Biota Environmental Sciences

Asian Renewable Energy Hub Detailed Flora and Vegetation Survey

Prepared for NW Interconnected Power

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Biota Environmental Sciences

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1.0 Executive Summary

1.1 Project Background

NW Interconnected Power Pty Ltd is seeking to develop the Asian Renewable Energy Hub (hereafter 'the project'). The project is to construct and operate a large-scale wind and solar hybrid renewable energy project at a site approximately 220 km east of Port Hedland and 270 km southwest of Broome, in the northwest of Western Australia (WA).

1.2 Methodology

Biota Environmental Sciences (Biota) was commissioned to conduct a detailed terrestrial flora and vegetation survey of the study area. The first phase of the survey was carried out from 24th August – 4th September 2017 (dry season), while the second phase was carried out from 13th – 22nd March 2018 (wet season). The Phase 2 survey followed high rainfall in the locality, and conditions were optimal for the detection of annual and cryptic perennial species.

The surveys were completed as far as practicable in accordance with relevant Environmental Protection Authority (EPA) policy, specifically:

- *Environmental Factor Guideline: Terrestrial Flora and Vegetation* (EPA 2016a); and
- *Technical Guide - Terrestrial Flora and Vegetation Surveys* (EPA 2016b).

A total of 99 flora sampling quadrats and seven relevés (unbounded flora sampling sites) were assessed within the study area, representatively sampling the range of vegetation types present; 31 quadrats were sampled in two seasons. Targeted foot traverses were also completed to search for rare flora and compile detailed vegetation mapping notes. The work was undertaken by a team of experienced botanists who have previously completed many surveys in the Kimberley and Pilbara regions.

1.2.1 Vegetation

The vegetation of the study area was generally in Excellent or Very Good condition. The only substantial populations of weeds were recorded from the transmission cable corridor, where extensive grasslands of Buffel Grass (**Cenchrus ciliaris*) and Birdwood Grass (**C. setiger*) occurred on the near-coastal plains on Wallal Downs pastoral station.

Nine vegetation types (some with additional sub-types) were identified from five broad landforms:

- Drainage areas (coastal seasonal swamp, and inland minor drainage lines);
- Sand dunes (coastal and inland);
- Plains (coastal and inland);
- Low stony rises (inland only); and
- Rocky outcrops and breakaways (inland only).

In general the study area was dominated by sand plains and, to a lesser extent, low-elevation sand dunes and scattered laterite exposures. These supported hummock grasslands of Humpback Spinifex (*Triodia epactia*) and/or (Feathertop Spinifex) *T. schinzii*, with a sparse to open low tree or tall shrub overstorey dominated by *Corymbia, Acacia*, *Hakea* and *Grevillea* species. Small rocky outcrops were also scattered through the inland areas, and supported a distinct suite of species including Rock Figs (*Ficus brachypoda*). In addition, areas of Paperbark (*Melaleuca* spp.) thicket occurred in the coastal swamp near the northern end of the transmission cable corridor, while primary dunes at the northernmost end supported Beach Spinifex (*Spinifex longifolius*), *Triodia epactia* and *Whiteochloa airoides*.

None of the vegetation types present in the study area are considered to correspond to any Threatened Ecological Communities (TECs). The small areas at the northernmost end of the transmission cable corridor that were mapped as 'Beach' and vegetation type 'S1' (*Triodia epactia, Spinifex longifolius* open hummock grassland with *Whiteochloa airoides* open tussock grassland) would form part of the 'Eighty Mile Land System' Priority Ecological Community (PEC). The Paperbark thickets of vegetation type D1 (*Melaleuca glomerata, M. lasiandra, M. alsophila, Acacia ampliceps* tall shrubland over *Trianthema turgidifolium, Solanum esuriale* low open shrubland) appear consistent with vegetation that was identified as a key element of the Eighty Mile Beach Ramsar site. Vegetation type R1 (*Ficus brachypoda* low open woodland over *Acacia monticola, A. colei* var. *colei, Grevillea pyramidalis* tall open shrubland over *Triodia epactia* open hummock grassland) on rocky outcrops does not correspond to any listed PEC, but should be considered to be of elevated conservation significance due to the capacity of these habitats to act as refugia during periods of drought and fire.

1.2.2 Flora

A total of 315 native vascular flora taxa from 138 genera and 48 families were recorded from the study area during the current field surveys, and four additional taxa have previously been recorded from the area. This is thought to represent a comprehensive list of species in the area, given the limited range of habitats present.

Nine of the species confirmed are listed as conservation significant taxa (Section 1.2.3).

1.2.3 Flora Species of Conservation Significance

One Threatened flora species, *Seringia exastia*, has been recorded from the study area; a total of 334 individuals were recorded from six locations. This species is listed under both the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the State *Wildlife Conservation Act 1950* (Wildlife Conservation Act). In addition, approximately 146 additional individuals of a sterile *Seringia* were recorded from a total of 15 other locations; these may represent *S. exastia, S. katatona* (a Priority 3 species; see below), or one of two *Seringia* species that are not listed as being of conservation significance (*S. elliptica* or *S. nephrosperma*). As a precaution, these individuals should be treated as though they are *S. exastia*. The confirmed records extend the known range of S. exastia to 290 km, from near Broome to the eastern section of the study area. This range encompasses a very large area of suitable pindan plain habitat, and it is likely that this species is considerably more abundant than the current records indicate.

Eight species listed by the Department of Biodiversity Conservation and Attractions (DBCA) as State Priority species were recorded; *Bonamia oblongifolia* and *Tribulopis marliesiae* were recorded from the transmission cable corridor as well as the main study area, while all remaining species were only recorded from the main study area:

- *Tephrosia rosea* var. Port Hedland (A.S. George 1114) (Priority 1): 4% cover at one location (southwestern section of main study area);
- *Bonamia oblongifolia* (Priority 3): 0.1-1% cover at 13 locations (throughout study area);
- *Croton aridus* (Priority 3): 0.1-3% cover at five locations (southern section of main study area);
- *Indigofera ammobia* (Priority 3): 0.1% cover at seven locations (southern section of main study area);
- *Polymeria* ? sp. Broome (K.F. Kenneally 9759) (Priority 3): 0.1% cover at two locations (northwestern section of main study area); the specimens were sterile and therefore could not be confirmed, but are considered likely to be this taxon;
- *Seringia katatona* (Priority 3): 150 individuals at one location (in southeast of main study area);
- *Terminalia kumpaja* (Priority 3): 68 individuals at 36 locations (throughout main study area); and
- *Tribulopis marliesiae* (Priority 3): 176+ individuals at 45 locations (throughout study area).

While all of these species have broad ranges and appear to be more common than previously thought, the specimen of *Tephrosia rosea* var. Port Hedland (A.S. George 1114) is atypical and matches one other specimen attributed to this taxon; these may potentially represent a new species. Another entity recorded during the field survey, *Portulaca* aff. *australis*, may also represent a new species, however additional collections would be required to further investigate this.

The desktop assessment completed for this study (including searches of public and private databases, as well as previous botanical surveys in the vicinity of the study area) indicated that 11 additional Priority flora species have previously been recorded from the locality. Two of these species are considered likely to occur in the study area:

- *Goodenia hartiana* (Priority 3) has been recorded from a red sand dune 3.9 km southwest of the southwestern corner of the study area, and could occur on the sand dunes supporting vegetation type S2.
- *Corynotheca asperata* (Priority 3) has been recorded from sand plain 9.6 km south of the study area, and could occur on the pindan plains supporting vegetation type P3.

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2.0 Introduction

2.1 Proposal

NW Interconnected Power Pty Ltd is seeking to develop the Asian Renewable Energy Hub (hereafter 'the project'). The project is to construct and operate a large-scale wind and solar hybrid renewable energy project at a site on the northeast boundary of the Shire of East Pilbara, approximately 220 km east of Port Hedland and 270 km southwest of Broome (Figure 2.1).

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 four inert subsea power cables, with the marine component of the current proposal only extending to the limit of State Waters (Commonwealth Waters and international permitting will be the subject of a separate assessment).

The proposal would be implemented within a development envelope approximately 660,686 ha in size, which comprised the study area for the current assessment (Figure 2.1).

2.2 Study Objectives and Scope

Biota Environmental Sciences (Biota) was commissioned to conduct a Detailed flora and vegetation survey within the study area, as per EPA (2016b).

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 a controlled action under the terms of the Commonwealth EPBC Act, and the document provides technical support and data to inform that assessment.

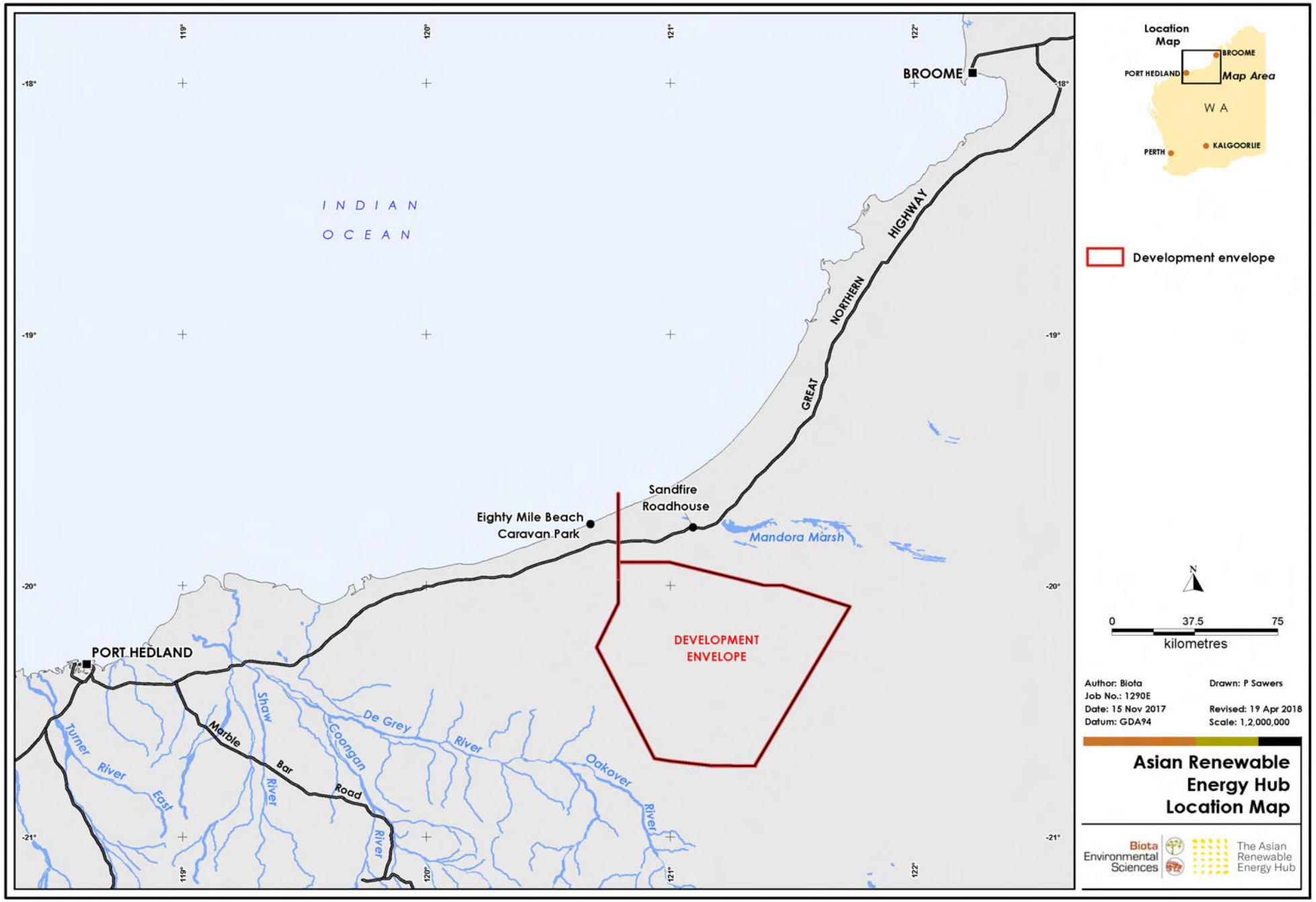

Figure 2.1: Location of the Asian Renewable Energy Hub study area.

3.0 Methodology

3.1 Desktop Assessment

The aim of the desktop assessment was to review all relevant available information to inform an accurate description of the existing environment within the study area. In particular, it sought to identify flora species and vegetation communities of conservation significance that had already been recorded from the study area, or those that were known from the broader locality and could potentially occur. Appendix 1 contains more information regarding the framework for conservation significance ranking of communities and species in WA.

The desktop assessment reviewed both public and privately-held databases (Section 3.1.1), as well as published and unpublished literature (Section 3.1.2).

3.1.1 Database Searches

Three databases were searched to identify flora species and vegetation communities of conservation significance that had already been recorded from the study area, or were known from the broader locality. These comprised the:

1. WA Department of Biodiversity, Conservation and Attractions' (DBCA) NatureMap database[1]: This database is the most comprehensive source of information on the distribution of WA's flora, and contains location records from the WA Herbarium Specimen Database (derived from lodgement of voucher specimens) and the DBCA WA Threatened and Priority Flora Database (derived from submission of Threatened and Priority Flora Report Forms). Two NatureMap searches were completed:
   - one within the boundary of the current study area, to identify species already recorded from the area; and
   - one extending out from this boundary, to identify additional species recorded from the locality that may potentially occur in similar habitats within the study area. To take into account the less intense collection in inland areas, and to incorporate an appropriate extent of habitat similar to that present in the study area, the buffer distance around the study area was variable for this search: approximately 50 km east-west along the coastal section traversed by the transmission corridor, approximately 30 km north and south of the main study area, and approximately 50 km east of the main study area.
2. The Australasian Virtual Herbarium (AVH) database[2]. This database incorporates records from voucher specimens and DNA specimens held at all major Australian and New Zealand herbaria. The study area boundary was used for this search.
3. Commonwealth Department of the Environment and Energy's EPBC Act Protected Matters database[3]: This database includes species and communities considered to be Matters of National Environmental Significance (MNES). The area for this search comprised a 100 km buffer around an approximate central point for the study area (-20.28699°S, 121.10484°E).
4. Biota's internal database of conservation significant flora records obtained from surveys in the locality. This included surveys completed in similar habitats within 50 km of the study area.

The vegetation community and flora species search results are summarised in Sections 4.7 and 4.8 respectively.

1 https://naturemap.dpaw.wa.gov.au

2 http://avh.chah.org.au

3 http://www.environment.gov.au/epbc/protected-matters-search-tool

3.1.2 Literature Review

The literature review included various general published references, such as those relating to bioregions and subregions (Graham 2003a, 2003b, Kendrick 2003), land systems (van Vreeswyk et al. 2004), Beard's vegetation system associations (Beard 1968, 1975), and the Eighty-mile Beach Ramsar site (Hale and Butcher 2009).

While some flora collections have been made in the study area according to the NatureMap and AVH searches (mainly historic records along the old telegraph track, some of which were attributed with inaccurate coordinates), no detailed systematic botanical surveys have been previously undertaken. However, ethnobotanic surveys of the Nyangumarta Warrarn Indigenous Protected Area (see Section 4.2) have documented numerous species occurring in the area, principally those with traditional uses (see Nyangumarta Warrarn Aboriginal Corporation 2016).

The following surveys completed in the broader locality were also reviewed:

- A rare flora survey completed by Biota (2018a) on Mandora Station, approximately 7 km east of the transmission cable corridor. This survey sampled an area of pindan habitat immediately north of the Great Northern Highway, equivalent to that within the near-coastal section of the study area.
- Vegetation and flora surveys completed by the DBCA in the Mandora Marsh / Walyarta area, approximately 25 km north of the study area (English et al. 2016, Markey 2017). While the focus of this survey was on sampling the mound spring communities in this area, some sites were also established in fringing pindan and sand dune habitats.
- A vegetation and flora survey on Pardoo Station, approximately 80 km west of the study area (EnviroWorks 2017a). This survey sampled areas of near-coastal pindan habitat, as well as *Melaleuca* thickets and tidal mudflats.
- A rare flora survey on Anna Plains Station, approximately 90 km north of the study area (EnviroWorks 2017b). This survey sampled areas of pindan habitat similar to those within the inland sections of the study area.
- A rare flora survey completed by Biota (2017) on Nita Downs Station, approximately 110 km northeast of the study area. This survey sampled areas of pindan habitat similar to those within the inland sections of the study area.

3.2 Field Survey

3.2.1 Study Team and Survey Timing

The field survey was undertaken over two phases; a dry season survey between the 24th of August and 4th of September 2017 (Phase 1) and a post-wet season survey between the 13th and 22nd of March 2018 (Phase 2). The team included various botanists from Biota, all of whom have extensive vegetation and flora survey experience, and was led by Michi Maier (Biota's Principal Botanist). Excluding travel time, a total of 72 person days were spent on the field component of this study. Table 3.1 summarises the experience of Biota's personnel and their respective roles in the study.

We also gratefully acknowledge various Nyangumarta Traditional Owners for granting permission for the survey team to access the area, and for their assistance with this study. In particular, we wish to thank Lynette Wilridge, Charmaine Wright, Waylon Hunter, Roberta Hunter and Elliot Hunter from the Nyangumarta Ranger Group for their assistance during the field surveys.

Table 3.1: Summary of the Biota personnel involved in the current study.

Name	Position at Biota	Qualification	Years of Survey Experience	Role in Study	Flora Licence No.
Michi Maier	Director | Principal Botanist	BSc (Botany & Zoology) (Hons)	27+	• Project Manager • Field survey: Phases 1 & 2: - Vegetation mapping - Quadrat sampling - Rare flora searches • Specimen identifications • Data entry and QA • Floristic analysis	SL012027 SL012300 DRF Permit No. 178-1617
Pierre-Louis de Kock	Level 2 Botanist | Specialist Taxonomist	BSc (Environmental Management)	12	• Field survey: Phases 1 & 2: - Quadrat sampling - Rare flora searches • Specimen identifications	SL012031 SL012303
Chloe Flaherty	Level 2 Botanist	BSc (Natural Resource Management) (Hons)	7	• Field survey: Phase 1: - Quadrat sampling - Rare flora searches • Specimen identifications • Data entry	SL012029
Prue Anderson	Level 1 Botanist	BSc (Natural Resource Management) (Hons)	9	• Field survey: Phase 1: - Quadrat sampling - Rare flora searches	NA
Scott Werner	Level 2 Biologist	BSc (Conservation Biology & Management) (Hons)	8	• Field survey: Phase 2: - Quadrat sampling - Rare flora searches	SL012032
Rebecca Mason	Level 1 Botanist	BSc (Environmental Restoration & Conservation Biology)	7	• Field survey: Phase 2: - Quadrat sampling - Rare flora searches • Specimen identifications • Data entry	SL012205
Melissa Robinson	Senior GIS Analyst	Dip. Cart.	20+	• GIS analysis • Map preparation • Data supply	NA
Paul Sawers	Senior GIS Analyst	Dip. Cart.	26+	• GIS analysis • QA of data deliverables	NA

3.2.2 Survey Conditions

The weather conditions (particularly rainfall) leading up to a biological survey are important factors that influence both the number and type of species recorded from an area, especially for flora. One of the more notable effects is the increased presence of annual species following high rainfall, in addition to a higher likelihood of plants bearing reproductive material (flowers and/or fruit). This typically results in a more complete list of species from the area, along with greater confidence in identifications.

Total monthly rainfall data relevant to the study area were sourced from the Bureau of Meteorology weather recording station at Mandora (station number 4019), located less than 6 km east of the transmission cable corridor. Figure 3.1 shows the total monthly rainfall received at Mandora from 12 months prior to the Phase 1 field survey until the Phase 2 survey, compared to the long-term climate-normal median rainfall (1961-1990) for the same months. Mean monthly maximum temperatures are also shown, compared to the climate-normal mean maximum temperature values.

These data show that the Phase 1 survey followed a typical period of negligible rainfall, although the preceding wet season was wetter than average. Temperatures in the months preceding the Phase 1 survey were also hotter than average, although this was still the cooler part of the year. Conditions such as these would typically combine to result in sub-optimal conditions for collecting, however numerous annual flora and cryptic perennial species were observed.

In contrast, the Phase 2 survey was timed as a wet-season survey, and followed a significantly wetter than average summer period in 2018; most of the rainfall was received over three major events in mid-January (Tropical Cyclone Joyce), late January and mid-February (Tropical Cyclone Kelvin) (see Figure 3.1). Maximum temperatures in the lead up to the Phase 2 survey were typically around or below the average. These conditions should have combined to result in optimal conditions for collecting, however few additional annual and ephemeral species were added, and in general fewer species were noted to be flowering during this survey period.

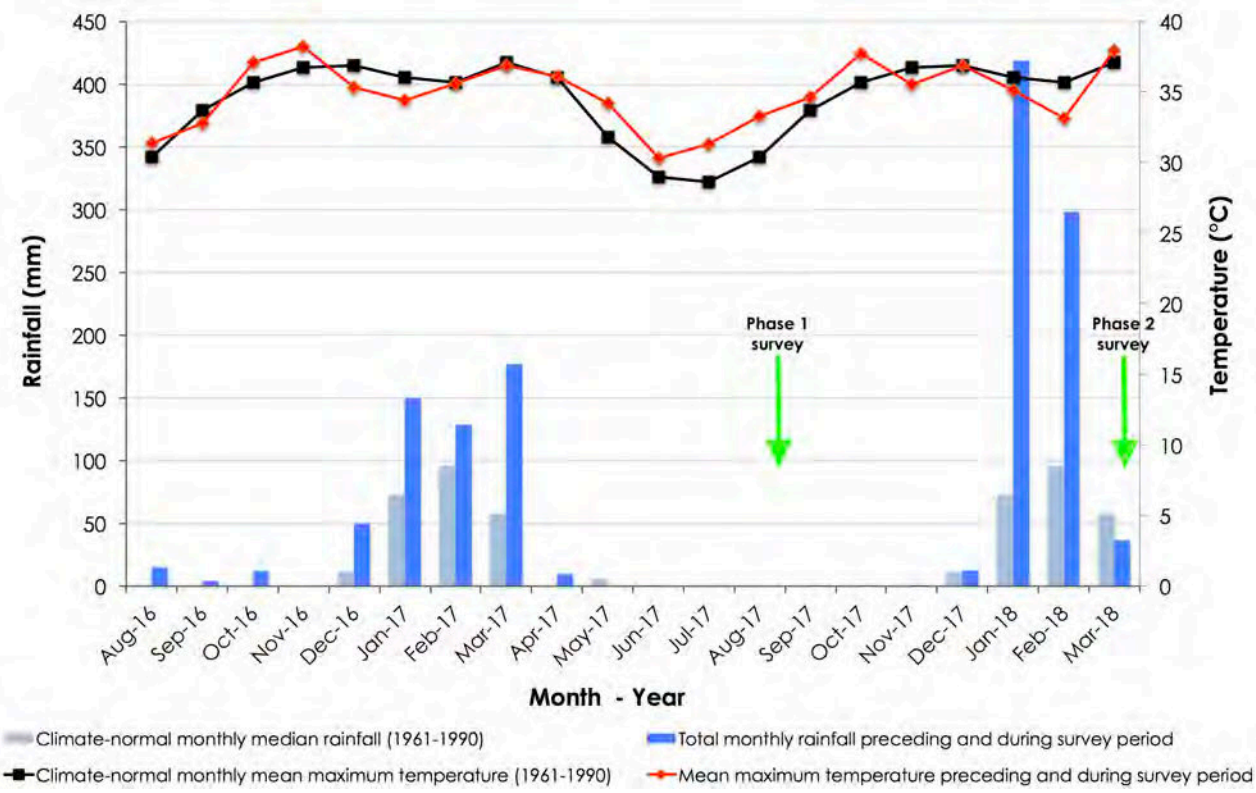

Figure 3.1: Total monthly rainfall and mean monthly maximum temperature at the Mandora weather recording station as of the 12 months prior to the current surveys, compared to the climate-normal median rainfall and mean maximum temperature for the same months.

3.2.3 Floristic Data Collection: Assessment of Quadrats and Relevés

Indicative sampling locations were selected prior to the field survey, based on the broad habitats and vegetation types apparent. Once in the field, the actual locations of the sampling sites were adjusted as necessary (e.g. to be placed in an area more representative of the broader vegetation type, to avoid recently burnt areas, etc).

Sampling sites were established as either:

1. Quadrats: bounded floristic sampling sites. The standard for the Kimberley bioregion comprises a 50 m x 50 m square (or a modified shape with an equivalent area). Quadrats were measured out using optical squares and measuring tapes, and permanently marked using steel fence droppers at each corner; or
2. Relevés: unbounded floristic sampling sites with a similar search area to a quadrat. Relevés were typically used where the target vegetation was too small or too narrow to effectively establish a quadrat. The relevés during the current survey were thoroughly surveyed for flora, but were not permanently marked.

The following parameters were recorded for all quadrats and relevés:

1. Location coordinates[4] (±5 m) were recorded using a hand-held Global Positioning System (GPS) unit; coordinates were recorded for all four corners of a quadrat; a central point was recorded as a minimum for all relevés, with a start and end point recorded for relevés that were undertaken in linear habitats such as in drainage lines or along breakaways;
2. Habitat: A description of the landform and habitat;
3. Soil: A broad description of the soil and any stony surface mantle or rocky outcropping;
4. Fire History: An estimate of time since last fire;
5. Disturbance Details: Vegetation condition was ranked according to the scale taken from EPA (2016b), based on that developed by Trudgen (1988), considering evidence of grazing, physical disturbance, weed invasion etc. (see Appendix 2);
6. Vegetation Description: A broad description based on the height and estimated cover of dominant species after Aplin's (1979) modification of the vegetation classification system of Specht (1970) (see Appendix 2);
7. Flora Species: the estimated percentage foliar cover of each flora species present within the quadrat, or in the vicinity of the relevé (within a ~30 m radius of the centre point); and
8. Photograph: A representative digital photograph of the vegetation was taken, typically from the north or northwestern corner of the quadrat or the central point of a relevé.

A minimum of three sampling sites was established within each vegetation type, consistent with the EPA (2016b) requirements for a Detailed vegetation survey, except where insufficient habitat was available (vegetation type S1). A total of 56 quadrats were established in Phase 1, all within the main study area; 31 of these quadrats were resampled in Phase 2 (55%). A total of 43 additional quadrats were established in Phase 2, when the availability of a helicopter enabled access to previously inaccessible parts of the main study area, and also to sample vegetation along the transmission cable corridor. A total of seven relevés were also assessed; three in Phase 1 and four in Phase 2. A summary of the raw data from the sites is provided in Appendix 3, with locations of the sampling sites shown in Figure 3.2 and Appendix 4.

3.2.4 Vegetation Description and Mapping

The scale of vegetation mapping is influenced by a range of factors including spatial characteristics of the survey area (e.g. the size and variety of habitats present), and other factors such as the scope of the survey and the availability of current, high resolution aerial photography. The vegetation types for this study were described at the association level (level V as per the National Vegetation Information System; NVIS)[5]. This level of detail would be considered fine-scale (intra-locality) delineation of vegetation types as per EPA (2016b). In general, minor variations in the vegetation were not clearly defined on aerial photography or were not practical to accurately map in the field (e.g. minor drainage lines). These minor variations were incorporated into the surrounding 'parent' vegetation type.

Vegetation types in the study area were sampled with 99 quadrats and seven relevés (see Appendix 3 for raw data), and also with mapping notes at numerous locations. Mapping notes were utilised to mark the boundaries of vegetation types in the field to allow for more accurate delineation of these boundaries following the survey. Mapping notes were also used as an additional way to define vegetation types when it was not practical to establish quadrats or relevés within the vegetation type.

Vegetation types and boundaries were subsequently verified using both the data collected in the field and digital imagery. Each vegetation type mapped for this assessment was given a unique alphanumeric code, comprising a character representing the broad landform group (i.e. 'D' for

[4] All coordinates presented in this report are in GDA94 datum and MGA51 projection.

[5] http://www.environment.gov.au/land/publications/nvis-taxonomic-review/introduction#del

drainage areas, 'S' for sand dunes, 'P' for plains, 'H' for low stony rises, and 'R' for rocky outcrops and breakaways), followed by a number sequence, and an additional letter as necessary to indicate a vegetation sub-type. The codes and a full description of each vegetation type are presented in Section 5.2.

Vegetation maps were created and consolidated using Geographical Information System (GIS) software (QGIS and MapInfo Professional), with point locations of sampling sites, mapping notes, conservation significant flora and weeds added. All maps in this report were produced by Mel Robinson (Senior GIS Cartographer with Biota) and Paul Sawers (GIS Manager with Biota) using MapInfo Professional (version 11).

3.2.5 Searches for Threatened, Priority Flora and Weeds

Due to the size of the study area and the lack of vehicle access, only a relatively small portion of the area could be searched using foot traverses. Targeted, non-systematic searches were conducted in areas considered to be potential habitat for conservation significant flora (i.e. Threatened and Priority listed species). The routes of the foot traverses intersected all major habitats and vegetation types in the study area (see Figure 3.2), and survey effort was increased in areas that were recognised as having a high potential to support conservation significant or restricted species (e.g. on rockpiles and along sand dunes). The distance between botanists during traverses varied depending on the terrain.

Locations of species of conservation significance or unknown taxa were recorded using a hand-held GPS unit. The number of individuals and extent of the population were also recorded for each location, together with the habitat and associated species.

Locations of introduced flora species (weeds) were also recorded during the foot traverses, along with an estimate of their population size.

Locations of conservation significant flora and weeds are tabulated in Appendix 5.

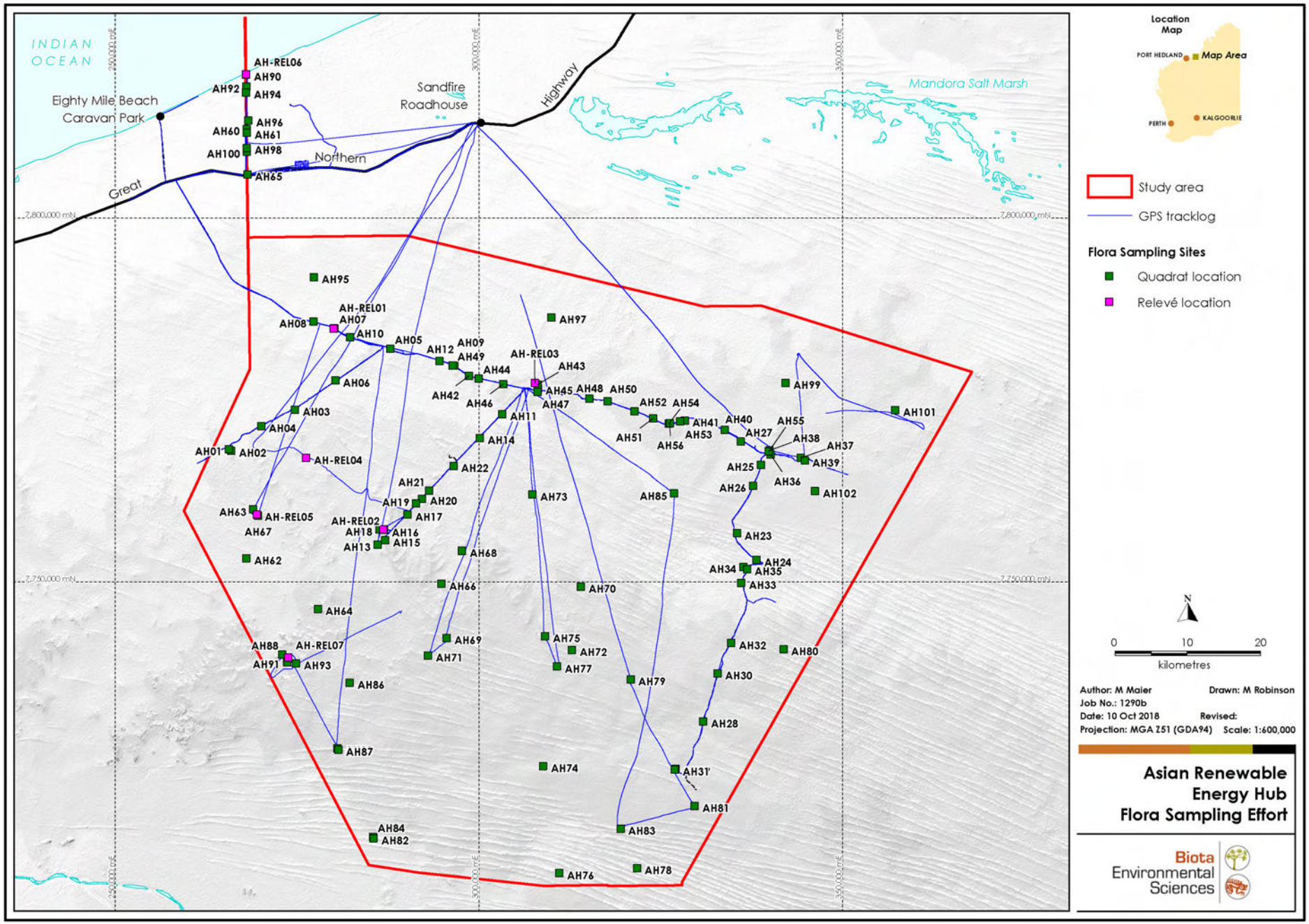

Figure 3.2: **Sample site locations and aerial (helicopter), vehicle and foot traverses in the study area.**
NB. Some track logs not recorded.

3.3 Specimen Identification, Nomenclature and Data Entry

Common taxa that were well known to the survey botanists were confirmed in the field. A voucher specimen was collected if the taxon was either difficult to determine without closer examination, belonged to a recognised species complex, was poorly collected or otherwise unusual, or was in very good condition (healthy specimens with flowers and/or fruits are often useful to submit to the WA Herbarium). Each voucher specimen was assigned a unique internal code to facilitate tracking of data. Specimens were pressed in the field and then returned to Perth for further examination and confirmation.

Voucher specimens were identified using all available flora keys, including a draft of a new Kimberley flora kindly provided by Dr Russell Barrett (CSIRO), and comparison with reference collections of specimens at the WA Herbarium and in-house at Biota. Most specimens were identified by Pierre-Louis de Kock (Level 2 Botanist / Specialist Taxonomist with Biota) and Michi Maier (Principal Botanist / Director with Biota). Assistance was also sought from a number of specialist taxonomists to further resolve specimen identifications during the study but could not be obtained due to existing engagements, with the exception of the following:

- Dr Matt Barrett (Kings Park and Botanic Gardens) assisted with determination of some specimens from a range of families.
- Dr Carol Wilkins (The University of WA) confirmed the identifications of flowering specimens of *Seringia exastia* and *S. katatona*.
- Ryonen Butcher and Steven Dillon (WA Herbarium) assisted with confirmation of some *Tephrosia* specimens from the study area. Steven Dillon also provided advice regarding *Neobassia astrocarpa*.

A full flora species list is provided in Appendix 6. Nomenclature and conservation significance rankings used in this report are consistent with the current listing of WA flora recognised by the WA Herbarium on FloraBase[6] at the time of preparation of this report.

All data were entered into a Microsoft Access database structure maintained at Biota, which was developed by Ted Griffin at the request of Malcolm Trudgen (M.E. Trudgen & Associates).

3.4 Analysis

3.4.1 Floristic Analysis

Hierarchical clustering analyses were conducted in PRIMER v6 (Clarke and Gorley 2006) to investigate the similarity of sampling sites based on their floristic composition. Analyses were conducted using only those sites within the study area in order to identify the floristic groups present, with a regional analysis also completed using the small amount of relevant data that could be sourced from the broader locality.

A total of 99 quadrats and five relevés sampled within the study area were included in the input data set, comprising all those sampled during the current surveys with the exception of:

- Relevé AH-REL06; this site on a primary dune contained only four species.
- Relevé AH-REL04; this site had been recently burnt (within the last year).

All weed records were removed with the exception of **Cenchrus ciliaris* and **C. setiger*, which were dominant in the vegetation at some sites; these were combined as "*Cenchrus* spp.". For sites that had been sampled twice, data from the two phases were merged; where cover values differed between phases, the highest cover value was retained.

6 http://florabase.dpaw.wa.gov.au

For the analysis that utilised only the sites in the study area, the percent cover data were used (transformed using a single square root transformation). The Bray-Curtis measure of similarity was used to produce a similarity matrix. The cluster analysis (group average method) was used to determine floristic groups, with statistically different groups identified through similarity profile analysis (SIMPROF). The similarity percentage test (SIMPER) was used to determine which species contributed most to the similarities between groups. Analyses were run using all species (perennial and annual), as well as perennial species only, given that seasonal differences in survey timing could potentially affect the suite of species present.

Only two studies contained quadrat data suitable for inclusion in a regional analysis[7], comprising:

1. A survey of vegetation in the area of Mandora Marsh, approximately 25 km north of the study area, by Markey (2017). All 25 quadrats from this report were included; these were from a variety of habitats, including mound springs, pindan plains and sand dunes.
2. A survey of Pardoo Station, approximately 85 km west of the current study area, by EnviroWorks (2017a). Six quadrats (q111, q112, q114, q138, a158 and q163) from *Melaleuca alsophila, M. lasiandra* shrublands were included in the analysis.

For the regional analysis, all weeds were removed, along with species present at only single sites. The combined species list from the surveys was reviewed for errors and inconsistencies in nomenclature. Where there were multiple taxa that could potentially represent the same species, these were all referred to a single taxon identification code, and this was treated as a single entity in the analysis. Where a taxon name could potentially refer to more than one entity across different projects (e.g. *Euphorbia* sp.), it was excluded from the analysis. The analysis was then run on presence-absence data, as only these data were provided in the two above reports. The Bray-Curtis measure of similarity was again used to produce a similarity matrix and the group average method cluster analysis was used to determine floristic groups. Separate analyses were again run using all species (perennial and annual), as well as perennial species only.

Results of all analyses were investigated through outputs including dendrograms (tree diagrams) of site similarity, and Non-metric Multi-Dimensional Scaling plots (NMDS plots). Selected inputs and outputs from the analyses are provided in Appendix 7. Due to the size of the analyses, the raw data and outputs from the larger tests are not presented in this document, however they are available on request.

3.4.2 Species Accumulation Analysis

Plots of species accumulation curves can be used to assess sampling adequacy: when a survey has sampled an adequate proportion of the floristic assemblage, the curve should plateau and approach an asymptote. EstimateS (Colwell 2013) was used to calculate smoothed species accumulation curves based on 100 random permutations of the species data; only quadrat and relevé data were used (opportunistic records were excluded), and the sampling sites were randomly assigned an order. Seasonally sampled quadrats were treated as separate samples.

Species accumulation curves alone cannot be reliably used to extrapolate predicted species richness for future biological sampling. In order to estimate asymptotic richness (i.e. an extrapolation of species richness) for the incidence data (i.e. presence, rather than abundance data), the Chao 2 Mean and ICE Mean estimators were calculated using EstimateS.

[7] Quadrats sampled by Phoenix (2017) in pindan vegetation on Shamrock Station, ~180 km north, were tested initially against the above sites; all were found to cluster separately, hence these have not been discussed further. These data are provided in Appendix 7 for completeness (quadrats S001-S023).

3.5 Limitations of the Study

In accordance with the EPA Technical Guidance for 'Flora and Vegetation Surveys for Environmental Impact Assessment' (EPA 2016b), potential constraints and limitations of this botanical survey of the study area are addressed in Table 3.2. While some limitations are relevant, the overall study still provides an assessment suitable to inform consideration of the project under Section 38 of the EP Act.

Table 3.2: Potential constraints and limitations of the current study.

Potential Constraint	Statement of Limitations
1. Sources of information	• While all publicly available databases and literature were reviewed for the current study, there has been only limited botanical survey work in the vicinity of the study area, and no previous systematic surveys within the study area itself. The current surveys added new data specific to the study area, however local level information is considered to be a limiting factor for the survey.
2. Survey scope	• The survey objective was to provide information on environmental values of the study area to support the environmental impact assessment (EIA) of the proposal. Given the size of the study area and the scope of the proposal, a Detailed flora and vegetation survey as per EPA (2016b) was considered appropriate and the requirements for this were met. • Targeted survey work for conservation significant flora was also undertaken, however systematic searches were not possible over the entire study area and are also not warranted given the very small percentage of the study area to be disturbed by the project. Further targeted survey work and searches will be undertaken once the project is in detailed design, ahead of clearing works being commenced.
3. Proportion of flora collected and identified	• Although only a proportion of the study area was surveyed, all vascular flora encountered were recorded and over 1,250 voucher specimens were collected. A total of 315 native vascular flora species and 10 introduced flora species were recorded during the current survey, which is a relatively large number given the limited range of habitats present. Some taxa (approximately 25) could not be conclusively identified, either because the collected material was inadequate or because the current taxonomic framework does not address all observed variation (see Section 6.3). Recognising these constraints, this is not considered to be a limitation for the current study.
4. Completeness of survey	• The field surveys included seasonal sampling of vegetation, with replication of sampling sites within each vegetation type. The vegetation types within the study area are considered to have been adequately described and surveyed. • Given the large size of the study area, it has not been completely surveyed for flora, nor would this be feasible in any realistic timeframe. However, the aerial reconnaissance and sites assessed showed the range of vegetation types to be relatively small for such an extensive study area, and the sampling completed adequately characterises the vegetation of the proposed disturbance areas. Further targeted survey work and searches will be undertaken once the project is in detailed design, ahead of clearing works being commenced.
5. Mapping reliability	• Vegetation types were described and mapped based on data collected during the systematic site sampling and targeted foot traverses within the study area. • Aerial imagery used in the mapping and reporting was the most current version available (varying from 2005 in the middle of the study area, to 2016 on the coast). This imagery was generally of sufficient resolution to map small stands of vegetation such as those occurring on rocky outcrops, however fire scars of different ages resulted in very variable photo signatures. Within this constraint, the mapping is considered to provide a reliable indication of the vegetation types described for the study area.
6. Timing, weather, season, cycle	• The timing of the seasonal surveys was adequate for recording annual and cryptic perennial flora species present at the time, and the combined list of vascular flora documented from the study area is comprehensive. This is not considered to be a limitation for the current study.

Potential Constraint	Statement of Limitations
7. Disturbances	• There were no disruptions during the survey and it was undertaken as planned. Only small sections of the study area have been previously cleared or otherwise disturbed.
8. Intensity of survey	• The Detailed botanical survey was considered adequate to address the vegetation values of the study area as required to support the EIA. A total of 99 quadrats and seven relevés were completed in the study area, and over half of the quadrats established in Phase 1 were resampled. This sampling intensity was considered to be adequate to document the range of vegetation types within the study area. • It was not possible to survey the entire study area systematically for flora, given the lack of vehicle access and the large size of the area. Additional flora species and additional populations of the conservation significant flora would undoubtedly be recorded with additional survey work. Intensity of flora survey work is a key limitation for the current study.
9. Resources and experience levels	• Sufficient time was allocated to the flora and vegetation field survey component (a total of 72 person days), given that the survey was never expected to comprehensively survey the entire area. The botanists undertaking the survey were all suitably qualified and experienced to identify flora. External specialist taxonomists were contacted during the specimen identification process for particular taxa, but only limited assistance was received; specimens will be lodged where required to enable further investigation. Overall, resources and experience levels were not considered to be limitations for the current study.
10. Access issues	• There was limited vehicle access within the study area, although this was mitigated by the use of a helicopter during the Phase 2 survey. In addition, the coastal swamp area within the transmission cable corridor was flooded during the Phase 2 survey (see Plate 5.1), limiting access to this area as well as the fringing habitats. Given the above, access was a limitation for this study, particularly given the large size of the study area.

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4.0 Existing Environment

4.1 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 4.1).

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 palaeoriver 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 Amadeus 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). The vegetation is similar to the McLarty subregion.

4.2 Conservation Reserves in the Locality and Existing Land Use

The nearest conservation reserves to the study area comprise the following (all distances are from the closest point of the study area; see Figure 4.1):

- **Eighty Mile Beach Marine Park** – a small section of the study area 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.

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.

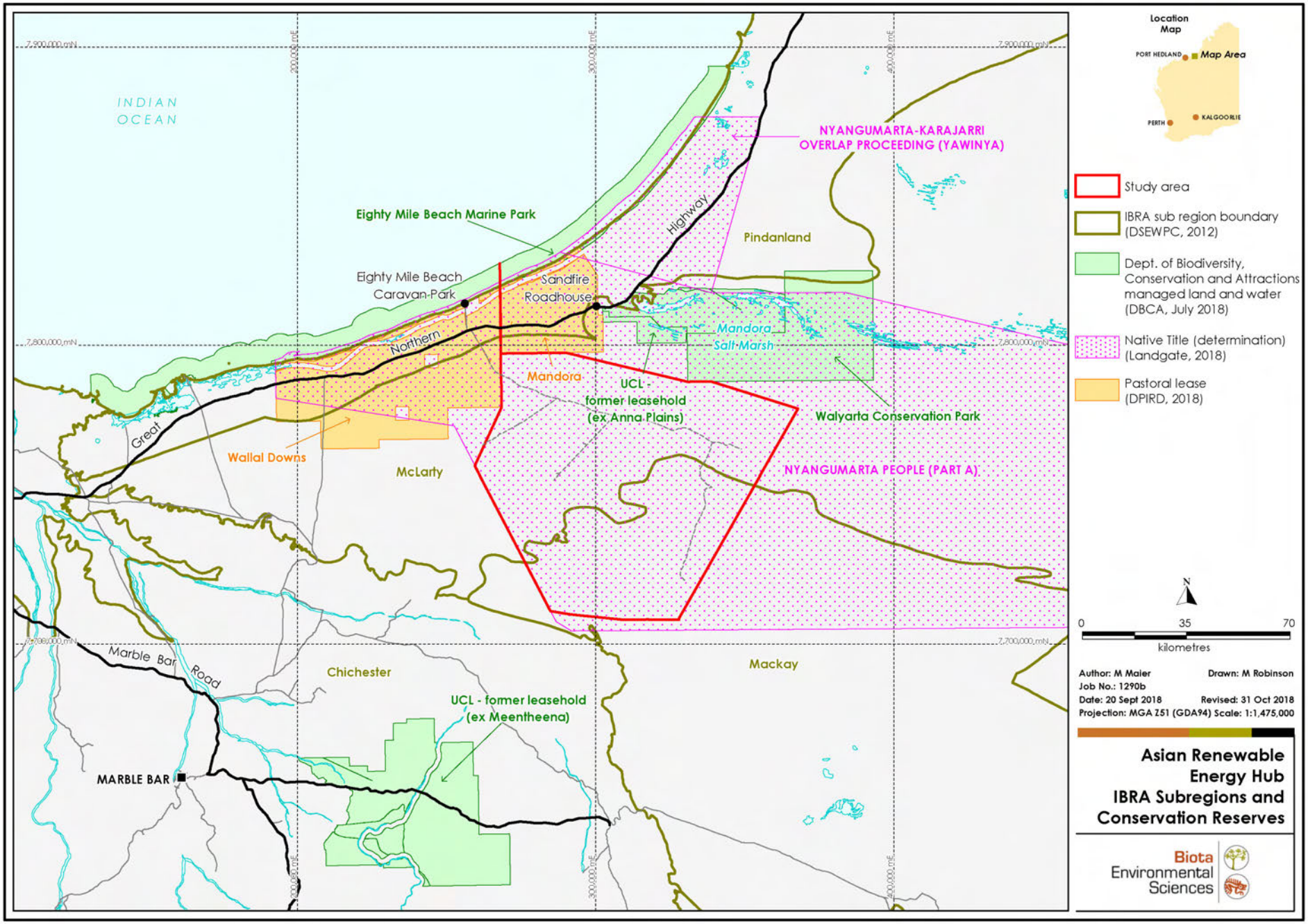

Figure 4.1: IBRA subregions and conservation reserves in the locality of the study area.

4.3 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 4.1 and Figure 4.2).

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: the eastern margin of the study area was 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.

4.4 Soils and Surface Geology

Four broad soil types have been mapped within the study area (Agriculture Western Australia 1967) (see Table 4.2 and Figure 4.3). Red earthy sands dominate the majority of the study area: units AB21 and AB22 dominate the pindan plains of the northern section of the study area, while AB39 dominates the southern section. Calcareous earths (unit Lh1) occur in the coastal areas along the transmission cable corridor.

Mapping of the surface geological units in the locality was prepared based on data from Geoscience Australia (2008); this incorporated the 1:250,000 scale mapping prepared by the Department of Mines and Petroleum for the Mandora (SE51-13), Yarrie (SF51-01) and Anketell (SF51-02) map sheets. The geological units are summarised in Table 4.3, while their extent is shown in Figure 4.4. Sandplain (Czs) and dunes (Qd) dominate the majority (87.7%) of the study area, together with numerous smaller areas of ferruginous duricrust (Czl) and Callawa Formation (JKsc).

Table 4.1: 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	364,535.0	55.2%	1,429,175.4	25.5%	Sandplains supporting shrubby spinifex grasslands with occasional trees.
Little Sandy	253,483.6	38.4%	676,256.8	37.5%	Sandplains with linear and reticulate dunes supporting shrubby hard and soft spinifex grasslands.
Callawa	35,539.8	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	6,995.9	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 4.2: Description and extent of soil units in the study area (source: Geoscience 2008).

Soil Unit	Description	Area (ha)	% of Study Area
AB21	Pindan country: gently undulating sand plain with a few small rocky sandstone residuals; no external drainage: chief soils are red earthy sands (Uc5.21), with associated (Uc5.11) and hummocks of siliceous sands (Uc1.23).	320,860.0	48.6%
AB22	Gently undulating sand plain as for unit AB21 but with many rocky sandstone residuals: chief soils are red earthy sands (Uc5.21), with (Uc5.11) and (Uc1.23) as for unit AB21. Associated are bare rock and shallow sands, probably (Uc1.4), of the sandstone residuals.	157,085.0	23.8%
AB39	Gently undulating plains dominated by longitudinal dunes of varying frequency; some exposures of ironstone gravels on low rises occur in the dune swales: chief soils are red earthy sands (Uc5.21) on dune slopes, and interdune plains with red siliceous sands (Uc1.23) on the dunes. Other soils include (KS-Uc5.21) on the gravelly rises where an ironstone (laterite) duricrust is present at about 18 in. depth; and (Um5.11) on small included areas of calcrete (kunkar).	182,753.0	27.7%
Lh1	Coastal plains, mainly beyond marine flooding influence: main soils are pedal calcareous earths (Gc2.22) with some associated highly calcareous earths (Gc1.12). On the seaward side are firstly samphire flats (Gc1.1) and then bare saline mud (Uf). Calcareous dunes (Uc1.11) commonly occur on the seaward edge of the plains.	44.0	0.01%
Water	Water	32.0	<0.01%

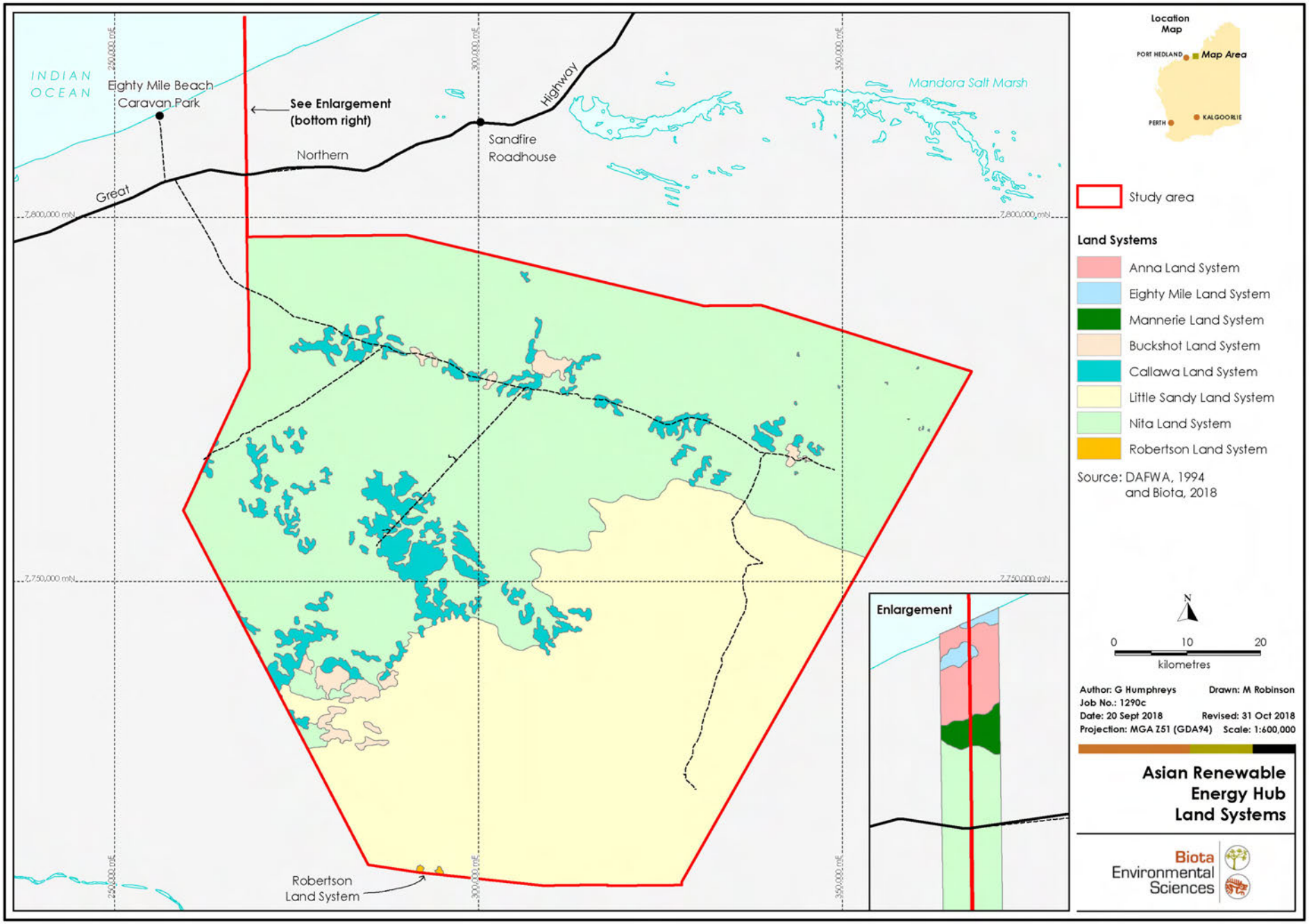

Figure 4.2: Land systems in the study area.

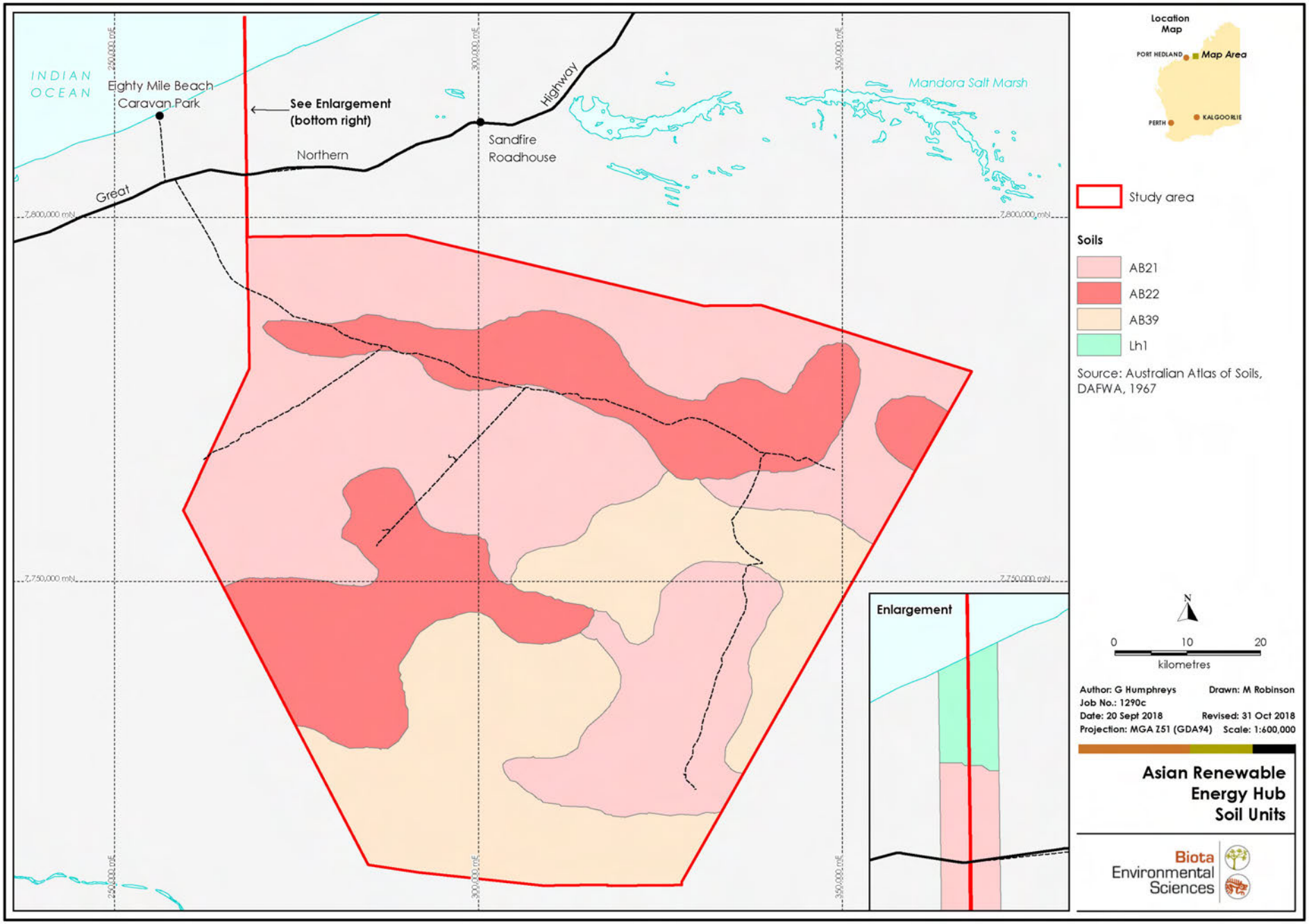

Figure 4.3: Soil units in the study area.

Table 4.3: Description and extent of surface geology units in the study area (source: Geoscience 2008).

Geological Unit	Description	Area (ha)	% of Study Area
Czl	Ferruginous duricrust: Pisolitic, nodular or vuggy ferruginous laterite; some lateritic soils; ferricrete; magnesite; ferruginous and siliceous duricrusts and reworked products, calcrete, kaolinised rock, gossan; residual ferruginous saprolite.	52,167.6	7.9%
Czs	Sand plain: Sand or gravel plains; quartz sand sheets commonly with ferruginous pisoliths or pebbles, minor clay; local calcrete, laterite, silcrete, silt, clay, alluvium, colluvium, aeolian sand.	400,728.7	60.6%
JKsc	Callawa Formation: Fluviatile cross-bedded very fine to coarse-grained sandstone, granule conglomerate and minor siltstone; plant and trace fossils.	18,438.9	2.8%
Ksfr	Frezier Sandstone: Fine- to coarse-grained poorly sorted, poorly bedded sandstone; minor conglomerate, mudstone.	1,200.1	0.2%
Kspa	Parda Formation: Mudstone, claystone; minor fine-grained sandstone; macrofossils; shallow marine deposits.	3,595.7	0.5%
Nlyw	Waroongunyah Formation: Laminated to massive dolomite, stromatolitic dolomite, sandy dolomite, siliceous oolite, sandstone, siltstone and shale.	10.2	<0.01%
Nstb	Broadhurst Formation: Interbedded fine to coarse sandstone, siltstone, silty shale, dolomite, stromatolitic dolomite, local basalt.	78.6	0.01%
Nstc	Coolbro Sandstone: Thickly bedded massive sandstone, minor siltstone, shale and pelitic schist, carbonate, and basal polymictic conglomerate.	337.4	0.1%
Psp	Paterson Formation: Poorly sorted sandstone, claystone, conglomerate, tillite, siltstone, diamictite; varves and erratics in places - glacigene, lacustrine, to fluvioglacial.	164.4	<0.01%
Qa	Alluvium: Channel and flood plain alluvium; gravel, sand, silt, clay, locally calcreted.	3,465.3	0.5%
Qd	Dunes: Sandplain with dunes and swales; may include numerous interdune claypans; residual and aeolian sand with minor silt and clay; aeolian red quartz sand, clay and silt, in places gypsiferous; yellow hummocky sand.	178,792.3	27.1%
Qdc	Coastal dunes: Beach sand, sand dunes, coastal dunes, beaches, and beach ridges; calcareous and siliceous, locally shelly and/or cemented (beach rock); locally reworked.	12.6	<0.01%
Qe	Estuarine and delta deposits: Coastal silt and evaporite deposits; estuarine, lagoonal, and lacustrine deposits.	28.2	<0.01%
Qrc	Colluvium: Colluvium, sheetwash, talus; gravel piedmonts and aprons over and around bedrock; clay-silt-sand with sheet and nodular kankar; alluvial and aeolian sand-silt-gravel in depressions and broad valleys in Canning Basin; local calcrete, reworked laterite.	1,715.1	0.3%
water	Water.	38.4	0.01%

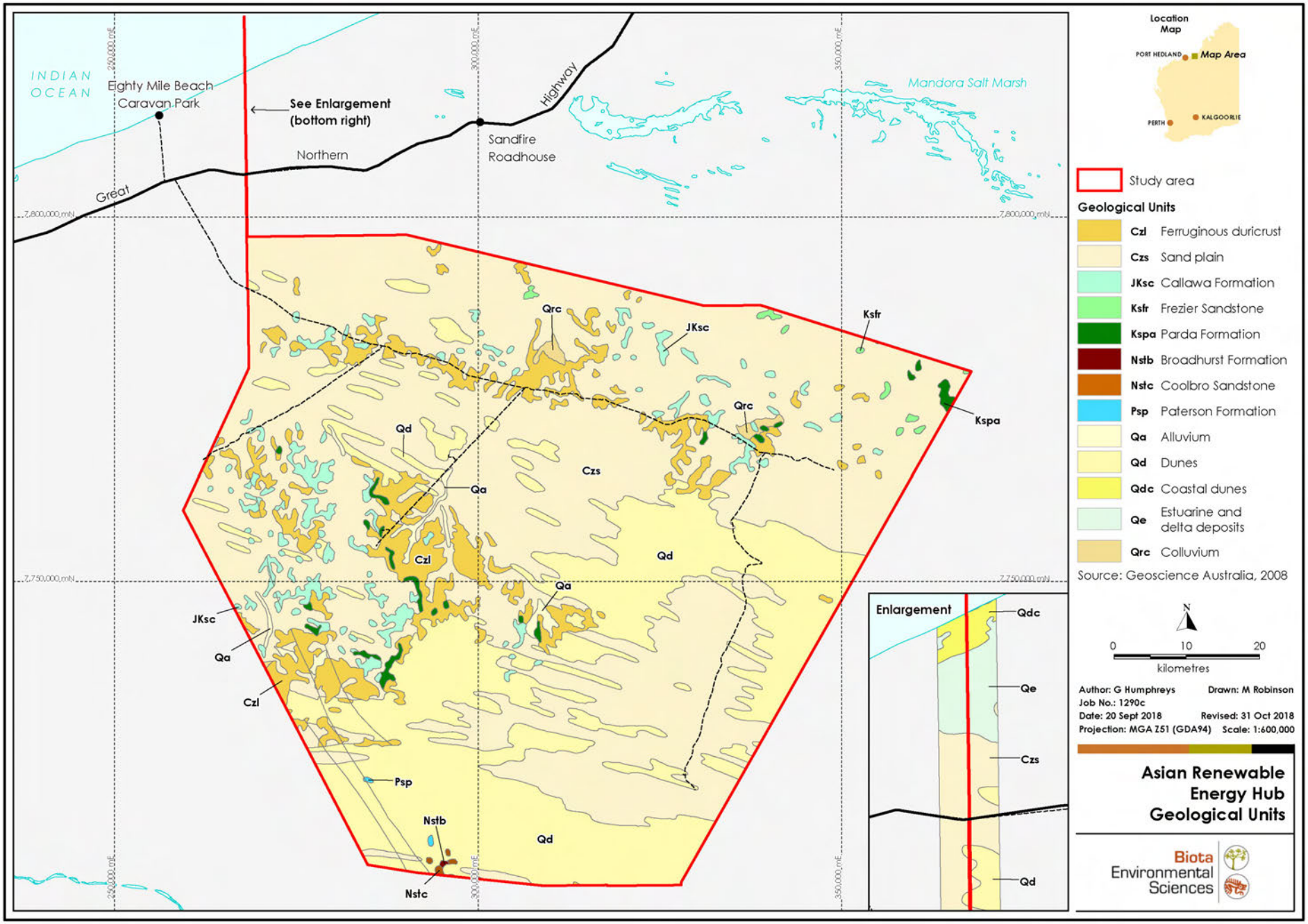

Figure 4.4: Geological units in the study area.

4.5 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 4.4 and Figure 4.6). The majority of the study area was mapped by Beard as hummock grasslands with sparse to open shrublands. Finer scale delineation of vegetation types for the study area, including their correspondence with Beard's units, is provided in Section 5.2.

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 4.4 and Figure 4.6).

4.6 Previous Botanical Surveys in the Study Area

The only previous botanical surveys in the study area comprise the ethno-botanical work in the Nyangumarta Warrarn IPA completed by Vicki Long and Associates (2014, 2015). Neither report was sighted, however a number of the flora species from this work have been documented in Nyangumarta Warrarn Aboriginal Corporation (2016).

In addition, there have been some opportunistic (mostly historic) flora collections by various persons, as identified through the NatureMap and AVH database searches. In general, the study area and the broader Great Sandy Desert to the east have been poorly collected (see Figure 4.5).

Species identified through the above sources that could be confidently attributed to the study area have been included in the species list within Appendix 6.

Figure 4.5: Flora records obtained from AVH for the locality, highlighting the limited botanical collections in the study area.

Table 4.4: Description and extent of Beard's broad vegetation units in the study area, together with pre-European and current extents (from Government of Western Australia 2018).

Beard's Vegetation System Association (ordered from coast to furthest inland)	System Association Code	Area in Study Area (ha)	% of Study Area	Extent in McLarty, Mackay and Pindanland Subregions		% of Current Extent in Study Area	Beard's Description
				Pre-European Extent	Current Extent		
Mandora Coastal Plain 73	73.2	28.4	<0.01%	238,066.9	237,526.7	0.01%	Grasslands, short bunch grass savanna, grass; Saltwater Couch grassland (*Sporobolus virginicus*).
Mandora Coastal Plain 41	41.3	15.7	<0.01%	3,106.9	3,106.9	0.5%	Shrublands; teatree scrub.
Pindan 32	32.1	41.8	<0.01%	244,906.4	244,874.7	0.02%	Shrublands, pindan; *Acacia* shrubland with scattered low trees over *Triodia* spp.
Mandora - East 80	80.1	152,538.8	23.1%	294,534.4	294,534.4	51.8%	Hummock grasslands, low tree steppe; Desert Walnut over soft spinifex between sand ridges.
Mandora - East 117	117.1	30,209.4	4.6%	242,002.0	235,135.0	25.5%	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%	249,037.1	248,987.9	0.4%	
Mandora - East 101	101.1	117,960.2	17.9%	570,038.9	569,993.1	34.3%	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%	391,130.9	391,130.9	2.3%	
Great Sandy Desert 134	134.1	242,642.9	36.7%	11,218,535.7	11,217,944.1	2.2%	Mosaic: Hummock grasslands, open low tree steppe; Desert Bloodwood and Feathertop Spinifex (*Triodia schinzii*) on sandhills / Hummock grasslands, shrub steppe; mixed shrubs over spinifex between sandhills.

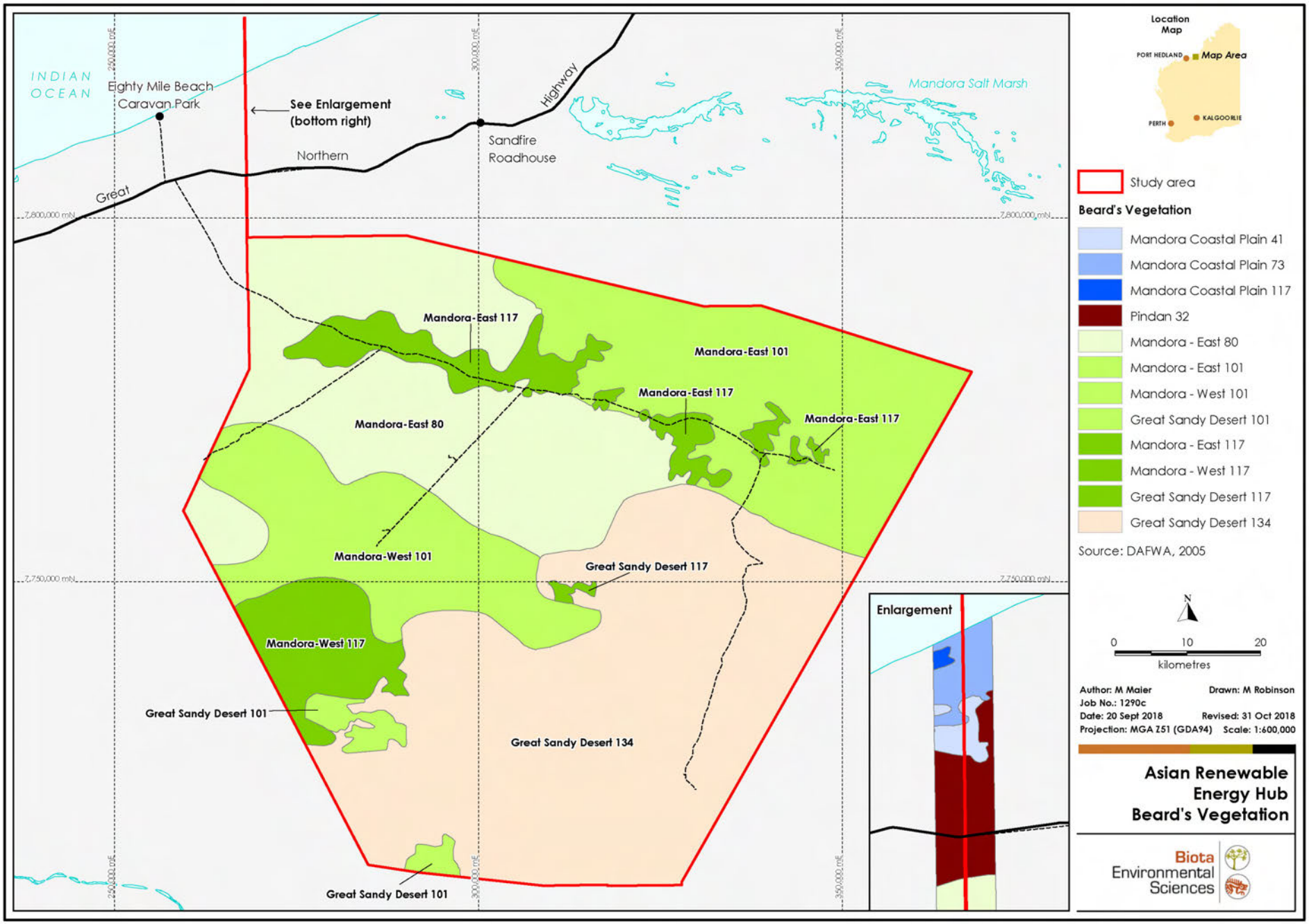

Figure 4.6: Beard's vegetation associations for the study area.

4.7 Communities of Conservation Significance from the Locality

Four communities of particular conservation significance occur in the locality (one TEC and three PECs). In addition, a listed Ramsar site also incorporates the TEC and two of the PECs; Ramsar sites are wetlands that are listed as being of international importance. The communities and the Ramsar site are described briefly below:

1. Mandora Mounds TEC

The only TEC in the locality comprises the "organic springs and mound springs of the Mandora Marsh area" (DBCA 2018). This community is listed as a TEC for WA but is not listed under the Commonwealth EPBC Act. The closest mound springs of Mandora Marsh are located approximately 22 km north of the study area, and there is no suitable habitat in the study area for this community.

2. Inland Mangrove (*Avicennia marina*) community of Salt Creek PEC

This Priority 1 PEC is described as occurring on Anna Plains and Mandora stations (DBCA 2017). No mangal habitat is known from the study area.

3. Vegetation Association 73 as defined by John Beard's vegetation mapping for the Kimberley (Beard 1979) PEC

This Priority 3(iii) PEC, hereafter referred to as 'the Vegetation Association 73' PEC, is described as comprising "Grasslands, short bunch grass savanna, grass; salt water grassland (*Sporobolus virginicus*)", which are under threat from "extensive threatening processes acting at landscape scales, namely altered fire regimes, over grazing, and weed invasion" (DBCA 2017). A small amount of Beard's vegetation association 73 is mapped at the northern end of the transmission cable corridor (see Section 4.5), however this vegetation is already extensively degraded (see Section 5.2.3).

4. Eighty Mile Land System PEC

This Priority 3(iii) PEC is described as "Beach foredunes, longitudinal coastal dunes and sandy plains with tussock grasslands and spinifex grasslands", which are under threat from "extensive threatening processes acting at landscape scales, namely altered fire regimes, over grazing, erosion, and weed invasion (Buffel Grass)" (DBCA 2017). Areas of this land system are mapped at the northern end of the transmission cable corridor (see Section 4.3), but only the coastal dunes at the far northern end remain in good condition (see Section 5.2.2).

5. Eighty Mile Beach Ramsar Site

The Eighty Mile Beach Ramsar site includes two elements:

- the Eighty Mile Beach stretch of beachfront and associated tidal mudflats; and
- the Mandora Salt Marsh, which includes Lake Walyarta, East Lake, and the surrounding intermittently inundated paperbark thickets, all of which are inundated by rainfall and local runoff; together with Salt Creek and a series of small permanent mound springs, which are groundwater-fed systems through the Broome Sandstone Aquifer (Hale and Butcher 2009).

Hale and Butcher (2009) described this Ramsar site as meeting six criteria for listing as a wetland of international importance, two of which included botanical values:

- "Criterion 1: Eighty-mile Beach represents the greatest extent of continuous intertidal mudflat in excellent condition within the Northwest (IMCRA) bioregion. In addition, Mandora Salt Marsh contains an important and rare group of wetlands within the arid Western Plateau bioregion (Semeniuk and Semeniuk 2000). In particular the peat mound springs can be considered both bioregionally rare and outstanding examples of this wetland type in Western Australia."
- "Criterion 3: The Mandora Salt Marsh contains temporary and permanent wetlands in a predominantly arid bioregion (Western Plateau) and has been recognised as important refugia for biological diversity in arid Australia (Morton et al. 1995). The inland Grey Mangroves lining Salt Creek represent the most inland occurrence of this species (Semeniuk and Semeniuk 2000)."

The boundary of the Ramsar site along the beach is defined by the tide, extending from Mean Low Water (MLW) to 40 m above Mean High Water (MHW). The eastern edge of the site is bounded by coastal dunes; the discontinuous linear floodplains, immediately inland of the frontal sand dunes, are predominantly outside the Ramsar boundary (Hale and Butcher 2009). The small section of beach within the transmission cable corridor would comprise part of this Ramsar site, but does not have any particular botanical values.

There are four groups of vegetation that Hale and Butcher (2009) stated could be considered critical components of the ecological character of the Eighty Mile Beach Ramsar site:

- Mangroves;
- Paperbark thickets;
- Samphire; and
- Freshwater aquatic vegetation.

Hale and Butcher (2009) noted that "with the exception of the extent of mangroves, there is no quantitative information on the extent and composition of vegetation communities within the Ramsar site" and recommended "mapping of extent of vegetation (remote sensing) and community composition (ground surveys) to set a baseline against which change can be assessed".

4.8 Flora of Conservation Significance Known from the Locality

A total of 19 flora species of conservation significance were identified through the desktop assessment as having been recorded from the locality, comprising two Priority 1, four Priority 2, and 13 Priority 3 species (Table 4.5). The EPBC Act Protected Matters search did not identify any Threatened species listed as MNES as having been recorded or potentially occurring in the area, and no Threatened species had been recorded in the locality prior to the current surveys.

Table 4.5: Flora species of conservation significance identified through the desktop assessment as having been recorded from the locality of the study area (within 20-50 km) or potentially occurring in the habitats present.

Taxon	Status	Source (see Section 3.1)				Habitat of Local Collections (NR = nearest confirmed record)	Likelihood of Occurrence in the Study Area (Prior to the Current Surveys)
		AVH / Nature Map	Biota Flora Database †	EnviroWorks (2017a) – Pardoo	EnviroWorks (2017b) – Anna Plains		
Atriplex eremitis	Priority 1	✓				Saline plain near mound springs (NR 22 km north).	Unlikely; no suitable habitat.
Tephrosia sp. Port Hedland (A.S. George 1114)	Priority 1	✓				Sand dune (NR 17 km west).	Likely; extensive suitable habitat and recorded in close proximity.
Eragrostis filicaulis	Priority 2	✓				Saline plain with *Eragrostis falcata* and *Panicum decompositum* (NR 11 km east).	May potentially occur; minimal suitable habitat.
Euphorbia australis var. *glabra*	Priority 2	✓				Major river (NR 20 km south).	Unlikely; no suitable habitat.
Goodenia hartiana	Priority 2	✓				Sand dune (NR 3.9 km southwest).	Likely; extensive suitable habitat and recorded in close proximity.
Solanum oligandrum	Priority 2	✓				*Melaleuca alsophila* shrubland over *Triodia epactia* hummock grassland on calcrete (NR 27 km north).	Unlikely to occur; no particularly suitable habitat.
Bonamia oblongifolia	Priority 3	✓	✓	✓	✓	Pindan plain (NR 7 km east).	Likely; extensive suitable habitat and recorded in close proximity.
Corynotheca asperata	Priority 3	✓				Sand plain (NR 9.6 km south).	Likely; extensive suitable habitat and recorded in close proximity.
Croton aridus	Priority 3	✓				Sand plain (NR 0.4 km west).	Likely; extensive suitable habitat and recorded in close proximity.
Fuirena incrassata	Priority 3	✓				Ephemeral claypan with *Eucalyptus victrix* (NR 21 km north).	Unlikely; no suitable habitat.
Gymnanthera cunninghamii	Priority 3	✓				*Melaleuca alsophila* shrubland over *Triodia epactia* hummock grassland on calcrete (NR 27 km north; another historic record in the study area is considered erroneous).	Unlikely; no suitable habitat.
Indigofera ammobia	Priority 3	✓				Sand dune (NR 21 km north).	Likely; extensive suitable habitat.
Lawrencia sp. Anna Plains (N.T. Burbidge 1433)	Priority 3	✓				Dense woodland of *Melaleuca alsophila* and *M. glomerata*; semi-saline drainage depression on coastal plain (NR 17 km north).	May potentially occur; minimal suitable habitat.
Nicotiana heterantha	Priority 3	✓				Saline plain with shrubland of *Melaleuca glomerata* (NR 18 km east).	May potentially occur; minimal suitable habitat.

Taxon	Status	Source (see Section 3.1)				Habitat of Local Collections (NR = nearest confirmed record)	Likelihood of Occurrence in the Study Area (Prior to the Current Surveys)
		AVH / Nature Map	Biota Flora Database †	EnviroWorks (2017a) – Pardoo	EnviroWorks (2017b) – Anna Plains		
Polymeria sp. Broome (K.F. Kenneally 9759)	Priority 3	✓	✓			Pindan plain (NR 5 km east).	Likely; extensive suitable habitat and recorded in close proximity.
Pterocaulon xenicum	Priority 3	✓				Outwash fan and alluvial floodplains (NR 22.5 km southwest).	Unlikely; no particularly suitable habitat.
Seringia katatona	Priority 3		✓			Pindan plain (NR 7 km east).	Likely; extensive suitable habitat and recorded in close proximity.
Terminalia kumpaja	Priority 3	✓	✓			Pindan plain (NR 7 km east).	Likely; extensive suitable habitat and recorded in close proximity.
Tribulopis marliesiae	Priority 3	✓	✓	✓		Pindan plain (NR 7 km east).	Likely; extensive suitable habitat and recorded in close proximity.

† Includes data from Biota (2017, 2018a).

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5.0 Vegetation of the Study Area

5.1 Overview

Mapping of the vegetation types in the study area is provided in Appendix 4, while the units are summarised in Table 5.1.

A total of 88.4 ha (0.01%) of the study area comprised elements with no particular botanical values:

- Ocean: 41.5 ha;
- Beach: 0.4 ha
- Water (an inundated area in the transmission cable corridor): 2.8 ha; and
- Disturbed areas (the Great Northern Highway and Nyangumarta Highway): 43.7 ha.

Nine vegetation types were identified for the remainder of the study area, associated with five broad landforms:

- Drainage areas;
- Sand dunes;
- Plains;
- Low stony rises; and
- Rocky outcrops and breakaways.

Drainage areas, sand dunes and plains were differentiated into coastal and inland habitat types, while the stony rises and rocky outcrops and breakaways were only present in the inland areas (see Plate 5.1 to Plate 5.8). The coastal sections of the study area lie within the southern end of the Pindanland subregion of the Dampierland bioregion, while the inland areas lie near the western ends of the McLarty and Mackay subregions of the Great Sandy Desert bioregion. The vegetation types identified in these areas were consistent with those recorded from these bioregions in the locality.

The only significant drainage feature in the study area was an area of low-lying habitat located between the coastal dunes and the pindan plain; this was completely inundated at the time of the Phase 2 survey as a result of heavy rainfall from two cyclones and a tropical low in January/February 2018. This coastal swamp area was dominated by tall shrublands of *Melaleuca glomerata* (Desert Honey-myrtle), *M. alsophila* (Saltwater Paperbark), *M. lasiandra* and *Acacia ampliceps* (Salt Wattle). In the inland areas, drainage was generally diffuse through the broad sandy plains. Small flowlines drained the low stony rises, but these were shallowly incised and typically only supported more dense tall shrublands dominated by species present in the surrounds. No mound springs or freshwater soaks were identified in the study area.

The primary dunes and associated swales had a white sand substrate, and occupied the areas closest to the coast. These were dominated by hummock grasslands of *Spinifex longifolius* (Beach Spinifex) and *Triodia epactia* (Humpback Spinifex) and would comprise part of the "Eighty Mile Land System" PEC. The sand dunes in inland areas had a pink to red pindan sand substrate, and were typically long linear dunes trending east-west. These were dominated by mixed open shrublands over open hummock grasslands of *Triodia schinzii* (Feathertop Spinifex).

The plains near the coast had a grey silty loam to light clay substrate, and were extensively degraded through weed invasion and heavy grazing by cattle. These areas would presumably once have supported hummock grasslands of *Triodia epactia*, which were now replaced by tussock grasslands of **Cenchrus ciliaris* (Buffel Grass) and **C. setiger* (Birdwood Grass). Further inland, the broad plains were more typical of the locality, with pink to red pindan soils. These

were in Excellent condition and supported typical pindan vegetation, comprising occasional trees of species such as *Corymbia zygophylla* (Broome Bloodwood), *Erythrophleum chlorostachys* (Ironwood) and *Owenia reticulata* (Native Walnut), over open to moderately dense mixed shrublands typically dominated by wattles (*Acacia* spp.), over hummock grasslands of *Triodia schinzii* and *T. epactia*.

Low rises with a surface covering of laterite gravel and pebbles occurred sporadically through the study area. These supported open hummock grasslands of *Triodia epactia* with a low open shrubland of the wattles *Acacia hilliana* (Hill's Tabletop Wattle) and *A. adoxa* var. *adoxa* (Grey Whorled Wattle); taller shrubs were typically sparse but included species such as *Grevillea refracta* (Silver-leaf Grevillea) and *G. wickhamii* (Wickham's Grevillea). In some places, these hills were surmounted by areas of rocky laterite outcropping and/or boulders, most of which were relatively small. One short rocky breakaway was also found on the western side of a laterite rise. These rocky areas supported some species that were not found in any other habitats in the study area, including *Ficus brachypoda* (Rock Fig), *Mallotus nesophilus* (Yellow Ball Flower), *Trichosanthes cucumerina* (Snake Gourd) and *Triumfetta incana*.

Plate 5.1: Coastal swamp.

Plate 5.2: Inland drainage line.

Plate 5.3: Coastal sand dune.

Plate 5.4: Inland sand dune.

Plate 5.5: **Coastal plain.**

Plate 5.6: **Inland plain.**

Plate 5.7: **Low stony rise.**

Plate 5.8: **Rocky outcropping.**

Table 5.1: Summary of vegetation types recorded from the study area.

Broad Landform	Vegetation		Description	Extent in Study Area	
	Type	Sub-Type		Hectares	%
Drainage areas	D1	–	*Melaleuca glomerata, M. lasiandra, M. alsophila, Acacia ampliceps* tall shrubland over *Trianthema turgidifolium, Solanum esuriale* low open shrubland	9.0	<0.01%
	D2	a	*Grevillea refracta, G. wickhamii, Acacia colei* var. *colei, A. monticola* tall shrubland to tall open scrub over *A. adoxa* var. *adoxa,* (*Indigofera monophylla*) low shrubland over *Triodia epactia* open hummock grassland with *Eulalia aurea,* (*Sorghum plumosum* var. *plumosum*) open tussock grassland	Minor flowlines, not mapped separately; included within extent of H1.	
		b	*Acacia tumida* var. *kulparn,* (*Grevillea refracta*) tall shrubland to tall open scrub over *Indigofera monophylla* low open shrubland over *Triodia epactia* very open hummock grassland		
Sand dunes	S1	–	*Triodia epactia, Spinifex longifolius* open hummock grassland with *Whiteochloa airoides* open tussock grassland	0.7	<0.01%
	S2	a	*Grevillea stenobotrya, G. wickhamii, Acacia anaticeps* tall open shrubland over *A. tumida* var. *kulparn, Cyanostegia cyanocalyx, Sida* sp. Western sand dunes (P.K. Latz 11980) open shrubland over *Dicrastylis doranii,* (*Dampiera cinerea, A. stellaticeps, Gompholobium simplicifolium, Newcastelia cladotricha*) low open shrubland over *Triodia schinzii* very open hummock grassland and *Eriachne obtusa, Aristida holathera* var. *holathera* very open tussock grassland	23,577.5	3.6%
		b	*Grevillea wickhamii* tall open shrubland over *Acacia tumida* var. *kulparn, Cyanostegia cyanocalyx* open shrubland over *Gompholobium simplicifolium, Jacksonia aculeata,* (*Dicrastylis doranii, Dampiera cinerea*) low open shrubland over *Triodia schinzii* very open hummock grassland		
Plains	P1	–	*Sida fibulifera* scattered shrubs over **Cenchrus ciliaris, *C. setiger* tussock grassland	27.9	<0.01%
	P2	–	*Acacia colei* var. *colei, A. sericophylla* tall open shrubland over *Corchorus incanus* subsp. *incanus* low open shrubland over *Triodia epactia* open hummock grassland	38.6	<0.01%
	P3	a	*Owenia reticulata, Erythrophleum chlorostachys* scattered low trees over *Acacia eriopoda, A. sericophylla* scattered tall shrubs over *Acacia stellaticeps, Androcalva loxophylla* low open shrubland over *Triodia schinzii,* (*T. epactia*) open hummock grassland	605,656.4	91.7%
		b	*Erythrophleum chlorostachys* scattered low trees over *Acacia ancistrocarpa, A. monticola* tall open shrubland over *Triodia schinzii,* (*T. epactia*) open hummock grassland		
		c	*Corymbia zygophylla, Erythrophleum chlorostachys* scattered low trees over *Grevillea eriostachya, G. wickhamii* scattered tall shrubs over *Gompholobium simplicifolium, Jacksonia aculeata,* (*Dicrastylis doranii, Dampiera cinerea, Acacia stellaticeps*) low open shrubland over *Triodia schinzii* very open hummock grassland		
		d	*Erythrophleum chlorostachys* scattered low trees over *Grevillea refracta* scattered tall shrubs over *Acacia ancistrocarpa, A. monticola, A. tumida* var. *kulparn* open shrubland over *Triodia epactia* open hummock grassland		
		e	*Grevillea refracta, Acacia monticola, A. colei* var. *colei* tall open shrubland over *A. hilliana, A. adoxa* var. *adoxa* scattered low shrubs over *Triodia epactia* open hummock grassland		
Low stony rises	H1	–	*Acacia hilliana,* (*A. adoxa* var. *adoxa*) low open shrubland over *Triodia epactia* open hummock grassland	30,988.7	4.7%
Rocky outcrops and breakaways	R1	–	*Ficus brachypoda* low open woodland over *Acacia monticola, A. colei* var. *colei, Grevillea pyramidalis* tall open shrubland over *Triodia epactia* open hummock grassland	387.2	0.06%

5.2 Description of Vegetation Types

5.2.1 Vegetation of Drainage Areas

Vegetation type D1 is representative of Beard's system association Mandora Coastal Plain 41 (see Table 4.4). It also broadly corresponds to the "Freshwater, tree-dominated wetlands (Xf)" unit described by Hale and Butcher (2009) for the Eighty Mile Beach Ramsar site: "To the south and north of Walyarta and east lake (but more extensive in the south) of the lakes within the Mandora Salt Marsh site are areas of clay soil that retain surface water for longer than the surrounding landscape (Graham 1999). These support stands and thickets of Saltwater Paperbark (*Melaleuca alsophila*) and could be considered temporary, freshwater, tree-dominated wetlands."

D1:	***Melaleuca glomerata, M. lasiandra, M. alsophila, Acacia ampliceps* tall shrubland over *Trianthema turgidifolium, Solanum esuriale* low open shrubland.**
Distribution and Extent	This vegetation type was recorded from seasonally inundated areas in the northern end of the transmission corridor (Plate 5.9 and Plate 5.10). The habitat would be described as paleo-tidal coastal plains.
Other Associated Species	Trees/Tall Shrubs**:** *Acacia colei* var. *colei.* Shrubs: *Myoporum montanum.* Low Shrubs: *Hibiscus apodus, Melhania oblongifolia, Threlkeldia diffusa.* Grasses: *Triodia epactia.* Herbs: *Amaranthus undulatus, Boerhavia burbidgeana, Cassytha capillaris, C. filiformis, Cynanchum carnosum, Ptilotus exaltatus, Rhynchosia minima, Trianthema triquetrum.*
Vegetation Condition	Excellent to Very Good; occasional cattle scats and weeds present. Kapok Bush (**Aerva javanica*) had been present at AH96 at high density, however the shrubs were dead at the time of survey due to inundation.
Sites in the Study Area	Quadrats AH60, AH61 and AH96. Much of this habitat was inundated during the field survey, and AH96 was consequently established outside the study area, in representative vegetation to the east.
Notes	*Triodia epactia* was only present as scattered individuals in this vegetation type. The quadrats in this vegetation type occurred in a distinct floristic group, regardless of whether all species or only perennial species were considered. Similarly described thickets were also recorded by EnviroWorks (2017a) in coastal areas on Pardoo Station, approximately 90 km southwest of the study area; this vegetation was described as '*Melaleuca-Acacia* Shrubland B', and quadrats q111, q114 and q163 had particularly similar dominant species. Melaleuca thickets were also described by Markey (2017).

Plate 5.9: Vegetation type D1 (AH61).

Plate 5.10: Vegetation type D1 (AH96).

There were numerous minor drainage lines dissecting the low lateritic rises (vegetation type H1) through the inland sections of the study area in the McLarty subregion. These were not mapped separately due to their small size but are described below. The drainage lines supported mixed tall shrublands to tall open scrub of *Acacia* (wattle) and *Grevillea* species over *Triodia epactia* open hummock grasslands. While two sub-types (D2a and D2b) were distinguished on the basis of the floristic analysis, neither showed a consistent association with a particular habitat and it is likely that fire history was a contributing factor.

D2a:	***Grevillea refracta, G. wickhamii, Acacia colei* var. *colei, A. monticola* tall shrubland to tall open scrub over *A. adoxa* var. *adoxa*, (*Indigofera monophylla*) low shrubland over *Triodia epactia* open hummock grassland with *Eulalia aurea*, (*Sorghum plumosum* var. *plumosum*) open tussock grassland.**
Distribution and Extent	This vegetation type was recorded from minor flowlines (see Plate 5.11 and Plate 5.12). Together with D2b, this sub-type formed a minor element within vegetation type H1.
Other Associated Species	Trees/Tall Shrubs: *Codonocarpus cotinifolius, Corymbia flavescens, C. greeniana, Grevillea pyramidalis, Santalum lanceolatum.* Shrubs: *Acacia ancistrocarpa, A. tumida* var. *kulparn, Dodonaea coriacea, Ptilotus calostachyus, Sida arenicola.* Low Shrubs: *Acacia hilliana, Corchorus sidoides* subsp. *vermicularis, Dampiera candicans, Hibiscus leptocladus, Hybanthus aurantiacus, Solanum dioicum, Tephrosia rosea* var. *clementii, T.* sp. Bungaroo Creek (M.E. Trudgen 11601). Grasses: *Aristida holathera* var. *holathera, Digitaria brownii, Eragrostis eriopoda, Eriachne ciliata, E. obtusa, Paspalidium rarum, Yakirra australiensis* var. *australiensis.* Sedges: *Bulbostylis barbata, Fimbristylis simulans.* Herbs: *Boerhavia coccinea, Bonamia alatisemina, B. oblongifolia, Cassytha capillaris, Cleome uncifera* subsp. *uncifera, C. viscosa, Evolvulus alsinoides, Goodenia armitiana, Oldenlandia pterospora, Polycarpaea corymbosa* var. *corymbosa, Ptilotus fusiformis, Trianthema pilosum, Tribulopis marliesiae, Trichodesma zeylanicum, Trigastrotheca molluginea.*
Vegetation Condition	Excellent.
Sites in the Study Area	Quadrats AH38, AH54 and AH93; relevé AH-REL03.
Notes	Bloodwood (*Corymbia* spp.) trees were present in some of these flowlines, but were not a consistent feature.

Plate 5.11: Vegetation type D2: sub-type D2a (AH54).

Plate 5.12: Vegetation type D2: sub-type D2a (AH38).

D2b:	***Acacia tumida* var. *kulparn*, (*Grevillea refracta*) tall shrubland to tall open scrub over *Indigofera monophylla* low open shrubland over *Triodia epactia* very open hummock grassland.**
Distribution and Extent	This vegetation type was recorded from some minor flowlines in the western section of the main study area (Plate 5.13 and Plate 5.14). Together with D2a, this sub-type formed a minor element within vegetation type H1.
Other Associated Species	Trees/Tall Shrubs: *Codonocarpus cotinifolius, Corymbia greeniana, Grevillea wickhamii.* Shrubs: *Gossypium australe, Ptilotus calostachyus.* Low Shrubs: *Corchorus sidoides* subsp. *vermicularis, Dampiera candicans, Hybanthus aurantiacus, Isotropis atropurpurea, Solanum dioicum, Tephrosia rosea* var. *clementii, T.* sp. Bungaroo Creek (M.E. Trudgen 11601). Climbers: *Cucumis variabilis.* Grasses: *Aristida holathera* var. *holathera, Digitaria brownii, Eragrostis eriopoda, Eriachne obtusa, Eulalia aurea, Paspalidium rarum, Sorghum plumosum* var. *plumosum, Yakirra australiensis* var. *australiensis.* Sedges: *Bulbostylis barbata.* Herbs: *Boerhavia coccinea, Bonamia alatisemina, B. oblongifolia, B. pannosa, Cassytha capillaris, Cleome uncifera* subsp. *uncifera, C. viscosa, Evolvulus alsinoides, Goodenia armitiana, Polycarpaea corymbosa* var. *corymbosa, Ptilotus fusiformis, Rhynchosia minima, Trianthema pilosum, Tribulopis marliesiae, Trichodesma zeylanicum, Trigastrotheca molluginea.*
Vegetation Condition	Excellent.
Sites in the Study Area	Quadrat AH91 and AH-REL05; insufficient areas identified to establish additional sites.
Notes	Bloodwood (*Corymbia greeniana*) trees were present in some of these flowlines, but were not a consistent feature.

Plate 5.13: Vegetation type D2: sub-type D2b (AH91).

Plate 5.14: Vegetation type D2: sub-type D2b (AH-REL05).

5.2.2 Vegetation of Sand Dunes

Beard's system association Mandora Coastal Plain 73 (see Table 4.4) included the small area of coastal foredune within the study area, which was mapped as vegetation type S1.

Hale and Butcher (2009) described primary beach dunes within the Eighty-mile Beach Ramsar site as being "stabilised by Beach Spinifex (*Spinifex longifolius*) and Green Birdflower (*Crotalaria cunninghamii*) (Burbidge 1944, Craig 1983). Secondary parallel, calcareous dune ridges and swales commonly feature scattered Dune Wattle (*Acacia bivenosa*) (McKenzie 1985). Important grasses include *Whiteochloa airoides* and the local endemic Grey Soft Spinifex[8] (*Triodia epactia*), a resinous hummock-forming species (Jacobs 1992)." These descriptions are consistent with vegetation type S1 observed within the study area.

S1:	***Triodia epactia, Spinifex longifolius* open hummock grassland with *Whiteochloa airoides* open tussock grassland.**
Distribution and Extent	This vegetation type was sampled on the primary dunes and swales close to the coast at the northern end of the transmission cable corridor. It occurred on a substrate of white sand. *Spinifex longifolius* was the dominant grass on the dunes (Plate 5.15), with *Triodia epactia* and *Whiteochloa airoides* becoming dominant in the swales (Plate 5.16). This vegetation type covered a very small area. It is representative of the "Eighty Mile Land System" PEC.
Other Associated Species	Shrubs: *Acacia bivenosa.* Grasses: *Panicum decompositum* var. *decompositum.* Herbs: *Cassytha capillaris, Cleome viscosa, Euphorbia trigonosperma, E. vaccaria* var. *vaccaria, Portulaca* aff. *australis, Salsola australis.*
Vegetation Condition	Excellent.
Sites in the Study Area	Quadrat AH90 and relevé AH-REL06 (only four species at the latter site, which was not included in the floristic analysis). There was insufficient area of this vegetation type in the study area to establish additional sites.
Notes	The quadrat in this vegetation type occurred as an outlier in the floristic analysis, both when all species were considered and when only perennial species were included. This was due to the presence of *Whiteochloa airoides*, which contributed 12% cover at this site and was only present at one other quadrat used for the analysis (providing 0.1% cover at AH100).

Plate 5.15: Vegetation type S1 on foredune (AH-REL06).

Plate 5.16: Vegetation type S1 in swale (AH90).

8 NB. This species is referred to as Humpback Spinifex by Barrett et al. (2017).

The area surrounding the majority of the inland sand dunes corresponded with Beard's vegetation association Great Sandy Desert 134, and the broad vegetation described by Beard (see Table 4.4) corresponds well with the descriptions from the current study. Two vegetation sub-types, S2a and S2b, were identified on the inland sand dunes taking into account the results of the floristic analysis. When all species were considered in the analysis, sites in the two sub-types clustered in separate groups, however when only perennial species were included, two of the sites in S2a grouped with S2b, while a third occurred as an outlier. There was no clear distinction in geographic distribution, although most sites from S2b were in the northern half of the study area, while sites in S2a were in the southern and northeastern sections. It was considered likely that fire history may have influenced the floristic composition, and as there was also no way to distinguish these sub-types using aerial photography, all inland dunes have been mapped as "S2".

A sand dune on the southern side of Mandora Marsh, 48 km north of the northernmost inland dune assessed for the current study area, was sampled with two quadrats (MAND16 and MAND17; see Markey 2017). Unfortunately site data were not presented in the report, hence these quadrats could not be included in the floristic analysis. The descriptions of these quadrats are relatively similar, apart from the presence of *Terminalia kumpaja*, which was only recorded from sites on plains during the current survey:

- MAND16: "very sparse tree-mallee and shrubland of *Acacia tumida, Erythrophleum chlorostachys* and isolated trees of *Gardenia pyriformis* and *Terminalia kumpaja*, over mid-dense hummock grassland of *Triodia schinzii, Triodia epactia*, and shrubs of *Dampiera candicans, Jacksonia aculeata* and *Gompholobium simplicifolium*"; and
- MAND17: "isolated tall shrubs of *Grevillea stenobotrya, Terminalia kumpaja* and *Grevillea wickhamii*, over mid-dense shrubland of *Acacia stellaticeps* and hummock grassland of *Triodia epactia*" (Markey 2017).

S2a:	***Grevillea stenobotrya, G. wickhamii, Acacia anaticeps* tall open shrubland over *A. tumida* var. *kulparn, Cyanostegia cyanocalyx, Sida* sp. Western sand dunes (P.K. Latz 11980) open shrubland over *Dicrastylis doranii,* (*Dampiera cinerea, A. stellaticeps, Gompholobium simplicifolium, Newcastelia cladotricha*) low open shrubland over *Triodia schinzii* very open hummock grassland and *Eriachne obtusa, Aristida holathera* var. *holathera* very open tussock grassland.**
Distribution and Extent	This vegetation unit was one of two sub-types recorded from the crests and slopes of the long, linear sand dunes in the inland sections of the study area (Plate 5.17 and Plate 5.18).
Other Associated Species	Trees/Tall Shrubs**:** *Acacia sericophylla, Erythrophleum chlorostachys.* Shrubs: *Acacia platycarpa. Crotalaria cunninghamii* subsp. *cunninghamii, Grevillea eriostachya, Thinicola incana.* Low Shrubs: *Calytrix carinata, Chamaecrista symonii, Gyrostemon tepperi, Indigofera ammobia, Jacksonia aculeata, Newcastelia spodiotricha, Ptilotus arthrolasius.* Grasses: *Eragrostis eriopoda, Eriachne aristidea.* Herbs: *Cassytha capillaris, Cleome uncifera* subsp. *uncifera, Corynotheca micrantha* var. *gracilis, Heliotropium transforme, Polygala isingii, Ptilotus polystachyus, Spermacoce occidentalis, Trianthema pilosum.*
Vegetation Condition	Excellent. Camel tracks and scats were noted at most sites but there was no particular evidence of grazing or trampling.
Sites in the Study Area	Quadrats AH23, AH31, AH35, AH69, AH76, AH77, AH83 and AH87.
Notes	These sites occurred in a single floristic group when both perennial and annual species were included. When only perennial species were considered, AH23 and AH83 grouped with sites in S2b, while AH76 occurred as a separate outlier.

Plate 5.17: Vegetation type S2: sub-type S2a (AH23).

Plate 5.18: Vegetation type S2: sub-type S2a (AH83).

S2b:	***Grevillea wickhamii* tall open shrubland over *Acacia tumida* var. *kulparn*, *Cyanostegia cyanocalyx* open shrubland over *Gompholobium simplicifolium*, *Jacksonia aculeata*, (*Dicrastylis doranii*, *Dampiera cinerea*) low open shrubland over *Triodia schinzii* very open hummock grassland.**
Distribution and Extent	This vegetation sub-type was also recorded from the crests and slopes of the long, linear sand dunes in the inland sections of the study area (Plate 5.19 and Plate 5.20).
Other Associated Species	Trees/Tall Shrubs: *Acacia anaticeps, A. eriopoda, Erythrophleum chlorostachys.* Shrubs: *Acacia platycarpa. Grevillea eriostachya.* Low Shrubs: *Acacia stellaticeps, Calytrix carinata, Newcastelia cladotricha, Ptilotus arthrolasius.* Grasses: *Aristida holathera* var. *holathera, Eragrostis eriopoda.* Herbs: *Cassytha capillaris, Cleome uncifera* subsp. *uncifera, Heliotropium transforme, Polygala isingii, Trianthema pilosum, Tribulopis marliesiae.*
Vegetation Condition	Excellent. Camel tracks and scats were noted at most sites but there was no particular evidence of grazing or trampling.
Sites in the Study Area	Quadrats AH21, AH22, AH32, AH82 and AH85.
Notes	The sites in this vegetation sub-type grouped in a single floristic group, regardless of whether all species or only perennial species were considered. This sub-type was floristically similar to vegetation sub-type P3c, which occurred on sandy plains. *Triodia schinzii* dominated the very open cover of spinifex, but *T. epactia* was also present as scattered individuals at some sites in S2b on the dunes; the latter species was not recorded from the sites in P3c.

Plate 5.19: Vegetation type S2: sub-type S2b (AH21).

Plate 5.20: Vegetation type S2: sub-type S2b (AH85).

5.2.3 Vegetation of Plains

Vegetation type P1 corresponded with the distribution of Beard's vegetation association Mandora Coastal Plain 73, and was consistent with a degraded version of this vegetation (see Table 4.4).

P1:	***Sida fibulifera* scattered shrubs over *C*enchrus ciliaris*, **C. setiger* tussock grassland.**
Distribution and Extent	This vegetation type was recorded from broad paleo-tidal coastal plains with grey silty loam to light clay substrates at the northern end of the transmission cable corridor (Plate 5.21).
Other Associated Species	Low Shrubs: *Solanum esuriale*. Grasses: *Eulalia aurea, Panicum decompositum* var. *decompositum*. Herbs: *Corchorus tridens, Crotalaria medicaginea* var. *neglecta, Rhynchosia minima*.
Vegetation Condition	Very Poor; there was considerable disturbance from cattle (heavy grazing, scats and tracks), and extensive weed invasion. The cover of **Cenchrus* species would be close to 100% if not grazed, and other weeds were also present (e.g. **Citrullus lanatus*).
Sites in the Study Area	Quadrats AH92 and AH94. Establishment of an additional quadrat was not considered warranted, given the degraded nature of this vegetation type.
Notes	The two sites in this vegetation type occurred in a separate floristic group, both when all species were included and when only perennial species were considered. Similar "Coastal Plain grasslands" dominated by **Cenchrus ciliaris* were also recorded from grey-white clay substrates on Pardoo Station by EnviroWorks (2017a).

Plate 5.21: Vegetation type P1 (AH94).

Vegetation type P2 corresponded well with the distribution and description of Beard's vegetation association Pindan 32 (see Table 4.4).

P2:	***Acacia colei* var. *colei*, *A. sericophylla* tall open shrubland over *Corchorus incanus* subsp. *incanus* low open shrubland over *Triodia epactia* open hummock grassland.**
Distribution and Extent	This vegetation type was recorded from broad plains with a pink to orange sandy substrate in the transmission cable corridor, extending from the southern side of vegetation type D1 to the vicinity of the Great Northern Highway (Plate 5.22 and Plate 5.23).
Other Associated Species	Trees/Tall Shrubs: *Acacia sabulosa, Bauhinia cunninghamii, Corymbia zygophylla.* Shrubs: *Sida arenicola.* Low Shrubs: *Corchorus sidoides* subsp. *vermicularis, Indigofera monophylla, Jasminum calcareum, Leptosema anomalum, Ptilotus astrolasius, Tephrosia* sp. D Kimberley Flora (R.D. Royce 1848). Climbers: *Tinospora smilacina.* Grasses: *Aristida holathera* var. *holathera, Eragrostis eriopoda, Eriachne obtusa, Sorghum plumosum* var. *plumosum, Urochloa holosericea* subsp. *velutina.* Herbs: *Boerhavia gardneri, Bonamia oblongifolia, Cajanus marmoratus, Cassytha capillaris, Cleome uncifera* subsp. *uncifera, C. viscosa, Crotalaria ramosissima, Euphorbia trigonosperma, E. vaccaria* var. *vaccaria, Evolvulus alsinoides* var. *decumbens, Heliotropium foliatum, H. leptaleum, Indigofera colutea, I. linifolia, Ipomoea muelleri, Ptilotus polystachyus, Trianthema pilosum, Tribulopis marliesiae, Trigastrotheca molluginea.*
Vegetation Condition	Very Good to Excellent; occasional weeds recorded at low density.
Sites in the Study Area	Quadrats AH65, AH98 and AH100.
Notes	While *Triodia epactia* was the dominant spinifex, *T. schinzii* was also present at low cover in some areas. These quadrats were distinct from all other sites in the analysis, with quadrats AH98 and AH100 more similar to each other than to AH65. The latter quadrat was located in a narrow area of vegetation adjacent to the Great Northern Highway, which had been patchily burnt more recently than the two other sites.

Plate 5.22: Vegetation type P2 (AH65).

Plate 5.23: Vegetation type P2 (AH98).

The vegetation of the broad inland pindan plains was the most variable with regards to species composition; this was often attributable to fire history and also appeared to be influenced by the depth to laterite. While the spinifex hummock grasslands were typically dominated by *Triodia schinzii,* areas close to low laterite hills usually also had some *T. epactia*. Common overstorey species included low trees of *Owenia reticulata* (Native Walnut) and *Erythrophleum chlorostachys*, as well as the tall shrubs *Acacia eriopoda, A. sericophylla, A. monticola* and *A. ancistrocarpa*.

P3a:	***Owenia reticulata, Erythrophleum chlorostachys* scattered low trees over *Acacia eriopoda, A. sericophylla* scattered tall shrubs over *Acacia stellaticeps, Androcalva loxophylla* low open shrubland over *Triodia schinzii,* (*T. epactia*) open hummock grassland.**
Distribution and Extent	This vegetation type was recorded from broad pindan plains, mainly through the McLarty subregion but with one record (AH30) from the Mackay subregion (Plate 5.24 and Plate 5.25).
Other Associated Species	Trees/Tall Shrubs: *Gardenia pyriformis* subsp. *keartlandii.* Shrubs: *Acacia ancistrocarpa, A. tumida* var. *kulparn.* Low Shrubs: *Gompholobium simplicifolium, Goodenia azurea* subsp. *hesperia, Halgania solanacea* var. *solanacea, Jacksonia aculeata, Ptilotus arthrolasius, P. astrolasius, Scaevola parvifolia.* Grasses: *Aristida holathera* var. *holathera, Eriachne lanata, E. obtusa, Sorghum plumosum* var. *plumosum, Yakirra australiensis* var. *australiensis.* Sedges: *Bulbostylis barbata.* Herbs: *Bonamia alatisemina, Cassytha capillaris, Cleome uncifera* subsp. *uncifera, Polycarpaea corymbosa* var. *corymbosa, Polygala isingii, Trianthema pilosum, Tribulopis marliesiae, Trigastrotheca molluginea.*
Vegetation Condition	Excellent.
Sites in the Study Area	Quadrats AH03, AH06, AH08, AH11, AH14, AH26, AH30, AH44, AH62, AH73, AH84, AH95, AH97, AH102.
Notes	*Erythrophleum chlorostachys* formed a low open woodland, *Acacia eriopoda* formed a tall open shrubland, and *A. stellaticeps* formed a low open heath in some areas. With the exception of AH84, which occurred as an outlier (due to the abundance of *Acacia stellaticeps*, likely a reflection of fire history), all of the sites in this vegetation sub-type clustered in a single group when only perennial species were considered. With the inclusion of annual species, the sites occurred in three separate groups.

Plate 5.24: Vegetation type P3: sub-type P3a (AH26).

Plate 5.25: Vegetation type P3: sub-type P3a (AH84).

P3b:	***Erythrophleum chlorostachys* scattered low trees over *Acacia ancistrocarpa, A. monticola* tall open shrubland over *Triodia schinzii,* (*T. epactia*) open hummock grassland.**
Distribution and Extent	This vegetation type was recorded from pindan plains in both the McLarty and Mackay subregions (Plate 5.26 and Plate 5.27).
Other Associated Species	Trees/Tall Shrubs**:** *Acacia colei* var. *colei, A. sericophylla, Grevillea refracta.* Shrubs: *Sida arenicola.* Low Shrubs: *Corchorus sidoides* subsp. *vermicularis, Hibiscus leptocladus, Ptilotus astrolasius.* Grasses: *Aristida holathera* var. *holathera, Eragrostis eriopoda, Sorghum plumosum* var. *plumosum, Yakirra australiensis* var. *australiensis.* Sedges: *Bulbostylis barbata.* Herbs: *Boerhavia gardneri, Cassytha capillaris, Goodenia armitiana, Polycarpaea corymbosa* var. *corymbosa, Ptilotus polystachyus, Trianthema pilosum, Tribulopis marliesiae, Trigastrotheca molluginea.*
Vegetation Condition	Generally Excellent; AH13 ranked as Very Good due to some signs of human disturbance.
Sites in the Study Area	Quadrats AH01, AH07, AH12, AH13, AH17, AH47, AH74, AH81, AH89.
Notes	*Erythrophleum chlorostachys* formed a low open woodland and *Sorghum plumosum* var. *plumosum* formed a very open tussock grassland in some areas. All of the sites in this vegetation sub-type clustered in a single group when only perennial species were considered. With the inclusion of annual species, sites AH47 and AH89 clustered separately.

Plate 5.26: Vegetation type P3: sub-type P3b (AH01).

Plate 5.27: Vegetation type P3: sub-type P3b (AH12).

P3c:	***Corymbia zygophylla, Erythrophleum chlorostachys* scattered low trees over *Grevillea eriostachya, G. wickhamii* scattered tall shrubs over *Gompholobium simplicifolium, Jacksonia aculeata,* (*Dicrastylis doranii, Dampiera cinerea, Acacia stellaticeps*) low open shrubland over *Triodia schinzii* very open hummock grassland.**
Distribution and Extent	This vegetation sub-type was typically recorded from narrow swales between sand dunes and sometimes from broader pindan plains, with all sites located in the southeastern section of the study area in the Mackay subregion (Plate 5.28 and Plate 5.29).
Other Associated Species	Trees/Tall Shrubs: *Acacia sericophylla.* Shrubs: *Acacia tumida* var. *kulparn, Gyrostemon tepperi.* Low Shrubs: *Calytrix carinata, Corchorus sidoides* subsp. *vermicularis, Goodenia azurea* subsp. *hesperia, Halgania solanacea* var. *solanacea, Newcastelia cladotricha, Ptilotus arthrolasius, Scaevola parvifolia.* Grasses: *Aristida holathera* var. *holathera, Eragrostis eriopoda, Eriachne obtusa.* Herbs: *Cassytha capillaris, Cleome uncifera* subsp. *uncifera, Oldenlandia pterospora, Polygala isingii, Trianthema pilosum.*
Vegetation Condition	Excellent.
Sites in the Study Area	Quadrats AH24, AH28, AH29, AH33, AH34, AH70, AH71, AH72, AH78, AH79 and AH80.
Notes	The sites in this vegetation type occurred in a single floristic group, regardless of whether all species or just perennial species were considered. These sites were floristically similar to the sites in the dune vegetation sub-type S2b, however some species such as *Corymbia zygophylla* and *Acacia stellaticeps* were not present in the dune sites.

Plate 5.28: Vegetation type P3: sub-type P3c (AH28).

Plate 5.29: Vegetation type P3: sub-type P3c (AH80).

P3d:	***Erythrophleum chlorostachys* scattered low trees over *Grevillea refracta* scattered tall shrubs over *Acacia ancistrocarpa, A. monticola, A. tumida* var. *kulparn* open shrubland over *Triodia epactia* open hummock grassland.**
Distribution and Extent	This vegetation sub-type was recorded from the McLarty subregion, mainly in the northeastern section of the main study area (Plate 5.30 and Plate 5.31). It was similar to P3b, however *Triodia epactia* was dominant at all of the sites, and *Triodia schinzii* was only present at two of the sites. This could be explained by depth to laterite, however while some sites were in close proximity to low laterite rises, others were in broad expanses of pindan plain with few stony features.
Other Associated Species	Shrubs: *Ptilotus calostachyus, Sida arenicola.* Low Shrubs: *Goodenia azurea* subsp. *hesperia, Hibiscus leptocladus, Ptilotus astrolasius.* Grasses: *Aristida holathera* var. *holathera, Eragrostis eriopoda, Sorghum plumosum* var. *plumosum, Yakirra australiensis* var. *australiensis.* Sedges: *Bulbostylis barbata.* Herbs: *Bonamia alatisemina, Cassytha capillaris, Euphorbia psilosperma, Goodenia armitiana, Polycarpaea corymbosa* var. *corymbosa, Trianthema pilosum, Tribulopis marliesiae, Trigastrotheca molluginea.*
Vegetation Condition	Excellent; signs of camels were seen at AH52 in Phase 1 and AH86 in Phase 2, but there was no obvious grazing.
Sites in the Study Area	Quadrats AH25, AH36, AH37, AH40, AH48, AH51, AH52, AH53, AH86, AH88, AH99 and AH101.

Plate 5.30: Vegetation type P3: sub-type P3d (AH36).

Plate 5.31: Vegetation type P3: sub-type P3d (AH48).

P3e:	***Grevillea refracta, Acacia monticola, A. colei* var. *colei* tall open shrubland over *A. hilliana, A. adoxa* var. *adoxa* scattered low shrubs over *Triodia epactia* open hummock grassland.**
Distribution and Extent	This vegetation sub-type was recorded from the McLarty subregion (Plate 5.32 and Plate 5.33). All sites in sub-type P3e were located in the northern section of the study area.
Other Associated Species	Trees/Tall Shrubs: *Acacia ancistrocarpa, A. sericophylla, Grevillea wickhamii.* Shrubs: *Ptilotus calostachyus, Sida arenicola.* Low Shrubs: *Corchorus sidoides* subsp. *vermicularis, Dodonaea coriacea, Goodenia azurea* subsp. *hesperia, Hibiscus leptocladus, Leptosema anomalum, Ptilotus astrolasius.* Grasses: *Aristida holathera* var. *holathera, Eragrostis eriopoda, Eriachne obtusa, Eulalia aurea, Paspalidium rarum, Sorghum plumosum* var. *plumosum, Yakirra australiensis* var. *australiensis.* Sedges: *Bulbostylis barbata.* Herbs: *Boerhavia gardneri, Cassytha capillaris, Cleome viscosa, Euphorbia psilosperma, Goodenia armitiana, Polycarpaea corymbosa* var. *corymbosa, Ptilotus fusiformis, Trianthema pilosum, Trigastrotheca molluginea.*
Vegetation Condition	Excellent; there was evidence of camels at AH18 in Phase 1, but no sign of grazing.
Sites in the Study Area	Quadrats AH18, AH39, AH46, AH49 and AH55.
Notes	This vegetation was dominated by *Triodia epactia,* and *T. schinzii* was only present at one site, at 0.1% cover. All sites were located in close proximity to low laterite rises, suggesting that laterite close to the surface may be influencing the floristic composition of the sites. A very open tussock grassland occurred at some sites, dominated by species such as *Sorghum plumosum* and/or *Eulalia aurea*.

Plate 5.32: Vegetation type P3: sub-type P3e (AH39).

Plate 5.33: Vegetation type P3: sub-type P3e (AH55).

5.2.4 Vegetation of Low Stony Rises

Lateritised uplands were largely encompassed within Beard's vegetation associations 101 and 117, particularly within Mandora – West 101, Great Sandy Desert 101, and Mandora – East and Mandora – West 117.

H1:	***Acacia hilliana*, (*A. adoxa* var. *adoxa*) low open shrubland over *Triodia epactia* open hummock grassland.**
Distribution and Extent	This vegetation type was recorded from low stony (gravelly) lateritic rises scattered through the inland sections of the main study area (Plate 5.34 and Plate 5.35).
Other Associated Species	Trees/Tall Shrubs: *Acacia inaequilatera, A. monticola, Grevillea refracta, G. wickhamii.* Shrubs: *Acacia tumida* var. *kulparn, Ptilotus calostachyus*. Low Shrubs: *Calytrix carinata, Dampiera candicans, Dodonaea coriacea, Goodenia scaevolina, Halgania solanacea* var. *solanacea, Scaevola browniana* subsp. *browniana.* Grasses: *Eriachne lanata, E. pulchella.* Sedges: *Bulbostylis barbata, Fimbristylis simulans.* Herbs: *Cleome viscosa, Polycarpaea corymbosa* var. *corymbosa, Trigastrotheca molluginea.*
Vegetation Condition	Excellent.
Sites in the Study Area	Quadrats AH02, AH04, AH05, AH09, AH10, AH15, AH16, AH19, AH20, AH41, AH42, AH43, AH45, AH50, AH64, AH66, AH67, AH68, AH75; relevé AH-REL07.
Notes	Tall shrubs were typically absent or scattered (see Plate 5.34), but formed a tall open shrubland in some areas (Plate 5.35). Most of the sites in this vegetation type clustered in a single floristic group, however a small number grouped more closely with sites on plains or on rocky outcroppings; this reflects the widespread nature of many of the species recorded.

Plate 5.34: Vegetation type H1 (AH04).

Plate 5.35: Vegetation type H1 (AH50).

5.2.5 Vegetation of Rocky Outcrops and Breakaways

R1:	***Ficus brachypoda* low open woodland over *Acacia monticola, A. colei* var. *colei, Grevillea pyramidalis* tall open shrubland over *Triodia epactia* open hummock grassland.**
Distribution and Extent	This vegetation type was recorded from areas of rocky outcropping on the crests of stony rises and along low breakaways at the edge of hills (Plate 5.36 and Plate 5.37).
Other Associated Species	Trees/Tall Shrubs**:** *Grevillea wickhamii.* Shrubs: *Abutilon leucopetalum.* Low Shrubs: *Acacia hilliana, Indigofera monophylla, Ptilotus incanus, Senna venusta, Solanum dioicum, S. diversiflorum, Tephrosia rosea* var. *clementii, T. rosea* var. *rosea, Triumfetta incana, T. johnstonii.* Climbers: *Tinospora smilacina.* Grasses: *Eriachne ciliata, E. lanata, Paspalidium tabulatum, Sorghum plumosum* var. *plumosum.* Sedges: *Bulbostylis barbata, Fimbristylis simulans.* Herbs: *Amaranthus undulatus, Cleome viscosa, Cucumis variabilis, Gomphrena cunninghamii, Polycarpaea corymbosa* var. *corymbosa, Trachymene oleracea* subsp. *oleracea, Trigastrotheca molluginea.*
Vegetation Condition	Excellent to Very Good; scattered weeds at some sites (**Aerva javanica* and **Bidens bipinnata*).
Sites in the Study Area	Quadrats AH27, AH56 and AH63; relevés AH-REL01, AH-REL02 (burnt 1-2 years ago) and AH-REL04 (burnt within the past year and not included in the floristic analysis).
Notes	The three unburnt sites in this vegetation type occurred in a distinct floristic group when only perennial species were considered. When annual species were also included, AH56 occurred as an outlier site, while AH27 and AH-REL01 occurred in a separate group with quadrat AH63, which had been burnt in the last few years.

Plate 5.36: Vegetation type R1 (AH27).

Plate 5.37: Vegetation type R1 (AH-REL02).

5.3 Condition of the Vegetation Types

With the exception of the near-coastal areas within the transmission cable corridor, the vast majority of the vegetation in the study area was in Excellent or Very Good condition (see Table 5.2); a separate vegetation condition map has therefore not been prepared. Clearing in the inland areas was largely limited to the roadway of the Nyangumarta Highway (Kidson Track) and three other vehicle tracks that are less frequently used (see Maps 9-16 in Appendix 4). Other very old tracks traverse the area but are no longer passable. One old small borrow pit was located near quadrat AH20 in the northwestern section of the main study area.

The transmission cable corridor runs along the eastern edge of Wallal Downs Station, at its boundary with Mandora Station. There was a cleared track along the boundary fence, and the Great Northern Highway also crosses this section of the study area (see Map 5 in Appendix 4). There was heavy grazing and trampling by cattle in the pastoral areas near the coast. Although camel tracks and scats were recorded at most sites, with a small number of individuals sighted during the surveys, there were no obvious signs of grazing or trampling in the inland areas.

Weeds were mainly recorded from the section of the transmission cable corridor between the Great Northern Highway and the coast, with *Cenchrus species (Buffel Grass and Birdwood Grass) being particularly abundant. Vegetation type P1 (Maps 1-3 in Appendix 4) was the only unit ranked as being in Very Poor condition, which was due to extensive invasion by *Cenchrus spp. In contrast, there were few records of weeds from the main study area (see Section 6.4).

Table 5.2: Extent of main condition ranking categories in the study area.

Condition Rating	Area (ha)	Proportion of Study Area
Excellent – Very Good	660,686.0	>99.9%
Very Poor	27.9	<0.01%
Completely Degraded	43.7	<0.01%
Not ranked (ocean, beach, water)	44.7	<0.01%

5.4 Floristic Analysis

Table 3 in Appendix 7 summarises the floristic groups that were generated by the three analyses that appeared to reveal the most consistent patterns of similarity for the sites from the study area; i.e. those completed for the current sites only (listed as 'AH only'), using the percent cover of either perennial species alone, or both perennial and annual species; and the analysis that included the small number of regional sites (listed as 'Inc regional sites'), which used presence/absence data for both perennial and annual species (with *Cenchrus removed). The dendrograms from these analyses are also provided in Appendix 7.

The three main analyses identified similar numbers of floristic groups: 23 groups for the two analyses using the sites from the current study area, and 25 groups when the regional sites were included. There was a reasonable correlation between the vegetation types identified for the current study and the floristic groups generated through the clustering analyses, although they rarely matched completely. This is a common occurrence when using botanical data of this sort, as many flora species can occupy a broader range of habitats than the vegetation types defined for these studies, which are quite narrowly circumscribed; the chance occurrence of species in other units can have a quite considerable effect on the grouping of sites. In addition, the vegetation in the study area represented a range of different fire ages, which would influence the presence of typical early-successional species; those that colonise an area rapidly after fire, but tend to be out-competed in the longer term.

This was particularly evident in sites from the inland drainages vegetation subtype D2a (AH38-AH-REL03 in Table 3 in Appendix 7). While these occurred mainly in a single floristic group, this also contained a number of sites from the plains vegetation subtype P3e, as well as a single site from

H1 on a laterite rise. In contrast, the two sites in the inland drainages vegetation subtype D2b (AH91 and AH-REL05 in Table 3 in Appendix 7) occurred in a single floristic group, separate from the other sites in the study area.

The three quadrats in the seasonally inundated coastal swamp near the northern end of the transmission cable corridor (vegetation type D1) also grouped together and were distinct from all other sites in the study area (AH60-AH96 in Table 3 in Appendix 7; see Figure 5.1). This reflected the presence of a number of species not recorded at the other sites (e.g. *Acacia ampliceps, Melaleuca glomerata, Trianthema turgidifolium* and *Amaranthus undulatus*); together with *Solanum esuriale*, which was only otherwise recorded from the two sites in the Very Poor condition, near-coastal plains habitat (AH92 and AH94 in vegetation type P1, which occurred in the most similar floristic group); and the general absence of common species that dominated the other habitats. Importantly, when the regional analysis was conducted using sites from mound springs habitats in the locality, all of these sites clustered in separate floristic groups (see Figure 5.2).

Quadrats on the inland sand dunes occurred in two distinct floristic groups. The first only contained sites on dunes (vegetation subtype S2a: sites AH23-AH87 in Table 3 in Appendix 7). These sites were characterised by a number of species that are particularly associated with such habitats (e.g. *Grevillea stenobotrya, Indigofera ammobia, Newcastelia spodiotricha, Sida* sp. Western sand dunes (P.K. Latz 11980) and *Thinicola incana*), and also typically contained *Aristida holathera* var. *holathera, Eriachne aristidea, E. obtusa,* and *Spermacoce occidentalis*. The second group contained a mix of sites on dunes (vegetation subtype S2b: sites AH21-AH85 in Table 3 in Appendix 7) and on sandy plains (vegetation subtype P3c: sites AH24-AH80 in Table 3 in Appendix 7). The dunes were less distinct from the plains, and tended to have less or none of the species mentioned previously, and more *Acacia eriopoda, Gompholobium simplicifolium, Grevillea eriostachya* and *Jacksonia aculeata*. The plains typically contained species lacking from the dunes, including *Corchorus sidoides* subsp. *vermicularis* and *Corymbia zygophylla;* and *Eriachne obtusa*, *Goodenia azurea* subsp. *hesperia, Gyrostemon tepperi, Halgania solanacea* var. *solanacea* and *Tinospora smilacina* were more frequently recorded. *Triodia epactia* was also recorded from a number of the quadrats in S2b but was not recorded in P3c.

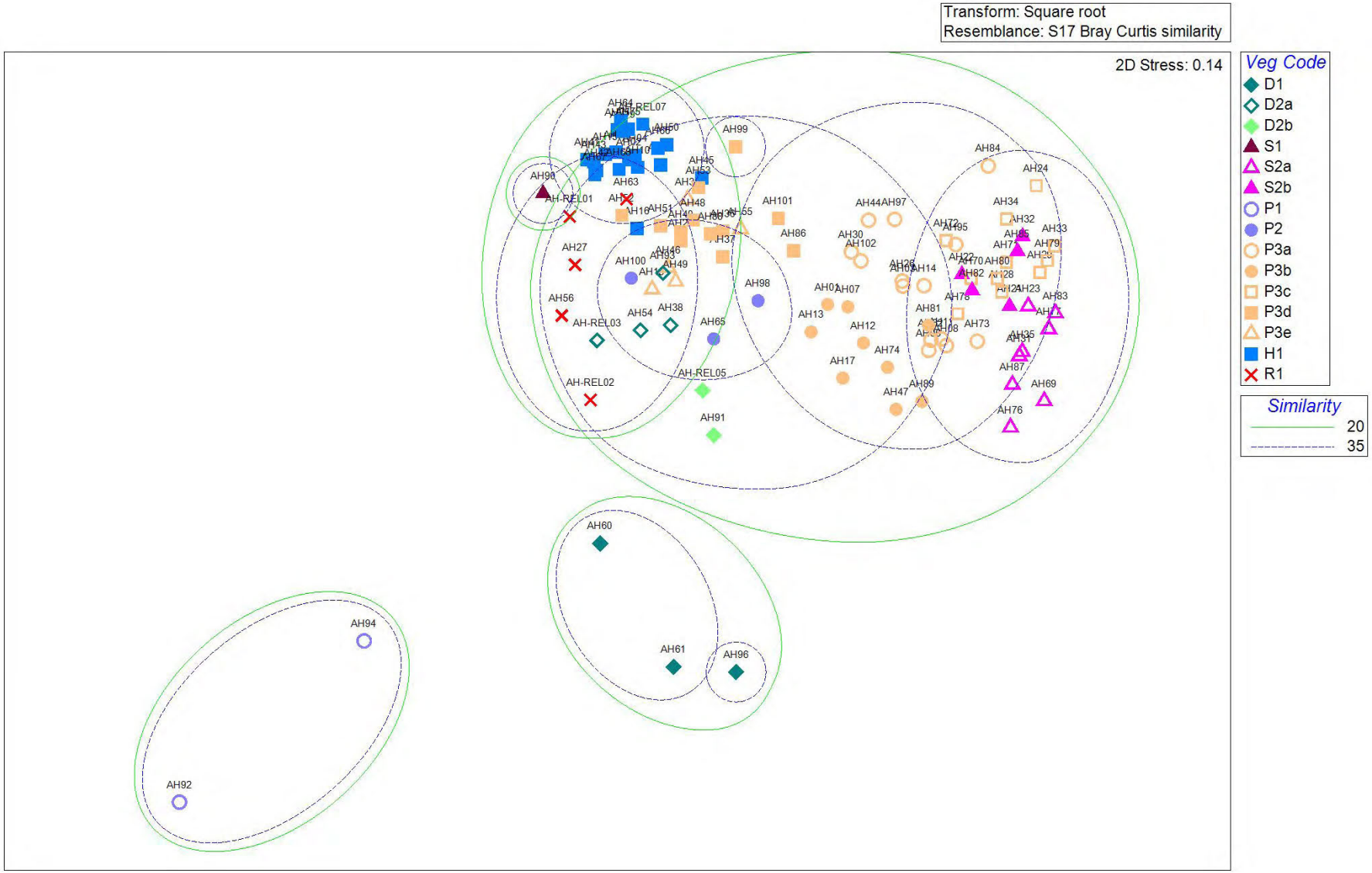

Figure 5.1: NMDS plot of sites in the study area, coded by vegetation type (analysis based on percent cover data for perennial species).

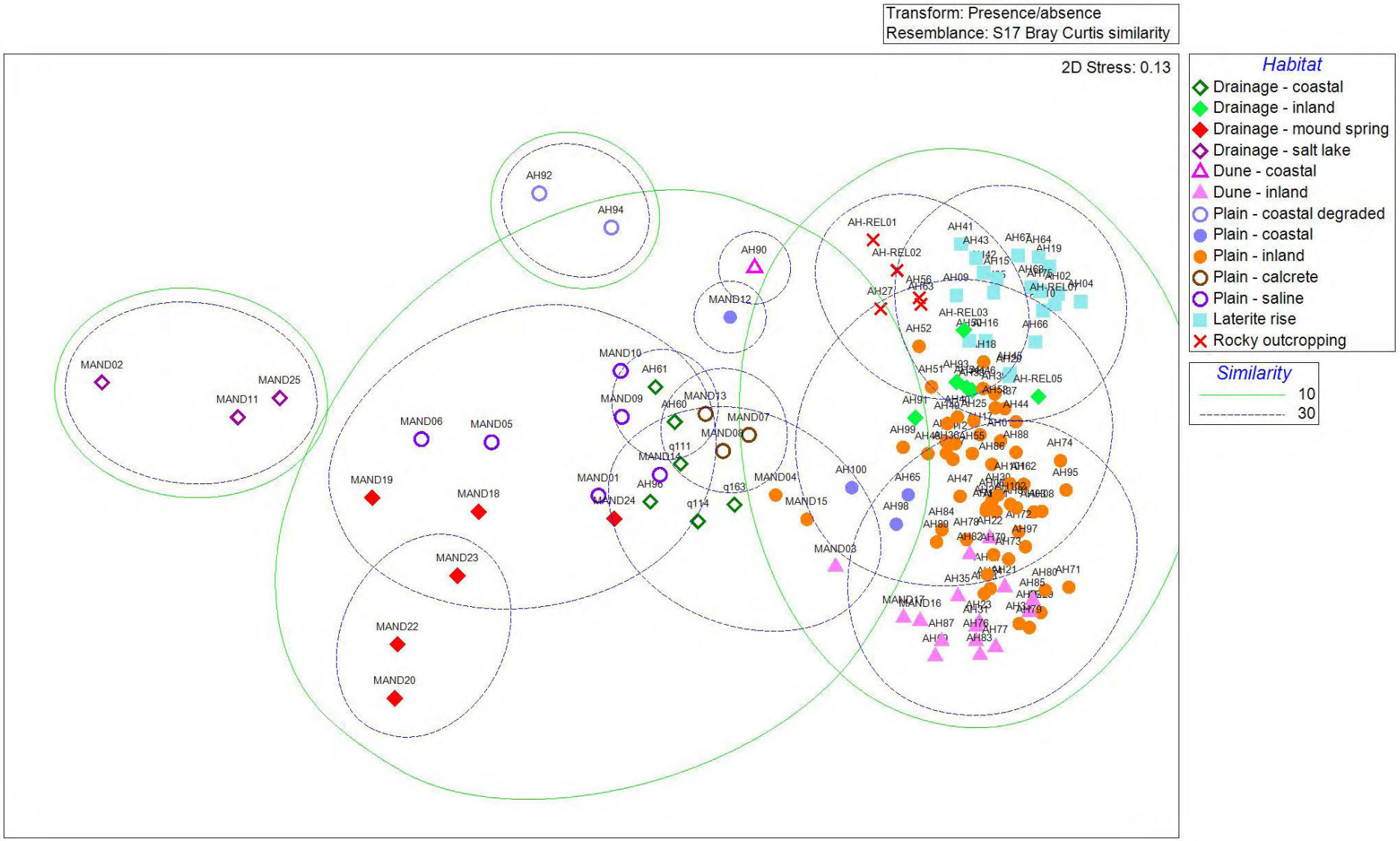

Figure 5.2: NMDS plot of sites in the study area together with selection of regional sites, coded by habitat type (analysis based on presence/absence data for both perennial and annual species).

5.5 Vegetation of Conservation Significance

With regards to the communities of conservation significance that have been formally designated for the locality (as described in Section 4.7):

- No mound springs or mangroves are known to occur in the study area, and the 'Mandora Mounds' TEC and the 'Inland Mangrove (*Avicennia marina*) community of Salt Creek' PEC are therefore not relevant to the current study.
- The small area of coastal grassland (vegetation unit P1) near the northern end of the transmission cable corridor would correspond to the 'Vegetation Association 73' PEC. However, weed invasion is listed as one of the key threatening processes for this PEC (DBCA 2017), and the vegetation in this area has already been substantially degraded through invasion by two introduced grass species (**Cenchrus ciliaris* and **C. setiger*). Given the poor condition of the community in this locality, it is unlikely that this area of the PEC would be considered of particular conservation value.
- The very small areas at the northernmost end of the transmission cable corridor that were mapped as 'Beach' and vegetation type S1 would correspond to the 'Eighty Mile Land System' PEC. The area of 'Beach', which would also form part of the Eighty Mile Beach Ramsar site, has no particular botanical values but remains characteristic of the PEC. Vegetation type S1 was in Excellent condition, and would represent a good quality example of the PEC (albeit very small in area).
- This leaves only those elements of vegetation that could be regarded as being key components of the Eighty Mile Beach Ramsar site: namely mangroves, freshwater aquatic vegetation (occurring in mound springs), samphire, and paperbark thickets.
    - As mentioned above, no mangroves or mound springs occur in the study area.
    - No samphire vegetation has been recorded. It is possible that some may occur in the low-lying areas of the transmission cable corridor that were inundated at the time of the survey, although there is no evidence of this on aerial imagery.
    - Paperbark thickets (vegetation type D1) were recorded in the areas of coastal swamp along the transmission cable corridor. Similar vegetation (thickets of *Melaleuca alsophila*) was also described as occurring within the Eighty Mile Beach Ramsar site "on clay soils which retain moisture longer than the surrounding landscape" (Hale and Butcher 2009), and on soils "that become seasonally waterlogged and occasionally inundated" (Graham 1999). As per Hale and Butcher (2009), "It is thought that direct precipitation and surface water flow are the main hydrological source for these systems (Graham 1999, Semeniuk and Semeniuk 2000). As such, climate and the water holding clay soils are the components that are the most critical to providing these wetland habitats."

One other vegetation community should be considered to be of local conservation significance; vegetation type R1, occurring on rocky outcrops and breakaways. These habitats form isolated 'islands' within the broader sandy landscape, which may form refuges during both fire and drought for particular species, and the habitats may support species restricted to these areas.

The key vegetation types of particular conservation significance are summarised in Table 5.3. This is not meant to imply that the remaining vegetation types have no conservation value; with the exception of vegetation type P1, which is extensively degraded through weed invasion, all of the remaining vegetation in the study area would represent intact native vegetation in Excellent or Very Good condition. Such vegetation has inherent conservation value, as a part of the natural ecosystem biodiversity (Natural Resource Management Ministerial Council 2010).

Table 5.3: Vegetation types of elevated conservation significance within the study area.

Vegetation Code	Description	Conservation Ranking (Reasons)
S1	*Triodia epactia, Spinifex longifolius* open hummock grassland with *Whiteochloa airoides* open tussock grassland	**Significant – Subregion scale** (part of the 'Eighty Mile Land System' PEC and Eighty Mile Beach Ramsar site, and in Excellent condition; but small in size and located within a partly disturbed corridor along a pastoral station boundary).
D1	*Melaleuca glomerata, M. lasiandra, M. alsophila, Acacia ampliceps* tall shrubland over *Trianthema turgidifolium, Solanum esuriale* low open shrubland	**Significant – Subregion scale** (may comprise part of the Eighty Mile Beach Ramsar site, and in Excellent to Very Good condition; but small in size and located within a partly disturbed corridor along a pastoral station boundary).
R1	*Ficus brachypoda* low open woodland over *Acacia monticola, A. colei* var. *colei, Grevillea pyramidalis* tall open shrubland over *Triodia epactia* open hummock grassland	**Significant – Local scale** (small area of extent; isolated areas of habitat supporting restricted species and potentially representing fire refugia)

6.0 Flora of the Study Area

6.1 Overview

A total of 315 native vascular flora taxa from 138 genera and 48 families were recorded from the study area during the Phase 1 and Phase 2 field surveys, and four additional taxa (*Eriachne gardneri, Ptilotus axillaris, Urochloa piligera* and *Grevillea pyramidalis* subsp. *leucadendron* have apparently been previously collected in the area based on records available on NatureMap (see Appendix 6). Note that five additional species have apparently been recorded from the study area based on NatureMap, however the location coordinates for these appear erroneous and they have not been included in further discussion:

- *Cullen pustulatum* (specimen PERTH 02918536, collected in 1982): location described as "31 km southwest of Sandfire Flat on the Great Northern Highway"; this distance would place it east of the study area.
- *Frankenia ambita* (specimen PERTH 08418063, collected in 1965): habitat described as a "swamp" and location described as "telegraph line north of Radi Hills"; this suggests it was probably collected near the Mandora Marsh, to the north of the study area.
- *Gymnanthera cunninghamii* (specimen PERTH 03613054, collected in 1965): habitat described as a "saline marsh" and location described as "near Radi Hills"; this again suggests this specimen was probably collected near the Mandora Marsh, to the north of the study area, particularly as there is another voucher from that area.
- *Rhagodia eremaea* (specimen PERTH 02612720, collected in 1988): coordinates erroneous, as collected from Melita Station in the Goldfields.
- *Sida platycalyx* (specimen PERTH 07514859, collected in 1984): coordinates erroneous, as collected from 13 km southwest of Mt Cecelia, which would place it well outside the study area.

The native flora known from the study area include several species of conservation significance (see Section 6.2). In addition to the above, 10 introduced flora species (weeds) from nine genera and seven families were recorded in the study area (Section 6.4).

The species accumulation curve generated from the survey data is approaching a plateau, indicating that the sampling of the survey area was relatively thorough (Figure 6.1). However, the two estimates of species richness (ICE and Chao2) both suggested that the actual number of species present in the area is approximately 360, which would mean that 86-87% of the total flora have been recorded during the current study (Table 6.1). These sorts of proportions are similar to those reported for other surveys of a similar nature (e.g. 83% (Ecoedge 2014); 84% based on quadrats (Ecologia 2016), 82% based on quadrats, and 88% including opportunistic records (Ecologia 2009); and 87% (Coffey 2015)).

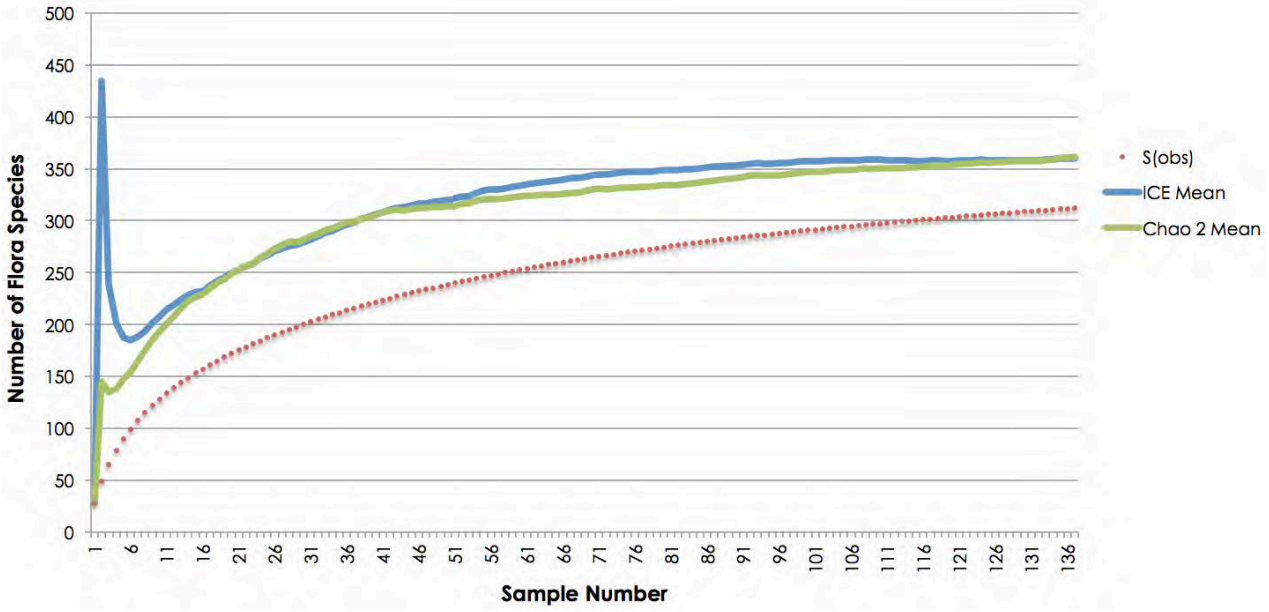

Figure 6.1: Species accumulation curve based on actual observations at the sampling sites (S(obs)), together with two estimates of species richness (ICE and Chao 2).

Table 6.1: Recorded species richness compared with predicted species richness using incidence-based estimators (without opportunistic records).

Parameter		Number of Species	Percent of Estimated Richness Recorded
Number of Species Recorded (from quadrats and relevés only)		312	
Estimated Number of Species	Chao 2 Mean	361	86%
	ICE Mean	360	87%

The dominant native plant families and genera recorded from the study area are presented in Table 6.2. The study area is located mainly in the Great Sandy Desert bioregion, with the transmission cable corridor crossing into the southern end of the Dampierland bioregion. The northeastern edge of the Pilbara bioregion is also relatively close (approximately 3 km from the southern boundary of the study area). As such, the study area contains elements of both the Northern and Eremaean floristic provinces and of all three bioregions. Flora species with particularly close affinities to the particular bioregions include *Acacia drepanocarpa* subsp. *drepanocarpa, Aristida holathera* var. *latifolia, Bonamia oblongifolia, Calandrinia strophiolata, Heliotropium leptaleum, Hibiscus apodus, Melaleuca alsophila, Ptilotus lanatus* and *Terminalia kumpaja* (Dampierland); *Acacia anaticeps, Dampiera cinerea, Dicrastylis doranii, Goodenia azurea* subsp. *hesperia, Indigofera ammobia, Sida* sp. Western sand dunes (P.K. Latz 11980) and *Thinicola incana* (Great Sandy Desert); and *Clerodendrum floribundum* var. *angustifolium*, *Commicarpus australis, Eriachne helmsii, Paspalidium tabulatum, Petalostylis labicheoides* and *Sida* sp. Pilbara (A.A. Mitchell PRP 1543) (Pilbara).

Table 6.2: Dominant native families and genera recorded from the study area.

Family	No. of Native Species	Genus	No. of Native Species
Fabaceae (peas, cassias and wattles)	67	*Acacia* (wattles)	21
Poaceae (grasses)	44	*Tephrosia* (a pea)	11
Malvaceae (hibiscus, sida etc)	28	*Ptilotus* (mulla-mullas)	10
Goodeniaceae (fan-flowers etc)	16	*Grevillea*	9

6.2 Flora of Conservation Significance

6.2.1 Species Recorded from the Study Area

One Threatened species and eight Priority species were recorded from the study area (see Table 6.3 and Appendix 5). One of the potential Priority species and a number of sterile *Seringia* specimens could not be confirmed due to a lack of material.

Table 6.3: Summary of conservation significant flora recorded from the study area.

Species	Status	No. of Individuals / % Cover and No. of Locations (Broad Distribution)
Seringia exastia	Threatened	334 individuals at six locations (northeastern section of main study area)
Seringia sp. (sterile)	Treated as Threatened for this report	146+ individuals at 15 locations (northern and central sections of main study area)
Tephrosia rosea var. Port Hedland (A.S. George 1114)	Priority 1	4% cover at one location (southwestern section of main study area)
Bonamia oblongifolia	Priority 3	0.1-1% cover at 13 locations (throughout study area)
Croton aridus	Priority 3	0.1-3% cover at 5 locations (southern section of main study area)
Indigofera ammobia	Priority 3	0.1% cover at seven locations (southern section of main study area)
Polymeria ? sp. Broome (K.F. Kenneally 9759)	Priority 3	0.1% cover at two locations (northwestern section of main study area)
Seringia katatona	Priority 3	150 individuals at one location (in southeast of main study area)
Terminalia kumpaja	Priority 3	68 individuals at 36 locations (throughout main study area)
Tribulopis marliesiae	Priority 3	176+ individuals at 45 locations (throughout study area)

- ***Seringia exastia*** **(Threatened)**

Seringia exastia is most easily distinguished from the other species in this genus by the acuminate tips and minutely denticulate margins of the calyx lobes (Plate 6.1). When originally described (as *Keraudrenia exastia*), the species was only known from a single locality, comprising pindan dune swale on the Dampier Peninsula near Broome (Wilkins 1999); as a consequence, it was listed as a Threatened species (DRF) for WA in 2006. This species was also subsequently listed in 2009 as a Threatened species under the Commonwealth EPBC Act, in the category of Critically Endangered; this was due to its (then) very restricted geographic distribution, and the perceived susceptibility of the population to threats including weed invasion and clearing for infrastructure (DEWHA 2009). *Seringia exastia* was subsequently recorded from a small number of additional locations approximately 140 km south of the Broome populations (based on records shown on NatureMap); and has also recently been recorded from two locations on Shelamar Station, which are within this range but closer to the coast (Emerge Associates 2017).

Flowering specimens of *Seringia exastia* were collected from six locations in the northeastern section of the study area; these were confirmed by Carol Wilkins, the specialist in this genus. The records were from pindan plains and inland dunes supporting vegetation sub-types P3a and S2b, but this species could potentially be expected in other sub-types within these broader units. A total of 334 individuals[9] were recorded from the six locations, with almost half (160) occurring at one of the locations.

In addition, sterile specimens of *Seringia* were collected from 15 locations. Without genetic analysis, these specimens cannot be positively identified; they may represent the Threatened

[9] Many members of the genus *Seringia* are believed to be clonal; where dense patches of shrubs occur, these may represent a single individual (one genotype), however this can only be confirmed through genetic analysis. For the purposes of this report, each *Seringia* shrub has been considered as an individual.

species *S. exastia*; the Priority 3 species *S. katatona* (see below); or one of two other species occurring in the area, neither of which are of conservation significance (*S. elliptica* or *S. nephrosperma*). As a precaution, the records of *Seringia* sp. should be treated as though they are of *S. exastia*, although at least the westernmost records from stony lateritic rises are unlikely to be this (or *S. katatona*). A minimum of 146 individuals of *Seringia* sp. were recorded (plants were not counted at all locations).

Based on the new confirmed records, the known range of *Seringia exastia* now extends over approximately 290 km, from near Broome to the eastern section of the current study area. This range encompasses a very large area of suitable pindan plain habitat, and it is likely that this species is considerably more abundant than the current records indicate.

Plate 6.1: ***Seringia exastia*: growth form and close-up of flowers.**

- ***Tephrosia rosea* var. Port Hedland (A.S. George 1114) (Priority 1)**

Tephrosia rosea var. Port Hedland (A.S. George 1114) is a low to medium-height shrub with a distinctive indumentum of white crimped hairs on the leaves (Plate 6.2). This species was recorded from a single location in the southwest of the study area, providing 4% cover at AH87; it was associated with vegetation sub-type S2a on an inland dune. Most of the specimens of this taxon are from near-coastal sandplain, with records clustered around Wickham and Port Hedland (a distance of more than 160 km). However, the specimen collected from the current study area differed from these other collections in having recurved stipules and broader leaflets, matching a single outlying collection from sandplain further inland, east of Warrawagine (S. Dillon and R. Butcher, WA Herbarium, pers. comm. 2018). These two outlying collections are 21 km apart, and the two specimens potentially represent a separate entity.

Plate 6.2: ***Tephrosia rosea* var. Port Hedland (A.S. George 1114): growth form and close-up of leaves.**

- ***Bonamia oblongifolia*** **(Priority 3)**

This species is a prostrate herb with blue flowers. Specimens broadly matching the description of *Bonamia oblongifolia* were recorded from the study area: these had small blue flowers (9-10 mm long); and hairy leaves that were 4-5(-6) mm wide and up to 20(-30) mm long, with a petiole approximately 3 mm in length, and rounded to acute leaf tips. Acute leaf apices appear inconsistent with this species' concept, however this may be due to a narrow circumscription based on only a few specimens. This species was recorded from 13 locations spread through the pindan plains in the main study area and transmission cable corridor. It occurred as scattered plants at each site, providing little cover.

Confirmed specimens of *Bonamia oblongifolia* are currently only lodged with the WA Herbarium from a few, widely spaced locations in the Dampierland and Great Sandy Desert bioregions, however an additional specimen from the northern Dampier Peninsula is lodged with the Northern Territory Herbarium (CHAH 2018). The vouchered range of this species therefore extends over approximately 460 km, from Wallal Downs Station to One Arm Point, with the closest vouchered population being 25 km west of the study area on Wallal Downs. While the species is not currently well documented, additional new populations were identified on Mandora Station, approximately 7 km east of the transmission cable corridor, following completion of the Phase 2 survey in the current study area (Biota 2018a), and other populations have been recently recorded on Pardoo Station, 80 km west of the study area by EnviroWorks Consulting (EnviroWorks) (2017a), and on Anna Plains Station, 80 km northeast (EnviroWorks 2017b). The combined populations at Wallal Downs, Pardoo and Anna Plains were estimated at over 1,200,000 plants (EnviroWorks 2017a). Additional populations were also recently recorded further north on Nita Downs Station, 110 km northeast (Biota 2017); near Bidyadanga, 150 km north (Biota 2018b); on Shamrock Station, 185 km northeast (Wells 2018); and along the Cape Leveque Road, 250 km north-northeast (38 individuals at 9 locations; Biota 2018d). Considered together, these records show that the species is clearly not uncommon.

Given the above, it appears that *Bonamia oblongifolia* occurs considerably more frequently in pindan vegetation through the region than was previously identified, which was likely recognised in its recent downgrading by DBCA from Priority 1 to Priority 3. Given the range of this species and its apparent abundance in suitable habitat, it is unlikely that it continues to warrant recognition as Priority flora.

- ***Croton aridus*** **(Priority 3)**

This robust shrub species grows to 1.5 m tall and has yellow flowers and grey leaves with a felty indumentum (Plate 6.3). It is represented in the WA Herbarium by only five voucher specimens from WA, spread over a distance of 370 km from near Shay Gap to the Edgar Ranges. There are also unvouchered records from north of Cockatoo Island in the Kimberley, which would extend the range within WA to more than 680 km. Based on vouchered specimens on AVH, the species' distribution reportedly extends through the Northern Territory and into Queensland, a range of over 1,900 km (CHAH 2018). All of the collections from WA are from flat plains with red-brown to red pindan soils; associated species include *Corymbia greeniana, C. flavescens, Grevillea refracta* subsp. *refracta, G. wickhamii, Acacia colei, Triodia epactia and T. schinzii.*

Croton aridus was recorded in the southern section of the study area from five locations, two of which were in very close proximity. These latter records were 15.6 km southeast of a vouchered collection with the WA Herbarium, which was from only 400 m west of the study area. The locations from the study area were associated with vegetation sub-type S2a on inland sand dunes and P3b on sandy pindan plains. This species generally occurred as only scattered individuals, but provided 3% cover at quadrat AH89.

Plate 6.3: ***Croton aridus*; growth form.**

- ***Indigofera ammobia*** **(Priority 3)**

This low shrub has an open habit, very fine narrow leaves and small pink flowers (Plate 6.4). It is represented in the WA Herbarium by 14 voucher specimens distributed across a range of more than 900 km, from near Shay Gap in the Pilbara, to Durack River Station in the Kimberley and Bilbarrd in the Great Sandy Desert. There are also vouchered records on AVH from the Northern Territory, which extend the known distribution to over 1,400 km (CHAH 2018).

Indigofera ammobia was recorded from seven locations in the southern section of the study area. All of the locations were associated with vegetation sub-type S2a on inland sand dunes, where this species occurred as scattered individuals. This appears to be typical habitat for this species, and it would be expected to occur more widely through the study area.

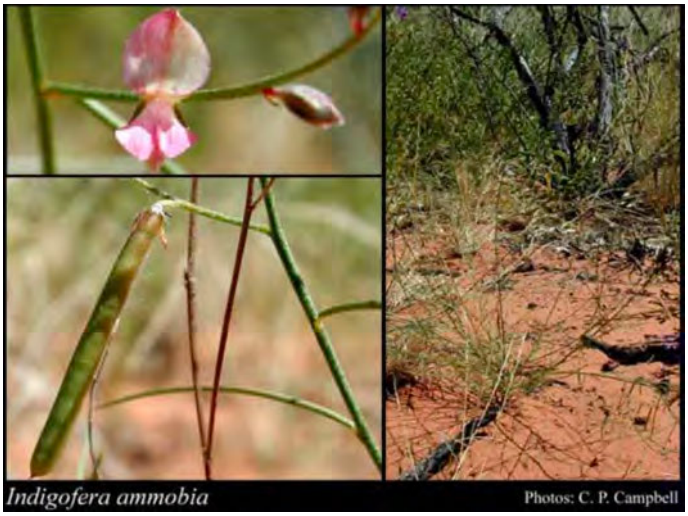

Plate 6.4: ***Indigofera ammobia* (clockwise from top left): flower; growth form; fruit and leaf.**
Photography by C.P. Campbell. Image used with the permission of the WA Herbarium, DBCA (https://florabase.dpaw.wa.gov.au/help/copyright). Accessed on Sunday, 30 September 2018.

- ***Polymeria* ? sp. Broome (K.F. Kenneally 9759)** **(Priority 3)**

This taxon is an erect herb with pink flowers (Plate 6.5); only sterile material was collected from the study area, however these specimens are considered likely to be this taxon. As for *Bonamia oblongifolia*, *Polymeria* sp. Broome (K.F. Kenneally 9759) is currently only vouchered from a few, widely spaced locations spanning 250 km in the Dampierland and Great Sandy Desert bioregions, extending from north of Broome to east of Sandfire Roadhouse (WA Herbarium 2018). However, additional populations were recently identified on Mandora Station, 7 km east of the transmission cable corridor (one individual only; Biota 2018a); near Bidyadanga, 150 km north, (370 individuals from 92 locations; Biota 2018b); on Shamrock Station, 185 km northeast of the study area (183 individuals at nine locations; Wells 2018); along the Cape Leveque Road, 250 km north-northeast

(368 individuals at 74 locations; Biota 2018d); and near One Arm Point, 350 km north-northeast (100 individuals from 32 locations; Biota 2018c). Taken together, these records extend the current known distribution to approximately 390 km, from the current study area to the northern Dampier Peninsula, and the species is clearly more widespread and common than previously thought. Given the already broad range of documented locations and the abundance of suitable pindan habitat, this species is likely to be poorly collected rather than genuinely rare and does not appear to warrant being listed as a Priority species.

Plate 6.5: ***Polymeria* sp. Broome (K.F. Kenneally 9759); photo not taken in study area.**

- ***Seringia katatona*** **(Priority 3)**

This species is a low shrub, which has leaves with a fine felty indumentum on the upper and lower surfaces, and flowers with a calyx that is wider than long (Plate 6.6) (description in Wilkins and Whitlock 2015). A single specimen that could be conclusively determined as *Seringia katatona* was collected from the current study area, which was from pindan vegetation in the southeastern section of the study area; a total of 150 individuals were present at this location. However, numerous sterile *Seringia* specimens were also collected from the study area, and some of these may represent this species (see discussion under *S. exastia*).

Based on NatureMap records, the current known distribution of *Seringia katatona* extends from Wallal Downs station (70 km west of the current study area) to Broome, and over 250 km southeast of Broome into the Great Sandy Desert; a maximum range of over 450 km. Wilkins and Whitlock (2015) noted that "given the extent of unexplored suitable habitat among the [then] known localities, the species is most likely not under threat…". This is supported by recent discoveries of new populations within the known range. A total of 1,268 *Seringia* individuals were recorded from pindan vegetation on Mandora Station, 7 km east of the transmission cable corridor, including two large stands of 200 and 1,000 plants; all individuals were assigned to *S. katatona* based on material from a small number of flowering shrubs (three) (Biota 2018a). Over 450 individuals were also recently recorded from approximately 26 locations on Nita Downs, approximately 110 km northeast of the study area (Biota 2017), and 19 individuals were recorded on Shelamar Station, 120 km northeast (Emerge Associates 2017).

On the basis of the data recorded, it is likely that *Seringia katatona* occurs more broadly through pindan vegetation in the locality, at a similar density to that observed in the current study area and at Mandora (i.e. in localised patches ranging from a few stems to several hundred stems). There is abundant suitable and contiguous habitat in the region, and this species cannot be considered to be rare.

Plate 6.6: ***Seringia katatona*: growth form, flowering branchlet and calyx.**

- ***Terminalia kumpaja*** **(Priority 3)**

Terminalia kumpaja is a tall shrub to low spreading tree with a dense canopy, distinct divaricate branching, and dark purple globular fruit with a walnut-like kernel (Plate 6.7). This species was only recently distinguished as distinct from *T. cunninghamii* (Barrett 2015). *Terminalia kumpaja* has been recorded from pindan vegetation over a range of approximately 280 km, from Wallal Downs Station to north of Broome. New populations have also recently been recorded along the Cape Leveque Road at the northern end of this species' distribution, 248 km north-northeast of the current study area (66 individuals at 14 locations; Biota 2018d). The closest vouchered specimen of this species is approximately 10 km east of the transmission cable corridor (WA Herbarium 2018), however numerous additional records totalling 136 individuals were recently made as close as 7 km east of this corridor during a survey on Mandora Station (Biota 2018a).

A total of 68 individuals[10] were recorded during the field survey at 36 locations, spread throughout the main study area. The majority of these records (59 individuals and 30 locations) were from an area of approximately 8 ha in the vicinity of quadrat AH11; this species was observed to be particularly abundant here, and additional foot traverses were completed to record all individuals in a relatively localised area, in order to establish an estimate of the density that may be expected in optimal habitat (approximately 7 individuals / ha). It should be noted that additional individuals could be seen in all directions from those counted, so this count does not comprise the entire population in this area.

Plate 6.7: ***Terminalia kumpaja*: growth form, branchlet and close-up of kernels.**

[10] The number of plants counted may not reflect the actual number of individuals, as some occurred in clumps, which may represent multiple suckers from a single individual. For the current purposes, each plant is considered a separate individual.

- ***Tribulopis marliesiae*** **(Priority 3)**

This spreading herb has a perennial rootstock with corky bark, yellow flowers, and compound leaves with up to four pairs of terete to very slightly compressed linear leaflets (Plate 6.8). At least 176 individuals were recorded from 45 locations during the current field surveys, spread throughout the pindan plains in the main study area and transmission cable corridor.

Tribulopis marliesiae has been vouchered with the WA Herbarium from the vicinity of Pardoo Roadhouse to Roebuck Plains station and inland over 250 km to the east (see Barrett and Barrett 2015). The closest vouchered locations are currently approximately 30 km north of the study area, on the southern side of Mandora Marsh (WA Herbarium 2018), however 18 individuals were recently recorded from 10 locations at Mandora Station, less than 7 km east of the transmission cable corridor (Biota 2018a). Additional populations of this species have also been recorded on Pardoo Station, 90 km west of the study area (EnviroWorks 2017a).

Given the already broad documented distribution of this species and the abundance of suitable pindan habitat in intervening areas between the known populations, *Tribulopis marliesiae* is clearly widespread and unlikely to be rare.

Plate 6.8: ***Tribulopis marliesiae*: growth form and close-up of flower.**

6.2.2 Additional Species that are Likely to Occur

It is considered that two additional species that were identified through the desktop assessment as being likely to occur in the study area (see Table 4.5) would probably be present, as extensive suitable habitat is available:

- *Goodenia hartiana* (Priority 3) has been recorded from a red sand dune 3.9 km southwest of the southwestern corner of the study area, and could occur on the sand dunes supporting vegetation type S2.
- *Corynotheca asperata* (Priority 3) has been recorded from sand plain 9.6 km south of the study area, and could occur on the pindan plains supporting vegetation type P3.

6.3 Other Species of Interest

Due to the limited botanical collecting that has been completed in the locality, numerous records from the current study represent extensions of the known range of the taxa (based on the records shown on NatureMap), or fill gaps in the known range (see Appendix 8). Apart from **Eragrostis minor* and *Orianthera centralis*, these taxa are all well collected from numerous other locations. Specimens of the taxa listed in Appendix 8 will be lodged with the WA Herbarium, provided suitable material is available.

A number of taxa recorded during the study belong to known species complexes for the region, as denoted by "sens. lat." (meaning "in the broad sense") in the species list in Appendix 6. Other taxa were either represented by insufficient material or did not appear to key well to existing

species based on the taxonomic keys available; these were generally denoted by "?", "aff." (meaning "with affinities to") or "sp.", with reasons provided in Appendix 6. Specimens of each of the taxa will be submitted to the WA Herbarium, provided suitable material is available. The most notable taxa are listed in Table 6.4; these represent those that could potentially be finalised in a reasonable timeframe (in contrast to the species complexes, which would likely take several years to resolve).

Table 6.4: Taxa from the study area that particularly warrant further resolution.

Taxon	Reason
Seringia sp.	Numerous sterile *Seringia* specimens cannot be resolved to species level without genetic analysis; see Section 6.2.
Calytrix carinata	Two forms appear to be present, differing in the length and shape of the leaves, and possibly the shape of the calyx lobes. Require additional collections of good flowering material.
Portulaca aff. *australis*	Identified by M. Barrett as being closest to *P. australis*, but potentially a new species. Require additional collections of good flowering and fruiting material, and field photographs and counts of stamens, styles and petal number.
Triumfetta aff. *plumigera*	Identified by M. Barrett as being closest to *T. plumigera*, but has unusually shaped leaves. Require additional collections.
Amaranthus aff. *undulatus*	This taxon has smaller round leaves and smaller tepals than *A. undulatus*, and is associated with rocky habitats such as rockpiles and gorges. It is not uncommon in such habitat in the Pilbara. Genetic analysis is required to determine if this taxon is distinct.

6.4 Introduced Species

Ten introduced flora species were recorded from the study area, with most species recorded from the transmission cable corridor (see Table 6.5 and Appendix 5).

Table 6.5: Summary of weed species recorded from the study area.

Family	Species	No. of Records (Broad Distribution)
Aizoaceae	**Trianthema portulacastrum*	1 (in the transmission cable corridor)
Amaranthaceae	**Aerva javanica*	8 (7 in the transmission cable corridor; 1 on a rocky outcrop in the northwest of the main study area)
Asteraceae	**Bidens bipinnata*	1 (rocky outcrop in the northeast corner of the main study area)
Cucurbitaceae	**Citrullus colocynthis*	3 (all in the transmission cable corridor)
Fabaceae	**Stylosanthes hamata*	1 (in the transmission cable corridor near the Great Northern Highway)
Poaceae	**Cenchrus ciliaris*	5 (all in the transmission cable corridor)
Poaceae	**Cenchrus setiger*	3 (all in the transmission cable corridor)
Poaceae	**Eragrostis minor*	2 (both in the transmission cable corridor)
Poaceae	**Setaria verticillata*	2 (1 in the transmission cable corridor; 1 in the northwest of the main study area)
Solanaceae	**Datura ? leichhardtii*	1 (in the transmission cable corridor)

The EPBC Act Protected Matters search identified **Parkinsonia aculeata* (Parkinsonia) as an additional weed of significance that may occur in the area. Parkinsonia is a large thorny shrub to low tree, which typically occurs along watercourses. This species was not recorded from the study area, and there is no particularly suitable habitat.

The species recorded from the study area are briefly described below:

- ***Aerva javanica* (Kapok Bush)** is a perennial herb to low shrub that is widespread through the northern half of WA. It is particularly common in sandy soils, especially in coastal areas and disturbed sites. Kapok Bush was recorded at several sites in the transmission cable corridor, usually as scattered individuals but occasionally in more dense patches near the coastal swamp vegetation type D1 and in the degraded coastal plain vegetation P1. Three plants were also recorded from a single rocky outcrop in the main study area.
- ***Bidens bipinnata* (Bipinnate Beggartick)** is an annual daisy with distinctive two-spined seeds, which is widespread through the northern half of WA from approximately Shark Bay to the Kimberley. It is a common weed of rockpiles, creeklines and other dense vegetation. Three individuals of this species were recorded from a single rocky outcrop in the northeastern section of the main study area.
- ***Cenchrus ciliaris* (Buffel Grass)** is a perennial grass that was introduced by pastoralists as a fodder species. It is widespread throughout WA and is commonly found in association with drainage lines, floodplains, sandy coastal areas and disturbed sites (WA Herbarium 2018), where it may form dense tussock grasslands. This species has demonstrated allelopathic capacities, whereby it releases chemicals that inhibit the growth of other plants, and it competes aggressively and effectively with native flora species (Cheam 1984a, 1984b, Hussain et al. 2010). Buffel Grass was recorded from five locations in the study area, all along the transmission cable corridor. Dense populations were recorded in the degraded coastal plain vegetation type P1, while scattered grazed plants were observed along the verge of the Great Northern Highway in vegetation type P2.
- ***Cenchrus setiger* (Birdwood Grass)** is an erect perennial tussock grass that occurs in similar habitats to Buffel Grass (creeklines, floodplains and sandy coastal areas). Birdwood Grass was recorded from three locations in the transmission cable corridor, in each case occurring with *C. *ciliaris* in vegetation types P1 and P2.
- ***Citrullus colocynthis* (Colocynth)** is a trailing creeper with melon fruits, which is widespread in WA from inland of Perth to the Kimberley. This species was recorded as scattered plants at three locations in the transmission cable corridor, within vegetation types D1 and P1 in the vicinity of the coastal swamp.
- ***Datura ? leichhardtii* (Native Thornapple)** is a robust annual herb that has been recorded from the Pilbara, Gascoyne and Carnarvon bioregions. A sterile specimen of **Datura* collected from the transmission cable corridor appeared most similar to **D. leichhardtii*; the identification could not be confirmed due to the lack of fruiting material. This taxon was only recorded at a single location within vegetation type D1 in the vicinity of the coastal swamp.
- ***Eragrostis minor* (Smaller Stinkgrass)** is an annual grass that has been recorded from a small number of locations in WA, from inland of Perth to the Kimberley (WA Herbarium 2018). Scattered plants of this species were recorded at two locations in the transmission cable corridor, both in vegetation type D1 fringing the coastal swamp.
- ***Setaria verticillata* (Whorled Pigeon Grass)** is an annual grass with distinctive bristly heads that have very short, recurved barbs. This species is widespread through WA, from the Southwest to the Kimberley (WA Herbarium 2018). Whorled Pigeon Grass was recorded from one location in vegetation type D1 in the transmission cable corridor, and another on a small rockpile in the main study area.
- ***Stylosanthes hamata* (Verano Stylo)** is a perennial herb to low shrub with yellow pea flowers and distinctive beaked fruit. Although introduced as a fodder species, Verano Stylo is considered an environmental weed. This species has been recorded from Exmouth to the Kimberley (WA Herbarium 2018), and is particularly common along road verges, where it may be spread by mowing equipment and earthworks. Verano Stylo was recorded as scattered plants from a single location in vegetation type P2 in the transmission cable corridor, in close proximity to the Great Northern Highway.

- ***Trianthema portulacastrum* (Giant Pigweed)** is an annual herb that has been recorded in northern Australia from the Pilbara to the Kimberley (WA Herbarium 2018). A single plant of this species was recorded from a location in vegetation type D1 in the transmission cable corridor.

7.0 Key Findings

7.1 Vegetation

With the exception of some areas of degraded coastal plain near the northern end of the transmission cable corridor, the vegetation of the study area was largely in Excellent condition. There has been minimal clearing (mainly associated with the two highways), and except for some areas of **Cenchrus* spp. tussock grassland near the coast, weeds were only scattered.

Nine vegetation types (some with additional sub-types) were identified in the area. Although there is very limited data against which to compare them, these appear typical of those observed in the broader locality, and they do not appear to represent an unusually diverse array of units. Based on the helicopter traverses completed through the study area and extensive inspection of the available aerial photography, it is considered that no additional vegetation types are likely to be present, with the possible exception of samphire vegetation; this could occur in a section of the transmission cable corridor, which was inundated at the time of the survey and could not be sampled.

The main vegetation types of elevated conservation significance comprise:

- Small areas of vegetation on coastal dunes, associated with the Eighty Mile Land System PEC;
- Areas of Paperbark thicket vegetation in the coastal swamp, consistent with key vegetation listed for the Eighty Mile Beach Ramsar site; and
- Vegetation of rocky outcrops, which contains species restricted to such habitats.

7.2 Flora

A total of 315 native flora taxa have been recorded from the study area, including nine conservation significant species, with the current surveys adding considerably to the knowledge of the area. However, a recognised limitation of this study is that while all the habitat types have been representatively sampled, the current surveys comprise only a small proportion of the study area. Based on the data collected so far, additional populations of conservation significant flora would be expected to occur throughout the study area.

The key flora species of importance with regards to the current proposal is the Threatened species *Seringia exastia*. A total of 334 individuals have been confirmed from six locations, however it is possible that some sterile *Seringia* specimens that were collected may also represent this species. Genetic analysis of the collected material would be required to determine the actual number of records from the study area, and it is clear that this species will be more widely distributed than is currently indicated. Given that the current records extend the known range to 290 km, a distance which spans a very considerable area of suitable habitat, the listing of *Seringia exastia* as Threatened should likely be reviewed.

The eight Priority species recorded are generally well known from the area and are distributed over broad ranges. The specimen of the Priority 1 *Tephrosia rosea* var. Port Hedland (A.S. George 1114) may, however, potentially represent a new entity, as it matches another atypical specimen that is currently lodged under this entity in the WA Herbarium collection.

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8.0 Glossary and Acronyms

*	Used prior to a species name to denote an introduced (weed) species.
aff.	Abbreviation of *affinis* (Latin); 'with affinities to'.
Annual (plant)	A plant that lives for only one year.
Biota	Biota Environmental Sciences.
Conservation significant	A plant, community or habitat that has a formally assigned conservation ranking, usually because it is recognised to be rare, unusual, new or poorly sampled (see Appendix 1 for more on the conservation framework).
Cryptic	Plants that die back to a perennial root-stock under dry conditions; considered cryptic (meaning hidden) because although they are consistently present, it is difficult to tell unless suitable conditions prevail.
DBCA	WA Department of Biodiversity, Conservation and Attractions (formerly Department of Parks and Wildlife; Department of Environment and Conservation (DEC); and Department of Conservation and Land Management (CALM)).
Dominant species	The species that occur most abundantly in an area or vegetation stratum.
EPA	Environmental Protection Authority of WA.
EP Act	WA *Environment Protection Act 1986*.
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.
Flora keys	Botanical publications containing a series of questions (regarding the plant's characteristics) aiding in the identification of a taxon.
Foot traverse	Consists of walking through an area to confirm or note the vegetation and/or species presence (usually sampling a narrow corridor/cross section of vegetation).
IBRA	Interim Biogeographic Regionalisation for Australia.
Land system	A land classification framework, which divides the region into broad systems, each consisting of a series of "land units" that occur on characteristic physiographic types within the land system.
Mapping note	A mapping note is a condensed form of sampling site, at which similar broad habitat and vegetation information is recorded as for a relevé, however the area is smaller in size and only the dominant flora species are recorded.
MNES	A Matter of National Environmental Significance listed under the Commonwealth EPBC Act.

Opportunistic record	Recorded by non-systematic sampling methods (i.e. outside of a quadrat or relevé site).
PEC	Priority Ecological Community (see Appendix 1 for more on the WA conservation framework).
Perennial	A plant that lives for more than two growing seasons.
Priority flora	Flora listed by the DBCA as requiring additional information to properly evaluate their conservation significance or requiring ongoing monitoring; see Appendix 1 for more on the WA conservation framework.
Quadrat	A bounded sample area of uniform vegetation in which all species present are recorded; the standard quadrat size for the Pilbara is 50 m by 50 m, or an equivalent area (2,500 m^2).
Relevé	An unbounded flora sampling site, with a similar area to a quadrat, in which most species present are recorded.
sens. lat.	Abbreviation of *sensu lato* (Latin), meaning "in the broad sense".
sp. (plural: spp.)	Abbreviation of 'species'.
Stratum (plural: strata)	A horizontal level of vegetation defined by growth habit (and sometimes height); e.g. low trees, tall trees, tussock grasses, hummock grasses).
Study area	The area in which the vegetation and flora survey was conducted.
subsp. (plural: subspp.)	Abbreviation of 'subspecies'.
Systematic sampling	Sampling at fixed quadrats or relevés established in a defined habitat.
TEC	Threatened Ecological Community (see Appendix 1 for more on the WA conservation framework).
Threatened flora	Flora protected by legislation, either listed under the Commonwealth EPBC Act or the WA *Wildlife Conservation Act 1950* (species known as Declared Rare Flora); see Appendix 1 for more on the WA conservation framework.
var.	Abbreviation of 'variety'.

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