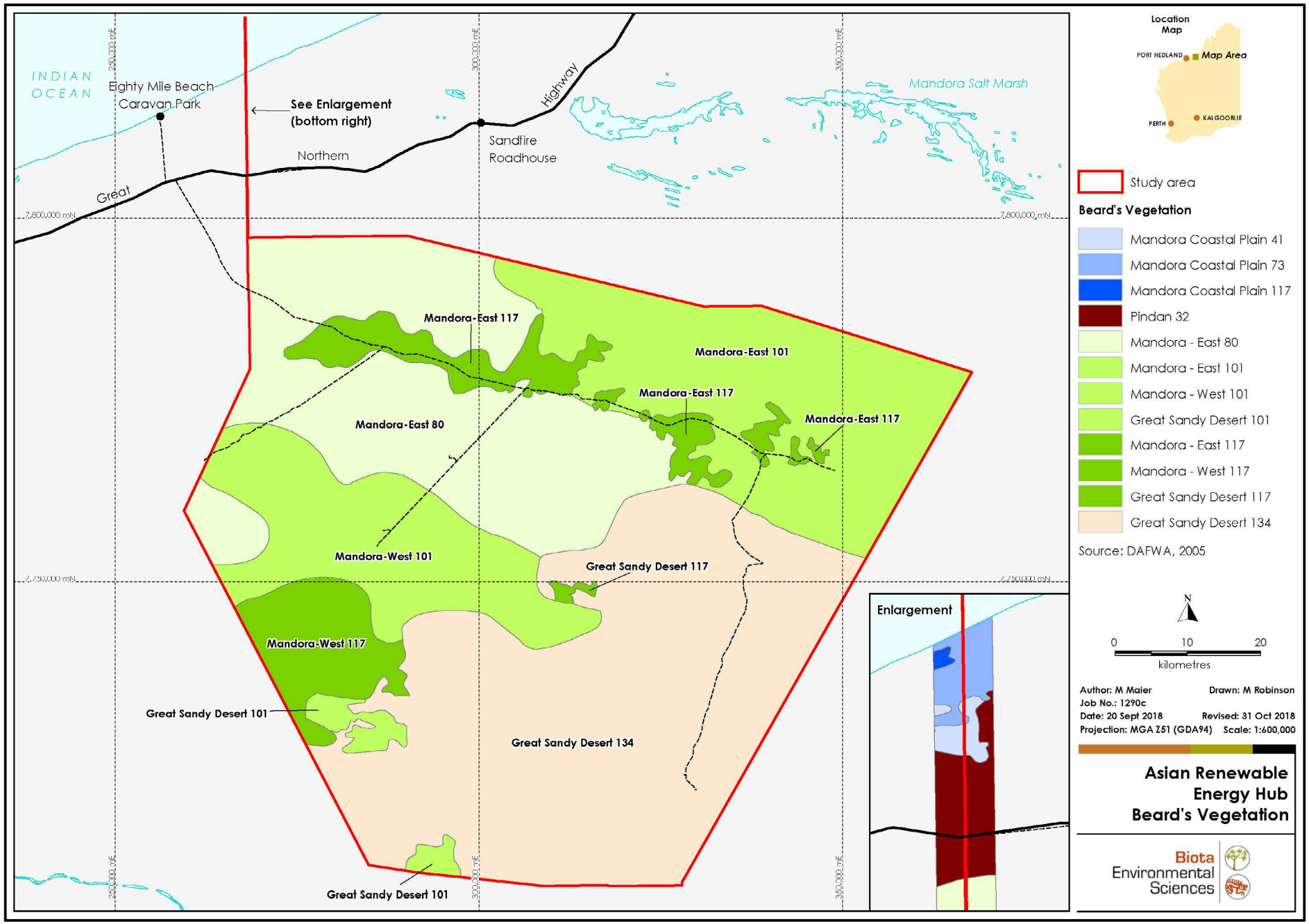


Figure 3.3: Beard's vegetation associations for the study area.

4.0 Methods

4.1 Desktop Review

4.1.1 Literature Review

Table 4.2 summarises the literature reviewed to compile the potential faunal assemblage of the study area. The species recorded in these previous studies have been consolidated with the database search results and are presented in Appendix 1.

It is expected that the records from these studies (with the possible exception of the WA Museum Great Sandy Desert survey conducted in the late '70s and early '80s (Burbidge and McKenzie 1983)) would exist within the NatureMap database. However, considering the studies individually also enables interpretation of how frequently species are recorded and in what area, and consequently, which past studies share habitats with the current study area.

The location of the study area, spanning the northern edge of the Pilbara to the southern extremities of the Kimberley, has been subject to relatively few comprehensive fauna surveys. As a result, the records returned from the NatureMap database were considered unlikely to represent the full potential fauna assemblage due to the lack of survey effort underpinning the database.

4.1.2 Database Searches

To inform the potential vertebrate fauna assemblage of the study area, the following databases were queried:

- **Department of Biodiversity, Conservation and Attractions (DBCA) NatureMap database**: this database represents the most comprehensive source of information on the distribution of Western Australia's fauna, comprising records from the Fauna Survey Returns Database and WA Threatened Fauna database (both of the DBCA), the WA Museum specimen database, and the Birds Australia Atlas. The search was conducted by using co-ordinates at four corners of the study area and adding a 35 km search buffer:
  - NW corner: 120.957222 E, 20.100278 S;
  - NE corner: 121.418611 E, 20.179444 S;
  - SE corner: 121.183056 E, 20.552222 S; nad
  - SW corner: 120.815833 E, 20.427222 S.
- **EPBC Act Protected Matters Search Tool:** which contains records and modeled distributions of species listed as Matters of National Environmental Significance (MNES). This was searched using a 65 km buffer around the central coordinate (121.09472 E, 20.29018 S) (Appendix 2).

4.1.3 Assessment of Likelihood of Conservation Significant Fauna Occurring

In order to determine which species of conservation significance had the potential to occur in the study area, the results of the database searches and previous surveys in the locality were examined while considering the known habitat preferences for the species. Habitats were defined prior to the field survey according to the landforms apparent on aerial imagery, and taking into account existing information regarding the environment and results from previous surveys (Section 4.1.1).

The likelihood that species of conservation significance would occur in the study area was then assessed as part of the desktop review using a set of rankings and criteria (Table 4.1). The term "close proximity" has been defined as being within 20 km of the study area, while the "locality" comprises the area up to 40 km from the study area.

Table 4.1: Ranking system used to assign the likelihood that a species would occur in the study area.

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

4.2 Habitat Definition

To ensure that survey effort encompassed all fauna habitats present in the study area, the following sources of information were used to delineate indicative broad fauna habitats of the study area before field-work commenced:

- aerial imagery;
- elevation modelling in Google Earth;
- Beard (1968, 1975, 1979) vegetation mapping; and,
- Land System mapping (van Vreeswyk et al. 2004).

Following the survey, fauna habitats were refined based on on-site descriptions and vegetation mapping conducted by Biota's botanical team (Biota 2018b). This process supported defining habitats along the same lines as the Land System mapping (van Vreeswyk et al. 2004) but with some additional delineation of microhabitats within each Land System. Using the Land System mapping to define habitats is beneficial as it can provide a much broader context for the occurrence of each habitat outside the study area.

A limitation of any habitat classification system is that it is not specific to any one species. Rather, the classification provides a convenient framework to summarise species occurrence. When considering habitat for individual species of elevated conservation significance, the habitat availability within the study area has been compared to a wider area using a scale appropriate to the species. For example, where these species are widely occurring and have broad habitat requirements, land system mapping may represent an appropriate scale, while for species with more constrained habitat requirements, finer scale mapping has been attempted.

The following criteria were used to define a significant fauna habitat:

1. it is uncommon;
2. supports a unique faunal assemblage;
3. supports fauna of elevated conservation significance or
4. any combination of these three factors.

Table 4.2: Literature reviewed in relation to the study area.

Report/Survey	Shortened title in Appendix 1 table	Description of Report/Survey	Dates of Survey	Location Relative to the Study Area
Goldsworthy Extension Project Phase 2: Consultative Environmental Review Report for BHP Billiton Iron Ore Pty Ltd by Dames & Moore Pty Ltd (1992)	"Gold'w Lvl1"	Level 1 fauna survey	2-5 October 1992	26 km south-west
Goldsworthy Extension Project - Biological Assessment Survey Report for BHP Billiton Iron Ore Pty Ltd by ecologia Environment (2005)	"Gold'w Lvl2"	A collation of several Level 2 fauna surveys	3-9 June 1998 0-21 December 2004 2-17 November 2004 22 November - 6 December, 2004	Yarrie: 30 km south-west Cattle Gorge: 34 km south-west Nimingarra: 60 km west Sunrise Hill: 45 km west
Biota of the Mandora System, Western Australia: - Mammals by Start, Kendrick and McKenzie (2008)	"Mandora Marsh"	Pit trapping, mist netting and Elliott trapping	12-17 August 1983 12-21 October 1999	30 km north
Assessment of the Bilby *Macrotis lagotis* on Wallal Downs Station; Homestead and Chirup project areas by Bamford Consultants (2016)	N/A	Level 1 targeted survey	17 - 18 August 2016	Homestead: 28 km Northwest Chirup: 40 km Northwest
Wildlife of the Great Sandy Desert, Western Australia by Burbidge and McKenzie (1983)	"GSD WAM"	Comprehensive and broad ranging survey by the Western Australian Museum. Survey effort included a total of 5633 metal trap-nights and 190 pit-fence nights.	Five survey phases between 1976 and 1980	Sites ranged over much of the Great Sandy Desert.

4.3 Vertebrate Fauna Field Survey

4.3.1 Survey Timing and Weather Conditions

Phase 1 of the terrestrial fauna survey was carried out from the 24th August – 5th September 2017 and Phase 2 from the 13th – 21st March 2018. Weather observations during the survey and long-term averages were sourced from data collected at Mandora Station (Bureau of Meteorology weather station number 004019) (Table 4.3).

Mean annual rainfall at Mandora is 377 mm and during the five years preceding the survey average annual rainfall ranged from below to well above the mean (262 – 750 mm) with an average 422 mm. On this basis, productivity in the landscape was not considered a limitation to the fauna survey.

Conditions during the year preceding Phase 1 of the study were typical with slightly above average Summer rainfall and slightly lower than average Autumn and Winter rainfall. Phase 1 of the study was conducted in late Winter/early Spring and weather conditions were warm to hot and dry. Daily maximum temperatures ranged from 29.5 - 39.6°C while overnight temperatures were generally cool. This timing was conducive to the trapping of reptiles and mammals. Conditions were also favourable for the recording of birds, particularly in the cool early mornings.

Phase 2 of the study was conducted in early Autumn following a summer with considerably higher than average rainfall (Figure 4.1). Conditions during the second phase were hot and minor rainfall was recorded on two days. While the warmer overnight temperatures were particularly conducive to the recording of nocturnal reptiles, it was necessary to consider the welfare of animals in this trapping programme such that the use of trap types that subject animals to dehydration (particularly Elliott traps) was reduced to a number that could be checked and emptied before becoming too hot.

Table 4.3: Weather conditions during the field survey (data from BOM, Mandora Station 004019).

	Date	Minimum Temperature (°C)	Maximum Temperature (°C)	Rainfall (mm)
Phase 1	24/08/17	14.7	39.6	0
	25/08/17	17.4	37.5	0
	26/08/17	17.9	34.4	0
	27/08/17	13.9	34.7	0
	28/08/17	15.5	33.3	0
	29/08/17	10.6	33.3	0
	30/08/17	11	34.8	0
	31/08/17	11.8	32.8	0
	1/09/17	11.6	29.5	0
	2/09/17	16.4	31.3	0
	3/09/17	15.1	34.5	0
	4/09/17	19.1	35.3	0
	5/09/17	19.3	36	0
	Avg./Total	**14.9**	**34.4**	**0.0**
Phase 2	13/03/18	26.9	39.8	0
	14/03/18	23.4	38.6	0
	15/03/18	21.2	37.9	0
	16/03/18	21.6	38.7	0
	17/03/18	24.8	36.8	0.2
	18/03/18	22.6	41.5	0
	19/03/18	24.7	40.4	0
	20/03/18	27.6	36.3	0
	21/03/18	25	36.8	6.8
	Avg./Total	**24.2**	**38.5**	**7.0**

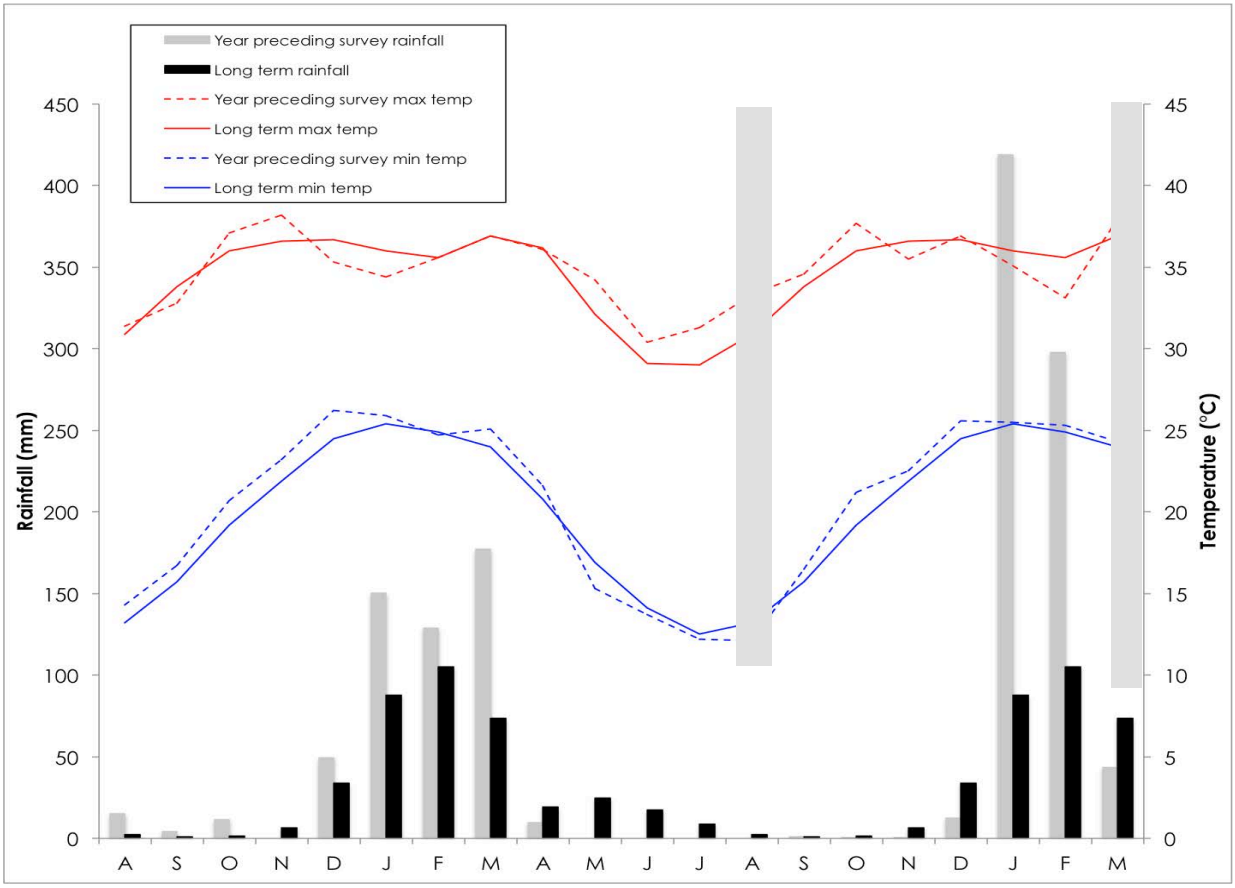


Figure 4.1: **Weather observations in the year preceding the survey (August 2016 – March 2018) compared to long-term (1913 – 2018) climatological averages** (data from the Bureau of Meteorology Mandora Station 004019).

4.3.2 Survey Team

The fauna survey was conducted under Regulation 17 "Licence to Take Fauna for Scientific Purposes" Permit No. 08-000993-4 issued by the DBCA to Mr Daniel Kamien (Appendix 3).

The survey team comprised Mr Garth Humphreys, Mr Roy Teale, Mr Dan Kamien, Dr Stewart Ford, Mr Michael Greenham, Ms Penny Brooshooft, Ms Jacinta King, Dr Sylvie Schmidt, and Mr David Keirle (all of Biota). All team members are qualified and experienced zoologists, with at least six years experience as a consulting zoologist in the arid zone, with specialist experience in a range of areas including ornithology, mammals, reptiles and short-range endemic fauna.

We also gratefully acknowledge various Nyangumarta Traditional Owners for their assistance with this study, including for granting permission for the survey team to access the area, and members of the Nyangumarta Ranger Group for their assistance during the field surveys.

4.3.3 Sampling Effort

An overview of the field sampling effort deployed within the study area is provided in Figure 4.2. Systematic and non-systematic sampling methods were used to sample the terrestrial fauna at a combined total of 190 sites, distributed across the study area (Figure 4.2). A detailed account of the effort and methods for each sampling techniques follows in Sections 4.3.4 to 4.3.7.

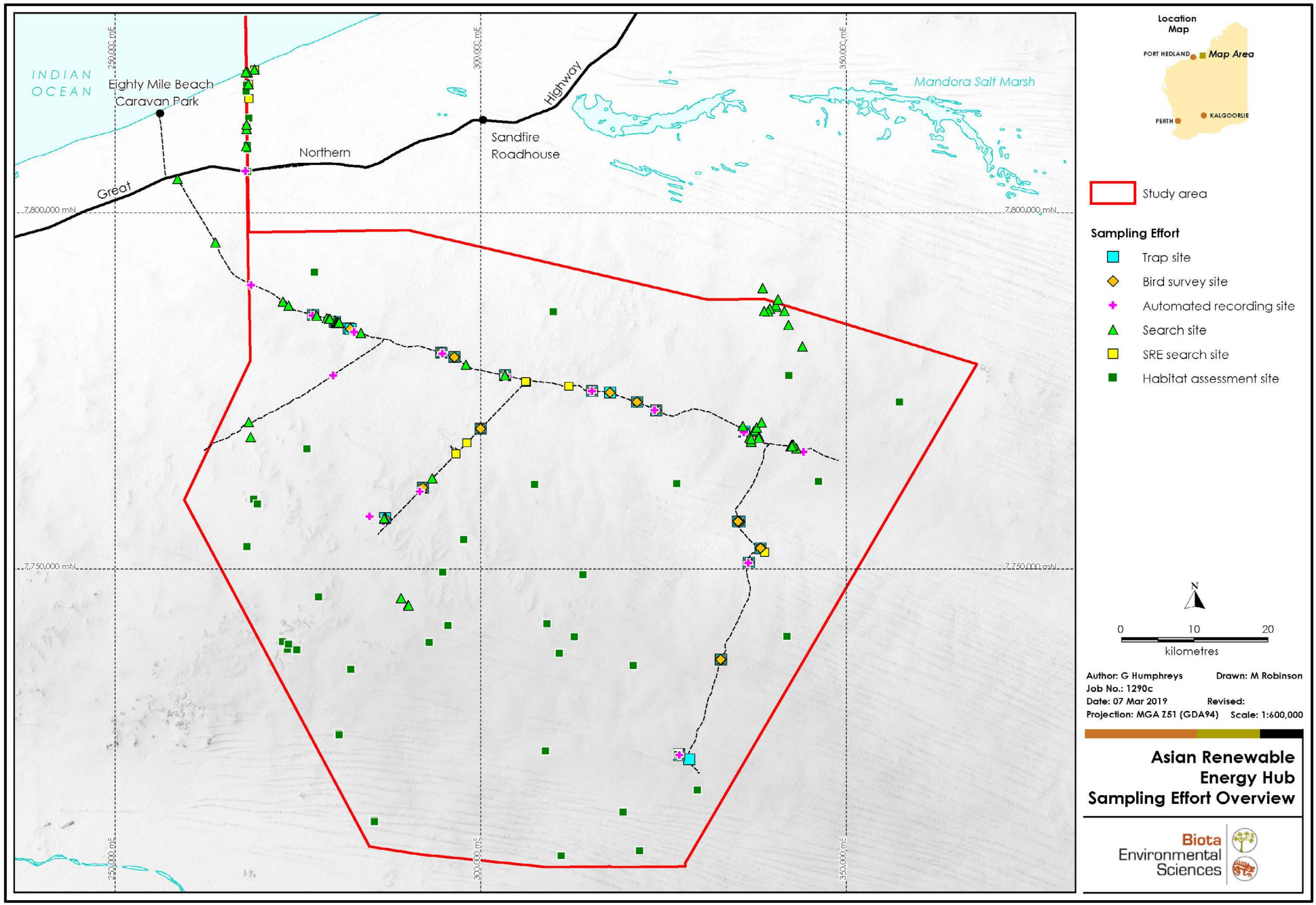


Figure 4.2: Overview of fauna sampling effort within the study area (see Figures 4.3 to 4.7 for more detail on each sampling method).

4.3.4 Trapping Effort

Indicative trapping sites were identified based on the results of the desktop review and preliminary habitat assessment, and were subsequently ground-truthed during a reconnaissance site visit (6th – 9th August 2017), following which the final location of fauna sampling sites were chosen. The reconnaissance also include an aerial over-flight and ground-truthing of the range of habitats within the study area via helicopter.

A total of 22 fauna trapping sites were installed with the aim of trapping as many species from the potential vertebrate assemblage as possible. Sites were distributed to representatively sample the range of fauna habitats in the study area, while giving consideration to access and ensuring traps could be checked in a timely manner each morning to meet fauna sampling ethics requirements.

The locations of the sites are illustrated in Figure 4.3, and are further detailed in Table 4.4 and Table 4.5. The trapping sites comprised the following:

- Sixteen pitfall and funnel trapping transects, consisting of 10 pitfall traps arranged as alternating 20 litre buckets and PVC tubes (diameter: 150 mm, depth: 700 mm) connected by a 110 m long, 30 cm high fly wire fence. One pair of funnel traps was also set at each end. These sites were run during both survey phases.
- One funnel trapping transect, consisting of 20 funnel traps, arranged in pairs and distributed along a 110 m length of 30 cm high fly wire drift fence. This site was run during the first phase only, as hotter temperatures during Phase 2 raised concern for the welfare of potentially trapped animals at this site, which was located in rocky habitat (see Table 4.5).
- Five Elliott and cage trapping sites were also deployed. The number of Elliott and cage traps set at each site varied depending on the habitat and target taxa, which included specific conservation significant mammal species such as the Northern Quoll, Bilby, Brush-tailed Mulgara, Western Pebble-mound Mouse and Black-flanked Rock-wallaby. Two of these sites were also run during Phase 2.

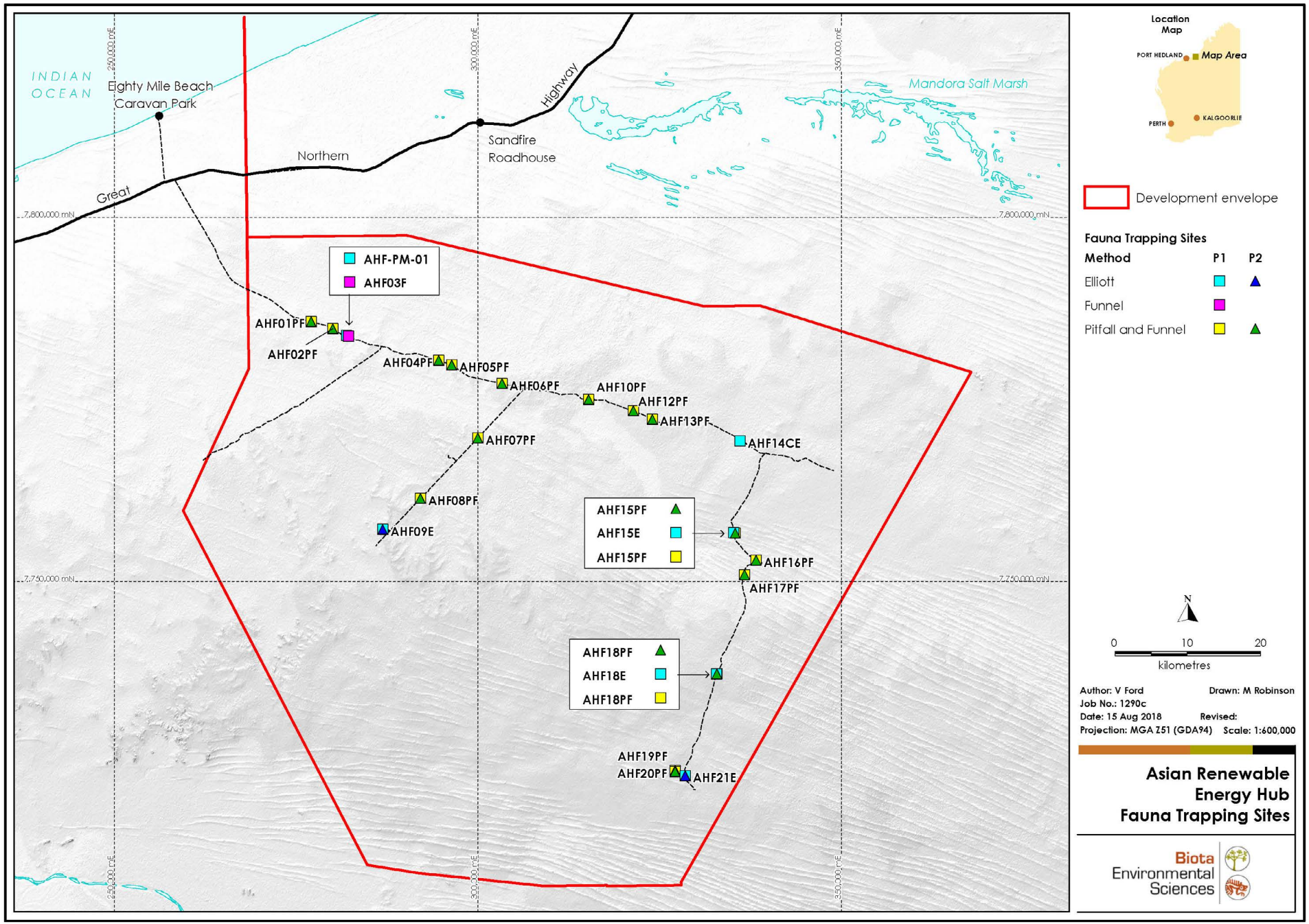


Figure 4.3: Location of fauna trapping sites within the study area.

Table 4.4: Details of trap site locations and sampling effort (trap-nights) per phase.

					Phase 1			Phase 2			
Site ID	**Method**	**Line Location**	**Latitude**	**Longitude**	**Start**	**End**	**Trap nights**	**Start**	**End**	**Trap nights**	**Total**
AHF01PF	10 Pitfall, 4 Funnel	Start End	-20.01249 -20.011732	120.869162 120.869383	28/08/17	4/09/17	P: 70 F: 28	13/03/18	21/03/18	P: 80 F: 32	P: 150 F: 60
AHF02PF	10 Pitfall, 4 Funnel	Start End	-20.021538 -20.020868	120.897614 120.897457	28/08/17	4/09/17	P: 70 F: 28	14/03/18	21/03/18	P: 70 F: 28	P: 140 F: 56
AHF03F	20 Funnel	Start End	-20.031228 -20.031835	120.917786 120.917462	29/08/17	4/09/17	F: 120	*not run			F: 120
AHF04PF	10 Pitfall, 4 Funnel	Start End	-20.062857 -20.063596	121.036155 121.035942	28/08/17	4/09/17	P: 70 F: 28	13/03/18	20/03/18	P: 70 F: 28	P: 140 F: 56
AHF05PF	10 Pitfall, 4 Funnel	Start End	-20.068389 -20.067508	121.053044 121.053323	28/08/17	4/09/17	P: 70 F: 28	13/03/18	20/03/18	P: 70 F: 28	P: 140 F: 56
AHF06PF	10 Pitfall, 4 Funnel	Start End	-20.092331 -20.091659	121.11885 121.119381	28/08/17	4/09/17	P: 70 F: 28	14/03/18	21/03/18	P: 70 F: 28	P: 140 F: 56
AHF07PF	10 Pitfall, 4 Funnel	Start End	-20.159488 -20.160098	121.086371 121.086912	28/08/17	4/09/17	P: 70 F: 28	13/03/18	20/03/18	P: 70 F: 28	P: 140 F: 56
AHF08PF	10 Pitfall, 4 Funnel	Start End	-20.233738 -20.234212	121.010161 121.01069	29/08/17	4/09/17	P: 60 F: 24	13/03/18	20/03/18	P: 70 F: 28	P: 130 F: 52
AHF09E	25 medium Elliott, 10 large Elliott	Start End	-20.271538 -20.270458	120.959911 120.960073	2/09/17	4/09/17	E: 70	15/03/18	20/03/18	E: 175	E: 145
AHF10PF	10 Pitfall, 4 Funnel	Start End	-20.113576 -20.112878	121.232507 121.232449	27/08/17	4/09/17	P: 80 F: 32	13/03/18	20/03/18	P: 70 F: 28	P: 150 F: 60
AHF12PF	10 Pitfall, 4 Funnel	Start End	-20.127737 -20.127032	121.291481 121.29175	27/08/17	4/09/17	P: 70 F: 28	13/03/18	20/03/18	P: 70 F: 28	P: 140 F: 56
AHF13PF	10 Pitfall, 4 Funnel	Start End	-20.138511 -20.139188	121.315972 121.315665	27/08/17	4/09/17	P: 70 F: 28	13/03/18	20/03/18	P: 70 F: 28	P: 140 F: 56
AHF14CE	40 medium Elliott, 20 large Elliott, 5 Cage	Start End	-20.166872 -20.166906	121.431171 121.431151	28/08/17	4/09/17	E: 420 C: 35	*not run			E: 420 C: 35
AHF15PF	10 Pitfall, 4 Funnel	Start End	-20.280832 -20.281003	121.423455 121.424132	26/08/17	3/09/17	P: 70 F: 28	14/03/18	21/03/18	P: 70 F: 28	P: 140 F: 56
AHF15E	10 Elliott	Start End	-20.280415 -20.28066	121.421374 121.422771	28/08/17	3/09/17	E: 60	*not run			E: 60
AFH16PF	10 Pitfall, 4 Funnel	Start End	-20.314623 -20.315103	121.450957 121.450132	27/08/17	3/09/17	P: 70 F: 28	14/03/18	21/03/18	P: 70 F: 28	P: 140 F: 56
AHF17PF	10 Pitfall, 4 Funnel	Start End	-20.332338 -20.332656	121.435382 121.436049	27/08/17	3/09/17	P: 70 F: 28	14/03/18	21/03/18	P: 70 F: 28	P: 140 F: 56

					Phase 1			Phase 2			
Site ID	**Method**	**Line Location**	**Latitude**	**Longitude**	**Start**	**End**	**Trap nights**	**Start**	**End**	**Trap nights**	**Total**
AHF18PF	10 Pitfall, 4 Funnel	Start End	-20.455252 -20.45475	121.39752 121.396541	27/08/17	3/09/17	P: 70 F: 28	14/03/18	21/03/18	P: 70 F: 28	P: 140 F: 56
AHF18E	15 medium Elliott	Start End	-20.455129 -20.454449	121.397321 121.39706	28/08/17	3/09/17	E: 90	*not run			E: 90
AHF19PF	10 Pitfall, 4 Funnel	Start End	-20.574697 -20.574346	121.341528 121.340935	27/08/17	3/09/17	P: 70 F: 28	14/03/18	21/03/18	P: 70 F: 28	P: 140 F: 56
AHF20PF	10 Pitfall, 4 Funnel	Start End	-20.575968 -20.575807	121.341206 121.34042	27/08/17	3/09/17	P: 70 F: 28	14/03/18	21/03/18	P: 70 F: 28	P: 140 F: 56

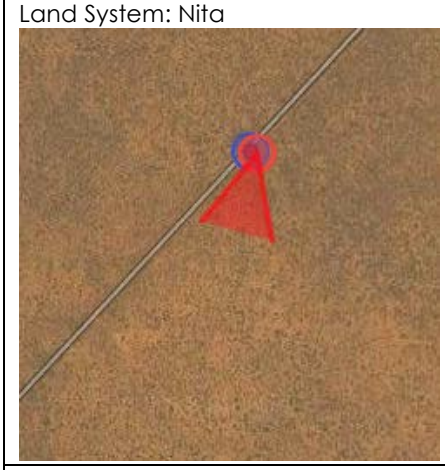
Pit-trap effort (trap-nights)	**2,250**
Funnel-trap effort (trap-nights)	**900**
Elliott-trap effort (trap-nights)	**715**
Total trap effort (trap-nights)	**4,065**

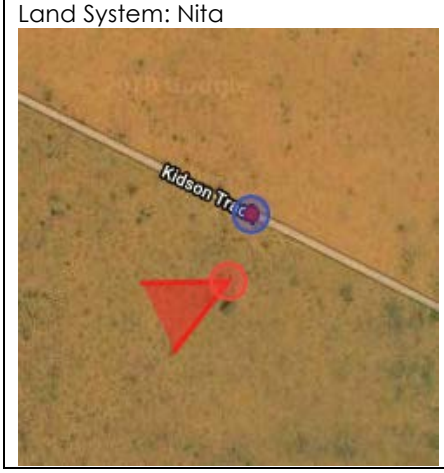
*not run due to temperature constraints

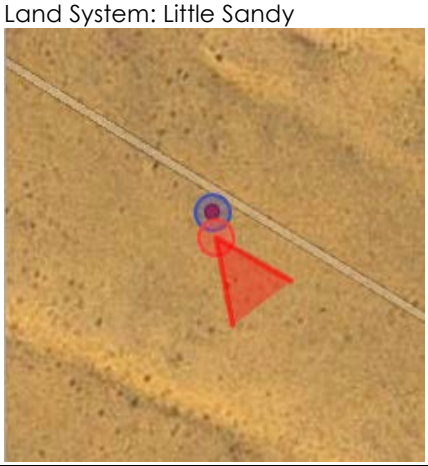
Table 4.5: Trapping site descriptions and photographs.

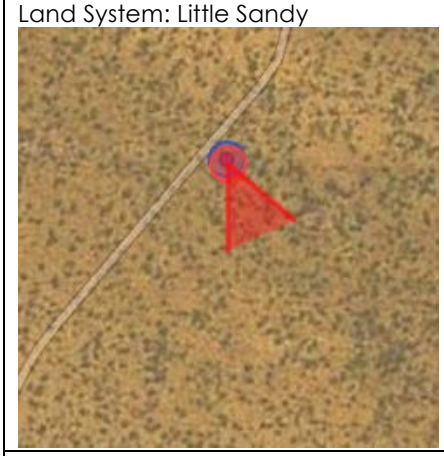
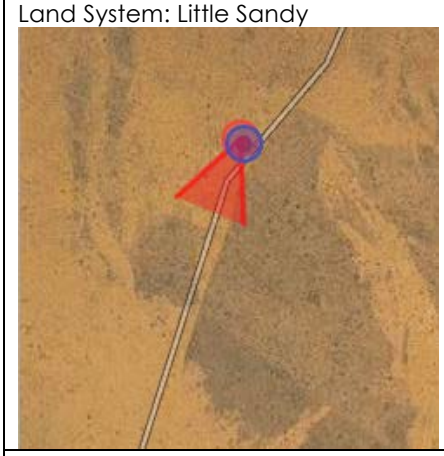
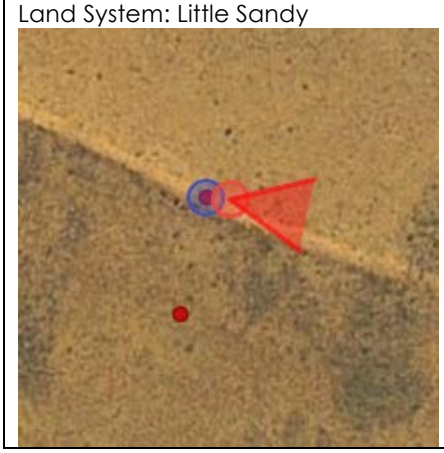
Site Description	Site Photograph
AHF01 Pitfall trapping, Funnel trapping FLATS: Sandplain Scattered low trees and shrubs 1 – 2 m over hummock grassland Land System: Nita 	
AHF02 Pitfall trapping, Funnel trapping FLATS: Sandplain Scattered low trees over closed hummock grassland Land System: Callawa 	
AHF03 Funnel trapping HILLS AND SLOPES: Gradual hill slope Scattered low shrubs over low open hummock grassland Land System: Callawa 	

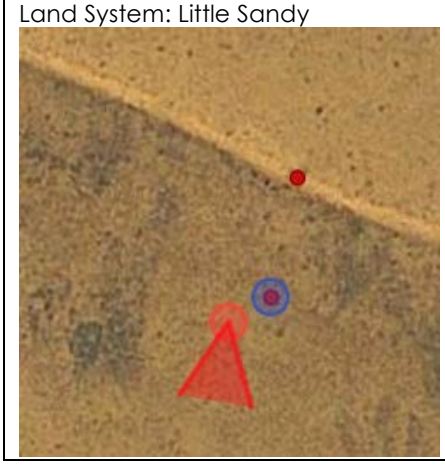
Site Description	Site Photograph
AHF04 Pitfall trapping, Funnel trapping FLATS: Sandplain Scattered ironwood trees, open shrubs 1 - 2 m over hummock grassland (small hummocks) Land System: Nita 	
AHF05 Pitfall trapping, Funnel trapping FLATS: Sandplain Open hummock grassland (hummocks moderate in size) Land System: Callawa 	
AHF06 Pitfall trapping, Funnel trapping FLATS: Sandplain Scatttered tall shrubs (>2 m) and low shrubs (1-2 m) over open hummock grassland Land System: Nita 	

Site Description	Site Photograph
AHF07 Pitfall trapping, Funnel trapping FLATS: Sandplain Open shrubland over hummock grassland Land System: Nita 	
AHF08 Pitfall trapping, Funnel Trapping HILLS AND SLOPES: Gentle rocky hill slope Scattered low shrubs and tall shrubs over low hummock grassland Land System: Callawa 	
AHF09E Elliott trapping HILLS AND SLOPES: Free Face Scattered low trees, open low shrubland over open hummock grassland Land System: Callawa 	

Site Description	Site Photograph
AHF10 Pitfall trapping, Funnel trapping FLATS: Sandplain Scattered tall and low shrubs over open hummock grassland Land System: Nita 	
AHF12 Pitfall trapping, Funnel trapping FLATS: Sandplain Scattered tall and low shrubs over open hummock grassland Land System: Nita 	
AHF13 Pitfall trapping, Funnel trapping FLATS: Sandplain Scattered tall and low shrubs over hummock grassland Land System: Nita 	

Site Description	Site Photograph
AHF14E Cage and Elliott trapping HILLS AND SLOPES: Rock Hill slope Scattered Ficus and Acacia shrubs over open hummock grassland Land system: Nita 	
AHF15 Pitfall trapping, Funnel trapping, Elliott trapping DUNES: Longitudinal dune ridge Scattered tall shrubs, low open shrubland and very open tussock grassland Land System: Little Sandy 	
AHF16 Pitfall trapping, Funnel trapping FLATS: Sandplain Scattered trees over low shrubland over very open tussock grass Land System: Little Sandy 	

Site Description	Site Photograph
AHF17 Pitfall trapping, Funnel trapping FLATS: Sandplain Open woodland over open shrubland over very open hummock grassland Land System: Little Sandy 	
AHF18 Pitfall trapping, Funnel trapping, Elliott trapping FLATS: Sandplain Scattered trees over scattered tall shrubs over hummock grassland Land System: Little Sandy 	
AHF19 Pitfall trapping, Funnel trapping DUNES: Longitudinal dune Scattered tall shrubs over low open shrubland over open hummock grassland Land System: Little Sandy 	

Site Description	Site Photograph
AHF20 FLATS: Sandplain Shrubs of *Erythrophleum*, *Eucalyptus* and *Acacia* over open Triodia hummock grassland. Land System: Little Sandy 	

4.3.5 Bird Surveys

Birds were recorded using the following techniques:

- unbounded area searches (30 minutes in duration) conducted within defined habitats at the 16 pitfall and funnel trapping transect sites (shown on Figure 4.4);
- unbounded area searches conducted at opportunistic locations containing habitats or microhabitats likely to support previously unrecorded species (see Figure 4.3);
- opportunistic observations of birds whilst traversing the study area; and
- automated recordings (see Section 4.3.6).

A total of 23.2 hours were dedicated to avifauna census across both survey phases at the pitfall and funnel trapping sites (Table 4.6). As conditions were hot during the second phase, birds ceased calling early in the morning limiting productive birding opportunities.

A number of species were also recorded opportunistically within the study area by ornithologists conducting work targeting migratory species outside of the two seasonal phases (Biota 2018a). These species have been added to the overall inventory in this report.

Automated recorders were also deployed to target both the Night Parrot and shorebirds (see Section 4.3.6.3) but the calls of terrestrial bird species were also collated while analysis the recordings. Water birds and migratory shorebirds are the subject of a concurrent dedicated study, reported separately (Biota 2018a).

Table 4.6: Avifauna census times at each trapping site (minutes).

	Phase 1								Phase 2		
	28/08/17	**29/08/17**	**30/08/17**	**31/08/17**	**1/09/17**	**2/09/17**	**3/09/17**	**Total**	**15/03/18**	**Total**	**Grand Total**
AHF01		20	20	20	20	20		100	30	30	130
AHF02		20	20	20	20			80	30	30	110
AHF03			20	20	20			60			60
AHF04		20	20	20				60	30	30	90
AHF05		20	20	20				60			60
AHF06			20					20			20
AHF07			20		40			60	20	20	80
AHF08					20			20	20	20	40
AHF09							20	20			20
AHF10		20		20	40	20		100	20	20	120
AHF11				20				20			20
AHF12		20	20	20	20	20		100			100
AHF13		20	20	20	20	20		100			100
AHF14E		20	20	40	40			120			120
AHF15	40							40			40
AHF16	20	20						40			40
AHF17	20	20						40			40
AHF18	20	20	20		20			80			80
AHF19		20	20	20				60			60
AHF20		20	20	20				60			60
								1,240		**150**	**1,390**

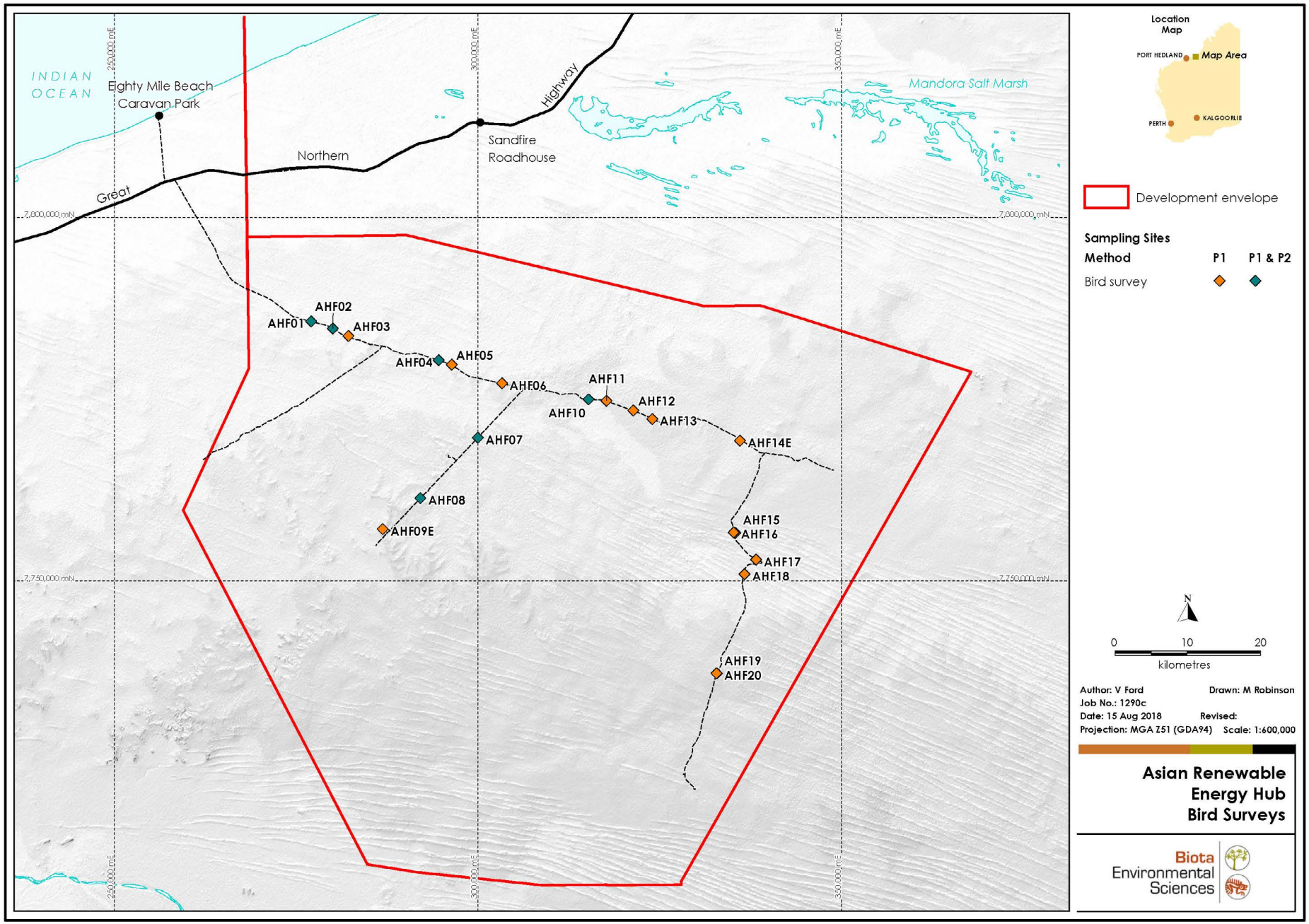


Figure 4.4: Locations of systematic bird census sites.

4.3.6 Automated Recorders

4.3.6.1 Motion Cameras

Infrared motion cameras (Bushnell Trophy Cam) were primarily used to target the Northern Quoll, Black-footed Rock-wallaby and Bilby, and as such were placed in rocky habitats and at entrances of apparently active Bilby burrows. Details of infrared cameras sites and trap effort are provided in Table 4.7, and locations are shown in Figure 4.5.

Table 4.7: Motion camera sites.

	Site ID	Latitude	Longitude	Start	End	Nights
P1	AHF14E-MC-01	-20.167298	121.429874	29/8/17	3/9/17	5
	AHF14E-MC-02	-20.166507	121.430589	29/8/17	3/9/17	5
	AHFCAM026-01	-20.022127	120.900598	30/08/17	2/09/17	3
	AHFCAM015-02	-20.022196	120.900574	31/08/17	3/09/18	3
	AHFCAM015-01	-20.021757	120.8985	28/08/17	31/08/17	3
P2	AHF09E-MC-P2-01	-20.27295457	120.9585567	17/03/18	22/03/18	5
	AHF09E-MC-P2-02	-20.274116	120.958064	17/03/18	22/03/18	5
	AHFCAM08-01	-20.268047	120.940056	15/03/18	22/03/18	7
					Total Nights	**36**

4.3.6.2 Ultrasonic Sound Recorders

Bats were surveyed using SongMeter (SM2BAT and SM4BAT) units, which detect and record ultrasonic echolocation calls emitted by bats during flight. The selectable filters and triggers, jumper and audio settings used followed the manufacturer's recommendations for bat detection (Wildlife Acoustics 2010). Bat sampling effort is detailed in Table 4.8 and the locations of recorders shown in Figure 4.5. Bat echolocation call analysis was conducted by Mr Dan Kamien of Biota using Kaleidoscope Pro software (version 4.3.2), and following methods recommended by the Australasian Bat Society (2006) in conjunction with available reference data (Churchill 2008, McKenzie and Bullen 2009). Only sequences containing good quality search phase calls were considered for identification.

Table 4.8: Bat-call recording sites.

	Site ID	Latitude	Longitude	Start	End	Nights
P1	AHF897-1	-20.021	120.897	29/08/17	31/08/17	2
	AHF827-1	-20.092	121.120	29/08/17	1/09/17	3
	AHF4654-02	-20.237	121.006	1/09/17	3/09/17	2
	CAM654-14E	-20.167	121.430	29/08/17	2/09/17	4
	AHF1169-02	-20.173	121.450	1/09/17	3/09/17	2
	AHFBat1169-01	-20.332	121.435	29/08/17	31/08/17	2
	AHF897-02	-20.575	121.342	1/09/17	3/09/17	2
				Phase 1 Total		**17**
P2	AHF04195-01	-20.272979	120.958622	15/03/18	17/03/18	2
	AHF04195-02	-19.769224	120.785736	17/03/18	22/03/18	5
	AHFSM2827	-19.828062	120.783763	18/03/18	22/03/18	4
				Phase 2 Total		**11**
					Total Nights	**28**

4.3.6.3 Recording in the Audible Range

The Interim guideline for preliminary surveys of the Night Parrot (*Pezoporus occidentalis*) (DBCA 2017a) recommends passive acoustic surveys as an effective low impact survey method. Therefore, SongMeter SM4BAT units were set to record in the audible range at 12 sites (Figure 4.5). At six of these sites recorders were set for 56 consecutive days while at the remaining sites recorders were maintained for 11 months (Table 4.9); site locations are shown in Figure 4.5.

Audio files were analysed by Mr Dan Kamien of Biota using a combination of visual scanning of spectrograms using Kaleidoscope Pro software (version 4.3.2) followed by manual confirmations. Spectrograms of reference calls of the Night Parrot from both western Queensland and Western Australia[1] were imported into the software for comparison.

[1] https://nightparrot.com.au/index.php/resources/night-parrot-calls

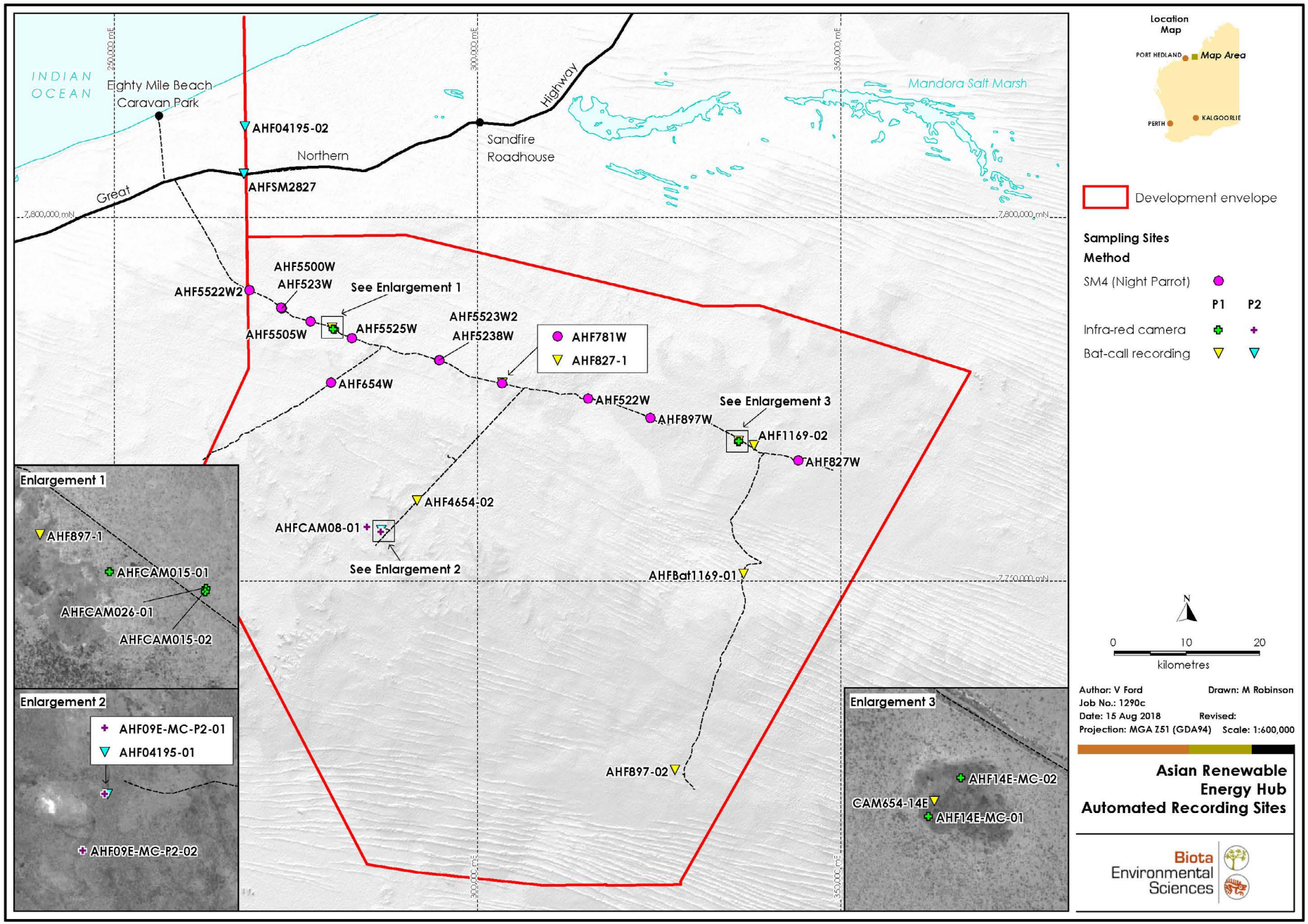


Figure 4.5: Locations of automated recording units.

Table 4.9: Details of SM4 units deployed to record in the audible range.

Unit	Set	Collected	Days	Latitude	Longitude
AHF522W	4/09/17	30/10/17	56	-20.11252286	121.2325648
AHF654W	4/09/17	30/10/17	56	-20.088908	120.894758
AHF781W	4/09/17	30/10/17	56	-20.09235502	121.1196803
AHF827W	4/09/17	30/10/17	56	-20.19193761	121.5081527
AHF897W	4/09/17	30/10/17	56	-20.13723002	121.3142784
AHF523W	4/09/17	30/10/17	56	-19.99582113	120.83136
AHF5238W	4/09/17	3/08/18	334	-20.06277654	121.0372213
AHF5500W	4/09/17	3/08/18	334	-19.99493958	120.8301003
AHF5505W	4/09/17	3/08/18	334	-20.01244669	120.8689437
AHF5522W2	4/09/17	3/08/18	334	-19.97268356	120.788973
AHF5523W2	4/09/17	3/08/18	334	-20.06286272	121.0377932
AHF5525W	4/09/17	3/08/18	334	-20.03426177	120.9225773
		Total:	**2,340**		

4.3.7 Search Sites, Habitat Assessments and Opportunistic Records

Numerous transect searches and point searches were undertaken to more comprehensively characterise the habitats of the study area and to supplement the fauna trapping inventory (Figure 4.6 and Table 4.10). The types of searches and non-systematic assessments were as follows:

- General searches were carried out on foot in areas of habitat with the potential to support species of conservation significance. Areas that might represent habitat of interest were chosen using aerial photography and thematic layers such as land systems mapping.
- Searching for Bilby evidence was undertaken via 32 transect walks. Transect sites were selected on the basis of habitat quality or following incidental detection of sign. During transect walks burrows, tracks, scats and diggings of bilbies were recorded. Details of type of sign, location, personnel, date, general habitat and a photograph were taken with each record. The work targeting the Bilby within the study area was intended to supplement a larger study conducted by the DBCA, which incorporated the search of 2 ha sign plots as described in DBCA (2017b).
- General searches for fauna (Figure 4.6) generally involved either diurnal searching for species that are not readily trapped or within habitats that were not accessible for the installation of traps.
- Twenty-one diurnal search sites targeted rocky habitat as potential habitat for the conservation significant Northern Quoll and Black-footed Rock-wallaby.
- Forty-two habitat assessments were conducted via helicopter jointly with the Biota (2018b) flora and vegetation survey (Figure 4.6). Data on substrate, vegetation structure and habitat type were collected at these sites. The purpose of this was two-fold: to validate the assumption that the systematic trapping sites were representative of the range of habitats in areas not accessible by vehicle, and to identify if any new or significantly different habitats were present.
- Nocturnal searches via road spotting (driving very slowly and spotting animals from the car) or on foot. Nocturnal searching was conducted on two nights of each of the survey phases, generally for 2.5 – 3 hours immediately following sunset. Nocturnal searches often add a number of new species to the inventory, most commonly snakes that are not easily trapped, and nocturnal birds such as owls, owlet-nightjars, frogmouths and nightjars.

Table 4.10: Summary of vertebrate fauna search effort.

	Date	BFRW & NQ Targeted	Bilby Transect	Bilby 2 ha Plot Search	General Search	Nocturnal Road Spot	Habitat Assessment	Nocturnal Foot Search
Phase 1	**28/08/17**	-	-	-	1	-	-	-
	29/08/17	-	3	-	3	-	-	-
	30/08/17	3	1	-	-	-	-	1
	31/08/17	-	1	-	-	-	-	-
	1/09/17	7	-	-	-	1	-	-
	2/09/17	-	16	-	3	-	-	-
	3/09/17	-	7	-	-	-	-	-
	4/09/17	-	-	-	1	-	-	-
Phase 2	**15/03/18**	6	2	-	3	-	6	-
	16/03/18	-	-	-	2	1	7	-
	17/03/18	-	2	-	3	-	6	-
	18/03/18	-	-	-	-	-	7	
	19/03/18	5	-	1	-	-	8	-
	22/03/18	-	-	-	-	1	8	-
	Total:	**21**	**32**	**1**	**16**	**3**	**42**	**1**

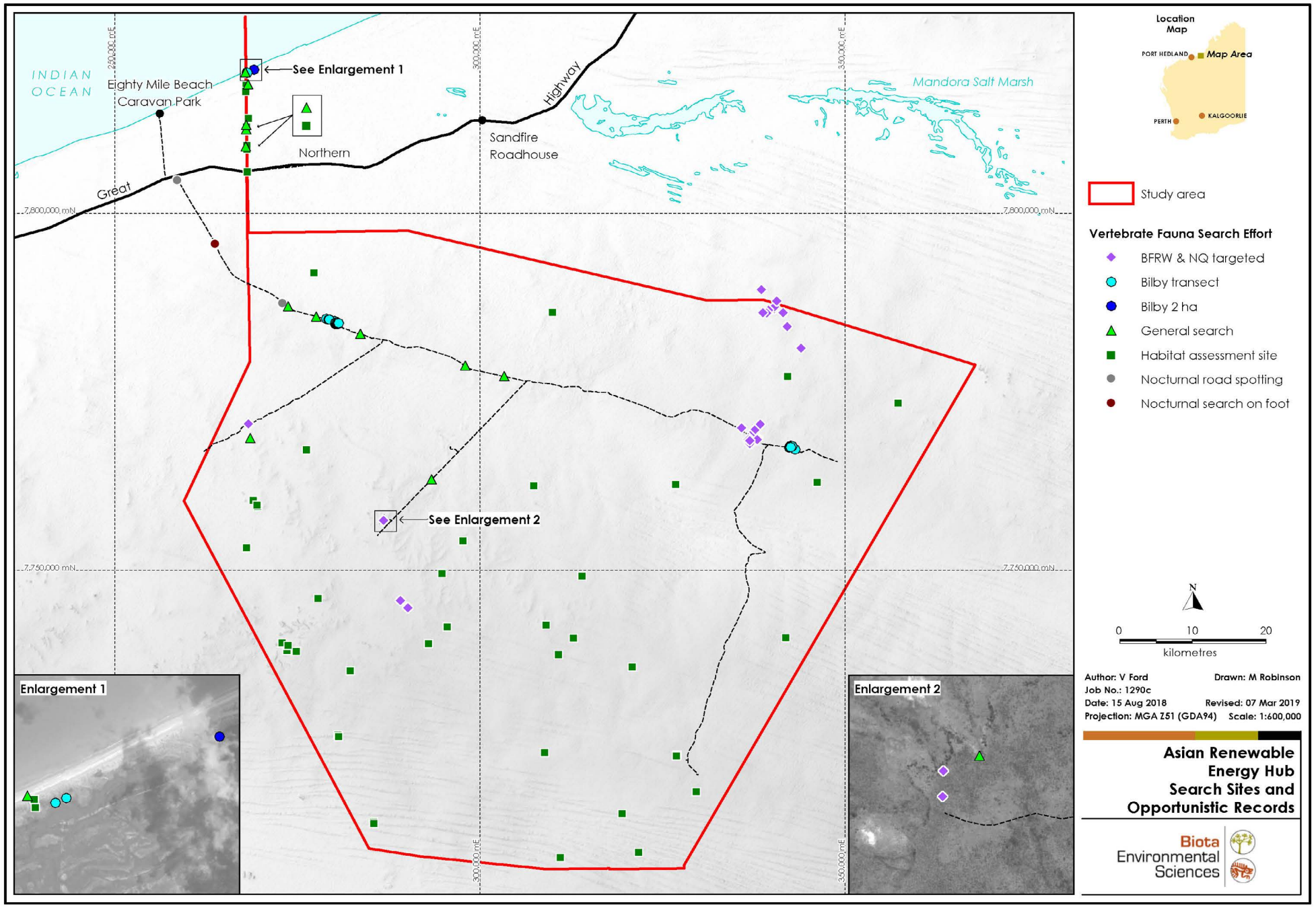


Figure 4.6: Location of search and habitat assessment sites.

4.4 SRE Fauna Survey

4.4.1 Sampling

Sampling of potential short-range endemic (SRE) invertebrate fauna targeted taxonomic groups known to contain SRE species as identified in EPA Guidance Statement 20 (EPA 2016c).

A combination of dry pitfall trapping (i.e. the pitfall trapping sites also used to sample for vertebrate fauna) and active searching was employed. A summary of the methods used and groups targeted is provided in Table 4.11. Details of the dry pitfall sites are provided in Section 4.3.2 and a summary of the targeted search sites for invertebrate fauna is provided in Table 4.12, with locations of sampling sites depicted in Figure 4.7 and habitats illustrated in Plate 4.1 to Plate 4.10.

Search effort was focused on microhabitats most likely to support potential SREs, which included on the south-west side of trees, amongst exposed roots in sheltered locations, and under the southern side of rockpiles, and clay-rich plains which all have more mesic microhabitats suitable for SRE fauna. In loose soil around the base of large trees, the surface layer of dirt was removed to reveal any camouflaged mygalomorph burrows as part of active searchges.

Collected specimens were preserved in 100% ethanol for later genetic analysis by Helix Molecular Solutions (Helix) (see Section 4.4.2).

Table 4.11: Summary of methods used to sample for short-range endemic invertebrate fauna.

	Dry Pitfall	Burrow Search	Under Rocks	Raking Soil and Leaf Litter	Sieving Soil and Leaf Litter
Mygalomorphae (trapdoor spiders)	•	•	•	•	
Pseudoscorpiones (pseudoscorpions)				•	•
Scorpiones (scorpions)	•	•	•	•	
Diplopoda (millipedes)	•		•	•	•
Pulmonata (land snails)			•	•	•

Table 4.12: Search sites targeting potential SRE invertebrate fauna.

Site ID	Latitude	Longitude	Method	Date
AHFSRE01	-20.16698271	121.4310645	Rock turning	29/08/17
AHFSRE02	-20.31955002	121.4562845	Burrow search	30/08/17
AHFSRE03	-20.10151849	121.1468678	Burrow search	1/09/17
AHFSRE03	-20.10028901	121.1459284	Burrow search	1/09/17
AHFSRE04	-20.1774758	121.0679128	Burrow search	3/09/17
AHFSRE05	-20.19130003	121.0535735	Burrow search	3/09/17
AHFSRE06	-20.23408412	121.0093232	Burrow search	3/09/17
AHFSRE07	-20.10725393	121.2021695	Burrow search	3/09/17
AHFSRE08	-19.71908859	120.7889261	Hummock turning; Rock turning	17/03/18
AHFSRE09	-19.701021	120.797262	Vegetation and leaf litter search	19/03/18
AHFSRE10	-19.737334	120.78926	Vegetation and leaf litter search	19/03/18

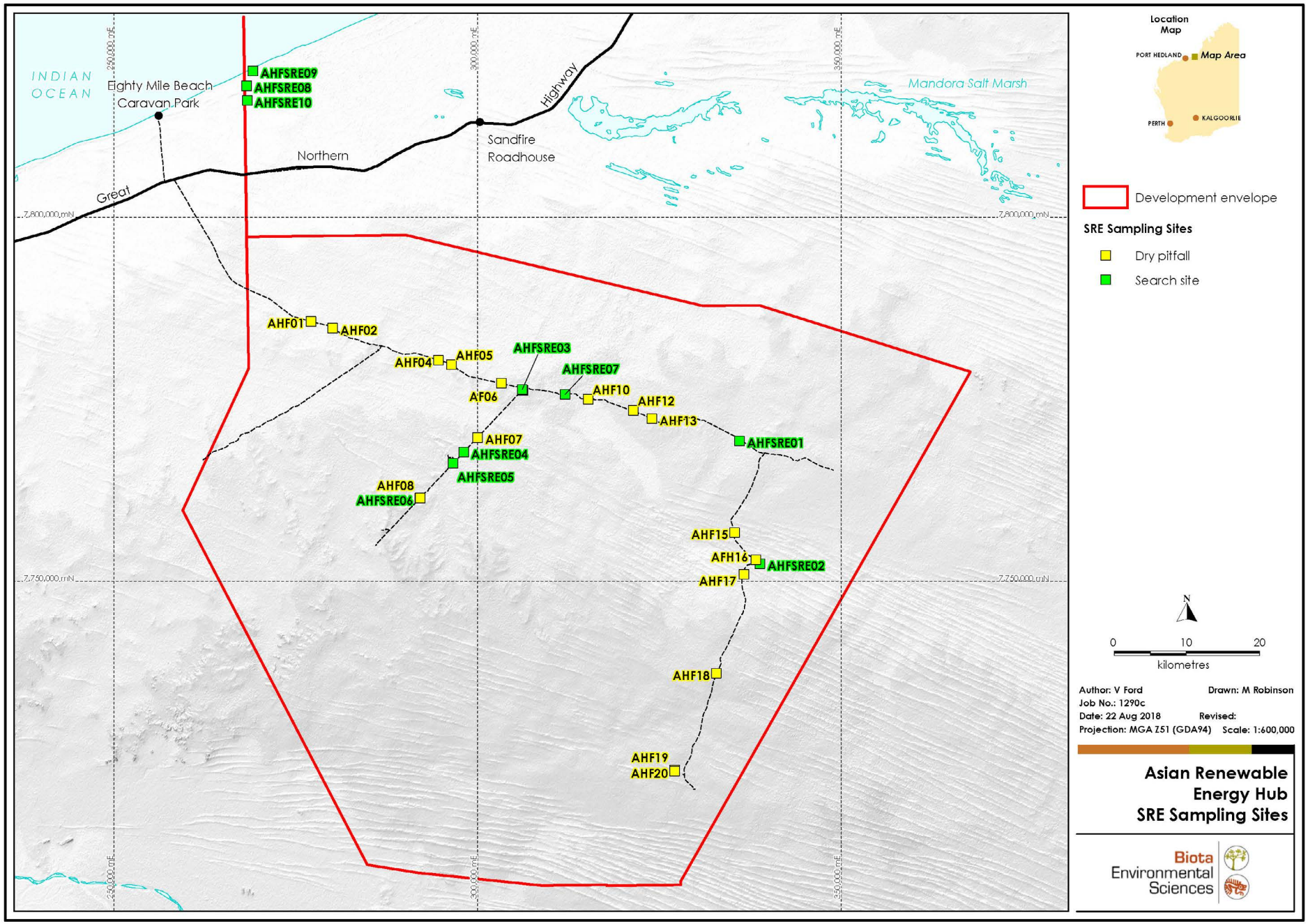


Figure 4.7: Locations of potential SRE invertebrate fauna sampling sites.

Plate 4.1: AHFSRE01.

Plate 4.2: AHFSRE02.

Plate 4.3: AHFSRE03.

Plate 4.4: AHFSRE04.

Plate 4.5: AHFSRE05.

Plate 4.6: AHFSRE06.

Plate 4.7: AHFSRE07.

Plate 4.8: AHFSRE08.

Plate 4.9: AHFSRE09.

Plate 4.10: AHFSRE10.

4.4.2 Molecular Analysis

All specimens collected were identified to species level through molecular (DNA) methods by Helix (Helix 2018). The Helix (2018) report, including detailed methods, is attached as Appendix 4, with only a summary of the methodology used presented here. Invertebrate fauna specimens were sequenced for variation at the mitochondrial cytochrome oxidase subunit I gene (COI). The resulting molecular sequences were then used in a phylogenetic analysis to determine the number of taxa present and place the study area taxa into context with reference sequences publically available on GenBank, within Helix's database or via collaboration with the WA Museum.

Molecular methods of identification were used to overcome limitations associated with using morphological methods alone to identify specimens within the target taxonomic groups for the study, which include:

- **Land snails**: morphological variation is not well correlated with phylogenetic distance: a single species can show broad variation in shell morphology while in other groups convergent evolution has led to consistent shell morphologies between species.
- **Scorpions**: for the largest family of scorpions, the Buthidae, morphological taxonomy is limited in differentiating and defining species boundaries, with findings that several currently recognised species are actually species groups comprising multiple undescribed taxa.
- **Trapdoor spiders**: identification of species has traditionally been performed using morphological techniques, however, only males can be used in identification, as both females and juveniles lack the diagnostic characters required for species level identification. Additionally, extensive molecular work has been conducted on the trapdoor spider fauna of Western Australia by Helix and the WA Museum, and this data set offers a molecular framework that can be used to provide regional context to study area taxa.

4.4.2.1 Determining SRE Status

The SRE status of species is primarily based on their geographic distributions, which are described by two summary statistics. The first is the 'maximum spanning distance', which is the maximum linear distance between two records. The second statistic is the 'minimum spanning area', which is the area of the smallest polygon that can be drawn around all of the records. The minimum spanning area can be used as a means for objectively establishing SRE status by comparison against the 10,000 km^2 criterion established by Harvey (2002). Table 4.13 details the criteria used to determine the SRE status of putative species for the purposes of this report.

Table 4.13: Criteria used to determine SRE status.

SRE Status	Defining Criteria
Known SRE	• Species, morphotype or genetic type has a documented range of <10,000 km^2. • Species, morphotype or genetic type is well collected with numerous specimens typed and habitat preference understood.
Potential SRE	• Species, morphotype or genetic type has a documented range of <10,000 km^2 but is poorly sampled. • Specimen may not be formally described or assigned to a morphotype / genetic type. • Short-range endemism may be common in genus or family. • May have been collected from restricted, refugial or isolated habitats.
Unlikely to be an SRE	• Species, morphotype or genetic type has a documented range of <10,000 km^2 but is poorly sampled. • Specimen may not be formally described or assigned to a morphotype / genetic type. • Short-range endemism is not common in genus or family. • Taxon was not collected from restricted, refugial or isolated habitats. • Few other individuals of the taxon collected, but records are separated by long distances (>100 km).
Not an SRE	• Specimen formally described or assigned to a morphotype / genetic type. • Species, morphotype or genetic type has a documented range of >10,000 km^2.
Undetermined	• Taxa where there is insufficient taxonomic framework available to provide any informed comment on the species-level distribution of the fauna or, therefore, the risk of small-scale spatial restrictions.

4.5 Nomenclature

Consistent with EPA Guidance (EPA 2016b), species nomenclature used in this report for vertebrate fauna follows that of the Western Australian Museum checklist for reptiles, amphibians and mammals, and that of Christidis and Boles (2008) for birds. Nomenclature for invertebrates follows that of the WA Museum.

Distributional information refers only to Western Australia unless otherwise stated.

4.6 Data Analysis

4.6.1 Vertebrate Fauna Assemblage Analysis

Similarity in fauna assemblage amongst trapping sites was analysed by Bray-Curtis similarity matrices, calculated in PRIMER v6.1, where were then represented as CLUSTER dendrograms (Clarke and Gorley 2006). Sites with similar assemblages were then further examined to assess whether this related to landscape units.

A screened site-by-species matrix for each fauna group, including abundance data, was imported into PRIMER and square-root transformed to reduce the influence of high abundance species on the similarity analyses (Clarke and Gorley 2006).

A resemblance matrix was then constructed using the Bray-Curtis similarity index, which produces a similarity value for all pairs of sites based on species representation and transformed abundances. The resultant resemblance matrix was then run through PRIMER's CLUSTER routine, using group average linkage to construct a dendrogram, grouping the survey sites into clusters based on similarity of species composition. Lastly, PRIMER's similarity profile (SIMPROF) permutation tests were applied to the outputs to determine if any of the groups were significantly different.

4.6.2 Species Accumulation Curves

Species accumulation curves graph the detection of new species as a function of increasing sampling effort. When a survey has sampled a high proportion of the fauna assemblage, and few new species are added with additional sampling, the curve will plateau and approach an asymptote. In this way, the species accumulation curve can provide an indication of survey adequacy. In addition, nonparametric estimators can be used to estimate the total species richness based on the frequency of singletons (species only recorded from one individual) and doubletons in the sampling data, that is, the total number of species, including those that may be present but have not yet been detected. EstimateS version 9.1.0 (Colwell 2009) was used to calculate smoothed rarefaction curve based on 500 random permutations of the species data, using each day's sampling across the suite of sites as the sampling unit (n = 16), for comparison with observed actual species . The Chao 1 richness estimator was selected as most appropriate to the data set, as it contained a number of rarely recorded species (nine species of the 69 trapped ground species recorded as singletons and 11 of 44 bird species).

Records from the 16 systematic trapping sites with equal trap effort were included in the analysis. Species recorded using targeted trapping methodologies (e.g. bat targeted trapping and targeted use of Elliott traps) were excluded from the analysis given the limited scope of these methodologies to capture species other than those targeted. Opportunistic fauna records were also removed from the data given the unpredictable nature of such records that are not derived from equivalent sampling methods across sites.

4.7 Survey Limitations

As required by EPA Surveys (2016d), the following limitations to survey and this report are identified for the reader's information:

- Systematic fauna sampling was completed in all fauna habitats, but it was not possible to ground-truth every part of the study area; and nor was it necessary with the very small proportion of the study area that will actually be affected by the project. Some areas were inaccessible by vehicle, so installation and regular checking of fauna traps in these areas was not possible. This limitation applied primarily to the southern-most extent of the study area, which was largely inaccessible by vehicle, but this limitation was addressed by means of helicopter ground-truthing to confirm the habitats sampled systematically were representative of inaccessible areas.
- Many potential SRE taxa are difficult to sample adequately (e.g. mygalomorph spiders are difficult to locate, and morphological identification requires adult male specimens, which are often in low abundance and only emerge from their burrow during selective, specific conditions). While this is a common limitation of these types of surveys, the most prospective microhabitats of the study area were targeted and personnel experienced in SRE sampling undertook the work.
- There is a general lack of past biological survey effort in the locality, which may have limited some assessments of potential wider distributions (e.g. for SRE taxa and where range extensions for some species have been identified in this report).

Despite the above limitations, the overall study still provides an adequate assessment suitable to inform consideration of the project under Section 38 of the *Environmental Protection Act 1986*.

4.8 Legislation and Policy Conformance

All surveys were completed as far as practicable in accordance with relevant State and Commonwealth policy, and to a standard that would provide adequate information to assess the proposal against principals and environmental aims relating to the environmental factor 'Terrestrial Fauna' (EPA 2016a). Table 4.14 provides a summary of the most important and relevant legislation, policy and guidelines relating to this study.

Table 4.14: State and Commonwealth legislation, policy and guidelines of most relevance to this study.

Legislation, Guideline or Policy	Application to this Study	Regulating Authority
Commonwealth		
Environment Protection and Biodiversity Conservation Act 1999	The Australian Government's central piece of environmental legislation.	Department of Environment and Energy
Western Australia		
Environmental Factor Guideline: Terrestrial Fauna (EPA 2016a).	Overall aim of the study is to provide adequate information to assess the proposal against the objective of the environmental factor Terrestrial Fauna, stated to be "To protect terrestrial fauna so that biological diversity and ecological integrity are maintained".	Environmental Protection Authority
Technical Guide – Sampling Methods for Terrestrial Fauna (EPA 2016b)	Provides the State's advice on fauna sampling techniques and methodologies for the analysis, interpretation and reporting requirements for environmental impact assessment.	Environmental Protection Authority
Technical Guide - Terrestrial Fauna Surveys (EPA 2016d)	The State's central guideline on scope and methods for vertebrate fauna inventory.	Environmental Protection Authority
Technical Guide - Sampling of Short Range Endemic Invertebrates (EPA 2016c).	The State's central guideline as to what constitutes SRE invertebrate fauna and how to sample them.	Environmental Protection Authority

Legislation, Guideline or Policy	Application to this Study	Regulating Authority
Interim guideline for preliminary surveys of Night Parrot *Pezoporus occidentalis* in Western Australia (DBCA 2017a).	Targeted survey methodology for Night Parrots.	Department of Biodiversity Conservation and Attractions
Guidelines for surveys to detect the presence of bilbies, and assess the importance of habitat in Western Australia (DBCA 2017b).	Targeted survey methodology for bilbies.	Department of Biodiversity Conservation and Attractions

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