Desktop Fauna Assessment of the Cyclone Deposit Project (Diatreme Resources Limited)

Butler's Legless-lizard *Delma butleri* raked up from trackside spoilheaps within the Cyclone Tenement. Individual had recently commenced shedding its skin. (Photo: Brenden Metcalf)

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EXECUTIVE SUMMARY

Diatreme Resources Limited proposes to develop the Cyclone Mineral Sands deposit in Western Australia within the northern area of the Eucla Basin and flanking the South Australian border. As part of environmental impact assessment, Bamford Consulting Ecologists was engaged to conduct a preliminary desktop fauna assessment to identify the fauna values of the Cyclone deposit project area. The key objectives of the fauna assessment were to:

- conduct a desktop review to identify the vertebrate fauna assemblage that may occur within or adjacent to the project area;
- investigate the likelihood of conservation significant species being present;
- identify and describe general vegetation and soil associations ("habitats") present;
- identify potential impacts of the project upon fauna values, and
- propose management measures to mitigate these impacts.

The desktop assessment identified 195 fauna species that may occur in the project area, including 2 frog, 64 reptile, 100 bird and 29 mammal species. A total of 20 conservation significant fauna species was identified and include four mammals, two reptiles and 14 bird species. From the conservation significant taxa identified the species of most concern include the: Giant Desert Skink, Woma, Sandhill Dunnart, Southern Marsupial Mole, Crest-tailed Mulgara and Nullarbor Quail-thrush. Many of the conservation significant species that may occur in the area are likely to be sparse and widespread across the region and not restricted to habitats within the Cyclone deposit project area. A site visit in September 2011 confirmed the presence of some species and allowed vegetation and soil associations to be described, but not all of the project area could be visited. More detailed field investigations are recommended and should be discussed with government agencies.

Potential impacts from the proposed project were assessed under ecological processes such as: habitat loss leading to population decline, habitat loss leading to population fragmentation, increased mortality, hydrological changes, impacts of weed invasion, species interactions, dust, noise light and disturbance and changes in fire regimes. These processes are briefly discussed in the report and management recommendations are given.

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1 INTRODUCTION

1.1 Background

Diatreme Resources Limited (Diatreme) proposes to develop the Cyclone Mineral Sands deposit in Western Australia within the northern area of the Eucla Basin and flanking the South Australian border. As part of environmental impact assessment (EIA), Bamford Consulting Ecologists was engaged to conduct a preliminary desktop fauna assessment to identify the fauna values of the Cyclone deposit project area, in accordance with Environment Protection Authority (EPA, Western Australia) Guidance Statement No. 56 (EPA 2004). In this report, the project area refers to the proposed mine and all associated infrastructure such as roads, accommodation area and processing facilities.

This report presents the results of the preliminary desktop fauna assessment conducted in July 2011. It is intended to provide government agencies with the information needed to assess the significance of impacts under State and Commonwealth legislation. The impact assessment process effectively has three components:

1. Values - The identification of fauna values of the site. These include the range of fauna habitats present, the composition of the fauna assemblage including the presence of significant species, and the distribution of that fauna assemblage across the landscape;
2. Impacts - The identification of ecological processes that maintain the fauna assemblage and how these processes may interact with the proposed development, and therefore what impact the proposed development may have on the fauna; and
3. Management - The identification of management recommendations to minimise effects on these ecological processes.

The report was prepared by Cameron Everard and Brenden Metcalf, and reviewed by Dr Mike Bamford.

1.2 Study Objectives

The key objectives of the fauna studies are listed below:

- conduct a desktop review to identify the vertebrate fauna assemblage that may occur within or adjacent to the project area;
- investigate the likelihood of conservation significant species being present;
- identify and describe general vegetation and soil associations ("habitats") present;
- identify potential impacts of the project upon fauna values, and
- propose management measures to mitigate these impacts.

The EPA describes the desktop review as: "Background research or 'desktop' study with the purpose to gather background information on the target area (usually at the locality scale). This involves a search of all sources for literature, data and map-based information (EPA 2004)". The assessment is not intended to produce a definitive list of species confirmed to be present, but intended to provide information to allow the assessment of impacts of the proposed development upon biodiversity. Faunal assemblages are dynamic in space and time, and therefore understanding factors such as significant species, habitat diversity and ecological processes that drive biodiversity of an area, and how a proposed project may interact with these factors, is considered more relevant to impact assessment than producing a detailed species list at a particular time and for a select number of locations within that project area.

1.3 Location

The Cyclone deposit project area is located approximately 730 kilometres (km) east north-east of Kalgoorlie, Western Australia, 240km north of the Forrest railway station (Trans-Australian Railway) and 25km west of the WA/SA border (Figure 1). The project area is situated approximately 20km north of the north-eastern boundary of the Great Victoria Desert Nature Reserve (Figure 2) and occurs within E 69/1920 (approximately 1,558ha in area), which is one of six exploration licences held by Diatreme within the Eucla Basin (Figure 3). In addition to the Cyclone tenement, the project area also includes associated infrastructure including the camp, airstrip, several water pipeline options (heading south-west, south and east from the deposit) and several haul road options (heading either south-west or south-east from the deposit).

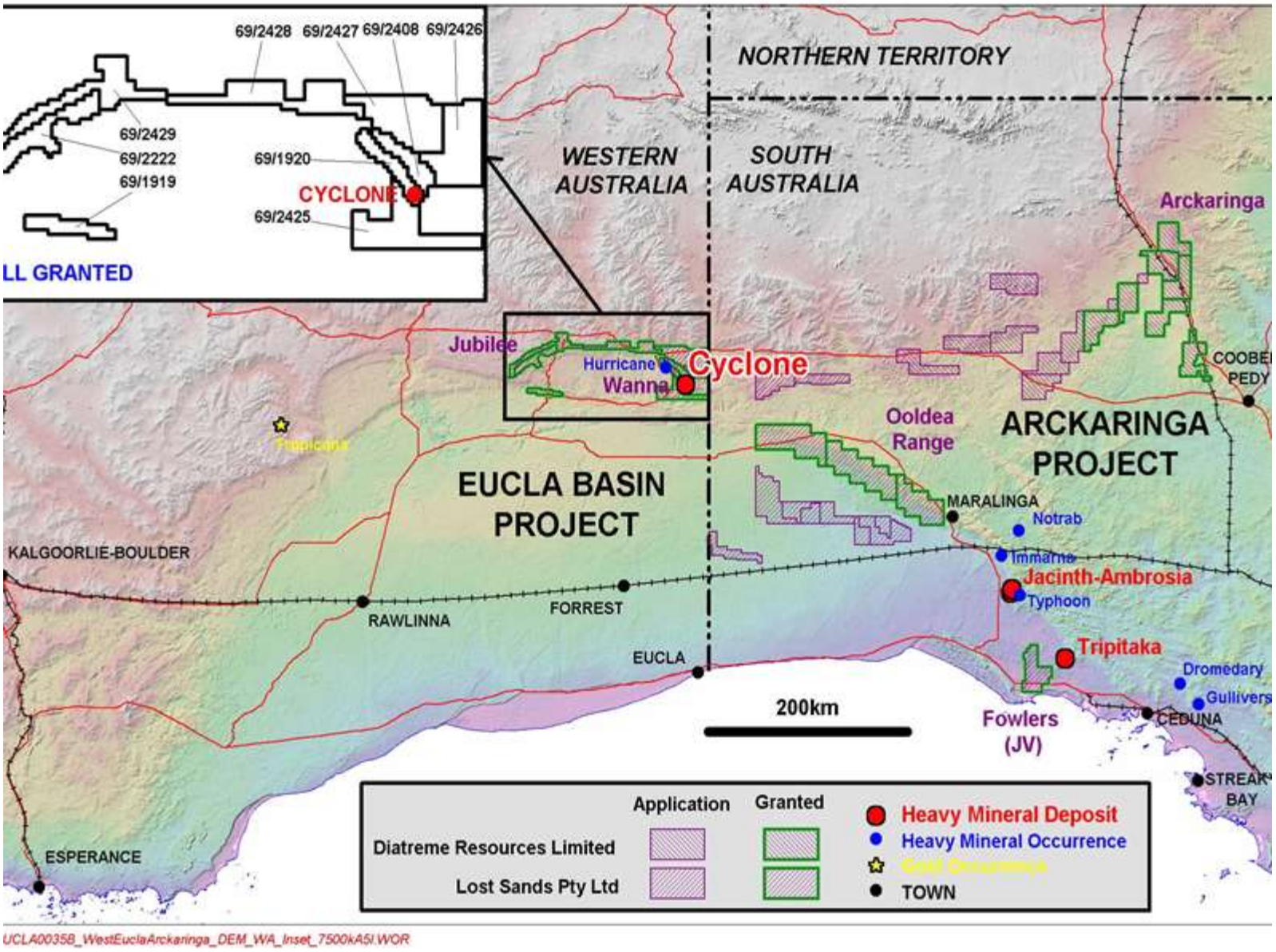

Figure 1. Regional location of the Cyclone deposit project area.

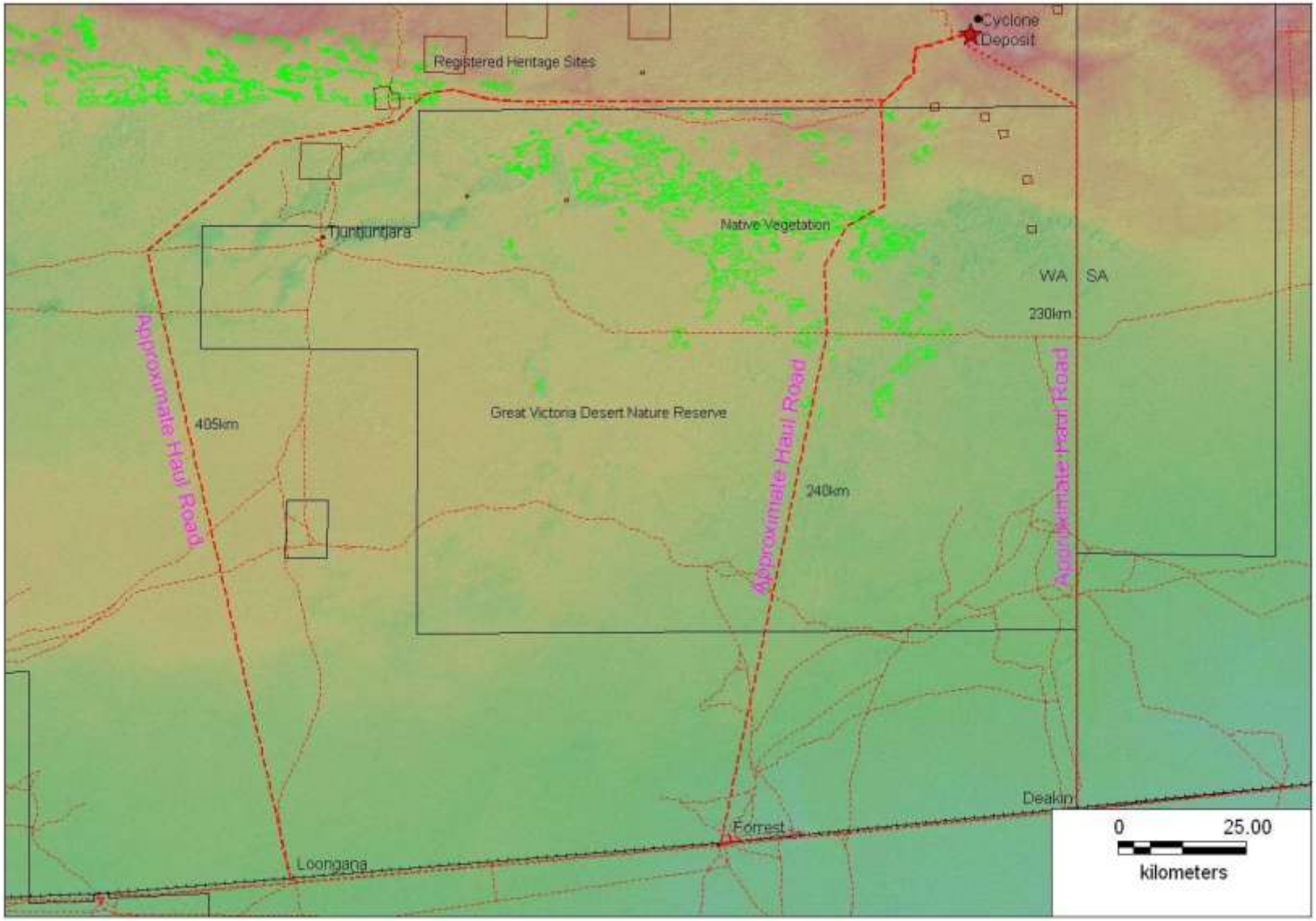

Figure 2. Location of the Cyclone deposit project area.

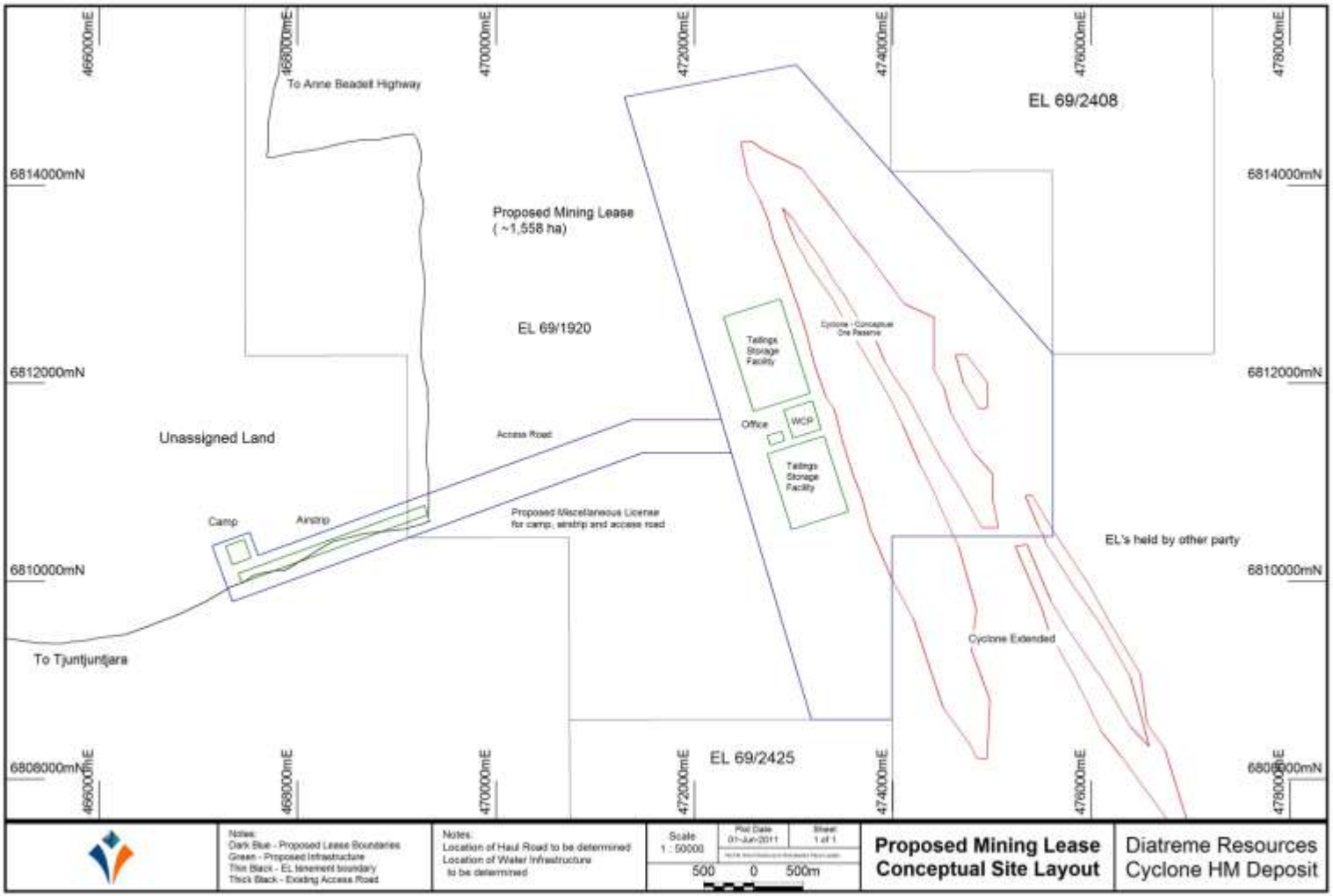

Figure 3. Conceptual site layout of the Cyclone deposit project area.

1.4 Regional Description

The Cyclone deposit project area lies within the Eastern Maralinga (GVD3) subregion of the Great Victoria Desert Bioregion, with the proposed haul road options traversing the Central (GVD2) subregion of the Great Victoria Desert Bioregion, and the Carlisle (Northern Band, NUL1) and Nullabour Plain (Central Band, NUL2) subregions of the Nullabour Bioregion, as classified by the Interim Biogeographical Regionalisation for Australia (IBRA) classification system (EA 2000, McKenzie *et al*. 2003). The Great Victoria Desert Bioregion falls within the Bioregion Group 4 classification of the EPA (2004) i.e. those Bioregions that have "native vegetation which is largely contiguous but is generally not used for commercial grazing", whilst the Nullabour Bioregion falls within the Bioregion Group 2 classification i.e. those Bioregions that have "native vegetation which is largely contiguous but used for commercial grazing"; both Bioregions are located in the Eremean botanical province.

The general features of the Eastern Maralinga (GVD3), Central (GVD2), Northern Band – Carlisle (NUL1) and Central Band – Nullabour Plain (NUL2) subregions are summarised by McKenzie *et al*. (2003).

The Eastern Maralinga (Great Victoria Desert 3) subregion crosses the Western Australia border to South Australia; Barton and Cown (2001b) describe the area as being:
"underlain by Devonian sediments of the Gunbarrel Basin, with extensive sandplains of deep Quaternary aeolian sands. Landforms consist of salt lakes and major valley floors with lake derived dunes. Sand plains with extensive seif dunes running east west, occasional outcropping (breakaways) and quartzite hills provide minor relief. Vegetation is primarily a Tree steppe of *Eucalyptus gongylocarpa*, Mulga and *E. youngiana* over hummock grassland dominated by *Triodia basedowii* on the aeolian sands, *Acacia*, dominates the colluvial soils with *Eremophila* and *Santalum* spp, halophytes are confined to edges of salt lakes and saline drainage systems. The climate is arid, with summer and winter rain averaging 150 –180mm. Subregional area is 5, 051, 155ha."

The Central (Great Victoria Desert 2) subregion lies wholly within Western Australia. Barton and Cowan (2001a) describe the area as:
"arid active sand-ridge desert with extensive dune fields of deep Quaternary aeolian sands overlying Permian strata of the Gunbarrel Basin. Landforms consist of salt lakes and major valley floors with

lake derived dunes. Sand plains with extensive seif dunes running east west, occasional outcropping (breakaways) and quartzite hills provide minor relief. Vegetation is primarily a Tree steppe of *Eucalyptus gongylocarpa*, Mulga and *E. youngiana* over hummock grassland dominated by *Triodia basedowii* on the aeolian sands. The *Acacia* dominates colluvial soils with *Eremophila* and *Santalum* spp., halophytes are confined to edges of salt lakes and saline drainage systems. The climate is arid, with summer and winter rain averaging 150 –180mm. Subregional areas is 14, 286, 995ha."

Both subregions of the Nullarbor Bioregion cross the Western Australia-South Australia border. Barton and Cowan (2001c) describe the the Nullarbor bioregion as:

"extending over most of the onshore part of the Eucla Basin – an epeirogenic basin of cretaceous and tertiary sediments on an irregular basement predominantly of Precambrian granite and metamorphic rocks"

The Northern Band – Carlisle subregion (as per Barton and Cowan, 2001c):

"lies along the northern edge of the Bunda Plateau comprised primarily of the Carlisle Plain which has deeper soil profiles with a high proportion of red quartz rich sand mixed with loams and calcareous clays which is partly calcreted over calcareous sandstone. It is part of an old, now inactive paleodrainage system, which flows into the Nullarbor Karst. Landforms consist of salt lakes and major valley floors with lake derived dunes. Sand plains with extensive seif dunes in the northern areas of the subregion, occasional outcropping (breakaways) and quartzite hills provide minor relief. Some Karst formations are found in the southern areas.

Vegetation in the Northern sections of the subregion are primarily a Tree steppe of Eucalyptus gongylocarpa, Mulga and E. youngiana over hummock grassland dominated by Triodia basedowii on the aeolian sands, Acacia, dominates the colluvial soils with Eremophila and Santalum spp. Halophytes are confined to edges of salt lakes and saline drainage systems. Low woodlands of Acacia papyrocarpa (Western Myall) over Maireana sedifolia (bluebush) are present in the central and southern areas. Includes Myoporum platycarpum and E. oleosa in the east and west and woodlands dominated by Acacia aneura (Mulga). Climate is arid non-seasonal, with average rainfall of 150 – 200 mm. The subregional area is 5,442,741 ha."

The Central Band – Nullabour (as per Barton et. al, 2002):

"is a tertiary limestone plain with subdued arid karst features. It has shallow calcareous soils, thinly mantling massive limestones. Small scale relief in the patterns of clay-filled depressions that alternate with rises of thin stony soils or bare limestone. Southern end of several paleodrainage lines extend onto the Nullarbor Plain. The Nullarbor Karst is one of the world's largest karst

systems. Extensive features are the shallow surface depressions (the dongas and ridge and corridor terrain).

Other karst features include drip pits, rillenkarren, rundkarren, pavements, solution pans and rockholes. Larger surface karst features such as collapse dolines and blowholes are also present. The Nullarbor Plain is a vast and remarkably flat treeless plain determined by the combination of aridity and the calcareous soils. Bluebush - Saltbush steppe in central areas; low woodlands of Acacia papyrocarpa (Western Myall) over Maireana sedifolia (bluebush) are present in peripheral areas, including Myoporum platycarpum and E. oleosa in the east and west. The climate is arid non-seasonal, with an average rainfall of 150 – 200 mm. The subregional area is 10,169,146 ha."

2 METHODOLOGY

2.1 Approach and Methods

The impact assessment process involves the identification of fauna values of a site, the identification of ecological processes that may impact on these fauna values and a discussion of how a proposed development might affect those processes (and therefore impact upon the fauna). Ecological processes that maybe affected then guide management recommendations to minimise impacts on fauna. Therefore, the impact assessment process can be examined under the following headings:

- Fauna values;
- Ecological processes that impact these values; and
- Management recommendations to minimise effects on these ecological processes.

The purpose of a desktop assessment is to identify the fauna values of the site and produce a species list that can be considered to represent the (vertebrate) fauna assemblage of the project area, although possibly with errors of inclusion rather than exclusion. A follow up site reconnaissance and seasonal trapping surveys are normally conducted to gather additional information from the site, in particular the type and distribution of fauna habitats and significant species, and to assess potential ecological processes that may be impacted on as a result of the proposal. A site reconnaissance survey was conducted in September 2011.

2.2 Desktop Assessment

2.2.1 **Sources of Information**

Information on the fauna assemblage of the project area was drawn from a range of sources including State and Commonwealth databases and results of regional studies. Databases accessed were the DEC Naturemap (incorporating the Western Australian Museum's FaunaBase), Birds Australia's Atlas Database, Atlas of Living Australia Database and the EPBC Protected Search Matters Tool (Table 1).

Some regional information on fauna was also sourced from Ecologica (2009), which included surveys of the Tropicana Gold mine, located west of the project area. Information from the above sources was supplemented with species expected in the area based on general patterns of distribution. However due to the remote location of the project there was a lack of survey data in proximity to the project area to draw upon.

Sources of information used for these general patterns were: Tyler *et al.* 2000 (frogs); Storr *et al.* 1983, 1990, 1999 and 2002 (reptiles); Blakers *et al.* 1984; Barrett *et al.* 2003, Johnstone and Storr 1998, 2004; Storr 1984 (birds); Churchill 1998 (bats); Strahan 1995; Menkhorst and Knight 2004 (mammals).

Table 1. Types of records held on database, area searched and their source location

Database	Type of records held on database	Area searched
NatureMap (DEC 2011)	Records of specimens on the DEC databases. Includes historical data.	Point search from: 28°49' 09'' S, 128°44' 00'' E, Plus 40km radius.
Birds Australia Atlas Database	Records of bird observations in Australia, 1998-2011.	1). Species list for the 1 degree grid cell containing 28°49' 09'' S, 128°44' 00'' E. 2). Laverton LGA (6440).
EPBC Protected Matters Search Tool	Records on matters protected under the EPBC Act, including threatened species and conservation estate.	1). Point search from: 28°49' 09'' S, 128°44' 00'' E Plus 50km radius 2). Line search* from 28°49' 09'' S, 128°44' 00'' E to 30°51' 01'' S, 128°06' 35'' E, Plus 1km buffer
Atlas of Living Australia	Records of species distributions and mapping tools.	Area search: Great Victoria Bioregion

* Line search from Cyclone deposit project area to Forrest along proposed haul road route.

2.2.2 **Interpretation of Species Lists**

Species lists generated from the review of sources of information are very generous as they include records drawn from a large region and possibly from environments not represented in the project area. Therefore, some species returned by the data searches have been excluded because their ecology or the habitat types within the project area, meant that it was highly unlikely that these species would be present. In general, however, species returned by the desktop review process are considered to be potentially present and may occur in the project area if suitable habitat was considered to be present.

2.3 Field Reconnaisance Survey (September 2011)

2.3.1 **Overview**

A Level 1 field reconnaissance survey was conducted between 7th-12th September 2011, by Mr Brenden Metcalf (*B.Sc Hons Env. Sci*) of Bamford Consulting Ecologists. As described within the EPA's Guidance Statement No. 56 (EPA, 2004), these Level 1 surveys "involve a target area visit by suitably qualified personnel to undertake selective, low intensity sampling of the fauna and faunal assemblages, and to provide habitat descriptions and habitat maps of the project area." This survey was used to gather information on the vertebrate fauna species and VSA's of the study area.

Areas were traversed by vehicle and on foot, and included the Cyclone tenement, parts of the three proposed water pipeline route options and parts of the proposed western haul road options (See Figure 4 for areas accessed). Due to difficulties with access, the two eastern haul road options were not surveyed.

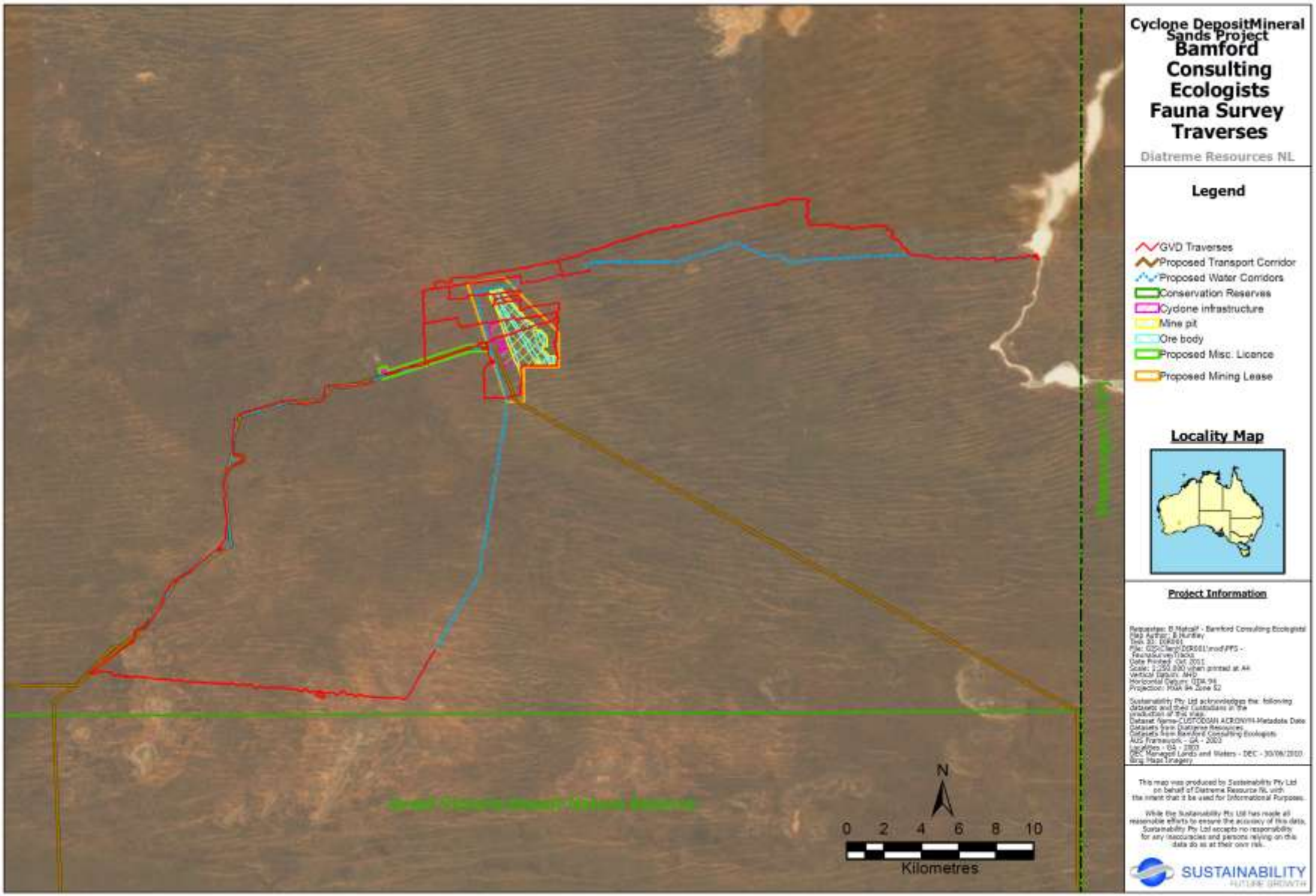

Figure 4. Areas surveyed via foot and vehicle traverses during the September 2011

2.3.2 **Survey Methods**

As this was a Level 1 survey a limited number of survey methods were used to record local fauna, including:

- General Observations: all observed fauna species were recorded during vehicle and foot traverses throughout the site. This included species recorded by both direct (birdwatching) and indirect (scats, tracks and/or burrows) methods.

- Evening vehicle traverses: on two nights (9th and 10th September 2011) vehicle traverses were conducted through the Cyclone tenement for 1.5-1.75 hrs each night. Activities undertaken during these traverses included call playback for nightbirds including owls, nightjars and stone-curlews, and vehicle-based spotlighting. No species were recorded from these traverses.

- Microhabitat searching: a number of road-side spoilheaps and fallen logs were searched for vertebrate fauna species, particularly reptiles.

- Motion-sensitive Cameras: two Bushnell TrophyCam motion-sensitive cameras were deployed in "Mulga woodland over chenopod shrubland on loamy sands", and "tall open *Allocasuarina decaisneana* woodland over open chenopod and acacia shrubland on calcareous soils" respectively. These cameras were baited with rolled oats, dried figs and sardines.

- Anabat (Bat Echolocation Monitoring): an Anabat II detector with a CFCZCAIM unit were used to sample bats from the Diatreme Camp (at 52 J 469909 6810881) and during evening vehicle traverses.

Further details and results for some of these survey methods are provided in Appendix 3.

2.4 Nomenclature and Taxonomy

As per the recommendations of EPA (2004), the nomenclature and taxonomic order presented in this report are based largely upon the Western Australian Museum's (WAM) *Checklist of the Vertebrates of Western Australia*. The authorities used for each vertebrate group are: amphibians and reptiles (Aplin and Smith 2001), birds (Christidis and Boles 2008), and mammals (How *et al.* 2001). Latin species names are presented in the following text only at the first mention of the species. Thereafter, English names (if available) only are used, with all Latin and English names presented in Appendix 1.

2.5 Definition of Conservation Significance

The conservation status of fauna species in Australia is assessed under Commonwealth and State Acts such as the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the *Wildlife Conservation Act 1950* (Wildlife Conservation Act). The Department of Environment and Conservation (DEC) also maintains a list of species it considers to be *"Priority"*. Local populations of some species may be significant even if the species as a whole has no formal recognition. In this report, therefore, three broad conservation significance categories are used:

***Conservation Significance (CS) 1*: Species listed under State or Commonwealth Acts.**

The category of Conservation Significances 1 includes species listed as threatened or migratory under the EPBC Act and/or that are listed under the Wildlife Conservation Act. Species listed under the EPBC Act are assigned to categories recommended by the International Union for the Conservation of Nature and Natural Resources (IUCN) and reviewed by Mace and Stuart (1994), or are listed as migratory. Migratory species are recognised under international treaties such as the China Australia Migratory Bird Agreement (CAMBA), the Japan Australia Migratory Bird Agreement (JAMBA), the Republic of South Korea Australia Migratory Bird Agreement (ROKAMBA), and/or the Bonn Convention (The Convention on the Conservation of Migratory Species of Wild Animals). The Wildlife Conservation Act has a list of Schedules (Appendix 2), but also recognizes the IUCN categories.

***Conservation Significance (CS) 2*: Species listed as 'Priority' by the DEC but not listed under State or Commonwealth Acts.**

In Western Australia, the DEC has produced a supplementary list of 'Priority' Fauna, being species that are not considered threatened under the Wildlife Conservation Act but for which the DEC feels

there is cause for concern. Some Priority species are also assigned to the Conservation Dependent category of the IUCN.

***Conservation Significance (CS) 3*: Species not listed under Acts or in publications, but considered of at least local significance because of their pattern of distribution.**

This level of significance has no legislative or published recognition and is based on interpretation of distribution information, but is used here as it may have links to preserving biodiversity at the genetic level (EPA 2002). If a population is isolated but a subset of a widespread (common) species, then it may not be recognised as threatened, but may have unique genetic characteristics. Conservation significance is applied to allow for the preservation of genetic richness at a population level, and not just at a species level. Species on the edge of their range, or that are sensitive to impacts such as habitat fragmentation, may also be classed as CS3.

In addition to the above conservation categories, species that have been introduced (INT) are indicated throughout the report.

2.5.1 Vegetation and Soil Associations

Vegetation and Soil Associations (VSAs) combine broad vegetation types, the soils or other substrate with which they are associated, and the landform.

VSAs are the environments that provide habitats for fauna. The term habitat is widely used in this context, but by definition an animal's habitat is the environment that it utilises (Calver *et al*. 2009), not the environment as a whole. Habitat is a function of the animal and its ecology, rather than being a function of the environment. For example, a species may occur in eucalypt canopy or in leaf-litter on sand, and that habitat may be found in only one or in several VSAs.

VSAs are not the same as vegetation types or Floristic Community Types (FCT), since these may not incorporate soil and landform, and recognise floristics to a degree that VSAs do not. Vegetation types and particularly FCTs may also not recognise minor but often significant (for fauna) structural differences in the environment. VSAs also do not necessarily correspond with Land Systems, Land Types or soil types, but may reflect some of these elements.

2.6 Impact Assessment – Fauna Values

2.6.1 VSAs and Habitat

Impacts upon fauna can be related to proportional impact upon a VSA; thus a large proportional loss upon a rare VSA can have significant impacts upon fauna.

2.6.2 Fauna Assemblage and Distribution

Fauna assemblage and distribution describe the number of species within a project area, their abundance and how they are distributed across the landscape. It includes general fauna and significant fauna. Generally, a fauna assemblage is not distributed evenly across the landscape or even within one VSA and thus there may be areas of high fauna richness that may be of particular significance.

2.6.3 Conservation Significant Fauna

Impacts of the project may be significant if species of conservation significance or habitat important for such species are affected. Impacts to populations of conservation significant fauna that already occur at low densities may be significant.

2.7 Impact assessment – Ecological Processes

2.7.1 Overview

Potential impacts of proposed developments upon fauna values can be related to ecological processes. This is recognised in the literature and under the EPBC Act, in which threatening processes are listed (Appendix 3). Ecological processes that may impact fauna values are identified here. Rather than being independent of one another, ecological processes are complex, interrelated and often result in a combination of both direct and indirect impacts. They are the mechanisms by which fauna can be affected by development.

2.7.2 Loss of Habitat Leading to Population Decline

Clearing for a development can lead to habitat loss for a species with a consequent decline in population size. This may be significant if the smaller population has reduced viability. Conservation significant species or species that already occur at low densities may be particularly sensitive to habitat loss affecting population survival.

2.7.3 Loss of Habitat Leading to Population Fragmentation

Loss of habitat can affect population movements by limiting movement of individuals throughout the landscape as a result of fragmentation. Obstructions associated with the development, such as roads, pipes and drainage channels, may affect movement of small, terrestrial species. Fragmented populations may not be sustainable and may be sensitive to effects such as reduced genetic transfer.

2.7.4 **Increased mortality**

Increased mortality can occur during project operations; for example from roadkill, animals striking infrastructure and entrapment in trenches. Roadkill as a cause of population decline has been documented for the Eastern Barred Bandicoot *Peremeles gunni* (Dufty 1989), Eastern Quoll *Dasyurus viverrinus* and Tasmanian Devil *Sarcophilus harrisii* (Jones 2000). Increased mortality due to roadkill is often more prevalent in habitats that have been fragmented (Jackson and Griffen 2000; Scheik and Jones 1999; Clevenger and Waltho 2000).

Increased mortality of common species during development is unavoidable and may not be significant for a population. However, the cumulative impacts of increased mortality of conservation significant species or species that already occur at low densities may have a significant impact on the population.

2.7.5 **Hydrological changes**

Interruptions of hydrological processes can affect the underpinning primary production in ecosystems where there are specific habitats that are hydrology-dependent. Fauna may be impacted by changes to groundwater level and chemistry, and altered flow regime (e.g. dewatering discharge). These changes may alter vegetation and may lead to habitat degradation or loss. For example, Mulga has a shallow root system and relies on surface sheet flow during flood events. If surface sheet flow is impeded Mulga can die (Kofoed 1998), which may impact on a range of fauna associated with this vegetation type. Surface and sub-surface water chemistry may also be modified by potential mine discharges, such as acid-mine drainage from waste rock landforms or tailings storage facilities.

2.7.6 **Habitat degradation due to weed invasion**

Development projects can introduce weeds into an area, and can create ideal conditions for weeds which are often pioneer species favoured by disturbed soil surfaces. Weed invasion can result in habitat degradation due to changes in vegetation structure and foraging value.

2.7.7 **Species interactions, including predation and competition**

Changes in species interactions can occur with development. Introduced species, including the feral Cat (*Felis cattus*), feral Dog/Dingo (*Canis lupus*), Fox (*Vulpes vulpes*) and Rabbit (*Oryctolagus cuniculus*) may have adverse impacts upon native species and development can alter their abundance. In particular, some mammal species are sensitive to introduced predators and the decline of many mammals in Australia has been linked to predation by the Fox, and to a lesser extent the feral Cat (Burbidge and McKenzie 1989). Introduced grazing species such as the Rabbit,

feral Goat (*Capra hircus*), Camel (*Camelus dromedarius*) and domestic livestock, can also degrade habitats and deplete vegetation that may be a food source for other species.

The provision of fresh water points can also affect the abundance of some native species. Harrington (2002) found the presence of artificial fresh waterpoints in the semi-arid mallee rangelands to influence the abundance and distribution of certain bird species, with common water-dependent birds often benefiting at the expense of rare water-independent species. Over-abundant native herbivores, such as kangaroos, can also adversely affect less abundant native species.

2.7.8 **Dust, noise, light and disturbance**

The potential for impacts from dust, noise, light and general disturbance upon fauna are difficult to predict, and consequently are rarely considered or assessed for development projects. Some studies have demonstrated the impact of artificial night lighting on fauna and suggest that lighting has greater impact than noise (Rich and Longcore 2006). These include impacts on predator-prey interactions, changes to mating and nesting behaviour and increased competition and predation within and between invertebrates, frogs, birds and mammals.

The death of large numbers of insects has been reported around some remote mine sites and this could attract other fauna (including introduced predators), as well as potentially reducing the populations of insects in surrounding habitats. The abundance of some insects can decline due to mortality around lights, although this has previously been recorded in fragmented landscapes where populations are already under stress (Rich and Longcore 2006). Artificial night lighting could potentially also lead to disorientation of migratory birds. The impacts of extended foraging period and reliable food sources on fauna populations are unknown.

2.7.9 **Changes in fire regime**

The role of fire in the Australian environment and its importance to vertebrate fauna has been widely acknowledged (e.g. Gill *et al*. 1981, Fox 1982, Letnic *et al.* 2004). Fire is a natural feature of the environment but frequent, extensive fires may adversely impact some fauna, particularly mammals and short-range endemic species. Changes to fire regimes, whether to more frequent or less frequent fires, may affect some fauna species. Development projects within areas of native vegetation may affect fire regimes, and fire management may be considered the responsibility of managers of large tracts of land.

3 RESULTS

3.1 Vegetation and Soil Associations

The five broad Vegetation and Soil Associations (VSA's) recorded from the study area are described and shown in Table 2.

Table 2. Description of Vegetation and Soil Associations recorded from the Cyclone study area

VSA description	Distribution/Abundance	Plates
Mallee and/or Mulga (*Acacia aneura*) woodland over open mixed shrubland and tussock/hummoch grassland within sand-dune systems.	Widespread throughout the Cyclone tenement and surrounding areas.	 
Open Mulga woodlands over mixed shrublands on loamy sands.	Widespread throughout the Cyclone tenement and surrounding areas.	
Tall *Allocasuarina decaisneana* woodland over open chenopod shrubland on calcareous sands.	Small areas within the Cyclone tenement; larger tracts outside of the study area e.g. on the road to Tjunjuntjara.	 
Low chenopod and samphire shrublands on claypans.	Common around Serpentine Lakes, with small isolated areas within the Cyclone tenement and on the road to Tjuntjuntjara.	

Bare open claypans.	Well represented at Serpentine Lakes.	

Of the VSAs present within the study area only one, a small area of "Low chenopod and samphire shrubland on claypans" at the western end of the proposed airstrip location (approximately 52 J 467518 6810031), is currently considered to be conservation significant. Although this VSA is widespread around the Serpentine Lakes, the small section within the airstrip footprint is isolated and potentially supports short-range endemic invertebrates.

3.2 Vertebrate Fauna Assemblage

The desktop assessment identified 195 fauna species that may occur in the project area, including 2 frog, 64 reptile, 100 bird and 29 mammal species (Appendix 1). Note that the species lists generated from the review of information have been drawn from a wide area. This was primarily due to the remote location of the project area and a paucity of historical survey data from the region.

A total of 22 conservation significant fauna species were identified, this was reduced to 20 following an assessment of distribution. The 20 conservation significant species consist of four mammals, two reptiles and 14 birds. Details of the conservation significant species that may occur based on distribution are given in Table 3.

The two conservation species for which the project area either lacks suitable habitat, or is outside their expected range, include: the Oriental Plover (*Charadrius veredus*) (EPBC Act - Migratory, WC Act - Schedule 3) and Cattle Egret (*Ardea ibis*) (EPBC Act - Migratory).

Overall the assemblage of vertebrate fauna is typical of the south eastern Eremaean. The assemblage within each vertebrate class is discussed below, including background information on species of conservation significance.

Table 3. Conservation significant fauna that may occur within or near the project area.

Common Name	Scientific Name	Conservation Status		
		EPBC Act	Wildlife Conservation Act	DEC Listing
CS1				
Sandhill Dunnart	*Sminthopsis psammophila*	Endangered		
Southern Marsupial Mole	*Notoryctes typhlops*	Endangered	Schedule 1	
Crest-tailed Mulgara	*Dasycercus cristicauda*	Vulnerable	Schedule 1	
Great Desert Skink	*Liopholis kintorei*	Vulnerable		
Woma	*Aspidites ramsayi*		Schedule 4	
Malleefowl	*Leipoa ocellata*	Vulnerable	Schedule 1	
Slender-billed Thornbill	*Acanthiza iredalei iredalei*	Vulnerable	Schedule 1	
Princess Parrot	*Polytelis alexandrae*	Vulnerable		Priority 4
Fork-tailed Swift	*Apus pacificus*	Migratory	Schedule 3	
Rainbow Bee-eater	*Merops ornatus*	Migratory	Schedule 3	
Major Mitchell's Cockatoo	*Cacatua leadbeateri*		Schedule 4	
Peregrine Falcon	*Falco peregrinus*		Schedule 4	
Naretha Blue Bonnet	*Northiella haematogaster narethae*		Schedule 4	
CS2				
Brush-tailed Mulgara	*Dasycercus blythi*			Priority 4
Australian Bustard	*Ardeotis australis*			Priority 4
Crested Bellbird	*Oreoica gutturalis gutturalis*			Priority 4
CS3				
Scarlet-chested Parrot	*Neophema splendida*			
Gibert's Whistler	*Pachycephala inornata*			
Nullarbor Quail-thrush	*Cinclosoma cinnamomeum alisteri*			
Striated Grasswren	*Amytornis striatus striatus*			

3.2.1 **Amphibians**

Two frog species may occur in the project area (Appendix 1). The Desert Trilling Frog is widespread throughout the region. No frog species of conservation significance are expected to occur within the project area. No frog species were recorded during the September 2011 field reconnaissance survey.

3.2.2 **Reptiles**

A total of 64 reptile species may occur in the project area (Appendix 1). Two reptile species of conservation significance may occur in the region and are discussed below.

Conservation Significance Level 1

Great Desert Skink ***Liopholis kintorei***

The Great Desert Skink is listed as Vulnerable under the EPBC Act. This species generally occurs on red sandplains and sand ridges of the Great Victoria Desert (Cogger *et al*. 1993). Habitat usually consists of hummock grassland (*Triodia basedowii, T. pungens* and *T. schinzii*), with some scattered shrubs and occasional trees (*Acacia spp*., *Eucalyptus spp*., *Hakea spp*., *Grevillea spp*. and *Allocasuarina decaisneana*) (Cogger *et al*. 1993). This species has been recorded in the Gibson Desert, north of the project area. Scattered isolated populations occur in the Tanami Desert, Uluru and the Gibson Desert (McAlpin 2001). On the basis of distribution it is unlikely that this species will be present in the project area. Regenerating vegetation appears to be a critical habitat requirement (McAlpin 1997). This species is sensitive to feral predation.

Woma ***Aspidites ramsayi***

The Woma is listed under Schedule 4 of the WA Wildlfie Consrvation Act, and the southern population is most threatened due to clearing for agriculture. The status of the species in the Great Vicoria Desert is uncertain, but there are some recent records (B. Maryan pers. comm.).

A total of five reptile species were recorded during the September 2011 reconnaisance survey, with another five identified from photos taken by Diatreme staff throughout the study area. None of the 10 species identified were conservation significant; details are provided in the annotated species (see Appendix 2).

3.2.3 **Birds**

A total of 100 bird species may occur in the project area (Appendix 1), although this may be an underestimate due to lack of data. Of these, 14 species of conservation significance were identified, as discussed below.

Conservation Significance Level 1

Malleefowl ***Leipoa ocellata***

This species is listed as Vulnerable under the EPBC Act and Schedule 1 (Rare or Likely to Become Extinct) of the Wildlife Conservation Act. Malleefowl were recorded historically in the eastern Great Victoria Desert and old mounds have been recorded at Plumridge Lakes Nature Reserve approximately 350km to the north east.

There are recent records of the species in the northern Great Victoria Desert and the Mamungari Conservation Park, east of the project area. These recent records suggest that although no mounds or individuals were recorded during the September 2011 reconnaisance survey, the species is still present within the broader landscape, albeit in very low densities. The distribution of the Malleefowl is severely fragmented i.e. many of the remaining Malleefowl populations are small and are isolated from other extant populations, which increases their risk of extinction (Benshemesh 2000).

Slender-billed Thornbill ***Acanthiza iredalei iredalei***

The Slender-billed Thornbill is listed as Vulnerable under the EPBC Act, although Garnett and Crowley (2000) list this subspecies as Least Concern. Other subspecies (*A.i. hedleyi* and *A.i. rosinae*) have experienced significant decline and although this subspecies has experienced some decline, much of the population is considered secure (Garnett and Crowley, 2000). Populations of this species have been recorded south and east of the project area, and are considered likely to occur within the water pipeline and haul road options of the project. It usually occurs in association with the tall chenopod shrublands present within some of the VSA's of the study area.

Princess Parrot ***Polytelis alexandrae***

This species is listed as Vulnerable under the EPBC Act and Priority 4 by DEC. The Princess Parrot has been recorded in the Mamungari Conservation Park in South Australia (ca. 50km east of the project area) and the Neale Junction Nature Reserve in Western Australia (Birdata 2011). It is often recorded from the swales of dune systems, a landform abundant throughout the Cyclone tenement.

Fork-tailed Swift ***Apus pacificus***

Rainbow Bee-eater ***Merops ornatus***

These two species are listed as Migratory under the EPBC Act and are also under Schedule 3 of the Wildlife Conservation Act. The Fork-tailed Swift is a widespread aerial species largely independent of terrestrial habitats. The Rainbow Bee-eater is also widespread across mainland Australia and although considered likely to nest within the study area, it is unlikely to be impacted by the proposed development.

Major Mitchell's Cockatoo ***Cacatua leadbeateri***

Peregrine Falcon ***Falco peregrinus***

Naretha Blue Bonnet ***Northiella haematogaster narethae***

These three species are listed under Schedule 4 (Other Specially Protected Fauna) of the Wildlife Conservation Act. The Peregrine Falcon has been recorded approximately 30kms north of the project area and in the Great Victoria Desert Nature Reserve, approximately 80km south (Birdata 2011). The Naretha Blue Bonnet has been recorded in the Great Victoria Desert Nature Reserve may potentially be impacted by the proposed haul road/s. Major Mitchell's Cockatoo was recorded in the Mamungari Conservation Park in South Australia (150km east of the project area) (Birdata 2011) and pairs had been seen occasionally on the Cyclone tenement by Diatreme staff prior to the September 2011 reconnaisance survey.

Conservation Significance Level 2

Australian Bustard ***Ardeotis australis***

Crested Bellbird ***Oreoica gutturalis gutturalis***

These species are classified as Priority 4 by DEC and are widespread across the region. Both were recorded during the September 2011 reconnaisance survey, the Crested Bellbird was common in the study area and the Australian Bustard was seen occasionally by Diatreme staff prior to the September 2011 visit.

Conservation Significance Level 3

Scarlet-chested Parrot ***Neophema splendida***

Gilbert's Whistler ***Pachycephala inornata***

Nullarbor Quail-thrush ***Cinclosoma cinnamomeum alisteri***

Striated Grasswren (sandplain) ***Amytornis striatus striatus***

These four bird species are considered of Conservation Interest and occur in the region.

Scarlet-chested Parrots have previously been recorded approximately 30 km north of the project area and east in the Mamungari Conservation Park; pairs were seen regularly during the September 2011 reconnaisance survey throughout a range of habitats in the study area.

Gilbert's Whistler has been sighted in several locations within 50 km north of the project area and the eastern part of the Great Victoria Desert (Birdata 2011); although there is habitat considered suitable for the species within the study area, no individuals were sighted.

The Nullarbor Quail-thrush is associated with locally dense patches of shrubland on the Nullarbor Plain. The Cyclone project will only impact these shrubland areas through the construction and operation of a haul road; however as these southern areas were not visited during the September 2011 reconnaisance survey the significance of any such impact could not be assessed

The Striated Grasswren occurs in mallee over spinifex but its current distribution is very fragmented, so its status in the region is poorly known. Suitable habitats was present within the study area, however no individuals were sighted.

A total of 56 bird species were recorded during the September 2011 reconnaisance survey, including several identified by Diatreme staff but not sighted. This included four conservation significant species, as discussed above. Details of all species recorded are provided in the annotated species list (Appendix 2).

3.2.4 **Mammals**

A total of 24 native and five non-native mammal species may occur in the project area or regionally (Appendix 1), of these, four conservation significant species were identified.

Conservation Significance Level 1

Sandhill Dunnart ***Sminthopsis psammophila***

The Sandhill Dunnart is listed as Endangered under the EPBC Act. The Sandhill Dunnart occupies sand dunes and spinifex hummock grass and has been historically recorded in the eastern region of the Great Victoria Desert. Although this species has not been recorded in the study area, suitable habitat is present.

Southern Marsupial Mole ***Notoryctes typhlops***

The Southern Marsupial Mole is listed as Endangered under the EPBC Act and Schedule 1 (Rare or Likely to Become Extinct) of the Wildlife Conservation Act. This blind marsupial lives mostly underground in sand dunes, interdune flats and sandy soils along river flats. It occasionally comes to the surface, apparently more frequently after rain (Maxwell *et al*. 1996). The Southern Marsupial Mole has been recorded in the sand dunes of the Great Victoria Nature Reserve (Australian

Heritage Database 2011) south of the project area, the Gibson Desert and the eastern part of the Great Victoria Desert.

Crest-tailed Mulgara ***Dasycercus cristicauda***

This species is listed as Vulnerable under the EPBC Act and Schedule 1 (Rare or Likely to Become Extinct) of the Wildlife Conservation Act. There are currently two recognised species of mulgara, the Crest-tailed Mulgara and the Brush-tailed Mulgara. Due to recent re-classifications there is some confusion in museum records and under legislation between these. For most of the last 30 years only the Crest-tailed Mulgara was recognised. More recently, Woolley (2005, 2006) re-assigned the species to the Brush-tailed Mulgara (*D. blythi*) and Crest-tailed Mulgara (*D. cristicauda*). The historical taxonomic confusion means that the distribution of the two mulgara species is somewhat unclear (Woolley 2005, 2008) and even museum specimens need to be reviewed. However, both species have suffered significant population reduction and fragmentation over the past 80 years (Woolley 2008).

The Crest-tailed Mulgara occurs primarily in Sandhill Canegrass (*Zygochloa paradoxa*) dominated dunes, Nitre Bush (*Nitraria billardierei*) grasslands, and Sandhill Canegrass flats near salt lakes (Woolley 2008), and is known with certainty from some of the desert regions along the border between Northern Territory and South Australia. This species also occurs in the eastern part of the Great Victoria Desert, the Mamungari Conservation Park and Nullabor Regional Reserve in South Australia. Some of the habitats within the study area are considered suitable for the species, although foot traverses through some of these areas did not record any signs e.g. tracks or burrows, of the species.

The Brush-tailed Mulgara is discussed below (under Conservation Significance Level 2).

Conservation Significance Level 2

Brush-tailed Mulgara ***Dasycercus blythi***

The Brush-tailed Mulgara is listed as Priority 4 by DEC. It has recently been separated from the similar Crest-tailed Mulgara as discussed above. The Brush-tailed Mulgara can be separated from the Crest-tailed Mulgara on the basis of the following characteristics (Woolley 2005, 2006): 1) The appearance of black hairs on the distal half of the tail (a brush in versus a dorsal); 2) The number of upper pre-molar teeth (two in the Brush-tailed Mulgara versus three in the Crest-tailed Mulgara); and 3) in females, the number of teats (six in the Brush-tailed Mulgara versus three in the Crest-tailed Mulgara).

The Brush-tailed Mulgara is widely distributed in arid regions of the central and western parts of the country (Woolley 2008). It occurs in scattered populations at fairly low density. The density of Brush-tailed Mulgara populations fluctuates depending on long-term climatic conditions and is also sensitive to fire (Woolley 2008). This species occupies Spinifex (*Triodia spp*.) grasslands, and burrows in flats between sand dunes. The Brush-tailed Mulgara has been recorded at the Neale Junction Nature Reserve and Queen Victoria Spring Nature Reserve. Some of the habitats within the study area are considered suitable for the species, although foot traverses through some of these areas did not record any signs e.g. tracks or burrows, of the species.

Unlike other fauna groups, the mammal assemblage includes introduced species (which can impact native fauna). It also includes extinct (^{ex}) and locally extinct (^{lex}) species: mammal extinctions from the region include the Chuditch^{lex} (*Dasyurus geoffroii*), Pig-footed Bandicoot^{ex} (*Chaeropus ecaudatus*), Western Barred Bandicoot^{lex} (*Perameles bougainville*), Bilby^{lex} (*Macrotis lagotis*), Dwarf Nullabor Bettong^{ex} (*Bettongia pusilla*), Boodie or Burrowing Bettong^{lex} (*Bettongia lesuer*), Crescent Nailtail Wallaby^{ex} (*Onychogalea lunata*), Lesser Stick-nest Rat^{ex} (*Leporillus apicalis*), Greater Stick-nest Rat^{lex} (*L. conditor*), Short-eared Hopping Mouse or Yoontoo^{ex} (*Notomys amplus*) and the Long-tailed Hopping Mouse^{ex} (*Notomys longicaudatus*).

A total of nine mammal species were recorded during the September 2011 reconnaisance survey, including five feral and one naturalised (Dingo/dog) species. The three native species included the Red Kangaroo, Gould's Wattled Bat and White-striped Freetail Bat. Details for all mammal species recorded are included in the annotated species list (Appendix 2).

3.3 Invertebrate Fauna

The potential exists for short-range endemic (SRE) invertebrates to occur in the vicinity of the Cyclone survey area. Harvey (2002) notes that the majority of species that have been classified as short-range endemics have common life history characteristics such as poor powers of dispersal or confinement to discontinuous habitats. Several groups, therefore, have particularly high instances of short-range endemic species: Gastropoda (snails and slugs), Oligochaeta (earthworms), Onychophora (velvet worms), Araneae (mygalomorph spiders), Pseudoscorpionida (pseudoscorpions), Schizomida (schizomids), Diplopoda (millipedes), Phreatoicidea (phreatoicidean crustaceans), and Decapoda (freshwater crayfish). The poor understanding of the taxonomy of many of the short-range endemic species hinders their conservation (Harvey 2002).

Within areas such as the current study area, mesic refugia within the arid landscape are considered the most likely habitats for SRE invertebrates. The majority of VSA's within the study area are dry

and widespread, however isolated and restricted habitats such as the area of"Low chenopod and samphire shrublands on claypans" at the western end of the proposed airstrip may provide suitable habitat for SRE invertebrates. Further south, the Nullabour Plain with its significant karst features, is known to support a range of styofauna. This may be an issue for the proposed haul road options.

3.4 Significant Fauna

A relative risk assessment for the vertebrate species of conservation significance is presented in Table 4. This is a subjective assessment based on:

- The level of conservation significance of each species (i.e. CS1, CS2 or CS3; see Background);
- The inferred status of the species within the survey area (based on observations made during the field surveys, published information about the range and preferred habitats of each species, and the consultants' experience with these species);
- The type and magnitude of the potential impacts relevant to each species, and the likelihood of these impacts actually occurring. From the conservation significant taxa identified above and on the basis of provision that suitable habitat exists within the project area (including the Cyclone tenement, water pipeline and haul road options) the species of most concern include the:
  - Giant Desert Skink;
  - Woma;
  - Sandhill Dunnart;
  - Southern Marsupial Mole;
  - Crest-tailed Mulgara; and
  - Nullarbor Quail-thrush.

Many of the significant species expected in the area are likely to be sparse and widespread across the region and not restricted to habitats within the Cyclone deposit project area. The potential impacts upon ecological processes and therefore fauna are discussed in Section 4.

Table 4. Relative risk assessment of conservation significant species that are likely to occur in the vicinity of the survey area.

		Status on Site	Greatest Potential Impact(s)	Relative Overall Risk of Impact
Conservation Significance Level 1 Species				
Giant Desert Skink	*Liopholis kintorei*	Not recorded on site; outside the known species distribution but suitable habitat present.	Habitat loss and clearing mortality.	Moderate to High.
Woma	*Aspidites ramsayi*	Not recorded, but suitable habitat present.	Road mortality.	Moderate to High.
Malleefowl	*Leipoa ocellata*	Not recorded on site; habitat considered suitable during the Sept 2011 visit but may not be during drier years. May be present at very low densities.	Habitat loss and road mortality.	Moderate.
Slender-billed Thornbill	*Acanthiza iredalei iredalei*	Unlikely within the Cyclone tenement, but suitable habitat present nearby e.g. around Serpentine Lakes.	Habitat loss.	Low.
Princess Parrot	*Polytelis alexandrae*	Not recorded, but suitable habitat present.	Habitat loss.	Low.
Fork-tailed Swift	*Apus pacificus*	Not recorded; an aerial species largely unaffected by terrestrial habitats.	N/A	Low.
Rainbow Bee-eater	*Merops ornatus*	Not recorded, but suitable habitat present. Likely to occur on a seasonal basis	Habitat loss and disturbance.	Low.
Major Mitchell's Cockatoo	*Cacatua leadbeateri*	Recorded from the Cyclone tenement and nearby by Diatreme staff prior to the Sept 2011 field survey.	Habitat loss (particularly nesting habitat).	Low to Moderate.
Peregrine Falcon	*Falco peregrinus*	Not recorded, but suitable habitat present.	Habitat loss.	Low.
Naretha Blue Bonnet	*Northiella haematogaster narethae*	Not recorded, but considered more likely to occur further south of the Cyclone tenement, in areas traversed by the proposed haul road options.	Habitat loss.	Low to Moderate.
Sandhill Dunnart	*Sminthopsis psammophila*	Not recorded, but suitable habitat present within the Cyclone tenement.	Habitat loss and clearing mortality.	Moderate to High.
Southern Marsupial Mole	*Notoryctes typhlops*	Not recorded, but suitable habitat present.	Habitat loss, population fragmentation and clearing mortality.	Moderate to High.
Crest-tailed Mulgara	*Dasycercus cristicauda*	Not recorded, but suitable habitat present.	Habitat loss.	Moderate to High.

		Status on Site	Greatest Potential Impact(s)	Relative Overall Risk of Impact
Conservation Significance Level 2 Species				
Australian Bustard	*Ardeotis australis*	Present; recorded from a range of VSA's during the September 2011 field survey.	Road mortality	Low.

Crested Bellbird *Oreoica gutturalis gutturalis*	Present; recorded from a range of VSA's during the September 2011 field survey.	Habitat loss.	Low.
Brush-tailed Mulgara *Dasycercus blythi*	Not recorded, but suitable habitat present.	Habitat loss.	Moderate.
Conservation Significance Level 3 Species			
Scarlet-chested Parrot *Neophema splendida*	Present; recorded from a range of VSA's during the September 2011 field survey.	Habitat loss.	Low.
Gibert's Whistler *Pachycephala inornata*	Not recorded but suitable habitat present.	Habitat loss.	Low.
Nullarbor Quail-thrush *Cinclosoma cinnamomeum alisteri*	Not recorded; considered more likely further south in areas traversed by the proposed haul road options.	Habitat loss, road mortality and	Moderate to High.
Striated Grasswren *Amytornis striatus striatus*	Not recorded but suitable habitat present.	Habitat loss.	Low.

4 DISCUSSION OF POTENTIAL IMPACTS UPON FAUNA

4.1 Overview

Impacts of the proposed project upon ecological processes (as described in Section 2.6) and management recommendations are discussed below.

4.2 Loss of Habitat Leading to Population Decline

Conservation significant taxa may be locally sensitive to loss of habitat. Direct mortality of fauna during vegetation clearing and earthworks is inevitable. To reduce habitat loss: protect any significant fauna habitat during clearing, utilise previously cleared areas where possible, minimise the disturbance footprint, clearly delineate the permitted clearing area and progressively rehabilitate disturbed areas as soon as practical.

4.3 Loss of Habitat Leading to Population Fragmentation

Habitat fragmentation is unlikely to be an issue for the project. However potential effects of fragmentation should be minimised by limiting footprint size and facilitating rehabilitation where possible. Infrastructure such as pipes and roads can restrict dispersal of small, terrestrial species and should be designed to minimise these effects: e.g. pipelines can be raised or buried. The haul road options currently all pass either through the Great Victoria Desert Nature Reserve or along its eastern boundary. These routes may be able to utilise existing corridors e.g. roads, fencelines, firebreaks, elsewhere there may be issues with impacts to restricted habitats. Further fieldwork will need to be conducted to assess the potential fauna impacts of the various haul road route options.

4.4 Increased mortality

Impacts of ongoing mortality may be significant for larger species and species that already occur at low numbers such as Malleefowl and Nullabour Quail-thrush. Loss of small numbers of these species may significantly impact local populations. Some mortality is inevitable during operations as the development is adjacent to habitat containing fauna. Sources of ongoing mortality could include striking infrastructure or collision with vehicles, both within the Cyclone tenement and on haul roads/access roads. Fauna may be attracted into mine areas in search of food, such as dead insects underneath lights. Mortality from collision with vehicles can be reduced through implementing minimum speed limits, education of mine personnel (inductions) and locating roads and infrastructure away from key fauna habitats (where this is possible). In areas of known wildlife activity signs should be placed to alert drivers.

4.5 Hydrological changes

Changes in hydrology within the landscape may result from the project, particularly where drainage lines are affected. Hydrology may also be affected through stormwater diversion or from dewatering which could lead to impacts to the surrounding vegetation and loss of habitat outside the proposed project area. Habitats situated at the lower slopes and flat broad valleys may be reliant on surface and sub-surface flows, which may be altered by clearing, earthworks, or drainage works. It is recommended surface water hydrology is managed to minimise impacts to fauna.

4.6 Habitat degradation due to weed invasion

Weed outbreaks tend to occur on recently disturbed ground such as road sides and drainage channels; this can be seen on the road between Tjunjuntjara and the Cyclone deposit, where Ruby Dock (*Rumex vesicarius*) has established populations. While not considered to be a major concern to fauna, it is recommended that weed monitoring and control measures are implemented such as vehicle hygiene and spraying of weeds where outbreaks occur.

4.7 Species interactions, including predation and competition

The fauna assemblage in the project area includes species sensitive to predation by feral species such as Foxes and feral Cats. Conservation significant fauna sensitive to feral predation include: Malleefowl, Mulgara, Sandhill Dunnart and the Giant Desert Skink. Feral predators i.e. foxes and feral cats, are present in the project area and the wider region, and have the potential to increase in abundance in response to disturbance and human activities. Introduced herbivores e.g. Rabbits and Dromedary Camels, are known to occur in the area and contribute to an increase in grazing pressure on native vegetation and the degradation of fauna habitats. They can also impact upon rehabilitation.

The provision of artificial fresh water sources (if this occurs) may favour some native species, potentially at the expense of other native species. Bird species that are water-independent may decline in abundance in areas adjacent to artificial water points. Standard waste management measures for foodstuffs are recommended to limit introduced species' access to food resources. Access to freshwater by wildlife should be avoided where possible

4.8 Dust, noise, light and disturbance

Disturbances from these factors during the construction and operation of the project are poorly understood, but a precautionary approach is recommended. Management strategies to reduce impact on fauna from disturbances could include: restrict vehicles and equipment on-site, avoid night works (including night-driving) as far as practicable, direct lighting away from areas of native vegetation, and implement dust suppression and traffic management strategies.

4.9 Changes in fire regime

Fire is an important factor in the terrestrial ecology of the region and needs to be managed, both for safety, property protection, and conservation. The likelihood of fire changes caused by the project is low as the risk of fire can be managed through standard fire prevention actions. Maintaining a range of fire ages and the retention of some long unburnt may be beneficial for fauna.

Large fires may be catastrophic for species such as Malleefowl (if present) as the birds are poor fliers and do not appear to disperse widely as fires approach (Benshemesh 1990, Benshemesh 1992, Benshemesh 2000). Fire alters Malleefowl habitat by removing understorey vegetation and accumulated leaf-litter. Repeated fires may also permanently remove Malleefowl habitat from a local area (Benshemesh 2000). Management needs to recognise the ecological role of fire, such as the maintenance of recently-burnt and long-unburnt areas. A fire management plan may be developed in consultation with the Tjunjuntjara community.

5 MANAGEMENT RECOMMENDATIONS

The September 2011 reconnaisance field survey was useful to gather information on the vertebrate fauna of a poorly known region, and particularly to gain some understanding of the environments present within the project area. However, the limited amount of regional fauna data available from the desktop review means that site-specific surveys will be needed. The aims of such surveys are to target significant species and to gather information on the patterns of distribution and abundance of the fauna in relation to the vegetation and soil associations. The surveys will also confirm the presence of many species and provides the opportunity to search for SRE invertebrates.

Details of the surveys required should be discussed with the DEC and OEPA but given the remote location and lack of existing data, several more surveys are likely to be required, including separate autumn and spring surveys of the Cyclone tenement and associated areas of proposed disturbance footprint e.g. camp, airstrip and water pipeline routes. In addition, the proposed haul road routes are likely to require, at the very least, a vehicle traverse by experienced personnel to identify significant VSA's, including those areas suitable for significant fauna species.

6. REFERENCES

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Appendix 1. Species lists indicating those expected in the region.

Frogs that may be present in the project area.

See Methods for an explanation of status.

Species		Status	Record
Hylidae			
Main's Frog	*Cyclorana maini*		
Myobatrachidae			
Desert Trilling Frog	*Neobatrachus centralis*		
	Number of frog species expected: 2		

Reptiles that may be present in the project area.

See Methods for an explanation of status.

Those species recorded during the September 2011 reconnaisance survey are marked (+), whilst those identified solely from descriptions or photos taken by Diatreme staff are marked (*)

Species		Status	Record
Gekkonidae (geckoes)			
Fat-tailed Gecko	*Diplodactylus conspicillatus*		
	Diplodactylus granariensis		
	Diplodactylus pulcher		
	Gehyra purpurascens		
Tree Dtella	*Gehyra variegata*		+
Bynoe's Gecko	*Heteronotia binoei*		+
Beaded Gecko	*Lucasium damaeum*		
Smooth Knob-tailed gecko	*Nephrurus laevissimus*		
	Nephrurus levis		*?
Beaked Gecko	*Rhynchoedura ornata*		
Jewelled Gecko	*Strophurus elderi*		
Barking Gecko	*Underwoodisaurus milii*		*
Pygopodidae (legless lizards)			
Butler's Legless-lizard	*Delma butleri*		+
Burton's Legless-Lizard	*Lialis burtonis*		
Southern Scaleyfoot	*Pygopus lepidopodus*		
Agamidae (dragons)			
	Ctenophorus clayi		
Crested Dragon	*Ctenophorus cristatus*		+
Mallee Military Dragon	*Ctenophorus fordi*		
Central Military Dragon	*Ctenophorus isolepis*		
Painted Dragon	*Ctenophorus pictus*		
Central Netted Dragon	*Ctenophorus nuchalis*		+
Netted Dragon	*Ctenophorus reticulatus*		

Species		Status	Record
Thorny Devil	*Moloch horridus*		+
Western Bearded Dragon	*Pogona minor*		+
	Tympanocryptis houstoni		
Scincidae (skink lizards)			
	Cryptoblepharus plagiocephalus		
	Ctenotus atlas		
	Ctenotus brooksi		
	Ctenotus dux		
	Ctenotus helenae		
	Ctenotus leae		
	Ctenotus pantherinus		
	Ctenotus quattuordecimlineatus		
	Ctenotus regius		
	Ctenotus schomburgkii		
Slender Blue-tongue	*Cyclodomorphus melanops*		
Broad-banded Sand Swimmer	*Eremiascincus richardsonii*		
	Lerista bipes		
	Lerista desertorum		
	Lerista labialis		
	Lerista muelleri		
Desert Skink	*Liopholis inornata*		
Great Desert Skink	*Liopholis kintorei*	CS1	
Grey's Skink	*Menetia greyii*		
	Morethia boulengeri		
	Morethia butleri		+
	Proablepharus reginae		
Central Blue-tongue	*Tiliqua multifasciata*		
Western Blue-tongue	*Tiliqua occipitalis*		*
Varanidae (monitors or goannas)			
Pygmy Desert Monitor	*Varanus eremius*		
Pygmy Mulga Monitor	*Varanus gilleni*		
Gould's Monitor	*Varanus gouldii*		+
Black-headed Tree Goanna	*Varanus tristis*		
Typhlopidae (blind snakes)			
	Ramphotyphlops bituberculatus		
	Ramphotyphlops endoterus		
Boidae (pythons)			
Woma	*Aspidites ramsayi*	CS1	
Elapidae (front-fanged snakes)			
Desert Death Adder	*Acanthophis pyrrhus*		
Southern Shovel-nosed Snake	*Brachyurophis semifasciata*		
Yellow-faced Whipsnake	*Demansia psammophis*		
Monk Snake	*Parasuta monachus*		

Species		Status	Record
Mulga Snake	*Pseudechis australis*		
Ringed Brown Snake	*Pseudonaja modesta*		
Gwardar	*Pseudonaja nuchalis*		+
Desert Banded Snake	*Simoselaps anomalus*		
Jan's Banded Snake	*Simoselaps bertholdi*		
Number of reptile species expected: 65			

Birds that may be present in the project area.

See Methods for an explanation of status.

Those species recorded during the September 2011 reconnaisance survey are marked (+), whilst those identified solely from descriptions or photos taken by Diatreme staff are marked (*).

Species		Status	Record
Dromaiidae (emus)			
Emu	*Dromaius novaehollandiae*		
Megapodiidae (malleefowl)			
Malleefowl	*Leipoa ocellata*	CS1	
Anatidae (ducks)			
Grey Teal	*Anas gracilis*		
Accipitridae (kites, hawks and eagles)			
Black-shouldered Kite	*Elanus axillaris*		+
Spotted Harrier	*Circus assimilis*		+
Brown Goshawk	*Accipiter fasciatus*		
Collared Sparrowhawk	*Accipiter cirrhocephalus*		+
Wedge-tailed Eagle	*Aquila audax*		+
Little Eagle	*Hieraaetus morphnoides*		
Falconidae (falcons)			
Peregrine Falcon	*Falco peregrinus*	CS1	
Australian Hobby	*Falco longipennis*		+
Brown Falcon	*Falco berigora*		+
Nankeen Kestrel	*Falco cenchroides*		+
Otidae (bustards)			
Australian Bustard	*Ardeotis australis*	CS2	+
Turnicidae (button-quails)			
Little Button-quail	*Turnix velox*		+
Charadriidae (lapwings and plovers)			
Inland Dotterel	*Charadrius australis*		
Banded Lapwing	*Vanellus tricolor*		
Columbidae (pigeons and doves)			
Common Bronzewing	*Phaps chalcoptera*		+
Crested Pigeon	*Ocyphaps lophotes*		+
Diamond Dove	*Geopelia cuneata*		

Species		Status	Record
Spinifex Pigeon	*Geophaps plumifera*		
Cacatuidae (cockatoos)			
Galah	*Cacatua roseicapilla*		
Major Mitchell's Cockatoo	*Cacatua leadbeateri*	CS1	*
Cockatiel (wiero)	*Nymphicus hollandicus*		+
Psittacidae (lorikeets and parrots)			
Budgerigar	*Melopsittacus undulatus*		+
Australian Ringneck	*Barnardius zonarius*		+
Naretha Blue Bonnet	*Northiella haematogaster narethae*	CS1	
Mulga Parrot	*Psephotus varius*		+
Bourke's Parrot	*Neophema bourkii*		+
Princess Parrot	*Polytelis alexandrae*	CS2	
Scarlet-chested Parrot	*Neophema splendida*	CS3	+
Cuculidae (cuckoos)			
Pallid Cuckoo	*Cuculus pallidus*		+
Black-eared Cuckoo	*Chrysococcyx osculans*		+
Horsfield's Bronze-Cuckoo	*Chrysococcyx basalis*		+
Strigidae (hawk-owls)			
Southern Boobook Owl	*Ninox novaeseelandiae*		
Podargidae (frogmouths)			
Tawny Frogmouth	*Podargus strigoides*		
Aegothelidae (owlet-nightjars)			
Australian Owlet-nightjar	*Aegotheles cristatus*		+
Caprimulgidae (nightjars)			
Spotted Nightjar	*Eurostopodus argus*		+
Apodidae (swifts)			
Fork-tailed Swift	*Apus pacificus*	CS1	
Halcyonidae (forest kingfishers)			
Red-backed Kingfisher	*Todiramphus pyrrhopygia*		+
Meropidae (bee-eaters)			
Rainbow Bee-eater	*Merops ornatus*	CS1	
Climacteridae (treecreepers)			
White-browed Treecreeper	*Climacteris affinis*		
Rufous Treecreeper	*Climacteris rufa*		
Maluridae (fairy-wrens)			
Splendid Fairy-wren	*Malurus splendens*		+
Variegated Fairy-wren	*Malurus lamberti*		+
White-winged Fairy-wren	*Malurus leucopterus*		+
Rufous-crowned Emu-wren	*Stipiturus ruficeps*		
Striated Grasswren	*Amytornis striatus*	CS3	
Pardalotidae (pardalotes and allies)			
Red-browned Pardalote	*Pardalotus rubricatus*		
Striated Pardalote	*Pardalotus striatus*		

Species		Status	Record
Rufous Fieldwren	*Calamanthus campestris*		
Redthroat	*Sericornis brunneus*		
Weebill	*Smicrornis brevirostris*		
Western Gerygone	*Gerygone fusca*		
Inland Thornbill	*Acanthiza apicalis*		+
Slender-billed Thornbill	*Acanthiza iredalei*	CS1	
Chestnut-rumped Thornbill	*Acanthiza uropygialis*		+
Slaty-backed Thornbill	*Acanthiza robustirostris*		
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*		
Southern Whiteface	*Aphelocephala leucopsis*		+
Meliphagidae (honeyeaters)			
Spiny-cheeked Honeyeater	*Acanthagenys rufogularis*		+
Yellow-throated Miner	*Manorina flavigula*		+
Singing Honeyeater	*Lichenostomus virescens*		+
Grey-fronted Honeyeater	*Lichenostomus plumulus*		
White-fronted Honeyeater	*Phylidonyris albifrons*		+
Grey Honeyeater	*Conopophila whitei*		
Black Honeyeater	*Certhionyx niger*		+
Pied Honeyeater	*Certhionyx variegatus*		+
Crimson Chat	*Epthianura tricolor*		+
Petroicidae (Australian robins)			
Jacky Winter	*Microeca fascinans*		+
Red-capped Robin	*Petroica goodenovii*		+
Hooded Robin	*Melanodryas cucullata*		+
Pomatostomidae (Australian babblers)			
White-browed Babbler	*Pomatostomus superciliosus*		+
Cinclosomatidae (quail-thrushes and allies)			
Chiming Wedgebill	*Psophodes occidentalis*		
Chestnut Quail-thrush	*Cinclosoma castanotus*		
Neosittidae (sittellas)			
Varied Sittella	*Daphoenositta chrysoptera*		
Pachycephalidae (whistlers)			
Crested Bellbird	*Oreoica gutturalis gutturalis*	CS2	+
Gilbert's Whistler	*Pachycephala inornata*	CS3	
Rufous Whistler	*Pachycephala rufiventris*		+
Grey Shrike-thrush	*Colluricincla harmonica*		+
Dicruridae (flycatchers)			
Magpie-lark	*Grallina cyanoleuca*		
Willie Wagtail	*Rhipidura leucophrys*		+
Campephagidae (cuckoo-shrikes)			
Black-faced Cuckoo-shrike	*Coracina novaehollan*		+
Ground Cuckoo-shrike	*Coracina maxima*		
White-winged Triller	*Lalage sueurii*		+

Species		Status	Record
Artamidae (woodswallows)			
Masked Woodswallow	*Artamus personatus*		+
Black-faced Woodswallow	*Artamus cinereus*		+
White-browed Woodswallow	*Artamus superciliosus*		+
Grey Butcherbird	*Cracticus torquatus*		
Pied Butcherbird	*Cracticus nigrogularis*		
Australian Magpie	*Gymnorhina tibicen*		+
Corvidae (ravens and crows)			
Australian Raven	*Corvus coronoides*		+
Little Crow	*Corvus bennetti*		+
Torresian Crow	*Corvus orru*		
Motacillidae (pipits and true wagtails)			
Australian Pipit	*Anthus novaeseelandiae*		+
Passeridae (finches and allies)			
Zebra Finch	*Taeniopygia guttata*		+
Dicaeidae (flower-peckers)			
Mistletoebird	*Dicaeum hirundinaceum*		
Hirundinidae (swallows)			
White-backed Swallow	*Cheramoeca leucosternus*		+
Sylviidae (Old World warblers)			
Rufous Songlark	*Cincloramphus mathewsi*		+
Brown Songlark	*Cincloramphus cruralis*		+
	Number of bird species expected:100		

Mammals that may be present in the project area.

See Methods for an explanation of status.

Those species recorded during the September 2011 reconnaisance survey are marked (+), whilst those identified solely from descriptions or photos taken by Diatreme staff are marked (*).

Species		Status	
Tachyglossidae (echidna)			
Echidna	*Tachyglossus aculeatus*		
Dasyuridae (carnivorous marsupials)			
Crest-tailed Mulgara	*Dasyurus cristcauda*	CS1	
Brush-tailed Mulgara	*Dasyurus blythi*	CS2	
Southern Marsupial Mole	*Notoryctes typhlops*	CS1	
Ride's Ningaui	*Ningaui ridei*		
Mallee Ningaui	*Ningaui yvonneae*		
Fat-tailed Dunnart	*Sminthopsis crassicaudata*		
Hairy-footed Dunnart	*Sminthopsis hirtipes*		
Ooldea Dunnart	*Sminthopsis ooldea*		
Sandhill Dunnart	*Sminthopsis psammophila*	CS1	
Macropodidae (kangaroos)			

Species		Status	
Euro	*Macropus robustus*		
Red Kangaroo	*Macropus rufus*		+
Molossidae (freetail bats)			
Inland Freetail Bat	*Mormopterus planiceps* sp		
White-striped Mastiff Bat	*Tadarida australis*		+
Vespertilionidae (evening bats)			
Gould's Wattled Bat	*Chalinolobus gouldii*		+
Chocolate Wattled Bat	*Chalinolobus morio*		
Lesser Long-eared Bat	*Nyctophilus geoffroyi*		
Inland Broad-nosed Bat	*Scotorepens balstoni*		
Little Broad-nosed Bat	*Scotorepens greyii*		
Inland Forest Bat	*Vespadelus baverstocki*		
Muridae (rats and mice)			
House Mouse	*Mus musculus*	Int	+
Spinifex Hopping Mouse	*Notomys alexis*		
Poonta or Bolam's Mouse	*Pseudomys bolami*		
Mingkiri or Sandy Inland Mouse	*Pseudomys hermannsburgensis*		
Canidae (dogs and foxes)			
Dingo/feral dog	*Canis lupus*		+
European Red Fox	*Vulpes vulpes*	Int	+
Felidae (cat)			
Feral Cat	*Felis catus*	Int	+
Camelidae (camel)			
Dromedary Camel	*Camelus dromedarius*	Int	+
Leporidae (rabbits and hares)			
European Rabbit	*Oryctolagus cuniculus*	Int	+
	Number of mammal species expected: 29		

Appendix 2. Annotated Species List

REPTILES

Gehyra variegata	Several raked up from roadside spoil heaps.
Heteronotia binoei	Several raked up from roadside spoil heaps.
Underwoodisaurus milli	Recorded from around the Cyclone tenement previously by Diatreme staff; verified from a photo.
Nephurus sp.	Recorded from around the Cyclone tenement previously by Diatreme staff; verified from a photo.
Delma butleri	One raked up from a roadside spoil heap.
Ctenophorus cristatus	Recorded from around the Diatreme camp previously by Diatreme staff; verified from a photo.
Ctenophorus nuchalis	Recorded from around the Diatreme camp previously by Diatreme staff; verified from a photo.
Pogona minor	A gravid female found laying eggs on the north-south access track, east of the Diatreme camp (11/9).
Moloch horridus	Recorded from around the Diatreme camp previously by Diatreme staff; verified from a photo.
Morethia butleri	One caught from leaf litter under a large Eucalypt in Open woodland over spinifex on sand dunes.
Tiliqua occipitalis	Identified from description by Diatreme staff; recorded from the Cyclone study area previously by Diatreme staff.
Varanus gouldii	Recorded from around the Diatreme camp previously by Diatreme staff; verified from a photo.
Pseudonaja nuchalis	Recorded from around the Diatreme camp previously by Diatreme staff; verified from a photo.

BIRDS

Black-shouldered Kite	One seen over dunes within the tenement, south of Line 6 (8/9).
Collared Sparrowhawk	A pair seen in Sheoak woodland near Serpentine Lakes (11/9).
Spotted Harrier	One seen over open grasslands west of Tjuntjuntjara (12/9)
Wedge-tailed Eagle	Recorded by Diatreme staff prior to Sept 2011 fieldwork.
Australian Hobby	A pair seen hunting and courting at Tjuntjuntjara (7/9).
Brown Falcon	Common throughout the Cyclone tenement, in a range of habitat types (7-11/9).
Nankeen Kestrel	One seen over dunes within the tenement, south of Line 6 (9/9).
Australian Bustard	Recorded previously by Diatreme staff; one seen along the entrance road (9/9).
Little Button-quail	Common throughout the Cyclone tenement (7-11/9).
Common Bronzewing	One seen on track through dunes near southern water pipeline route (10/9).
Crested Pigeon	Several seen in open Sheoak woodland near southern water pipeline route (10/9).

Major Mitchell Cockatoo	Pairs seen previously by Diatreme staff in the Cyclone area.
Cockatiel	A pair seen in open shrubland between Tjuntjuntjara and the Cyclone tenement (7/9). Flocks of 3 - 15 recorded from a range of open woodland habitats west of Tjuntjuntjara (12/9).
Budgerigar	Very common throughout the study area; large flocks (300+) recorded (7-11/9).
Australian Ringneck	Moderately common; pairs seen occasionally throughout the study area (8-11/9).
Mulga Parrot	Moderately common; pairs seen regularly throughout the study area; a juvenile recorded near the southern water pipeline route (8-11/9).
Bourke's Parrot	Uncommon; heard pre-dawn around the Diatreme camp (8/9); a trio seen in Mixed Mallee/Mulga over Spinifex in sand dunes, in the northern part of the Cyclone tenement (11/9).
Scarlet-chested Parrot	Moderately common; pairs seen regularly throughout the study area in a range of habitat types (8-11/9).
Pallid Cuckoo	Common; heard and seen throughout the study area in a range of habitat types (7-11/9).
Black-eared Cuckoo	Uncommon; one seen in Mallee over spinifex in sand dune country near Diatreme camp (8/9).
Horsfield's Bronze-Cuckoo	Common; heard and seen throughout the study area in a range of habitat types (7-11/9).
Spotted Nightjar	Heard pre-dawn around the Diatreme camp (10/9).
Australian Owlet-nightjar	Heard overnight around the Diatreme camp (9/9) and seen on the access road near the Diatreme camp pre-dawn (12/9).
Red-backed Kingfisher	Uncommon; Several individuals seen throughout the site in a range of Open Woodland habitats, including a pair (possibly nesting) near Serpentine Lakes. (10-11/9).
Splendid Fairy-wren	Common; parties of 3-5 seen in a range of shrubland habitats throughout the study area (7-11/9).
Variegated Fairy-wren	Moderately common; parties of 3-6 seen mainly in the north of the Cyclone tenement, in a range of shrubland habitats throughout the study area (9-11/9).
White-winged Fairy-wren	One male seen in low chenopod shrubland west of Tjuntjuntjara (12/9).
Inland Thornbill	Common; seen regularly in the Mallee/Mulga woodland and Acacia shrublands throughout the study area (7-11/9).
Chestnut-rumped Thornbill	Common; seen regularly in the Mallee/Mulga woodland and Acacia shrublands throughout the study area (7-11/9).
Southern Whiteface	Moderately common; small groups of 2-4 seen regularly in open Mulga over spinifex/tussock grassland on the western side of the Cyclone tenement (7-11/9).
Spiny-cheeked Honeyeater	Very common throughout the study area; heard and seen regularly in a range of habitat types throughout the study area (7-11/9).
Yellow-throated Miner	Common; individuals and groups of 2-7 recorded from a range of habitats throughout the Cyclone tenement (7-11/9).

Singing Honeyeater	Common; recorded from a range of habitats throughout the Cyclone tenement (7-11/9).
White-fronted Honeyeater	Common; groups of 2-5 recorded regularly from a range of shrubland habitats within the study area (7-11/9).
Black Honeyeater	Uncommon; several individuals seen and heard in a range of Open Mulga woodland habitats throughout the study area (8-11/9).
Pied Honeyeater	Uncommon; several individuals seen and heard in a range of Mulga and Mallee woodland habitats throughout the study area (8-11/9).
Crimson Chat	Abundant; large flocks recorded from throughout the study area (7-12/9).
Jacky Winter	Uncommon; several individuals recorded from open Mulga woodland near the Diatreme camp (7-9/9).
Red-capped Robin	Common; pairs recorded regularly from a range of Mulga and Mallee woodland habitats throughout the study area (7-11/9).
Hooded Robin	Uncommon; one pair seen on the Cyclone tenement, near the Diatreme camp, in Mallee woodland over spinifex in sand dunes (11/9).
White-browed Babbler	Moderately common; groups of 4 - 8 seen occasionally throughout the study area, in a range of habitat types (8-11/9).
Crested Bellbird	Common; individuals and pairs heard and seen throughout the study area in a range of habitat types (7-11/9).
Rufous Whistler	Moderately common; individuals heard and occasionally seen from a range of habitat types throughout the study area (7-11/9).
Grey Shrike-thrush	Moderately common; individuals heard and seen throughout the study area in a range of habitat types (7-11/9).
Willie Wagtail	Common; Individuals seen and heard from throughout most habitat types within the study area (7-11/9).
Black -faced Cuckoo-shrike	Uncommon; a pair seen between the Cyclone tenement and Serpentine Lakes (11/9)
White-winged Triller	Moderately common; pairs seen regularly, most often in Mulga/Mallee woodlands habitats within the Cyclone tenement (7-11/9).
Masked Woodswallow	Abundant; large flocks (>200) seen over various habitats throughout the study area. One nest, with a single egg, found within Mallee woodland over spinifex in dune systems (7-11/9).
Black-faced Woodswallow	Abundant; common within flocks of Masked Woodswallows within the study area; juveniles seen regularly amongst birds perching (7-11/9).
White-browed Woodswallow	Several, including juveniles, seen amongst flocks of Masked and Black-faced Woodswallows (7-11/9).
Australian Magpie	Several small groups seen between Tjunjuntjara and the Diatreme camp (7,12/9)
Australian Raven	One seen near Diatreme camp (11/9).
Little Crow	A small flock seen between Tjunjuntjara and the Diatreme camp (7/9).
Australian Pipit	Common; individuals recorded throughout open habitats within the study area (7-11/9).

White-backed Swallow	Uncommon; several small groups seen throughout the study area, often in association with dune ridges, particularly where vehicle tracks had created small vertical banks suitable for nesting (8, 10/9).
Rufous Songlark	Moderately common; Heard and seen regularly from throughout a range of habitat types within the Cyclone tenement (7-11/9).
Brown Songlark	Common along the road between Tjunjuntjara and the Diatreme camp (12/9).

MAMMALS

Red Kangaroo	Uncommon; Reported by Diatreme staff as being seen occasionally throughout the site.
White-striped Freetail Bat	Common; Heard regularly over camp at night and during night spotlighting around the site (7-11/9).
Gould's Wattled Bat	Common; Recorded regularly from throughout the site (8-11/9).
House Mouse	Moderately common; seen and heard around camp (7-11/9).
Dingo/Dog	Moderately common; Tracks seen regularly throughout the site and reported by Diatreme staff as being seen occasionally around camp and.
European Red Fox	Uncommon; one seen on the roadside between Tjuntjuntjara and the Diatreme camp (7/9). Scats and tracks seen occasionally throughout the site.
Feral Cat	Uncommon; one seen crossing the road between Tjuntjuntjara and the Diatreme camp.
Dromedary Camel	Common; Individuals and groups of 3-10 seen regularly throughout the study area and fresh tracks covering vehicle tracks on a daily basis (7-11/9).
European Rabbit	Moderately common; large warrens observed along the roadside between Tjuntjuntjara and the Diatreme camp; several individuals seen throughout the Cyclone study area (8-11/9).

Appendix 3. Survey Effort and Results from the September 2011 reconnaisance survey.

Motion Camera Data

Both cameras used were Bushnell Trophy-Cam Motion-sensitive cameras.

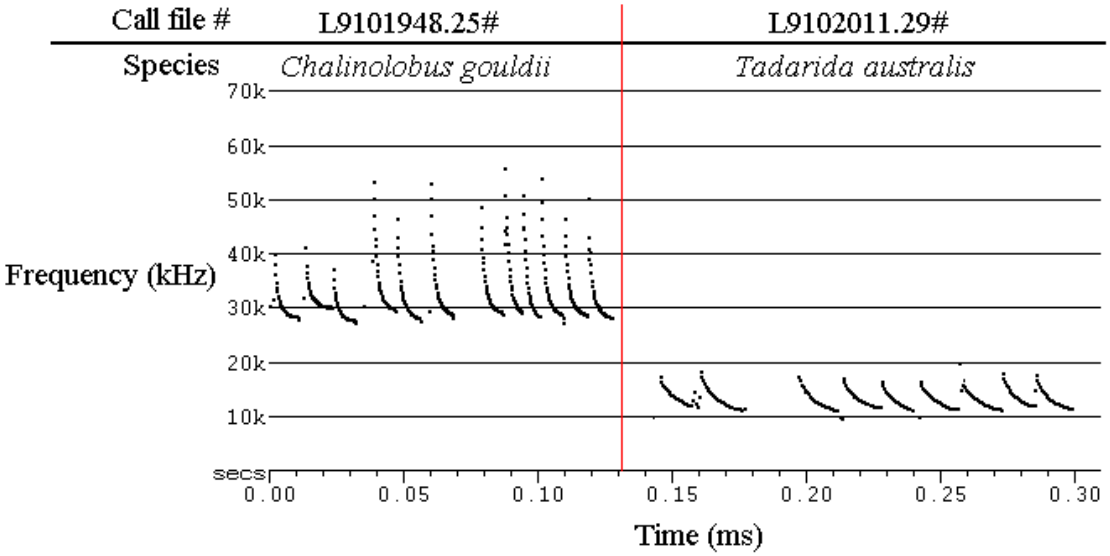
Dates of operation	Co-ordinates (UTM)	Location	Habitat	Photos?
08-11 Sept 2011	52 J 469288 6811724	North-South Access Rd	Open Sheoak Woodland over open Mulga woodland and mixed open shrubland; loamy red sands over calcrete.	3x dingo/dog
08-11 Sept 2011	52 J 469426 6810649	Camp Access Rd	Mulga woodland over moderately dense Eremophila shrubland; loamy red sand in a dune swale	

Anabat Recording Locations

Date	Location	Co-ordinates	Habitat
8/09/2011	Diatreme Camp	52 J 469906 6810878	Open Mulga Woodland over hummock grassland on red sand.
9/09/2011	Line 6 and south within tenement & Diatreme Camp	n/a	Range of woodland/shrublands in sand dune systems
10/09/2011	Line 6 and north within tenement & Diatreme Camp	n/a	Range of woodland/shrublands in sand dune systems
11/09/2011	Diatreme Camp	52 J 469906 6810878	Open Mulga Woodland over hummock grassland on red sand.

Micro-bat Species recorded through Anabat

Time vs Frequency graph showing representative Zero-crossings Analysis call files, from the two species recorded from the Cyclone Study area



	Chalinolobus gouldii	*Tadarida australis*
N. of pulses	12	9
Fc (kHz)	28.3	12
Fmax (kHz)	47.8 (± 2.21)	23.6 (± 0.18)
Fmin (kHz)	28.3 (± 0.37)	12 (± 0.9)
Dur (ms)	8.4 (± 0.57)	21.3 (± 0.31)

No. of pulses: Number of pulses within the sampled call file.
Fc: Average Characteristic Frequency, as determined by AnalookW software.
Fmax: Average maximum frequency from all pulses within a call sequence.
Fmin: Average minimum frequency from all pulses within a call sequence.
Dur: Average duration of each pulse within a call sequence.

Appendix 4. Assessment of conservation status.

Table A. Categories used in the assessment of conservation status

IUCN categories (based on review by Mace and Stuart, 1994) as used for the *Environment Protection and Biodiversity Conservation Act 1999* (C'th).

Extinct. Taxa not definitely located in the wild during the past 50 years.

Extinct in the Wild. Taxa known to survive only in captivity.

Critically Endangered. Taxa facing an extremely high risk of extinction in the wild in the immediate future.

Endangered. Taxa facing a very high risk of extinction in the wild in the near future.

Vulnerable. Taxa facing a high risk of extinction in the wild in the medium-term future.

Near Threatened. Taxa that risk becoming Vulnerable in the wild.

Conservation Dependent. Taxa whose survival depends upon ongoing conservation measures. Without these measures, a conservation dependent taxon would be classed as Vulnerable or more severely threatened.

Data Deficient (Insufficiently Known). Taxa suspected of being Rare, Vulnerable or Endangered, but whose true status cannot be determined without more information.

Least Concern. Taxa that are not Threatened.

Table B. Schedules used in the *Wildlife Conservation Act 1950* (WA)

Schedule 1. Rare and Likely to become Extinct.

Schedule 2. Extinct.

Schedule 3. Migratory species listed under international treaties.

Schedule 4. Other Specially Protected Fauna.

Table C. WA Department of Environment and Conservation Priority species (species not specifically protected under the *Wildlife Conservation Act 1950* (WA), but for which there is some concern).

Priority 1. Taxa with few, poorly known populations on threatened lands.

Priority 2. Taxa with few, poorly known populations on conservation lands; or taxa with several, poorly known populations not on conservation lands.

Priority 3. Taxa with several, poorly known populations, some on conservation lands.

Priority 4. Taxa in need of monitoring. Taxa which are considered to have been adequately surveyed, or for which sufficient knowledge is available, and which are considered not currently threatened or in need of special protection, but could be if present circumstances change.

Priority 5. Taxa in need of monitoring. Taxa which are not considered threatened but are subject to a specific conservation program, the cessation of which would result in the species becoming threatened within five years (IUCN Conservation Dependent).

Appendix 5. Ecological processes

Ecological processes are processes that maintain ecosystems and biodiversity. They are important for the assessment of impacts of development proposals, because ecological processes make ecosystems sensitive to change. The issue of ecological processes, impacts and conservation of biodiversity has an extensive literature. Following are examples of the sorts of ecological processes that need to be considered.

Ecological processes relevant to the conservation of biodiversity in Australia (Soule *et al.* 2004):

- Critical species interactions (highly interactive species);
- Long distance biological movement;
- Disturbance at local and regional scales;
- Global climate change;
- Hydroecology;
- Coastal zone fluxes;
- Spatially-dependent evolutionary processes (range expansion and gene flow); and
- Geographic and temporal variation of plant productivity across Australia.

(Taken from http://www.wilderness.org.au/articles/wc_science, viewed 30 December 2008)

Threatening processes (EPBC Act)

Under the EPBC Act, a key threatening process is an ecological interaction that threatens or may threaten the survival, abundance or evolutionary development of a threatened species or ecological community. There are currently 17 key threatening processes listed by the Commonwealth Department of the Environment, Water, Heritage and the Arts).

- Competition and land degradation by feral/unmanaged Goats (*Capra hircus*);
- Competition and land degradation by feral Rabbits (*Oryctolagus cuniculus*);
- Dieback caused by the root-rot fungus (*Phytophthora cinnamomi*);
- Incidental catch (bycatch) of Sea Turtles during coastal otter-trawling operations within Australian waters north of 28 degrees South;
- Incidental catch (or bycatch) of seabirds during oceanic longline fishing operations;
- Infection of amphibians with chytrid fungus resulting in chytridiomycosis;

- Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris;
- Land clearance;
- Loss of biodiversity and ecosystem integrity following invasion by the Yellow Crazy Ant (*Anoplolepis gracilipes*) on Christmas Island, Indian Ocean;
- Loss of climatic habitat caused by anthropogenic emissions of greenhouse gases;
- Predation by exotic rats on Australian offshore islands of less than 1000 km^2 (100,000 ha);
- Predation by feral Cats (*Felis catus*);
- Predation by the European Red Fox (*Vulpes vulpes*);
- Predation, Habitat Degradation, Competition and Disease Transmission by Feral Pigs (*Sus scrofa*);
- Psittacine Circoviral (beak and feather) Disease affecting endangered psittacine species;
- The biological effects, including lethal toxic ingestion, caused by Cane Toads (Bufo *marinus*);
- The reduction in the biodiversity of Australian native fauna and flora due to the red imported fire ant, *Solenopsis invicta*.

(http://www.environment.gov.au/cgi-bin/sprat/public/publicgetkeythreats.pl
viewed on 30 December 2008)

General processes that threaten biodiversity across Australia (The National Land and Water Resources Audit):

- Vegetation clearing;
- Increasing fragmentation, loss of remnants and lack of recruitment;
- Firewood collection;
- Grazing pressure;
- Feral animals;
- Exotic weeds;
- Changed fire regimes;
- Pathogens;
- Changed hydrology—dryland salinity and salt water intrusion;
- Changed hydrology—other such as altered flow regimes affecting riparian vegetation; and
- Pollution.

(taken from Cork S, Sattler P and Alexandra J (2006), 'Biodiversity' theme commentary prepared for the 2006 Australian State of the Environment Committee, Department of the Environment and Heritage, Canberra, http://www.deh.gov.au/soe/2006/commentaries/biodiversity/index.html; viewed on 30 December 2008).