December 2018

PERDAMAN UREA PROJECT
Pre-Wet Season Biological Survey

Burrup Peninsula, WA

Prepared on behalf of Cardno by:

Animal Plant Mineral Pty Ltd

Burrup Peninsula:

Site F: TR 70/5461

Site C: TR 70/6697

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EXECUTIVE SUMMARY

The Perdaman Urea Plant Project (the Project) is located within the Burrup Strategic Industrial Area, on the Burrup Peninsula, approximately 13 kilometres northwest of Karratha and 1,300 kilometres north of Perth (Figure ES 1). The Burrup Peninsula is a narrow strip of land extending approximately 22 kilometres from the mainland and is part of the Dampier Archipelago, a group of 42 islands and islets. Large outcrops and ranges of fractured red/brown rock and spinifex-covered scree slopes dominate the landscape of the Burrup Peninsula. The land is elevated from the typically low and flat coastal plains of the West Pilbara. There are numerous gorges, creeks and drainage lines cutting across the landscape, which provides heterogeneity in the topography and the vegetation communities it supports. The landscape is distinctive in its appearance and is restricted to the Burrup Peninsula, some nearby islands and adjacent mainland (Department of Environment and Conservation, 2013).

To assist in the development of an Environmental Scoping Document for the Project, Animal Plant Mineral was engaged to undertake:

- Desktop flora, vegetation and fauna studies of the Project Area; and
- Pre-wet season flora, vegetation and terrestrial vertebrate fauna surveys of the Project Area.

The Project Area / Biological Survey Area is shown in Figure ES 1. Pre-wet season conditions prohibit the absolute categorisation of vegetation assemblages due to seasonal unavailability of deterministic species. The precautionary principle has therefore been used to allocate vegetation assemblage names to mapping units in this assessment. Vegetation association allocation and vegetation condition is subject to change under wet season conditions.

Fifteen rocky outcrops were identified that constitute the P1 Priority Ecological Community – Rockpiles of the Burrup Peninsula. These locations are not presently listed on the Department of Biodiversity, Conservation and Attractions database. Seven vegetation associations have been classified in this assessment to be synonymous with vegetation associations listed by M.E. Trudgen & Associates (2002) as being of conservation significance because they have less than 10 occurrences across the Burrup Peninsula and Angel, Gidley and Dolphin Islands. Two flora species of conservation significance were identified inside the Project Area. One individual *Terminalia supranitifolia* (P3) tree occurs on a rockpile in the north eastern extent of the Project Area which is also classified as the P1 PEC - Rockpiles of the Burrup Peninsula. One specimen of *Rhynchosia bungarensis* (P4) was collected from near the eastern Project Area boundary in a shallow drainage area.

A level 1 fauna survey was conducted, including descriptions and mapping of habitat types. Four broad fauna habitats are present within the Project Area, two of which represent suitable habitat for a range of conservation significant species. Rocky outcrops, which may be occupied by the Northern Quoll (*Dasyurus hallucatus*) and the Pilbara Olive Python (*Lialis olivaceus barroni*), and the samphire shrublands and saltplains, which may provide foraging habitat for a range of migratory waders during king tides. Four days of bird surveys were carried out. In total, nine conservation significant bird species were recorded during the survey, including the Red-necked Stint (*Calidris ruficollis*). In addition, four days of nocturnal searches and diurnal foraging, as well as deployment of camera traps and bat detectors was carried out. No mammals or reptiles of conservation significance were recorded.

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GRIFFIN RD

VILLAGE RD

BURRUP PENINSULA RD

HEARSON COVE RD

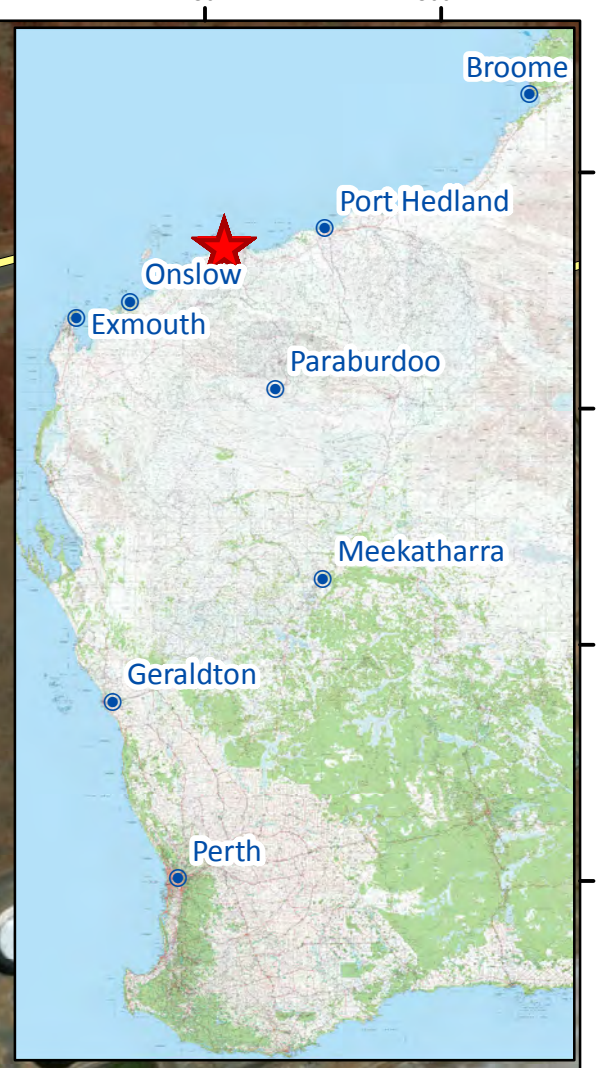

Figure ES 1: Project Location

Legend

- Project Area / Biological Survey Area
- Proposed Plant Footprint
- Main Roads WA

N

170 85 0 170 Meters

1 centimeter = 80 meters

Date: 10/12/2018

Coordinate System: GDA 1994 MGA Zone 50

Author: ems@animalplantmineral.com.au

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ABBREVIATIONS

Symbols and Units	Meaning
ha	Hectare
km	Kilometre
m	Metre

Abbreviation	Meaning
APM	Animal Plant Mineral
BoM	Bureau of Meteorology
BSIA	Burrup Strategic Industrial Area
CAMBA	China and Australian Migratory Bird Agreement
Cth	Commonwealth
DBCA	Department of Biodiversity Conservation and Attractions
DEC	Department of Environment and Conservation
DoEE	Department of the Environment and Energy
DPaW	Department of Parks and Wildlife
EPA	Environmental Protection Authority of Western Australia
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
JAMBA	Japan and Australian Migratory Bird Agreement
ROKAMBA	Republic of Korea-Australian Migratory Bird Agreement (
WA	Western Australia
WC Act	*Wildlife Conservation Act 1950*

1 INTRODUCTION

1.1 PROJECT AND LOCATION

The Perdaman Urea Plant Project (the Project) is located within the Burrup Strategic Industrial Area (**BSIA**), on the Burrup Peninsula, approximately 13 kilometres (**km**) northwest of Karratha and 1,300 km north of Perth (Figure 1-1). The Burrup Peninsula is a narrow strip of land extending approximately 22 km from the mainland and is part of the Dampier Archipelago, a group of 42 inshore islands. Large outcrops and ranges of fractured red/brown rock and spinifex-covered scree slopes dominate the landscape of the Burrup Peninsula. The land is elevated from the typically low and flat coastal plains of the West Pilbara. There are numerous gorges, creeks and drainage lines cutting across the landscape, which provides heterogeneity in the topography and the vegetation communities it supports. The landscape is distinctive in its appearance and is restricted to the Burrup Peninsula and some nearby islands and adjacent mainland (Department of Environment and Conservation (**DEC**), 2013). The Project Area is shown in Figure 1-1.

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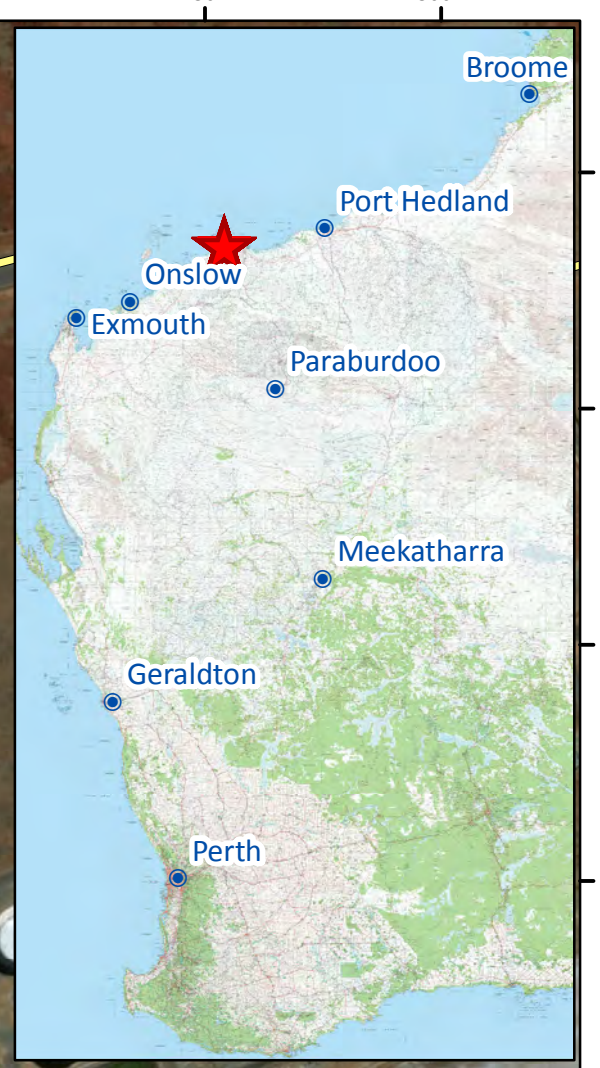

Figure 1-1: Project Location

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- Project Area / Biological Survey Area
- Proposed Plant Footprint
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1.2 SCOPE OF WORK

To assist in the development of an Environmental Scoping Document for the Project, Animal Plant Mineral (**APM**) was engaged to undertake:

- Desktop flora, vegetation and fauna studies of the Project Area; and
- Pre-wet season flora, vegetation and terrestrial vertebrate fauna surveys of the Project Area.

1.2.1 Flora and Vegetation

The aims of the desktop survey are to:

- Establish vegetation associations previously determined for the site and the region in order that field results can be compared for assessment;
- Identify species previously determined as present on site including Declared Rare and Priority Flora (under the provisions of the Wildlife Conservation Act 1950 (WC Act) and Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act));
- Identify species previously determined as present on site regarded as being "significant" on both a local and regional scale;
- Identify vegetation types previously determined as present on site regarded as being "significant" on both a local and regional scale;
- Identify weed species previously determined as present on site in particular any Declared Weeds; and
- Identify and describe areas previously determined as present on site that are designated as conservation areas based on flora and vegetation significance.

The aims of the field survey are to:

- Determine vegetation associations on the site;
- Identify species present on site including Declared Rare and Priority Flora (under the provisions of the WC Act and EPBC Act);
- Identify species present on site that are regarded as being "significant" on both a local and regional scale;
- Identify vegetation types present on site that are regarded as being "significant" on both a local and regional scale;
- Locate and identify, as far as possible, weed species, in particular any Declared Weeds;
- Map the vegetation and sensitive species; and
- Identify and describe areas within the Project Area that are designated as conservation areas based on flora and vegetation significance.

1.2.2 Terrestrial Fauna

The aims of the desktop survey are to:

- Establish faunal assemblage previously determined for the site and the region;
- Identify species previously determined as present on site including Threatened and Priority Fauna (under the provisions of the WC Act and EPBC Act);
- Identify species previously determined as present on site regarded as being "significant" on both a local and regional scale;
- Identify habitat types previously determined as present on site regarded as being "significant" on both a local and regional scale; and
- Identify introduced species previously determined as present on site.

The aims of the field survey are to:

- Identify the fauna habitat values present at the site.
- Identify habitat that may be suitable for Threatened and Priority Fauna (under the provisions of the WC Act and EPBC Act);
- Assess the likelihood of occurrence of Threatened and Priority Fauna (under the provisions of the WC Act and EPBC Act);
- Assess the likelihood of occurrence of species that are regarded as being "significant" on both a local and regional scale; and
- Assess the habitat suitability and likelihood of occurrence of introduced species.

2 BACKGROUND AND SUPPORTING INFORMATION

2.1 RELEVANT LEGISLATION

Species considered to be of National conservation significance are protected under the EPBC Act. Under this Act, activities that may have a significant impact on a species of National conservation significance must be referred to the Department of the Environment and Energy (**DoEE**) for assessment. In Western Australia (**WA**), all native flora and fauna species are protected under the WC Act. Flora species that are considered likely to become Rare, Threatened with extinction or are presumed to be Extinct are specially protected by four schedules in the WC Act. Fauna are protected by seven schedules in the WC Act which accommodate all fauna species in need of special protection, that are rare (likely to become extinct) or that are presumed extinct, as well as birds subject to International Agreements relating to the protection of migratory birds. The Department of Biodiversity Conservation and Attractions (**DBCA**) classifies specially protected flora and fauna into eight categories as listed in Appendix A. These categories also include potentially threatened species that do not meet survey criteria or are otherwise data deficient, these species are listed as Priority 1, 2 or 3. While species that are adequately known, are rare but not threatened, are listed as Priority 4.

Some species are protected under the 1991 Australian and New Zealand Environment Conservation Council Convention (Commonwealth (**Cth**)). Migratory birds are further protected under the following agreements:

- 1974 Japan and Australian Migratory Bird Agreement (**JAMBA**) (Cth);
- 1975 Ramsar Convention on Wetlands;
- 1983 Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention);
- 1986 China and Australian Migratory Bird Agreement (**CAMBA**) (Cth);
- 2004 Agreement on the Conservation of Albatrosses and Petrels;
- 2007 Republic of Korea-Australian Migratory Bird Agreement (**ROKAMBA**); and
- 2006 East Asian – Australasian Flyway Partnership.

All migratory bird species listed in the annexes to these bilateral agreements are protected in Australia as Matters of National Environmental Significance under the EPBC Act.

The *Biosecurity and Agriculture Management Act 2007* and the Biosecurity and Agriculture Management Regulations 2013 designate which weeds are Declared as Prohibited or requiring Control Actions in WA.

2.2 LAND USE

The BSIA is a well established industrial estate with vacant land for strategic industry in close proximity to gas, port and other key infrastructure in the Pilbara region. The BSIA is located within the City of Karratha. Under the City's Town Planning Scheme No.8, the BSIA is zoned 'Strategic Industry'.

The Burrup Peninsula Land Use Plan and Management Strategy (O'Brien Planning Consultants, 1996) was commissioned by the Burrup Peninsula Management Advisory Board for the purpose of allocating land for industry, conservation, heritage and recreation. This document also provides management objectives and outlines acceptable uses and development considerations. The plan was endorsed by Cabinet in 1996.

The BSIA has been created to take advantage of the region's natural gas resources and other competitive advantages. Industries currently located within the BSIA include the:

- Woodside-operated North West Shelf Venture project – a joint venture between Woodside, Shell, BHP Billiton, BP, Chevron and Japan Australia LNG;
- Woodside's Pluto LNG plant;
- Yara Pilbara Fertilisers plant; and
- Yara Pilbara Nitrates' technical ammonium nitrates plant.

The Department of Jobs, Tourism, Science and Innovation is the lead agency for the development of the BSIA and LandCorp is the estate manager.

The Project Area is on land parcels C and F of the BSIA and will also require an 'amalgamated C and F' zone between the two lots. Parts of Site F and the 'amalgamated C and F' zone have previously been disturbed for a construction camp and are rehabilitated.

The Project Area has previously been investigated for 2 projects that did not go ahead.

Site C was investigated for the proposed Ammonia-Urea Plant by Dampier Nitrogen Pty Ltd (Environmental Protection Authority of Western Australia (**EPA**), 2002). The EPA ruled that the project was capable of being managed in an environmentally acceptable manner given the proponents commitments. The commitments relevant to this study were to minimise clearing of conservation significant flora and vegetation and conservation significant fauna habitat.

Site F was investigated for the proposed Gas to Synthetic Hydrocarbons Plant by Syntroleum Sweetwater LLC (EPA, 2000).

2.3 CLIMATE

The Burrup Peninsula lies at the western edge of the semidesert tropical Pilbara region within Australia's arid zone. The climate is commonly described as having two seasons: warm and dry winters from May to November, and hot summers with periodic heavy rains from December to March.

The climate is monsoonal and seasonally controlled by the large high pressure cells that pass from west to east across the Australian continent. Strong easterly winds prevail in the winter due to the development and intensification of anticyclones over southern WA or South Australia. In summer prevailing winds are generally warmer and from the northwest and southwest.

Dampier Salt weather station (12 km to the south of the site, Station 005061) opened in 1969 and Karratha Airport weather station opened in 1971 (10 km to the south of the site, Station 004083) (Bureau of Meteorology (**BoM**), 2018). Rainfall data is available for the duration of opening for both stations. Recent temperature data is available only from Karratha Airport for the period 1993 to 2018.

For the period 1993 to 2018 the annual mean maximum recorded temperature at Karratha Airport is 32.4°C, with an annual mean minimum recorded of 20.8°C. Monthly mean maximum temperatures recorded range from 26.3°C in July to 36.2°C in March. Monthly minimum temperatures recorded range from 13.8°C in July to 26.8°C in January (BoM, 2018).

Annual rainfall in the region is characterised by low, highly variable and very localised rain events due to thunderstorm and tropical cyclone activity in the summer months. Average annual rainfall recorded at Karratha

Airport is 300.4 mm (BoM, 2018). Rainfall in the region is seasonal, usually with two peaks per year. The first peak is from January to March due to tropical cyclones, tropical lows or rain-bearing depressions and tropical thunderstorms. The second peak is from May to June due to the passage of low pressure systems through the south of Western Australia. Monthly average rainfall for the area ranges between 77.1 mm in February to 0.4 mm in October. Due to tropical cyclones, the area is prone to isolated extreme rainfall events. The highest rainfall recorded in a single month was 348.8 mm in February 2011, while all calendar months have at one stage recorded 0 mm of rainfall (BoM, 2018). Average monthly rainfall, median monthly rainfall and the total monthly rainfall for 2018 is shown in Table 2-1.

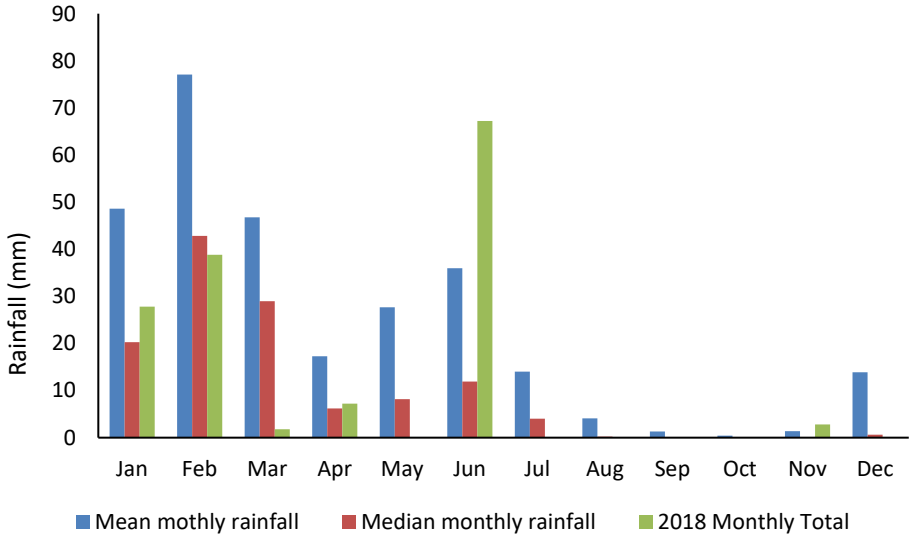

Table 2-1: Average monthly rainfall, median monthly rainfall and the total monthly rainfall for 2018

Rainfall for 2018 was below average for the period January to March yet was not dissimilar to the median values for those months. Rainfall for the period June to August was 126 % higher than average, with 67.2 mm falling between the 6th and 7th of June, but no rainfall in July and August.

Winds in the area of the Burrup Peninsula are predominately from the east during the winter months of April, May, June, July and August with average wind speeds ranging between 17 – 24 km/h. East to southeasterly winds are dominant in the mornings, shifting to northeasterly in the afternoon and easing in the evening in response to diurnal land temperature changes. From October through to February winds are predominantly westerly in the morning, shifting to dominant northwesterly onshore winds in the afternoon with mean wind speeds varying between 19 and 30 km/h. The months of February, March and September are transition months with less dominant wind patterns, with mean wind speeds varying between 19 and 28 km/h. Extreme wind conditions may be generated in the region by tropical cyclones, strong easterly pressure gradients, squalls and tornados. Tropical cyclones generate the most significant storm conditions in the region, wind gusts of 259kilometres per hour at Mardie being measured during cyclone Trixie in February 1975, and Dampier recording wind gusts of 183 kilometres per hour from cyclone Orson in 1989 (BoM, 2018).

2.4 BIOGEOGRAPHIC REGIONALISATION

The Interim Biogeographic Regionalisation for Australia (version 7) represents a landscape-based approach to classifying the land surface of Australia. Eighty-nine biogeographic regions and 419 sub regions have been delineated, each reflecting a unifying set of major environmental influences which shape the occurrence of flora and fauna and their interaction with the physical environment across Australia.

The Burrup Peninsula is within the Pilbara biogeographic region, within the Roebourne subregion (Department of the Environment, 2012). The 'Bioregional Summary of the 2002 Biodiversity Audit for Western Australia' (Mckenzie *et al*. 2003) describes the Roebourne subregion, as follows:

> *"Quaternary alluvial and older colluvial coastal and subcoastal plains with a grass savannah of mixed bunch and hummock grasses, and dwarf shrub steppe of Acacia stellaticeps or A. pyrifolia and A. inaequilatera. Uplands are dominated by Triodia hummock grasslands. Ephemeral drainage lines support Eucalyptus victrix or Corymbia hamersleyana woodlands. Samphire, Sporobolus and mangal occur on marine alluvial flats and river deltas. Resistant linear ranges of basalts occur across the coastal plains, with minor exposures of granite. Islands are either Quaternary sand accumulations, or composed of basalt or limestone, or combinations of any of these three. Climate is arid (semi-desert) tropical with highly variable rainfall, falling mainly in summer. Cyclonic activity is significant, with several systems affecting the coast and hinterland annually".*

The Burrup Peninsula lies within the Fortescue Botanical District, which is part of the biogeographical region known as the Eremaean Botanical Province (Beard, 1975).

The Burrup Peninsula, approximately 22 km long and 5 km wide, was originally an island that formed part of the Dampier Archipelago. It was joined to the mainland in the mid-1960s by a road causeway, forming the Burrup Peninsula. The Burrup Peninsula is bound by Mermaid Sound to the west and Nickol Bay to the east and is distinguished by large areas of weather resistant rocky outcrops and scree slopes. These high scree slopes form part of an extensive high scree range, which runs throughout most of the Burrup Peninsula and rise to 60 metres (**m**) above sea level in places and serve as the main catchment for water during rainfall events on the Burrup Peninsula.

Rocky outcrops exist in the northern and southern sections of the Project Area, with steeply inclined valleys, which occur along fault lines forming minor drainage lines, feeding into shallow drainage gullies through the mid to lower slopes of the site. These gullies then drain to the supra-tidal flats that run through the centre of the site before flowing in a westward direction to King Bay.

The topography of the Project Area is dominated by the supra-tidal flats that form an east-west trending valley at approximately 4 m Australian Height Datum from King Bay in the west to Hearson Cove in the east and divide the Burrup Peninsula into two separate units. The floor of this valley is composed of marine sediment.

The geology of the Burrup Peninsula has been previously investigated by the Geological Survey of WA and has been described by O'Brien Planning Consultants (1996). The Burrup Peninsula is composed mainly of an intrusive Proterozoic igneous rock outcrop known as the Gidley Granophyre, which is approximately 2,200 million years old. The main outcrop of Gidley Granophyre occurs in the Dampier Archipelago and the adjacent mainland, along basal unconformity of the Fortescue Group (Hickman, 1983).

The base of the intrusion consists of a differentiated coarse-grained gabbro and the main body is a fine-grained granophyre. The gabbro weathers to a dark brown and the granophyre to a lighter red-brown, and both rock types are resistant to erosion and form aggregates of split boulder screes. Rapid weathering of dolerite dykes that are also present has resulted in the formation of deeply incised, narrow valleys, amongst the exposed granophyre bedrock, generally trending either southwest to northeast or east to west throughout the Burrup Peninsula.

The proposed Project site includes exposed granophyre bedrock, colluvium of sand, silt and gravel in outwash fans of the supra-tidal flats that run through the middle of the Project Area and indicate a soil profile associated with a low energy marine depositional environment. The soil profile is largely comprised of sandy loams to silty

sands generally brown to grey in colour. The sediments are typically organically rich and often contain a thin veneer of shelly lenses.

2.4.1 Land Systems

Land Type 1 – Hills and Ranges with Spinifex Grasslands, Land System Granitic – Rugged granitic hills (Leighton, 1987) is the single land system of the Project Area. It is described as Granitic: Hill tracts of granitic rocks with pockets of shallow gritty surfaced acidic soils, relief up to 100 m, and makes up 2.2 % of the surveyed Pilbara Rangeland but is mostly distributed south and west of Marble Bar (Leighton *et al*. 1987).

Soils are of Group 423 - Red shallow sands, Soil sub-group - Red shallow sands on granite, which are described in van Vreeswyk (2004) as:

> *"These soils are uniform textured coarse sands or medium textured sands overlying weathered granite, sandstone or red-brown hardpan at shallow (25-50 cm) depth. Some soils occur over substrates such as conglomerate or quartz and are incorporated into this group. The soils are red to dark red in colour and non-calcareous with a weakly acidic to neutral soil reaction trend. The soils are mostly found within or adjacent to the parent rock resulting in gritty sands. The lower subsoil mostly overlies partially weathered granite rock and coarse fragments of quartz and granite are common throughout the profile. These soils often have a common to abundant (10>50%) stony mantle. Slightly saline soils may infrequently occur at the base of occasional large granite domes or outcrops. Domes and tors of bare rock are included in this soil group."*

2.4.2 Surface Water

No very small, small, medium or large water bodies occur in the Project Area (Department of Water and Environmental Regulation, 2018). Small ephemeral creeks drain water from the rocky outcrops in the north and south to the supra-tidal flats between King Bay and Hearson's Cove, in the centre of the Project Area.

2.4.3 Wetlands and Environmentally Sensitive Areas

The Project Area does not include and is not in close proximity to any wetlands listed as Ramsar sites (Department of Water and Environmental Regulation, 2018), nor does it occur within an Environmentally Sensitive Area. The Project Area is within an area zoned for Industrial Development on the Burrup Peninsula.

2.4.4 Previous Surveys

Many Private Industry Developments have commissioned independent studies on the Burrup Peninsula. Some of these are publicly available through the EPA assessment process. Table 2-1 lists those where an assessment overlapped, or was in close proximity to, the current Project Area.

Table 2-2: Existing Flora and Fauna Surveys and Investigations within the Burrup Peninsula and Surrounds Relevant to the Project

Report Title	Consultant	Year	Survey Type	Purpose
Flora and Vegetation				
Flora and Vegetation Survey of the Proposed Ammonia Plant	Astron Environmental	2001	Reconnaissance Survey	To map vegetation present on the site and to sample flora in order to confirm or negate the presence of flora of conservation significance. This site is adjacent to the Project Area and the survey area overlaps the project. Results of this survey are discussed in more detail in Section 4.1.3
A Flora, Vegetation and Floristic Survey of the Burrup Peninsula, some adjoining areas and part of the Dampier Archipelago, with comparisons to the floristics of areas on the adjoining mainland (Volume 2)	M. E. Trudgen & Associates	2001	Detailed Survey	To map vegetation present on the site and to sample flora in order to confirm or negate the presence of flora of conservation significance. This study is the most comprehensive assessment of the regional significance of flora and vegetation. Results of this survey are discussed in more detail in Section 4.1.3
A Flora, Vegetation and Floristic Survey of the Burrup Peninsula, some adjoining areas and part of the Dampier Archipelago, with comparisons to the floristics of areas on the adjoining mainland (Volume 1)	M. E. Trudgen & Associates	2002	Detailed Survey	To map vegetation present on the site and to sample flora in order to confirm or negate the presence of flora of conservation significance. This study is the most comprehensive assessment of the regional flora and vegetation. Results of this survey are discussed in more detail in Section 4.1.3
King Bay Eastern Lease Area Industrial Estate Vegetation and Flora Report	Astron Environmental	2003	Reconnaissance Survey	To map vegetation types at a broad scale and identify any significant flora or vegetation and weed species present on site to assist relevant government bodies in achieving a low-level assessment. This study was reviewed.
Dampier Nitrogen Plant Site Wet Season Vegetation and Flora Survey Report as prepared for URS Consultants (Ref: 3909 2005-RV-01)	Astron Environmental	2005	Detailed Survey	To map the vegetation and supplement information presented in the Astron 1997 dry-season report by conducting a wet-season survey to identify all Priority and Threatened flora, weeds and Declared weeds.
Pluto LNG Development Vegetation and Flora Survey Site A	Astron Environmental	2005	Detailed Survey	To map the vegetation and compare previously mapped vegetation associations to be used in significance assessment. Identify Priority and Threatened flora, weeds

Report Title	Consultant	Year	Survey Type	Purpose
				and Declared weeds in order to designate areas of sensitivity and conservation. This study was reviewed.
Technical Ammonium Nitrate Production Facility. Public Environmental Review for Burrup Nitrates Pty Ltd	Environmental Resources Management Flora and Vegetation assessment by Outback Ecology (2009)	2009	Reconnaissance Survey	To provide a comprehensive desktop assessment of the area (Site D) for the Technical Ammonium Nitrate Production Facility including vegetation communities, the extent of the now Murujuga National Park, broad landscape and vegetation attributes and hydrology and drainage. This site is within the same catchment as the Project Area. Results of this survey are discussed in more detail in Section 4.1.3
Pluto LNG Development Site B North – Flora and Vegetation Assessment Survey	ENV Australia	2006	Detailed Survey	To identify all flora and vegetation associations occurring within Site B North in order to assess conservation significance. This study was reviewed.
Pluto LNG Development Proposed Gas Trunkline Option 1: Flora and Vegetation Condition Assessment	ENV Australia	2006	Targeted Survey	To search and assess presence or absence of Priority flora and undertake a vegetation condition assessment for the Pluto LNG Development Proposed Pipeline Route Terminating at Gas Trunkline Option 1 where vegetation is likely to be disturbed along the pipeline route. This study was reviewed.
Pre-Wet Season Biological Survey	APM	2018	Detailed Survey	To undertake a pre-wet season survey to assess vegetation associations of Sites C and F and the 'C and F amalgamation' zone through detailed sampling of flora to identify the types of species assemblages and vegetation communities that are present within the Project and to shape the survey efforts for the following season survey and adequately determine if significant flora or vegetation are likely to occur at the Project, given the distribution of habitats.
Fauna				

Report Title	Consultant	Year	Survey Type	Purpose
Fauna and Marine Biota. In: Burrup Peninsula Draft Land Use and Management Plan, Technical Appendices. Unpublished report by O'Brien Planning Consultants	H. Butler	1996		Cited in Worley Astron 2006 – Scope and methodology of report not known as report is no longer available
Burrup Liquid Ammonia Plant targeted fauna survey. Unpublished report for Sinclair Knight Merz Pty Ltd	Biota Environmental Services	2001		Cited in Worley Astron 2006 – Scope and methodology of report not known as report is no longer available
Terrestrial Fauna and Habitats. In: Methanex Australia Pty Ltd, Methanol Complex, Burrup Peninsula Western Australia, Public Environmental Review (Section 5.8)	Biota Environmental Services	2002		Cited in Worley Astron 2006 – Scope and methodology of report not known as report is no longer available
Burrup Fertilisers Pty Ltd. Fauna of the Burrup Peninsula and the Proposed Ammonia Plant (Revised version). Unpublished report to Sinclair Knight Merz Pty Ltd	Astron Environmental	2001		Cited in Worley Astron 2006 – Scope and methodology of report not known as report is no longer available
Natural Gas to Synthetic Oil Project Product and Feed pipelines, Vegetation, Flora and Fauna Survey. Unpublished report for Syntroleum Corporation	Astron Environmental	1999		Cited in Worley Astron 2006 – Scope and methodology of report not known as report is no longer available
Terrestrial Fauna and Habitats. In: Burrup Peninsula Fertilisers Pty Ltd, Proposed 2,200 tpd Ammonia Plant, Burrup Peninsula Western Australia, Public Environmental Review (Section 5.8). August 2001. Prepared for Sinclair Knight Merz	Astron Environmental	1999		Cited in Worley Astron 2006 – Scope and methodology of report not known as report is no longer available
Vegetation, Flora and Fauna Survey. In: Syntroleum, Proposed Gas to Synthetic Hydrocarbons Plant, Burrup Peninsula Western Australia, Consultative Environmental Review. November 1999. Prepared for HLA – Envirosciences Pty Ltd	Astron Environmental	2001		Cited in Worley Astron 2006 – Scope and methodology of report not known as report is no longer available
Annual Report on Environmental Investigations and Monitoring	Woodside Offshore Petroleum Pty Ltd	1995		Cited in Worley Astron 2006 – Scope and methodology of report not known as report is no longer available

Report Title	Consultant	Year	Survey Type	Purpose
Annual Report on Environmental Investigations and Monitoring	Woodside Offshore Petroleum Pty Ltd	1997		Cited in Worley Astron 2006 – Scope and methodology of report not known as report is no longer available
Annual Report on Environmental Investigations and Monitoring	Woodside Offshore Petroleum Pty Ltd	1998		Cited in Worley Astron 2006 – Scope and methodology of report not known as report is no longer available
Annual Report on Environmental Investigations and Monitoring	Woodside Energy Pty Ltd	1999		Cited in Worley Astron 2006 – Scope and methodology of report not known as report is no longer available
Pluto LNG Development Survey of Non-marine Molluscs	S.M. Slack-Smith	2005	Targetted Survey	Cited in Worley Astron 2006 – A tyaregetted assessment of the non-marine mollusc fauna of thew Burrup Peninsula to allow assessment of the probable effect of the land based components associated with the Plutos LNG Development proposed by Woodside.
Fauna assessment surveys of the Pluto LNG Development pipeline corridors	ENV Australia	2006		Cited in Worley Astron 2006 – Scope and methodology of report not known as report is no longer available
Pluto LNG Development Holden Beach Sea Turtle Habitat Use Survey	Pendoley Environmental	2006	Targeted Survey	To search for evidence of sea turtle nesting activity within the vicinity of a trunkline shore crossing location associated with the proposed Pluto LNG Development at Holden Beach
Terrestrial Fauna of the Burrup Peninsula, unpublished report prepared for BGC Contracting	Astron Environmental	2003	Desktop Survey	To provide a comprehensive desktop assessment of the King Bay Eastern Leases area and determine fauna of significance that may inhabit the lease of adjoining areas
Pluto LNG Development Desktop Fauna Report	Worley Astron	2006	Level 1 Desktop Survey	To provide a comprehensive desktop assessment of the Pluto LNG Development area and determine fauna of significance that will be required to be assessed for presence/absence in future targeted surveys.
Technical Ammonium Nitrate Production Facility. Public Environmental Review for Burrup Nitrates Pty Ltd	Environmental Resources Management	2009	Reconnaissance Survey	To provide a comprehensive desktop assessment of the area (Site D) for the Technical Ammonium Nitrate Production Facility including noise monitoring sites, noise contouring and reduction measures, the extent of the now Murujuga National Park, broad landscape and vegetation attributes and hydrology and drainage.

3 METHODOLOGY

3.1 CONTRIBUTING AUTHORS

The planning and design of this survey was conducted by APM Principal Zoologist Dr Mitch Ladyman, and Senior Botanist Dr Eleanor Hoy. Fieldwork was carried out by E. Hoy, Senior Zoologist Dr Stuart Dawson, Environmental Scientist Sarah Flemington, and Senior Ornithologist Dr Floyd Holmes.

The report was drafted by S. Flemington, E. Hoy, S. Dawson, and M Ladyman, while Environmental Scientist Tony Smith conducted GIS analysis.

3.2 CONSTRAINTS

Constraints and their impacts on survey outcomes are discussed in Table 3-1.

Table 3-1: Constraints and the impacts on survey outcomes

Factor	Impact on survey outcomes
Access Problems	Most of the site was only accessible by foot. This was not a limiting factor, however, and all areas were adequately surveyed.
Experience levels	The personnel that executed these surveys included practitioners that are regarded as suitably qualified in their respective fields. • Dr Eleanor Hoy – Senior Botanist (10 years' experience) • Dr Stuart Dawson – Senior Zoologist (5 years' experience) • Sarah Flemington – Environmental Scientist (2 years' experience) • Dr Floyd Holmes – Senior Ornithologist (5 years' experience)
Scope: Flora	Many perennial species presented fertile material suitable for taxonomic discrimination. A small number of annual species were also present and in condition suitable for identification. The majority of expected short lived perennial, annual and ephemeral species were not present or were too senesced to identify. Many seasonally deciduous perennial plants were unable to be identified. A major limitation to the survey is the lack of available specimens and/or descriptions of the "species of conservation significance", as identified by M. E. Trudgen & Associates (2002), for confirmation of identification. For example there are five *Euphorbia* species on the list for conservation, some of which are apparently rare or newly recognised. At present, however, there are no specimens or detailed descriptions available in either the Western Australian or Pilbara Regional Herbariums with which comparisons can be made. There are in fact 13 taxa on this list which are only identified to genus level (eg. *Euphorbia* sp). Until such time as recognised formal descriptions are accepted and published, and at least specimens lodged in the herbarium, the assessment of the flora to species level on the Burrup Peninsula remains difficult to achieve.
Scope: Vegetation	The species characteristically dominant in the canopy and groundcover strata were present and generally in a condition suitable for identification. Mid layer shrubs were generally not present or lacked suitable material for identification.
Scope: Fauna	The scope of the fauna survey was a level 1 survey, with targeted bird surveys. Given this level of survey only requires a desktop survey, and a site visit with habitat assessment, the fieldwork time was ample to complete a detailed habitat assessment. The spotlight surveys and foraging undertaken where targeted to sample the Northern Quoll and Pilbara Olive Python, two species that are cryptic and often in low densities. As a result, this approach is limited by the biology of these species, and the absence of records does not necessarily indicate that these species are absent. In addition, the rocky outcrops where

Factor	Impact on survey outcomes
	these species are likely to be present are relatively inaccessible with many rocky holes and caves for species to hide, making the probability of detection of these species limited. The deployment duration of acoustic bat detectors and camera traps was limited to the four nights of the survey, which may limit the detection probability of some species, especially using camera traps. As these approaches are in fact additional to the requirements of a Level 1 survey, however, this is not considered a significant limitation. A wet season survey will nevertheless be required to obtain the full species complement at the Project Area.
Timing, weather, season, cycle	The current survey was undertaken in November (19th– 22nd 2018). The conditions were typical of late dry season. A significant rainfall occurred in early June and many perennial species had fertile material available as a result. A reasonable assessment of vegetation association mapping was available. Many fauna species would likely be more active (and therefore more detectable during foraging) in the late wet season than during the current survey. As a result, the species identified during foraging and camera surveys may be lower than at a more optimal time of year. A wet season survey will be required to obtain the full species complement at the Project Area. The survey timing did not include a period of spring tide, during which the tidal salt flats would be inundated, and the shorebird density is expected to be greatest. A wet season survey including a period of spring tide is required to maximise the detection probability of some shorebird species.
Sources of information	The flora of the Burrup Peninsula is well studied. The regional work by M. E. Trudgen & Associates (2002) maps the current site and many flora and vegetation assessment surveys have been undertaken as part of the Environmental Impact Assessment process on development sites adjacent to the Project. Similarly, the fauna assemblage of the Burrup Peninsula is well studied, largely due to the number of different facilities that have been built on the peninsula in the last 30 years, and the resulting biological surveys. Many of these surveys are not freely available, however, while being referred to in more recent documents. The literature search is therefore deliberately limited to include surveys that include data directly comparable to our survey. Given the number of previous surveys and database searches, this is not considered a limitation.
Completeness:Flora and vegetation	The field survey recorded 86 taxa, including species, subspecies and Variants, from 31 Families. 390 taxa have been recorded for the Burrup Peninsula (Astron Environmental, 2005). Astron Environmental (2005) recorded 143 taxa from 44 families for an area greater than but including Site C and the 'Site C and F amalgamation' zone. A wet season survey will be required to obtain the full species compliment from the Project.
Completeness: Fauna	297 vertebrate fauna taxa have either been recorded or are expected to occur in the Burrup Peninsula (Worley Astron, 2006). The survey effort included in a Level 1 survey is very superficial and is not likely to provide a complete inventory of the species occupying a site. As a result, the comparative low survey effort in the current study (excluding the bird survey) may contribute to an incomplete species list. Alternatively, and more likely, is that the broad nature of database searches will result in species being included that have not been adequately censused on the ground. A wet season survey will be required to obtain the full species compliment from the Project.

Factor	Impact on survey outcomes
	The bird survey was conducted in accordance with guidelines, however this survey must be repeated after the wet season to maximise the sample of migratory birds.

3.3 DATABASE SEARCHES

Table 3-2 details the database searches that were conducted prior to field survey.

Appendix B represents the results of the database searches (APM, 2018) and the desktop survey undertaken in 2006 by Worley Astron for Sinclair Knight Merz, as historical survey records (of various authors) of terrestrial vertebrate fauna have been included in their report. Some studies have been undertaken in the surrounding area of the Burrup Peninsula and Dampier Archipelago, however little fauna survey work has been done in the proximity or within the actual Project Area.

Table 3-2: Database Searches Conducted Prior to Field Survey

Database	Area Searched	Information	Administering Agency
Flora and Vegetation			
Australian Government Protected Matters Search Tool	Central co-ordinate within the Project Area with a 100 km buffer (Appendix C)	Matters of national significance and matters protected by EPBC Act	Department of Energy and Environment
Directory of Important Wetlands in Australia	Roebourne Biogeographic Subregion	Details of specific Ramsar and Directory Wetlands (Internationally and Nationally important wetlands, respectively)	
Threatened (Declared Rare) Flora Database	270 km of coastline plus the islands within 16 km, including the entire Burrup Peninsula (Appendix D)	Validated populations of declared rare flora and some priority flora	Department of Biodiversity Conservation and Attractions
Western Australian Herbarium Specimen Database		All records of declared Rare and Priority species from the Western Australian Herbarium collection of specimens, includes un-validated historical specimens	
Declared Rare and Priority Flora List		Declared Rare Flora and Priority Flora – provides a list of species and general distribution in an area of interest	
Priority Ecological Communities List		Priority Ecological Communities	
Fauna			

Australian Government Protected Matters Search Tool	Central co-ordinate within the Project Area with a 100 km buffer (Appendix C)	Matters of national significance and matters protected by *Environmental Protection and Biodiversity Conservation* (EPBC) *Act 1999*	Department of Energy and Environment
Atlas of Living Australia	Central co-ordinate within the Project Area with a 10 km buffer (Appendix E)	All species records that have been lodged with the database	Atlas of living Australia (NGO)
NatureMap	Central co-ordinate within the Project Area with a 10 km buffer (Appendix F)		Department of Biodiversity Conservation and Attractions (DBCA, WA)
Threatened Fauna Database	Area surrounding Project Area, including the entire Burrup Peninsula and islands within ~25 km (Appendix D)	Threatened and Priority Species listed under the *WC Act*	

3.4 FIELD SURVEY

3.4.1 Flora and Vegetation Survey Methodology

Vegetation classification is the process of identifying and characterising discrete vegetation units using empirical data. The aim of vegetation classification is to identify and describe the vegetation units present within a survey area, identify the local or regional significance of the identified units and to provide sufficient information to enable analysis of the significance of impacts. Two primary methods are used to classify vegetation units in Western Australia: one is based on dominant species and vegetation structure and the other is based on analysis of floristic composition data.

A consistent approach to vegetation classification and description across surveys in similar regions is critical for the assessment of cumulative impacts at the local and regional scale. Differences in classification and analysis methods, consideration of scale, interpretation of floristic and structural vegetation information and terminology can lead to incompatibility. In identifying the appropriate methodology for the current survey consideration was taken of the methodology used in other local and regional assessments, the seasonal limitations and adherence to the EPA (2016) *Technical Guidance: Flora and Vegetation Surveys for Environmental Impact Assessment*.

Field survey work was conducted over 4 field days by a Senior Botanist and assisting Environmental Scientist from the 19th to the 22nd of November 2018. The seasonal condition was pre-wet season. Flora surveys were undertaken in all of the vegetation/soil types/landform units present in the study area, at representative locations established following the desktop assessments and initial site reconnaissance. Figure 3-1 shows the survey site locations. Figure 3-2 shows APM's tracks made during the vegetation assessment and fauna search.

475500 000000 475750 000000 476000 000000 476250 000000 476500 000000 476750 000000 477000 000000 477250 000000

7720000 7719750 7719500 7719250 7719000 7718750 7718500 7718250 7718000 7717750

BURRUP PENINSULA RD
VILLAGE RD
KING BAY RD
GRIFFIN RD
HEARSON COVE RD

1 2 3 4 5 6 7 8 9 10 11 12 13 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40

Figure 3-1: Flora and Vegetation Survey Locations

Legend

- *APM Survey Locations*
- *Biological Survey Area*
- Main Roads WA

N

160 80 0 160 Meters

1 centimeter = 75 meters

Date: 10/12/2018

Coordinate System: GDA 1994 MGA Zone 50

Author: ems@animalplantmineral.com.au

Document Path: \\MAINSERVER\Documents\APM GIS and Mapping\03_Client\APM2018-19GIS\CAR\02_GIS Maps\20181210_CAR001_Fig3-1 Flora and vegetation survey locations.mxd

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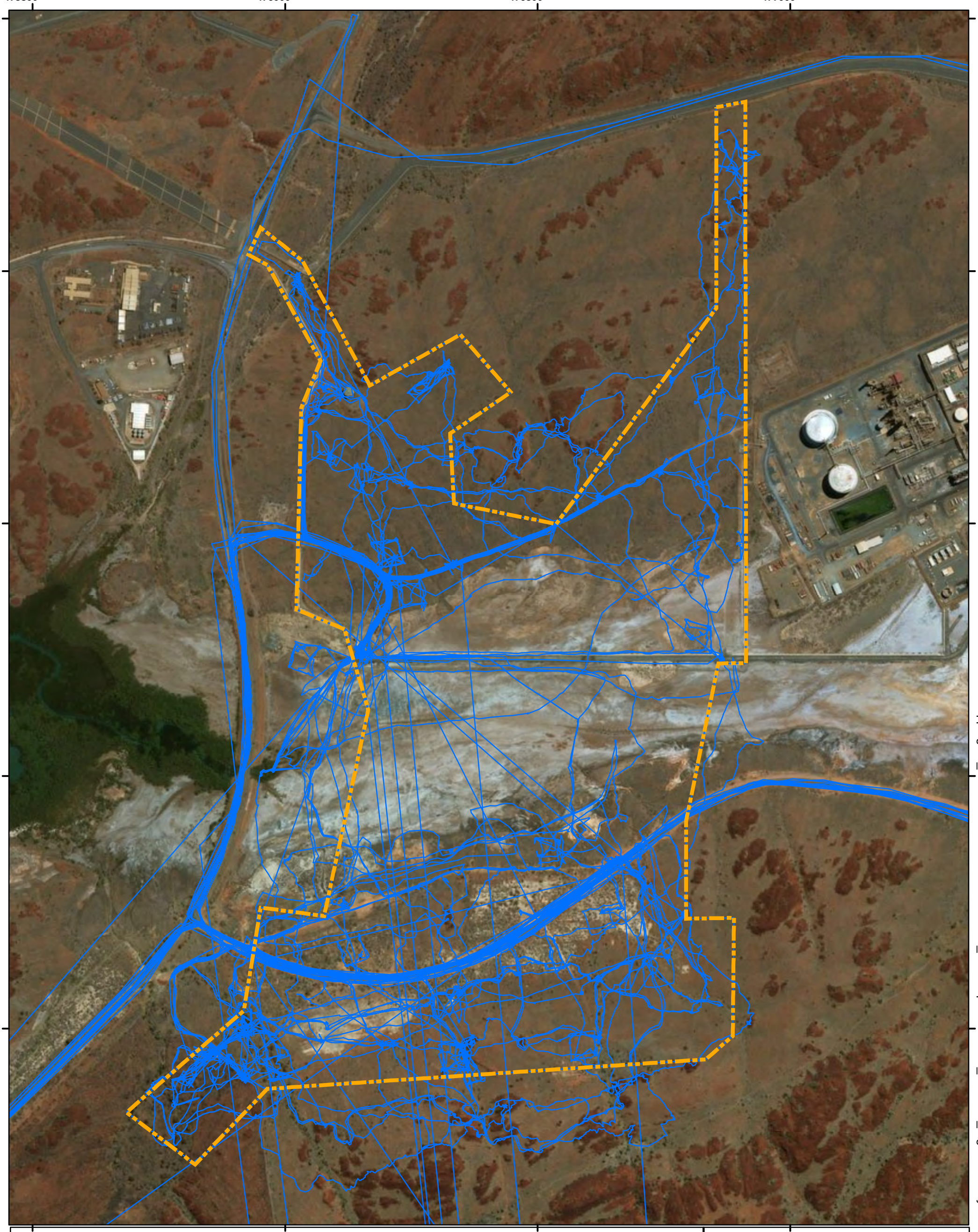

Document Path: \\MAINSERVER\Documents\APM GIS and Mapping\03_Client\APM2018-19GIS\CAR\02_GIS Maps\20181212_CAR001_Fig5-2 Survey effort.mxd

Figure 3-2: APM Pre-Wet Season Vegetation Assessment and Fauna Search Tracks within the Project Area

Legend

GPS Tracks - Burrup Survey Effort

Biological Survey Area

N

150 75 0 150 Meters

1 centimeter = 70 meters

Date: 12/12/2018

Coordinate System: GDA 1994 MGA Zone 50

Author: ems@animalplantmineral.com.au

Vegetation was mapped at the association scale. Survey sites were allocated to identified vegetation types to accurately describe the vegetation association. Vegetation units were identified, and boundaries delineated using a combination of aerial photography, topographical features and field data/observations. Vegetation units were allocated mapping codes with reference to previously described vegetation types in the region (see section 4.1.2) based on structure, dominant taxa and cover characteristics. Field observations on the distribution of vegetation units were made using traverses, where notes on the location, dominant species and vegetation condition were taken to help with the extrapolation of vegetation type and condition.

Survey sites represent Full Characterisation Sites (EPA, 2016) and were sampled using quadrats of 50 m x 50 m where possible. In riparian areas or where the vegetation types were of an irregular distribution, quadrat dimensions were altered but the 2,500 square metre search area was retained where possible. A number of vegetation units were substantially smaller than 2,500 square metres. These areas had clearly defined boundaries due to changes in vegetation composition, and the entirety of these vegetation units were sampled; where multiple small units of the same vegetation were present on the site, the compositions of the areas were combined to create a single data set for the vegetation assemblage.

Field data at each survey site was recorded on a *pro-forma* data sheet and included the parameters detailed in Table 3-3. Details of survey sites are provided in Appendix G. A flora inventory was compiled from taxa listed in described survey sites and from opportunistic floristic collections throughout the survey area, with at least one collection made for every taxa encountered. 104 specimens were identified by an experienced botanical taxonomist in the Herbarium using published reference material. The nomenclature applied is consistent with Florabase (Western Australian Herbarium, 2018).

Due to conditions typical of the pre-wet season, a large number of taxa are seasonally unavailable. This includes taxa that occurred as dominants in the previous vegetation mapping of the site. The absence of certain diagnostic features (this is a function of the seasonal cycles of flora species) prevented identification of some plants to genus or species level. The conservation status of all recorded flora was compared against the current lists available on Florabase (Western Australian Herbarium, 2018) and the EPBC Act List of Threatened Flora (DoEE, 2018a).

Vegetation Condition was assigned to areas using the scale developed for the Eremaean and Northern Botanical Provinces adapted from Trudgen (1988) as recommended in EPA (2016). Table 3-4: details the six potential categories. As the seasonal conditions limited the frequency and cover of invasive species potentially at the site, there may be some minor modifications to condition rating following a wet season survey.

Table 3-3: Parameters recorded at each Survey location

Variable	Parameters
Collection attributes	Personnel/recorder; date, quadrat dimensions and marking method, photographs of the quadrat from the northwest and south east corners, site code
Physical features	Landform, aspect, soil attributes, ground surface cover, rock type and physical attributes
Community Size	Width (m) if linear (e.g. riparian) or size (ha) if non-linear
Location	Coordinates recorded in GDA94 datum using a hand-held Global Positioning System (GPS) tool (Garmin) to accuracy approximately ± 5 m.
Vegetation condition	Vegetation condition was assessed using the condition rating scale devised by Trudgen (1988)
Disturbance	Level and nature of disturbances (e.g. weed presence, fire and time since last fire, impacts from grazing, infrastructure works).
Flora	List of dominant flora from each structural layer. List of all species within the quadrat including average height and cover

Table 3-4: EPA (2016) Vegetation Condition Scale

Vegetation Condition	Eremaean and Northern Botanical Provinces adapted from Trudgen (1988)
Excellent	Pristine or nearly so, no obvious signs of damage caused by human activities since European settlement
Very Good	Some relatively slight signs of damage caused by human activities since European settlement. For example, some signs of damage to tree trunks caused by repeated fire, the presence of some relatively non-aggressive weeds, or occasional vehicle tracks.
Good	More obvious signs of damage caused by human activity since European settlement, including some obvious impact on the vegetation structure such as that caused by low levels of grazing or slightly aggressive weeds.
Poor	Still retains basic vegetation structure or ability to regenerate it after very obvious impacts of human activities since European settlement, such as grazing, partial clearing, frequent fires or aggressive weeds.
Degraded	Severely impacted by grazing, very frequent fires, clearing or a combination of these activities. Scope for some regeneration but not to a state approaching good condition without intensive management. Usually with a number of weed species present including very aggressive species.
Completely Degraded	Areas that are completely or almost completely without native species in the structure of their vegetation; i.e. areas that are cleared or 'parkland cleared' with their flora comprising weed or crop species with isolated native trees or shrubs

3.4.2 Flora and Vegetation Data Analyses

Structural vegetation classification uses vegetation structure and dominant species to describe differences between vegetation units. Structural vegetation classification provides information on height of strata, foliar cover and dominant species. Structurally based classification has been selected as the most appropriate methodology in this study so as to retain consistency with local and regional vegetation mapping, and in consideration of the climatic conditions limiting the floristic richness of the vegetation assemblages, and the concomitant impact on statistical analysis.

It is anticipated that a wet season survey will employ floristic composition vegetation classification methodology with consideration given to the specific software and data treatments of the regional vegetation mapping.

3.4.3 Priority Flora Targeted Searches

Targeted searches were conducted around the rocky outcrops. All outcrops in the Project Area were searched for *Terminalia supranitifolia* (P3), *Gymnanthera cunninghammii* (P3) and *Rhynchosia bungarensis* (P4) as it was determined on-site that conditions were suitable for the detection of these three species.

3.4.4 Terrestrial Vertebrate Fauna

The terrestrial vertebrate fauna survey was conducted between 19th to 22nd of November, by Dr. S Dawson and Dr. F. Holmes. While a Level 1 survey generally only requires a site visit and description/mapping of fauna habitat, the current survey was expanded slightly to include daily bird surveys, camera trapping, and deployment of acoustic bat detectors.

Fauna habitat was surveyed using nine survey points, distributed throughout the site, and encompassing the range of habitats present. At each survey point, a range of substrate, landform, vegetation, and structural parameters were measured. Any fauna sighted during recording of these points was recorded. Some areas adjacent to the Project Area that represented unique or significant habitat values were also surveyed.

3.4.4.1 Targeted Searches and Bird Surveys

Bird Census

Bird surveys were conducted in in two sessions per day, one in the morning (approx. 5:00 – 9:30 AM), and one in the evening (approx. 3:00 – 6:00 PM), with an average of 10 plots searched in each session. Each plot was 2 hectares (**ha**), and searched/observed for 20 min. The number of individuals of each species sighted in each plot was recorded.

Diurnal Search

Concurrent to the bird surveys, diurnal searches for non-volant fauna were conducted in two sessions per day. These surveys were not restricted to certain search areas; instead they consisted of unplanned searches, stratified to include the entire Project Area and adjacent areas, as well as areas of significant habitat value (i.e. rocky outcrops). During searches, the quality of habitat was assessed, and sign (e.g. tracks, scats, burrows) was recorded.

Nocturnal Search

Each evening, spotlight searches were conducted for approximately 2 hours (6:30 – 8:30 PM). These surveys involved two people searching rocky outcrop areas, targeting Northern Quoll and Pilbara Olive Python.

3.4.4.2 Remote Monitoring

Two remote monitoring approaches were used; motion triggered camera traps and acoustic bat detectors. Reconyx HC500 HyperFire™ Semi-Covert IR were deployed at ten locations across the Project Area (Table 3-5). Acoustic bat detectors were deployed at four locations within the site. Two AnaBat Swift Passive Bat Detectors, and two D500x Ultrasound Detector/Recorders were used.

Table 3-5: Remote Monitoring (Bat Detector and Camera Trap) Survey Effort

Trap Location	Trap type	No. of traps	No. of trap nights	Notes
BC001	Camera Trap	1	4	
	Bat Detector (AnaBat Swift)	1	4	
BC002	Camera Trap	1	4	
BC003	Camera Trap	1	4	
BC004	Camera Trap	1	4	
	Bat Detector (D500x)	1	4	
BC005	Camera Trap	1	4	
BC006	Camera Trap	1	4	
	Bat Detector (AnaBat Swift)	1	4	
BC007	Camera Trap	1	0	Camera Failed
BC008	Camera Trap	1	4	
BC009	Camera Trap	1	4	
	Bat Detector (D500x)	1	4	
BC010	Camera Trap	1	3	
Total	**Camera Trap**		**35**	
	Bat Detector		**16**	

4 FLORA AND VEGETATION RESULTS

4.1 DESKTOP SURVEY

4.1.1 General Site Description

The King Bay to Hearson Cove valley is the only open valley of the Burrup Peninsula, which crosses east-west across the Peninsula. The Project straddles the western end of the valley with a catenary sequence from the elevated rocky hills in the north and to the south, to upper and mid slopes incised by drainage features, through hummock grasslands and plains to the floor of the valley which has a large area of saline mud flats fringed by samphire and sandy swales of tussock grasslands.

4.1.2 Previous Surveys

Beard (1975) described the vegetation of the botanical province as predominantly open grassy plains or mixed grass and spinifex with shrub steppe occurring further inland on the granite plains. Beard (1975) broadly classified the vegetation of the Burrup Peninsula as *Triodia pungens* hummock grassland with very few shrubs.

Thackway and Cresswell (1995) described the vegetation as "Quaternary alluvial plains with a grass savannah of mixed bunch and hummock grasses, and dwarf shrub steppe of *Acacia translucens* (now *A. stellaticeps*) over *Triodia pungens* (now *T. epactia*). Samphire, *Sporobolus* and Mangal occur on marine alluvial flats".

Blackwell and Cala (1979) looked specifically at the vegetation of the Burrup Peninsula and described a group of five basic vegetation units for the area, that were further divided into 28 communities. Blackwell and Cala (1979) recognised the Burrup Peninsula as part of the Abydos Plain which forms the landscape on the mainland, but also identified it as containing a unique mixture of coastal and eremaean species in close association with species more typical of the Northern (Kimberley) Botanical Province.

In anticipation of future development, the DEC commissioned a study of the vegetation of the Burrup Peninsula, Dolphin, Angel and Gidley Islands and Inland Ranges (M.E. Trudgen & Associates, 2002). The study identified 240 vegetation associations (each with a small area of occurrence), a rich flora for its size (383 native vascular plant species from 54 families), and a high number of geographically restricted or uncommon species (M.E. Trudgen & Associates, 2002). A significant geographic based pattern for the distribution of floristic units on the peninsula, in accordance with landscape groups (i.e. rock piles, slopes, drainage lines, etc.), was also identified (Trudgen and Griffin 2001; M.E. Trudgen & Associates, 2002). The vegetation of the Burrup Peninsula was found to be generally in very good or excellent condition, except in areas of coastal sand (M.E. Trudgen & Associates, 2002).

Trudgen & Griffin (2001) assessed the regional significance of vegetation on the Burrup Peninsula using the (Trudgen, 1988) vegetation mapping as a base. It was outside of the terms of reference to map the Samphire flats in detail and scale limitations led rock outcrops and rock pockets to be mapped as a single unit, but with descriptions of 11 rock outcrop and rock pocket vegetation units included in Volume 1. These limitations aside, the mapping and vegetation association descriptions as well as the analysis of significance for flora and vegetation associations detailed in Trudgen & Griffin (2001) and M.E. Trudgen & Associates (2002) are the most comprehensive treatment of the regional flora available. The two volumes form the basis of impact assessments for developments on the Burrup Peninsula subsequent to 2001.

Many private industry developments have commissioned independent studies on the Burrup Peninsula. Studies that overlap or are adjacent to the Project are summarised below. Although the vegetation associations mapped

by Trudgen and those mapped by botanists commissioned by private industry are generally similar, some differences are evident. The reasons for the differences generally include:

- Detailed description of samphire and beach vegetation associations. These were broadly mapped by Trudgen as one unit as they were not a part of the scope for that study;
- Detailed mapping of rockpile vegetation that was previously mapped by Trudgen as one unit/association due to scale restrictions when mapping the entire Core Study Area;
- Differences in rainfall prior to the surveys and subsequent effect on the dominance of shorter-lived perennial shrub species (e.g. *Acacia colei*, *Acacia bivenosa*); and
- More detailed survey/inspection of the site-specific survey area. The Trudgen mapping covered most of the Burrup Peninsula and to achieve mapping on that scale it was required to use aerial photo interpreted mapping to some extent or in some areas.

BFPL Ammonia – Astron Environmental (2001a)

The BFPL Ammonia processing site is immediately adjacent to the Project and a portion of the vegetation mapped by Astron Environmental (2001a) overlaps the current Project Development Envelope. Astron Environmental (2001a) conducted two vegetation surveys to coincide with the wet summer season and the dry season. Seven broad vegetation types and 15 vegetation assemblages were found to occur within the project lease.

The vegetation assemblages considered of conservation significance based on criteria compiled from Astron Environmental (2001a) and Trudgen *et al*. (2001), included:

- Vegetation assemblage 1a – rock pile vegetation;
- Vegetation assemblages 5a, 5b, 5c – drainage lines and broad drainage zones vegetation (especially mixed grevillea heath);
- Vegetation assemblages 6a, 6b and 6c – samphire communities;
- *Dolichandrone heterophylla* stand (rare on the Burrup) (now *Dolichandrone occidentalis*)

A total of 131 vascular species (100 – dry season, 117 – wet season) were recorded within the Project Area. However, as the rainfall for the wet and dry season was low, this may not represent the full total. No Declared Rare Flora occur within the project lease, but one Priority 3 Flora species (*Terminalia supranitifolia,* at the time of survey was classified as P1) was found on the site during the vegetation surveys. A total of 38 *Terminalia supranitifolia* individuals were located on or around the base of scree slopes and small rocky outcrops.

Dampier Nitrogen Pty Ltd Detailed Wet Season Survey (2005) and Addendum (2009) – Astron Environmental (2005)

Dampier Nitrogen Pty Ltd proposed a development of Site C within the King Bay/Hearson Cove Industrial Area. The area surveyed by Astron Environmental (2005) overlaps much of the northern end of the current Project Area as well as the tidal inlet and fringing vegetation in the centre of the current Project site. The Astron Environmental (2005) assessment covers a greater area than the current Project, encompassing a large area of rocky outcrop vegetation and tidal inlet that are outside of the current Project Area. Vegetation associations of

the rock outcrops, samphire and tussock grass areas were described in detail. Twelve broad vegetation groups are divided into 79 associations.

The 2005 field survey recorded 143 flora taxa from 44 families. 23 *Terminalia supranitifolia* (P3) and 2 *Rhynchosia bungarensis* (P4) were identified from the site. Two introduced species were recorded, **Cenchrus ciliaris* (buffel grass) and **Aerva javanica* (kapok bush). Two rockpile communities were considered to be of particular conservation significance. These occur outside of the current Project Area.

The mapping of the samphire vegetation in the Hearson Cove – King Bay Valley by Astron Environmental (2005) is the most comprehensive assessment of the distribution of these vegetation assemblages on the Burrup Peninsula.

Pluto LNG Development Site B North - ENV Australia (2006)

Site B North is situated less than 500 m northwest of the Project.

One hundred and twelve taxa were collected from within the study site. One species of Priority flora, *Terminalia supranitifolia* (P3), was located at four sites within rockpiles and drainage lines. Eight special interest flora taxa were recorded (as per M. E. Trudgen & Associates, 2002). One in particular is considered of greater significance in relation to the Site B North project. *Fimbristylis* aff. *dichotoma* (M75-4), is not uncommon where occurs. However, it is fairly restricted and a newly recognised taxon. Collection records exist at 21 locations on the Burrup Peninsula.

Two introduced species were recorded, **Cenchrus ciliaris* (buffel grass) and **Aerva javanica* (kapok bush).

One vegetation association mapped by M.E. Trudgen & Associates (2002) within Site B North is of conservation significance: *Triodia epactia* (Burrup form), *Cymbopogon ambiguus* hummock/tussock grassland (TeCa). The area of TeCa within Site B North represents less than 1% of the total area mapped for this association, and there is a relatively large number of occurrences on the Peninsula. This association is only represented by 4% in the conservation zone, hence its significance.

Burrup Nitrates – Outback Ecology (2009)

The Burrup Nitrates Project is located adjacent to the BFPL ammonia project and less than 1 km to the east of the Project. Five broad vegetation types were identified during the flora survey. The five broad vegetation types identified on the Site correspond to those vegetation assemblages previously identified and mapped as occurring within the area (as per M. E. Trudgen & Associates, 2002). These vegetation types also broadly correspond with the vegetation associations mapped at the adjacent BFPL site by Astron Environmental (2001a). Nine vegetation assemblages mapped by M.E. Trudgen & Associates (2002) as occurring within the site were not observed to be widespread or dominant during the level 1 survey.

Vegetation condition was described as Good to Very Good (Keighery, 1994). Three introduced species, **Cenchrus ciliaris* (Buffel Grass), **Aerva javanica* (Kapok bush) and **Vachellia farnesiana* were found during the survey. It was noted that the introduced **Cenchrus ciliaris* has increased its cover and dominance in the Coastal Flats vegetation type since the time of the M.E. Trudgen & Associates (2002) report.

No conservation significant flora species were identified within the site. While no Threatened or Priority Ecological Communities are known on the Burrup Peninsula Based, analysis of the M.E. Trudgen & Associates (2002) mapping undertaken by ENV Australia (2006) identified that the community mapped as Sm and described as Saline Inlet and Supra-tidal Flats was considered to represent a significant vegetation association. It was noted

that approximately 56% of this community's extent is represented within the proposed Burrup Peninsula Conservation Reserve.

4.1.3 Conservation Significant Vegetation

No Threatened Ecological Communities (TEC's) listed under the EPBC Act are known to occur on the Burrup Peninsula. No Threatened Ecological Communities (TEC's) listed under the BC Act are known to occur on the Burrup Peninsula (DBCA 2018).

Two Priority Ecological Communities (PEC's) are known from the Burrup Peninsula. These are:

- Burrup Peninsula rock pool communities. Priority 1: Calcareous tufa deposits. Interesting aquatic snails. Threats: recreational impacts, and potential development; possibly NO_x and SO_x emissions, weed invasion including **Passiflora foetida* (stinking passion flower); and
- Burrup Peninsula rock pile communities. Priority 1: Pockets of vegetation in rock piles, rock pockets and outcrops. Comprise a mixture of Pilbara and Kimberley species, communities are different from those of the Hamersley and Chichester Ranges. Short-range endemic land snails. Threats: industrial development dust emissions. Weed invasion including **Cenchrus ciliaris* (Buffel Grass) and **Passiflora foetida* (stinking passion flower)

Locations of Priority Ecological Communities listed in the DBCA databases for the Burrup Peninsula are shown in Figure 4-1. No known Priority Ecological communities are listed in the DBCA database as occurring in the Project Area.

Trudgen & Griffin (2001) assess "rarity" (and therefore significance) of vegetation based on methodologies outlined by Abrahams *et al*. (1995), using the minimum area for protection of an ecosystem as recommended by the International Union for the Conservation of Nature, and English and Blyth (1997). Using the formulas developed in these references, Trudgen calculates vegetation rarity as governed by area. He defines 2000 ha as the lower limit for definition of a "rare" undisturbed vegetation association and 30% remaining as the threshold for "threatened" status. Given this definition, all vegetation on the Burrup is "significant".

A map showing the frequency of vegetation types on the Burrup was produced by the Department of Mineral and Petroleum Resources (2002) utilising the results of M. E. Trudgen & Associates (2002). This map has a frequency scale ranging from 1 only to 100 or more occurrences on the Burrup Peninsula. The map is a useful tool in assessing the regional significance of vegetation on any one area of the Burrup Peninsula. According to M. E. Trudgen & Associates, ten or fewer occurrences of any vegetation association should be treated as significant, and more so if those occurrences are limited to the area zoned for industry.

Using Trudgen's significance assessment criteria, the vegetation communities identified by M. E. Trudgen & Associates (2002) from the Project Area that are considered significant are listed in Table 4-1. There are a number of statistical artefacts in the dataset that elevate map units to significance without merit. These are identified in the comments of Table 4-1. Units coloured yellow indicate there are at least ten occurrences and as such do not qualify as significant under the classification scheme. They have been included in the table here as other developments on the Burrup may have reduced the number below ten occurrences and thus need to be considered as part of the cumulative impact of development on the Peninsula.

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WITHNELL BAY ACCESS RD

ROB VITENBERGS DR (P)

MOF RD

KING BAY RD

STRECKFUSS PL (P)

VILLAGE RD

HEARSON COVE RD

BURRUP PENINSULA RD

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Figure 4-1: Department of Biodiversity Conservation and Attractions Threatened and Priority Ecological Communities in the vicinity of the Project area

Legend

DBCA_TecPec_Results

- Burrup Peninsula rock pile communities - P1
- Burrup Peninsula rock pool communities - P1
- *Biological Survey Area*
- Main Roads WA

N

750 375 0 750 Meters

1 centimeter = 346 meters

Date: 10/12/2018

Coordinate System: GDA 1994 MGA Zone 50

Author: ems@animalplantmineral.com.au

Table 4-1: Vegetation Communities from the Project Area that are Considered Significant using M. E. Trudgen & Associates (2002) Significance Assessment Criteria

Association Code	Association Name	Comments
***CcTs**	**Cenchrus ciliaris*, (*Triodia epactia* (BF)), (*Triodia angusta* (BF))grassland/hummock grassland with *Tephrosia* aff. *supina* (MET 12, 357), *Rhynchosia* cf. *minima* herbland	*Cc is a weed. This is red by simple reason of being unique but is not considered significant vegetation.
ItTa/AbTa	This is mapped as a combination of ItTa and AbTa.	As individually they are both light orange, this is considered to be light orange also
Sm/*Cc/D	This is mapped as a combination of Sm, *Cc and D.	Sm is dark green, *Cc is a weed and D is disturbed so this vegetation is not of conservation significance.
Sm/Sv	This is mapped as a combination of Sm and Sv	Sm and Sv are medium and light green respectively so this is not considered to be of conservation significance, excepting that a discussion of the conservation significance of the tidal inlet vegetation is found below.
Sv	Sporobolus virginicus tussock grassland	Most of this vegetation is mapped as (Te)Sv, which indicates with or without *Triodia epactia*. It is considered here that Sv is synonymous with (Te)Sv (mapped light green) and therefore is not of conservation significance.
TaTsRm	*Triodia angusta* (BF) *Triodia epactia* grassland with *Tephrosia* aff. *supina* (MET 12,375) herbland and *Rhynchosia* cf. *minima* lianes	1 occurrence
AbCgTe	*Acacia bivenosa*, *Cassia glutinosa* open shrubland to shrubland over *Triodia epactia* (BF), **Cenchrus ciliaris* grassland	Trudgen: Dark Orange 2 to 4 Occurrences
ChAbSg	*Corymbia hamersleyana* low open woodland over *Acacia bivenosa* high open shrubland over *Dichrostachys spicata* scattered shrubs over *Stemodia grossa* low shrubland to low open heath over *Triodia epactia* (Burrup form) hummock grassland	Trudgen: Dark Orange 2 to 4 Occurrences
Ev*CcTe	*Eucalyptus victrix* low open woodland to low woodland over (*Pittosporum phylliraeoides* var. *phylliraeoides*, *Rhagodia eremaea* high shrubs to shrubs) over **Cenchrus ciliaris*, *Triodia epactia* (BF) tussock/hummock grassland	Trudgen: Dark Orange 2 to 4 Occurrences
AbImTe	*Acacia bivenosa* high open shrubland to high shrubland over *Indigofera monophylla* (BF) scattered low shrubs to low open shrubland over *Triodia epactia* (BF) hummock grassland to closed hummock grassland	Trudgen: Light Orange 4 to 9 Occurrences

AbTa	*Acacia bivenosa* high open shrubs over *Triodia angusta* (BF) hummock grassland	Trudgen: Light Orange 4 to 9 Occurrences
AbWaTe	*Acacia bivenosa* high shrubland over *Whiteochloa airoides*, *Triodia epactia* (BF) tussock/hummock grassland with patches of **Cenchrus ciliaris* grassland	Trudgen: Light Orange 4 to 9 Occurrences
EvAa	*Eucalyptus victrix* low woodland over A*cacia ampliceps* open heath over *Cyperus vaginatus, Eriachne tenuiculmis, Triodia angusta* (Burrup form) sedgeland and tussock/hummock grassland	Trudgen: Light Orange 4 to 9 Occurrences
ItTa	*Indigofera trita* low shrubland over *Triodia angusta* (BF), (*Triodia epactia* (BF)) hummock grassland	Trudgen: Light Orange 4 to 9 Occurrences
ChImTe	*Corymbia hamersleyana* scattered low trees to low open woodland over (*Acacia bivenosa, Acacia coriaceae* subsp. *coriaceae*) scattered tall shrubs over *(Dichrostachys spicata)* scattered shrubs over *Indigofera monophylla* (BF) low open shrubs to low shrubland over *Triodia epactia* (BF) hummock grassland	Trudgen: Yellow 10 to 24 occurrences
EvDsTa	*Eucalyptus victrix* scattered low trees to low open woodland over *Dichrostachys spicata, (Acacia coriaceae subsp. coriaceae)* tall scattered shrubs to low open shrubland over *Triodia angusta* (BF) hummock grassland	Trudgen: Yellow 10 to 24 occurrences
GpCwTe	*Grevillea pyramidalis* subsp. *pyramidalis* open heath over *Corchorus walcottii* scattered low shrubs to low open heath over *Triodia epactia* (BF) hummock grassland	Trudgen: Yellow 10 to 24 occurrences
TcEtSe	*Terminalia canescens* low woodland over *Eriachne tenuiculmis*, *Triodia epactia* (BF) grassland/hummock grassland with *Sesbania cannabina* herbland	Trudgen: Yellow 10 to 24 occurrences

Red = 1 occurrence; **Dark Orange** = 2 to 4 Occurrences; **Light Orange** = 5 to 9 Occurrences; **Yellow** = 10 to 24 Occurrences.

Additionally, Astron Environmental (2005) considered two of the seven rockpile vegetation types to be very rarely occurring. These are:

- 2e DhTs Low woodland of *Dolichandrone occidentalis* (formerly *heterophylla*), *Terminalia supranitifolia* with *Brachychiton acuminatus* over very open grassland of *Triodia epactia* (Burrup form) and *Cymbopogon ambiguous*; and

- 2f ErvDhBa Low woodland of *Erythrina vespertilio* with *Dolichandrone occidentalis* and *Brachychiton acuminatus* over very open grasses of *Cymbopogon ambiguus* with *Triodia epactia* (Burrup form) over annual herbs.

Because the Project Area contains the only known occurrence of *Dolichandrone occidentalis* on the Burrup, its occurrence on the rock piles here is considered to have very high conservation value. Additionally, although *Erythrina vespertilio* does occur elsewhere on the Burrup, it is not abundant or widespread. Its occurrence with *Dolichandrone heterophylla* gives this community high conservation value. These mapped areas do not occur in the Project Area but are close to the border in the central section between the two north stretching arms.

ENV Australia (2006) mapped the *Triodia epactia* (Burrup form), *Cymbopogon ambiguus* hummock/tussock grassland (TeCa). This association is only represented by 4% in the conservation zone, hence its significance. There are more than 100 occurrences of this vegetation association on the Peninsula.

M. E. Trudgen & Associates (2002) identifies the tidal inlet between Hearson Cove and King Bay as being of conservation significance. The basic vegetation units mapped by M. E. Trudgen & Associates (2002) in the tidal inlet were designated Sm and (Te)Sv. In the assessment of occurrence Sm is represented by 50 to 99 occurrences and (Te)Sv is represented by 25 to 49 occurrences, both above the 10-occurrence threshold. Outback Ecology (2009) note also that there is approximately 56% of the Sm extent represented within the Burrup Peninsula Conservation Reserve (now the Murujuga National Park), above the 30 % threshold proposed by M. E. Trudgen & Associates (2002).

4.1.3.1 Conservation Significant Flora

No plants declared rare or threatened under the EPBC Act are known from the Burrup Peninsula, or within 100 km of the Project Area. No plants declared rare under the WC Act are known from the Burrup Peninsula.

DBCA Database Searches did not identify any known Priority flora locations within the Project Area. Priority Flora located on the Roeburn Bioregion coastal zone and Islands is shown in Figure 4-2. Table 4-2 identifies known habitat associations, distribution and flowering times of these taxa and makes an assessment of the likelihood of occurrence for each taxon given the habitats present in the Project Area. For the taxa assessed as likely to occur in the Project Area, an assessment is made about the likelihood of detection given the climatic conditions during survey. Table 4-2 identifies five taxa of conservation significance that may occur in the Project.

Additionally, M. E. Trudgen & Associates (2002) identified a number of species of conservation significance (Table 4-3). These are species identified as having high conservation value for being at the extent of their range or those for which there is a lack of scientific knowledge, or because their distribution is limited. Nine of these species are perennials, 16 are annuals, six are annual/ephemerals and five are ephemerals (one species was unknown). Some of the flora taxa of special interest listed by Trudgen has been accepted as a natural variation of a known and described taxa. *Rhynchosia* sp. Burrup (82-1C) is now known as *Rhynchosia bungarensis* (P4).

From the review of previous surveys it was noted that the Astron Environmental (2005) survey identified 23 *Terminalia supranitifolia* (P3). Most of these occur outside of the current Project Area. *Rhynchosia bungarensis* (P4) was also located in 2 areas.

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Figure 4-2: Conservation Significant Flora Identified by Department of Biodiversity Conservation and Attractions Database Search as Occurring in the Vicinity of the Project Area

Legend

Conservation Significant Flora

- Abutilon sp. Pritzelianum (S. van Leeuwen 5095), P1
- Goodenia pallida, P1
- Helichrysum oligochaetum, P1
- Tephrosia rosea var. Port Hedland (A.S. George 1114), P1
- Cucumis sp. Barrow Island (D.W. Goodall 1264), P2
- Pentalepis trichodesmoides subsp. hispida, P2
- Atriplex lindleyi subsp. conduplicata, P3
- Carpobrotus sp. Thevenard Island (M. White 050), P3
- Corchorus congener, P3
- Eleocharis papillosa, P3
- Eragrostis lanicaulis, P3
- Eragrostis surreyana, P3
- Eremophila forrestii subsp. viridis, P3
- Gomphrena cucullata, P3
- Gomphrena leptophylla, P3
- Gymnanthera cunninghamii, P3
- Oldenlandia sp. Hamersley Station (A.A. Mitchell PRP 1479), P3
- Owenia acidula, P3
- Schoenus punctatus, P3
- Stackhousia clementii, P3
- Terminalia supranitifolia, P3
- Themeda sp. Hamersley Station (M.E. Trudgen 11431), P3
- Triumfetta echinata, P3
- Vigna triodiophila, P3
- Goodenia nuda, P4
- Rhynchosia bungarensis, P4

N

4.52.25 0 4.5 Kilometers

1 centimeter = 2,500 meters

Date: 11/12/2018

Coordinate System: GDA 1994 MGA Zone 50

Author: ems@animalplantmineral.com.au

Document Path: \\MAINSERVER\Documents\APM GIS and Mapping\03_Client\APM2018-19GIS\CAR\02_GIS Maps\20181210_CAR001_Fig4-3 DBCA Consig flora.mxd

Table 4-2: Conservation Significant Flora identified from the Database Searches

Species	Current WA Conservation Status	Description & Habitat	Likelihood of Occurrence in Project Area and likelihood of Detection if Present
Abutilon sp. Pritzelianum (S. van Leeuwen 5095)	P1	Shrub to 1.5 m Red stony loam with *Acacia inaequilatera*, *Sida* sp., *A. coriacia, Hibiscus leptocladus*.	**Possible**. Known from 1 location 40 km to the east on the mainland. Possibly located during survey but may require more recent rainfall.
Goodenia pallida	P1	Balmoral Homestead. Corolla very pale purple. Plain, dry red sand. Annual grassland, Acacia steppe.	Unlikely. No suitable Habitat.
Helichrysum oligochaetum	P1	Erect annual, herb, to ca 0.25 m high. Fl. yellow, Aug to Nov. Red clay. Alluvial plains.	Unlikely. No suitable habitat
Tephrosia rosea var. Port Hedland (A.S. George 1114)	P1	Erect, spreading shrub 1 m Straggly open tomentose perennial. All parts densely grey/white felt, except inner petals. Deep burgundy flowers. Lower leaves becoming large. Raceme terminal 22-38 cm long. Legume 2.5-3 cm, tomentose. coastal dune sands, Open shrubland of *Acacia coriacea* subsp. *coriacea* and *Acacia sabulosa* over scattered shrubs of *Tephrosia rosea* var. Port Hedland over *Triodia epactia*, **Cenchrus ciliaris* and **Aerva javanica*. Also Small rocky hillcrest adjacent to lower-lying saline drainage areas at or just above sea level. with *Triodia wiseana, T. epactia* hummock grassland.	**Possible** but most locations on rocky terrain closer to the coast. Possibly located during survey but may require more recent rainfall.
Pentalepis trichodesmoides subsp. hispida	P2	0.5 m tall x 1.5 m wide with long stems extending from the base, or just above. Phyllodes, green-yellow lanceolate, tomentose, 8 x 0.9 cm, 3 prominent veins. Flowers yellow with 5 petals. Bracts present. Banks of creeks and edges of basalt screes	Unlikely. No suitable habitat.
Atriplex lindleyi subsp. conduplicata	P3	Open straggly rotund shrub, growing up to 0.2 m tall. Sparse tussock grassland of *Eragrostis xerophila*. Crabhole plains.	Unlikely. No suitable habitat.
Cucumis sp. Barrow Island (D.W. Goodall 1264)	P3	Barrow Island Nature Reserve Herbaceous climber, 0.4 m high, 0.4 m wide. Very sticky creeper. Stems and leaves hirsute. Leaves mid-green, trifoliate, simple from nodes at regular intervals. One leaf and flower at each node. Perianth 0.5 cm long, 5 bright yellow petals. Flower approximately 0.5 cm diameter. Gentle calcrete slope. Red, sandy loam. *Triodia angusta* with scattered *Grevillea pyramidalis*. Species in vicinity (burn area*): Acacia bivenosa, Acanthocarpus verticillatus, Adriana tomentosa, Corchorus congener, Diplopeltis eriocarpa*	Unlikely. Restricted to Barrow Island 140 km to the west. Flowering known from June and October.
Carpobrotus sp. Thevenard Island (M. White 050)	P3	Thevenard Island. Prostrate succulent, glabrous plant. Leaves sessile, triangular in cross section to 10 cm in length. Sides 17mm wide. Flowers cream, solitary, 3-5 cm in diameter on thick peduncles 4-5, 2 large, leaflike, others small. Fruit turbinate. Coarse white sand on top of dune. Disturbed area.	Unlikely. No suitable Habitat. Restricted to Thevenard Island 200 km to the south-west.
Corchorus congener	P3	Barrow Island. Spreading plant to 75 cm diameter. Old stems grey-brown. New stems pale green and plumose. Leaves pale green, dentate, oval, 1-3 cm long x 1-1.5 cm	Unlikely. Restricted to Barrow Island 140 km to the west. Flowering known from June and October.

Species	Current WA Conservation Status	Description & Habitat	Likelihood of Occurrence in Project Area and likelihood of Detection if Present
		wide, plumose. Flowers in umbels along stems. 4 bright yellow petals, numerous bright yellow stamens.	
Eleocharis papillosa	P3	Broad drainage area through sandy coastal plain Red clay over granite, open clay flats. Claypans. Mosaic of *Tecticornia* low shrubland with mixed tussock grassland of *Sporobolus mitchellii, Eriachne benthamii, Eulalia aurea*.	Unlikely. No suitable habitat.
Eragrostis lanicaulis	P3	Knotty or bulbous rhizomatous, perennial, grass-like or herb, 0.45-0.5 m high. Fl. Mar to May or Aug to Oct. Red sandy clay. Flats.	Unlikely. No suitable habitat.
Eragrostis surreyana	P3	Tufted annual grass 1-2 cm high. Seepage/wetland areas on boulder/rocky areas. Stoney soil of red-brown sandy-clay. *Cyperus vaginatus, Schoenus falcatus, Fimbristylis rara, Schoenoplectus littoralis, Eragrostis* sp. Mt Montague, sedgeland - tussock grassland with *Stemodia grossa, Pluchea rubelliflora, Stylidium fluminense, Peplidium* sp. E herbland.	Unlikely. No suitable habitat
Eremophila forrestii subsp. viridis	P3	Shrub, 0.8 - 1.5 m tall, Flowers pink-cream. Red sands - red/brown sandy loams of flat interdunal swales (not within dunes). Generally occurs on the flats where a hardpan develops in between inland dunes. *Acacia tetragonophylla, A. stellaticeps, Triodia epactia.*	Unlikely. No suitable habitat
Gomphrena cucullata	P3	Prostrate, compact herb 20 cm high x 55 cm wide. Wiry red stems, young stems slightly hairy. Revolute, linear leaves, acute 10-47 mm long x 1 mm wide. Flowers white-pink, orange stamens, corolla 4 mm long. Flower head cylindrical, 20 mm long x 7 mm wide. Floodplain, red loam, Grassland	Unlikely. No suitable habitat
Gomphrena leptophylla	P3	Prostrate, compact herb 20 cm high x 60 cm wide. Stem leaves acute, mucronate, revolute linear leaves 10-30 mm long x 1-2 mm wide. Flowers green, yellow stamens. Axillary corolla 5 mm long. Cylindrical flower head 20 mm long x 7 mm wide. Bracts incurved. Flowers white, Mar to Sep. Sand, sandy to clayey loam, granite, quartzite. Open flats, sandy creek beds, edges salt pans & marshes, stony hillsides.	**Possible**. Diverse range of habitat associations. Known flowering period is outside of survey.
Gymnanthera cunninghamii	P3	Enderby Island, Erect, multistemmed shrub to 2 m tall, Stem very pliable, bronze colour, glabrous. Leaves opposite, margins undulating, glossy, lime green above, dull beneath. Petioles 2-2.5 cm long. Milky sap. Growing in beach sand at base of dolerite hills.	Unlikely. No suitable Habitat. Records of flowering in all months.
Oldenlandia sp. Hamersley Station (A.A. Mitchell PRP 1479)	P3	Alluvial silt and clay in floodplain. Brown clay loam, Tussock Grassland of *Eriachne* sp. over Very Open Herbs.	Unlikely. No suitable habitat
Owenia acidula	P3	Mardie Station. Small tree to 3m, often dense stands as suckers. Leaves pseudopinnate. Known from sand dune, Shrub steppe,	**Possible**. Easily detected from vegetative growth all year.

Species	Current WA Conservation Status	Description & Habitat	Likelihood of Occurrence in Project Area and likelihood of Detection if Present
Rhynchosia bungarensis	P4	Burrup Peninsula. Creeper Viscid, spreading 1 m high. Steeply sloping rock pile (boulder scree) on valley side, E facing. Orange brown loam between cobbles (vegetated patch). Medium grained volcanic. Fire >10 years. *Terminalia canescens* high open shrubland (low open woodland) over *Acacia coriacea* subsp. *coriacea, Flueggia virosa* subsp. *melanthesoides* high open shrubland over *Scaevola spinescens* (narrow form), *Rhagodia eremaea* scattered shrubs over *Triodia epactia*	**Occurs in Project Area**. Locally common on the Burrup Peninsula. Suitable habitat exists on the rocky outcrops and slopes. Closest DBCA record less than 300 m from the Project Area. Fertile specimen positively detected in Project Area by APM.
Schoenus punctatus	P3	Tufting plant to 80 cm high. Mid green leaves and culms. Leaf base dark red. Heads fine panicles above leaves. Spikelets brown to dark brown. Growing near *Stylidium fluminense, Cyperus* sp. and other water dependent spp. in creekline mud.	Unlikely. No suitable habitat
Stackhousia clementii	P3	King Bay - Hearson Cove tidal inlet, Burrup Peninsula. Lime-green, more or less leafless plant (or scale like leaves) to 45 cm with numerous erect slender branches. Flowers in clusters, forming a cylindrical spike. Woody base. Soft, silty saline soil over limestone - with much limestone and coral rubble, on small 'island' within tidal inlet (very rarely inundated). But also with Tall shrubland of Acacia bivenosa over open hummock grassland of Triodia epactia with open tussock grassland of *Cenchrus ciliaris, on sandy clay loam flats.	**Likely.** Located in the supratidal zone common to the Project Area. Records located 600 m to the east of the Project Area. Perennial vegetative growth likely detectable in November. Records of flowering in all months.
Terminalia supranitifolia	P3	Rocky outcrops. Stunted canopy tree, very gnarled twisted trunk, intricate branches, grey in colour. Leaves glossy, silvery silky tomentum. Flowers lemon, fruits not winged. Leaves lemon-green colour.	**Occurs in Project Area**. Locally common in the central area of the Burrup Peninsula. Suitable habitat exists on the rocky outcrops. Closest DBCA record less than 300 m from the Project Area. Fertile specimen positively detected in Project Area by APM.
Themeda sp. Hamersley Station (M.E. Trudgen 11431)	P3	1.8m tall upright grass bases not buried in ground. Flowers Aug. Red clay. Clay pan, grass plain.	Unlikely. No suitable habitat
Triumfetta echinata	P3	Prostrate perennial shrub, spreading to ca 1 m diameter. sand dune with Soft spinifex.	Unlikely. No suitable habitat
Vigna triodiophila	P3	Burrup Peninsula. Herb. Slender vine entwined in Triodia epactia and rocks. Vine with thickened root - probably perennial but dying back to rootstock in dry. Flowers yellow. Rockpiles.	**Likely.** Locally common in the central area of the Burrup Peninsula. Suitable habitat exists on the rocky outcrops. Closest DBCA record is 700 m from the Project Area. Fertile material recorded in June.
Goodenia nuda	P4	Mardie Station Erect herb 0.3 m high x 0.2 m wide. Flowers yellow. Plain. Dry, red sand. Mesquite scrub.	Unlikely. No suitable Habitat.

Table 4-3: Flora Taxa of Special Interest as described by M. E. Trudgen & Associates (2002)

Characteristic of Interest	Flora Taxa
Uncommon or rare, very restricted, newly recognised taxa	*Stackhousia* sp. (BMor 153), *Euphorbia* sp. (B34-11), *Amaranthus* aff. *pallidiflorus* (D89), *Sida* aff. *cardiophylla* (B22-37), *Tephrosia* aff. *clementii* (5) B184, *Sida* aff. *fibulifera* (B181-5B), *Tephrosia* aff. *densa* (B16-22), *Sida* aff. *fibulifera* (B235-7), *Vigna* sp. Burrup (B18), *Sida* aff. *fibulifera* (D109).
Not common, very restricted, newly recognised taxa	*Cheilanthes* aff. *tenuifolia* (B18), *Euphorbia* sp. (G133), *Amaranthus* sp. (D111), *Triumfetta* cf. *propinqua* (B13-13), *Euphorbia* sp. (BPBS2), *Ehretia* ?(B23-22), *Euphorbia* sp. (D105-1)
Apparently rare, fairly geographically restricted, habitat restricted taxa	*Eragrostis* sp. Mt Montagu (M.E.Trudgen 15,246), *Rhynchosia* sp. King Bay (B181-13)
Apparently quite uncommon, but widespread taxa	*Cyperus blakeanus, Euphorbia* aff. *australis* type 1 (erect stems)
Locally common, moderately restricted, newly recognised taxa	*Paspalidium tabulatum* (Burrup form), *Themeda* sp. Burrup (B84)
Very uncommon, quite restricted, newly recognised taxa	*Tephrosia* aff. *clementii* (4) (M35-14), *Euphorbia* sp. (B170-4), *Abutilon* sp. Fortescue (M. Maier 28A-4), *Sida* aff. *fibulifera* (B64-13B)
Not uncommon where occurs, fairly restricted, newly recognised taxa	*Fimbristylis* aff. *dichotoma* (M75-4), *Tephrosia* aff. *densa* (B17)
Locally very common to abundant, moderately restricted, newly recognised taxa	*Triodia angusta* (Burrup form), *Corchorus walcottii, Triodia epactia* (Burrup form) *Triumfetta appendiculate* (Burrup form), *Triodia wiseana* (Burrup form), *Euphorbia tannensis* subsp. *eremophila* (Burrup form), *Rhynchosia* sp. Burrup (82-1C)
Species at or near their southern end of range and not common locally	*Abutilon indicum* var. *australiense*

4.1.4 Introduced Flora

No Declared weeds under the Western Australian Biosecurities Management Act have been previously recorded in the Project Area. Under the *Environmental Weed Strategy for Western Australia* (Department of Conservation and Land Management, 1999) weeds are rated according to three criteria:

- Invasiveness: ability to invade bushland in good to excellent condition or ability to invade waterways;
- Distribution: wide current or potential distribution including consideration of known history of wide spread distribution elsewhere in the world; and
- Environmental Impacts - ability to change the structure, composition and function of ecosystems. In particular an ability to form a monoculture in a vegetation community.

The rating of each weed is then given according to the following scoring system:

- High: a weed species would have to score yes for all three criteria. Rating a weed species as high would indicate prioritising this weed for control and/or research ie prioritising funding to it;
- Moderate: a weed species would have to score yes for two of the above criteria. Rating a weed species as moderate would indicate that control or research effort should be directed to it if funds are available, however it should be monitored (possibly a reasonably high level of monitoring);
- Mild: a weed species scoring one of the criteria. A mild rating would indicate monitoring of the weed and control where appropriate; and
- Low: a weed species would score none of the criteria. A low ranking would mean that this species would require a low level of monitoring.

Astron Environmental (2005) compiled the following list of weeds known from the Burrup Peninsula and its rating:

- *Aerva javanica - Kapok — High
- *Cenchrus ciliaris - Buffel Grass — High
- *Cenchrus setigerus - Birdwood Grass — High
- *Cenchrus enchinatus - Mossman River Grass — Low
- *Rumex vesciarius - Ruby Dock — High
- *Stylosanthes hamata - Caribbean stylo — Mild
- *Bidens bipinnata - Bipinnate Beggar-Ticks — TBA
- *Euphorbia hirsuta - Strawberry Weed — Moderate
- *Passiflora foetida - Wild Passionfruit — High
- *Solanum nigrum - Nightshade — Moderate
- *Chloris barbata - Purple-top chloris — Low
- *Pennisetum setaceum - Fountain grass — Mild

- **Malvastrum americanum* – Spiked Malvastrum Moderate

Trudgen *et al*. (2001) noted weed invasion of species not well established on the Peninsula which is occurring through the movement of seed on vehicles and establishing on roadsides. Some of these are native species that are very uncommon on the Burrup Peninsula but are appearing on roadsides and may become invasive. Three species of Acacia – *A. stellaticeps*, *A. trachycarpa* and *A. ancistrocarpa* are of noted as of concern for these reasons.

4.2 FIELD SURVEY

4.2.1 Summary of the quadrat data

Forty detailed surveys were conducted within the Project Area. The field survey recorded 86 taxa, including species, subspecies and variants, from 31 Families. Three hundred and ninety taxa have been recorded for the Burrup Peninsula (Astron Environmental, 2005). Astron Environmental (2005) recorded 143 taxa from 44 families for Site C and the 'Site C and F amalgamation' zone that overlaps the current Project Area. As the Astron Environmental (2005) survey area was much larger and contained more vegetation associations than the current Project Area, it is not expected that the same level of floristic richness will be obtained from the Project Area. A wet season survey will still be required, however, to obtain the full species complement from the Project Area.

4.2.2 Vegetation Associations

Vegetation has been mapped to the level of Association across the Project Area by M. E. Trudgen & Associates (2002), and across much of the northern and all of the central sections of the Project Area by Astron Environmental (2005). As M. E. Trudgen & Associates (2002) mapped the region at the association scale, APM have prioritised retention of descriptions published in the 2002 report where they are still relevant. This is to facilitate impact assessment as many completed projects on the Burrup use the 2002 report associations which allows for calculation of cumulative impact. Astron Environmental (2005) provides a more detailed description and mapping of rocky outcrop and tidal inlet vegetation associations and has mapped the area of tidal inlet extensively beyond the current project. APM have prioritised retention of the 2005 report descriptions where relevant, to allow for calculations of local cumulative impact.

In a few situations neither the M. E. Trudgen & Associates (2002) or Astron Environmental (2005) mapping adequately described the vegetation present. Astron Environmental (2005) also notes discrepancies between the vegetation present in 2005 and that recorded by M. E. Trudgen & Associates (2002). It is considered that the vegetation of the Burrup Peninsula is highly dynamic as a consequence of the stochastic nature of the magnitude and frequency of rainfall events. The dominance of short-lived perennial species in the vegetation composition means there can be significant fluctuations in the structure and floristic composition of specific locations over time.

35 vegetation associations were mapped by APM at the Project Area. These associations are shown in Figure 4-3. A species by site matrix is presented in Appendix H.