Diatreme Resources

Fauna Assessment of Transport Corridor Options for the Lost Sands Project (Cyclone Deposit)

A view across the edge of the Nullarbor Plain, along the Central transport corridor option. (Photo: B Metcalf)

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EXECUTIVE SUMMARY

Diatreme Resources, as part of the development of the Cyclone Deposit (located within the Great Victoria Desert, near the WA/SA border) have proposed three options for a potential transport corridor to transport resources south to the Trans-Australia Railway Line. The proposed construction of the transport corridor is subject to environmental impact assessment, and as part of this process Bamford Consulting Ecologists was commissioned to undertaken fauna investigations for impact assessment. BCE uses an impact assessment process with the following components:

- The identification of fauna values:
  - Assemblage characteristics: uniqueness, completeness and richness;
  - Species of conservation significance;
  - Recognition of ecotypes or vegetation/substrate associations (VSAs) that provide habitat for fauna, particularly those that are rare, unusual and/or support significant fauna;
  - Patterns of biodiversity across the landscape;
  - Ecological processes upon which the fauna depend.
- The review of impacting processes such as:
  - Habitat loss leading to population decline;
  - Habitat loss leading to population fragmentation;
  - Degradation of habitat due to weed invasion leading to population decline;
  - Ongoing mortality from operations;
  - Species interactions including feral and overabundant native species;
  - Hydrological change;
  - Altered fire regimes; and
  - Disturbance (dust, light, noise).
- The recommendation of actions to mitigate impacts.

The fauna investigations were based on a desktop review of data to produce a list of expected species, and a site reconnaissance to visit the three route options, enabling the consultant to make some fauna observations, identify Vegetation and Substrate Associations (VSAs) that provide habitat for fauna, and place the results of the desktop review into the perspective of the study area. This reconnaissance survey was undertaken in March 2012.

The desktop assessment identified 267 fauna species that may occur in the project area, including 5 frog, 93 reptile, 140 bird and 29 mammal species. Nine frog, 53 bird and 10 mammal species were found during field investigations. Key fauna values are:

Fauna assemblage – diverse and relatively complete within the northern sections of the routes i.e. the Great Victoria Desert and northern Nullarbor; central Nullarbor supports a low diversity of fauna with a significant population of introduced species i.e. rabbits. Numerous mammal species are known to have been lost from this area.

The fauna assemblage across the three transport corridor options is primarily Eremaean with some Bassian influences.

Significant species – including four reptiles, 18 birds (including some migratory waterbirds; others may visit the area occasionally), six mammals and an unknown number of invertebrates (including potential short range endemic invertebrates). Some of the significant fauna species are expected only as vagrants or occasional visitors, but others are known or expected to have significant populations in the project area. These include: Southern Marsupial Mole, Sandhill Dunnart, Crest-tailed Mulgara, Naretha Blue-bonnet and Nullarbor Quail-thrush. There is also some potential for SRE invertebrates at some locations e.g. karst formations on the Nullarbor.

Vegetation and Substrate Associations - most are very widespread e.g. Mallee/Spinifex on sand-dunes, Sheoak woodland on calcareous gravels, but some such as Gypsum salt-lakes and Dongas have restricted distribution. Although not investigated during this trip, there is potential for karst formations along the southern end of the transport corridor options. It should not be difficult to avoid directly impacting these restricted areas by altering the course of the chosen transport corridor option.

Patterns of biodiversity – species diversity is expected to decrease along a north-south gradient across the three transport corridor options. Within the Great Victoria Desert, diversity and abundance of species is expected to be higher than on the central Nullarbor where diversity and abundance is expected to be low as a function of lower habitat complexity; the results of previous surveys correlate with this.

Key ecological processes - main processes affecting the fauna assemblage along the three transport corridor options include landscape permeability (disruption of linear habitats utilised by fauna for movement, and traditional landscape burning regimes), local hydrology, fauna interactions (introduced predators and herbivores) and habitat degradation due to weed invasion.

The impact assessment found that the main concerns were with increased mortality primarily from roadkill (from vehicle movements along the chosen transport corridor option; moderate) and habitat degradation due to weed invasion (weeds spreading along the length of the transport corridor and altering VSAs, thereby affecting significant fauna; moderate).

The Central and Eastern options are significantly shorter than the Western option; if chosen, they will significantly reduce the transport corridor's footprint. The Eastern option currently passes through the conservation (and culturally) significant Forrest lakes system. A variation of the Eastern option that passes west of the Forrest lakes system before heading east to the border and southwards on its current route could potentially minimise all impacts.

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1 Introduction

1.1 Background

Diatreme Resources propose to develop the Cyclone Deposit of their Lost Sands Project, located within the Great Victoria Desert. As part of this project they have identified three options for a transport corridor, to allow for the transportation of the mineral resource south to the Trans-Australia Railway Line. The final choice of transport corridor will be subject to environmental impact assessment and as part of this process Bamford Consulting Ecologists (BCE) was commissioned by Sustainability Pty Ltd to conduct fauna investigations.

1.2 General Approach to Fauna Impact Assessment

The purpose of impact assessment is to provide government agencies with the information they need to decide upon the significance of impacts of a proposed development. BCE uses an impact assessment process with the following components:

- The identification of fauna values:
  - Assemblage characteristics: uniqueness, completeness and richness;
  - Species of conservation significance;
  - Recognition of ecotypes or vegetation/substrate associations (VSAs) that provide habitat for fauna, particularly those that are rare, unusual and/or support significant fauna;
  - Patterns of biodiversity across the landscape;
  - Ecological processes upon which the fauna depend.
- The review of impacting processes such as:
  - Habitat loss leading to population decline;
  - Habitat loss leading to population fragmentation;
  - Degradation of habitat due to weed invasion leading to population decline;
  - Ongoing mortality from operations;
  - Species interactions including feral and overabundant native species;
  - Hydrological change;
  - Altered fire regimes; and
  - Disturbance (dust, light, noise).
- The recommendation of actions to mitigate impacts.

Descriptions and background information on these values and processes can be found in Appendices 1 to 4. Based on this impact assessment process, the objectives of investigations are to: identify fauna values; review impacting processes with respect to these values and the proposed development; and provide recommendations to mitigate these impacts. Methods for investigations into the Cyclone deposit – transport corridor options are outlined in Section 3.

1.3 Description of Project

The Cyclone deposit is part of Diatreme Resources' Lost Sands Project. It is a mineral sands project located approximately 26km west of the WA/SA border, within the Great Victoria Desert (approximately 20km north of the GVD-NR, Great Victoria Desert Nature Reserve). As part of the development of this project, Diatreme Resources have identified three options for a proposed transport corridor, to allow for the transportation of mineral resources south to the Trans-Australia Railway Line.

The three options are between 229km and 405km in length.

Western Option (405km long). Heads westward from the Cyclone deposit, skirting the northern and western boundaries of the GVD-NR, before heading south to Loongana on the Trans-Australia Railway Line.

Central Option (252km long). Heads south to south-west from the Cyclone deposit, through the GVD-NR, to Forrest on the Trans-Australia Railway Line.

Eastern Option (229km long). Heads south-east from the Cyclone deposit to the north-eastern corner of the GVD-NR, on the WA/SA border, and then runs southwards, parallel to the border, to Deakin on the Trans-Australia Railway Line.

Key locations are:

- Cyclone deposit
- Three haul road options
- IBRA region boundaries
- Great Victoria Desert Nature Reserve boundary & eastern edge of Mamungari Conservation Park (in South Australia)
- Trans-Australia Railway Line, including Loongana, Forrest and Deakin
- WA/SA border
- Tjuntjuntjara community (and access roads)
- Carlisle, Shell and Forrest Lakes systems (marked as areas avoided for cultural reasons).
- Locations for Foot traverses (see Appendix 6, section 6.2);
- Motion Cameras (see Appendix 6, section 6.1); and
- Mole trenches (see Appendix 6, section 6.3)

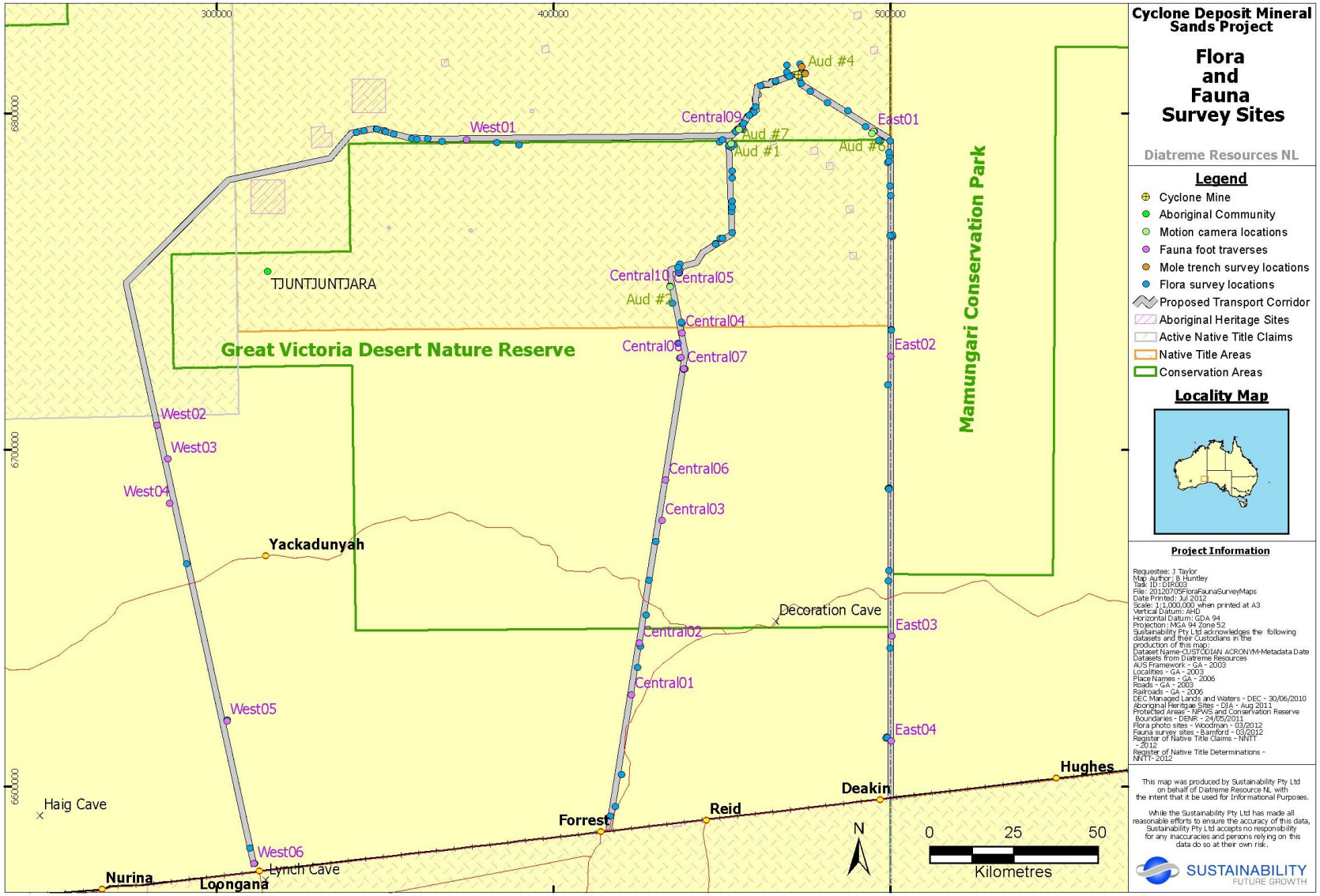

Figure 1. The project area, showing the Cyclone deposit and the three transport corridor options.

1.4 Description of Project Area

The three Cyclone Deposit transport corridor options cross two Bio-geographic regions as classified by the Interim Biogeographical Regionalisation for Australia (EA 2000; McKenzie *et al.* 2003, see Figure 2). In the north, the options cover one (central and eastern options) or two (western option) subregions of the Great Victoria Desert Bioregion, whilst in the south, all options cross the two subregions of the Nullarbor Bioregion.

The general features of the four subregions traversed by the transport corridor options are summarised by Barton and Cowan (GVD2/GVD3/NUL1, 2001a/2001b/2001c) and Barton *et al.* (NUL2, 2002). All four subregions experience an arid climate with non-seasonal rainfall patterns. Total annual rainfall is between 150-180mm (GVD2 and GVD3) and 150-200mm (NUL1 and NUL2).

Great Victoria Desert Bioregion

Including: GVD2 (Great Victoria Desert Central subregion: 14,286,995ha); and

GVD3 (Great Victoria Desert Eastern subregion: 5,051,155ha).

The two Great Victoria Desert subregions within the study area both contain the same broad landforms and vegetation types:

> "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 colluvial soils with *Eremophila* and *Santalum* spp., halophytes are confined to edges of salt lakes and saline drainage systems." (Barton and Cowan, 2001a, 2001b).

Nullarbor Bioregion

Including: NUL1 (Carlisle Plain subregion: 5,442,741ha); and

NUL2 (Nullarbor Central Band subregion: 10,169,146ha).

The Nullarbor Bioregion is largely contained within the Bunda Plateau, a large predominantly limestone plateau forming the onshore part of the Eucla Basin. The NUL1 subregion covers the Carlisle Plain on the northern edge of the Bioregion. When compared to NUL2 this subregion 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" (Barton and Cowan

2001c). The landforms and vegetation of this subregion are similar to those of the adjacent Great Victoria Desert Bioregion:

> "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 of NUL1. Includes *Myoporum platycarpum* and *E. oleosa* in the east and west and woodlands dominated by *Acacia aneura* (Mulga)." (Barton and Cowan, 2001c).

In comparison, the NUL2 subregion 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… …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." (Barton et. al. 2002).

Barton and Cowan (2001a, 2001b and 2001c) and Barton *et al.* (2002) provide information on significant fauna and ecosystems in the three subregions, and this information is included in the results of the literature review.

Figure 2. IBRA Subregions in Western Australia, with the Cyclone Deposit transport corridor options project area highlighted. Note the project area covers the Great Victoria Desert (subregions GVD2 and GVD3) and Nullarbor (subregions NUL1 and NUL2).

2 Methods

2.1 Overview

The methods used in these investigations are based upon the general approach to fauna investigations for impact assessment as outlined in Section 1.2 and with reference to Appendices 1 to 4. Thus, the impact assessment process involves the identification of fauna values, review of impacting processes and preparation of mitigation recommendations.

In addition, the approach to fauna impact assessment was carried out with reference to guidelines and recommendations set out by the Western Australian Environmental Protection Authority (EPA) on fauna surveys and environmental protection, and Commonwealth biodiversity legislation (EPA 2002; EPA 2004b). The EPA proposes two levels of investigation that differ in the approach to field investigations, Level 1 being a review of data and a site reconnaissance to place data into the perspective of the site, and Level 2 being a data review and intensive field investigations (eg. trapping and other intensive sampling). The level of assessment recommended by the EPA is determined by the size and location of the proposed disturbance, the sensitivity of the surrounding environment in which the disturbance is planned, and the availability of pre-existing data. This survey was conducted as a Level 1 reconnaissance, to familiarise the consultants with the VSA's of the route options and, if required, identify further survey work that may be required.

The following approach and methods is divided into three groupings that relate to the stages and the objectives of impact assessment:

- Desktop assessment. The purpose of the desktop review is to produce a species list that can be considered to represent the vertebrate fauna assemblage of the project area based on unpublished and published data using a precautionary approach.

- Field investigations. The purpose of the field investigations is to gather information on this assemblage: confirm the presence of as many species as possible (with an emphasis on species of conservation significance), place the list generated by the desktop review into the context of the environment of the project area, collect information on the distribution and abundance of this assemblage, and develop an understanding of the project area's ecological processes that maintain the fauna. Note that field investigations cannot confirm the presence of an entire assemblage, or confirm the absence of a species. This requires far more work than is possible in the EIA process. For example, in an intensive trapping study, How and Dell (1990) recorded in any one year only about 70% of the vertebrate species found over three years. In a study spanning over two decades, Bamford *et. al.* (2010) has found that the

vertebrate assemblage varies over time and space, meaning that even complete sampling at a set of sites only defines the assemblage of those sites at the time of sampling.

- Impact assessment. Determine how the fauna assemblage may be affected by the proposed development based on the interaction of the project with a suite of ecological and threatening processes.

2.2 Desktop Assessment

2.2.1 Sources of information

Information on the fauna assemblage of the project area was drawn from a wide range of sources. These included state and federal government databases and results of regional studies. Databases accessed were the DEC Naturemap (incorporating the Western Australian Museum's FaunaBase and the DEC Threatened and Priority Fauna Database), Birds Australia's Atlas Database (BA), the EPBC Protected Matters Search Tool and the BCE database (Table 1). Barton and Cowan (2001a, 2001b and 2001c) and Barton *et al.* (2002) provided information on significant species and ecosystems in each bioregion. Regional studies included the 1984 Nullarbor survey (McKenzie and Robinson, 1987) and work by Brooker and others (Brooker *et. al.* 1979; Brooker and Wombey, 1978; Brooker 1977).

Information from the above sources was supplemented with species expected in the area based on general patterns of distribution. Sources of information used for these general patterns were:

- Frogs: Tyler & Doughty (2009);
- Reptiles: Storr *et al.* (1983); Storr *et al.* (1990); Storr *et al.* (1999); Storr *et al.* (2002) and Wilson & Swan (2008);
- Birds: Blakers *et al.* (1984); Johnstone and Storr (1998, 2004) and Barrett *et al.* (2003); and
- Mammals: Menkhorst & Knight (2001); Strahan (2004); Churchill (2008); and Van Dyck and Strahan (2008).

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

Database	Type of records held on database	Area searched
NatureMap (DEC 2011)	Records in the WAM and DEC databases. Includes historical data and records on Threatened and Priority species in WA.	The four IBRA regions covered by the three transport corridor options: GVD2, GVD3, NUL1, NUL2
Birds Australia Atlas Database	Records of bird observations in Australia, 1998-2011.	A block covering 12 one degree squares: NW corner: 28°S, 126°E SE corner: 31°S, 130°E
EPBC Protected Matters Search Tool	Records on matters of national environmental significance protected under the EPBC Act, including threatened species and conservation estate.	A block with the NW corner @ 28.5°S, 126.2°E and the SE corner @ 31.2°S, 129.4°E.

2.2.2 Nomenclature and taxonomy

As per the recommendations of EPA (2004a), the nomenclature and taxonomic order presented in this report are based on the Western Australian Museum's (WAM) *Checklist of the Vertebrates of Western Australia* 2008. The authorities used for each vertebrate group are: amphibians and reptiles (Aplin & Smith 2008), birds (Christidis & Boles 2008; Johnstone 2008), and mammals (How *et al.* 2008). English names of species, where available, are used throughout the text; Latin species names are presented with corresponding English names in tables in the appendices.

2.3 Field Investigations

2.3.1 Overview of field investigations

Following an initial reconnaissance survey of the Cyclone Deposit in September 2011 (Everard, Bamford and Metcalf, 2011), this reconnaissance survey (conducted in March 2012) was primarily to assess the three transport corridor options for transporting the mineral resource of the Cyclone deposit, south to the Trans-Australia Railway line. Due to the lack of vehicle access to the three possible transport corridor routes, helicopters were used to fly-over the three routes and access areas of interest for further investigation.

In addition to a fauna assessment of the transport corridor options, a small-scale Marsupial Mole survey was undertaken within the Cyclone Deposit area.

2.3.2 Transport corridor options reconnaissance survey

The transport corridor option reconnaissance took place from the 22nd – 26th March 2012. Over these five days the entire length of all three routes were flown over and different vegetation/soil associations (VSA's) investigated along each route. This generally involved landing and conducting foot traverses for 0.5-1.5 hrs. Activities undertaken during the flight and/or foot traverses included:

- Searching for evidence of significant fauna either in-flight (e.g. Malleefowl) or during foot traverses (e.g. Giant Desert Skink, Mulgara);
- Recording vegetation and soil types throughout the alignment;
- Opportunistic observations on fauna (particularly birds); and
- Deploying motion-sensitive cameras set at five locations (see Appendix 6).

2.3.3 Marsupial Mole investigations.

Further to the reconnaissance survey conducted in September 2011 that focussed on the Cyclone deposit and adjacent areas, further investigations into the possible presence of Marsupial Moles within the region were conducted during the March 2012 visit. It should be noted that previous work by Benshemesh and Schulz (2008) recorded evidence of Moles ~35km to the north of the Cyclone deposit, suggesting it highly likely that evidence of Moles would be found in the study area. The March 2012 investigations were based on the Mole Trench survey methodology developed by Dr Joe Benshemesh (see Benshemesh, 2004); in summary:

- a series of three trenches were dug across a sand-dune, sampling the base, middle and crest of the dune;
- each trench was approximately 800mm deep x 1200mm long x 400mm wide;
- trenches were left for three to four days so that the trench walls could dry out, before one of the longer wall faces was smoothed off and inspected for evidence of backfilled marsupial mole tunnels (or molehole);
- for each trench, details recorded included:
  - Location (UTM Co-ordinates, WGS 84 datum);
  - Number of moleholes;
  - Topography (crest/midslope/base);
  - Trench dimensions (depth, width, height);
  - Fire age of surrounding landscape;
  - Root abundance (estimated number of large [>10mm thick], medium [1-10mm thick] and fine [<1mm] roots visible on trench wall in three levels [0-150mm, 150-350mm and 35-60mm]);
  - Vegetation type (plant spp. within 10m);

  - Vegetation cover (percentage estimated ground cover [below 1m] and cover of shrubs and trees [1m and above]);
  - Sand colour (white to red);
  - Soil crust (no surface cryptogamic crust, mix of crust and loose sand or continuous crust); and
  - Height (estimated height of the trench in relation to the base of the dune).
- for each mole hole, details recorded included:
  - Minimum and maximum diameter (mm);
  - Angle (0-90 degrees; only measured where the mole tunnel was at an angle to the trench wall);
  - Clarity (1: very unclear, 2: clear, 3: very clear);
  - Confidence (1: not confident object is made by mole, 2: confident, 3: very confident);
  - Age (1: very old, to 5: fresh with free-flowing sand); and
  - Depth (distance from the surface to the centre of the molehole).
- Trenches were filled in once all moleholes were recorded.

Figure 3.: Mole Trench

Figure 4.: Mole Hole

2.3.4 Licences and personnel

The reconnaissance survey was conducted under Department of Environment and Conservation (DEC) Regulation 17 licence number SF008215 and Regulation 4 licence number CE003323 (for work in the GVD-NR), both held in the name of Dr. Mike Bamford. Field personnel were:

- Brenden Metcalf (B.Sc. Hons. Env. Sc.);
- Peter Smith (Dip. Ag.); and
- Bruce Hogan of the Pila Nguru people (from Tjuntjuntjara community).

Figure 5.: Ctenophorus isolepis

Figure 6.: Ctenophorus nuchalis juvenile

Figure 7.: Moloch horridus

Figure 8.: Varanus gouldii

Figure 9.: Rainbow Bee-eater

Motion Camera Aud #6 – (Appendix 6)

Figure 10.: Hopping Mice

Figure 11.: Fox

Figure 12.: Feral Cat

2.4 Analysis and interpretation of data

2.4.1 Interpretation of species lists

Species lists generated from the review of sources of information are generous as they include records drawn from a large region and possibly from environments not represented in the project area. Therefore, some species that were returned by one or more of the data searches have been excluded because their ecology, or the environment 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 in the project area whether or not they were recorded during field surveys. This is because fauna are highly mobile, often seasonal and frequently cryptic. This is particularly important for significant species that are often rare and hard to find.

Interpretation of species lists generated through the desktop review included assigning an expected status within the project area to species of conservation significance. This is particularly important for birds that may naturally be migratory or nomadic, and for some mammals that can also be mobile or irruptive. The status categories used are:

- Resident: species with a population permanently present in the project area;
- Regular migrant or visitor: species that occur within the project area regularly in at least moderate numbers, such as part of annual cycle;
- Irregular Visitor: species that occur within the project area irregularly such as nomadic and irruptive species. The length of time between visitations could be decades but when the species is present, it uses the project area in at least moderate numbers and for some time;
- Vagrant: species that occur within the project area unpredictably, in small numbers and/or for very brief periods. Therefore, the project area is unlikely to be of important for the species; and
- Locally extinct: species that has not been recently recorded in the local area and therefore is almost certainly no longer present in the project area.

2.5 Survey limitations

The EPA Guidance Statement 56 (EPA 2004a) outlines a number of limitations that may arise during surveying. These survey limitations are discussed in the context of the BCE fauna survey at the project area in Table 2.

Table 2. Survey limitations as outlined by EPA (2004).

EPA Limitation	BCE Comment
Level of survey.	Level 1 (reconnaissance survey). This survey was designed to assess the three transport corridor options, with more detailed work to be completed in Spring 2012.
Competency/experience of the consultant(s) carrying out the survey.	The on-ground consultants have had extensive experience in conducting fauna assessments.
Scope. (What faunal groups were sampled and were some sampling methods not able to be employed because of constraints?)	Vertebrate fauna was identified to species (or genus) where possible, but the aim was to identify available habitats.
Proportion of fauna identified, recorded and/or collected.	All vertebrate fauna observed were identified to species level where possible.
Sources of information e.g. previously available information (whether historic or recent) as distinct from new data.	Sources include previous reports on the fauna of the region and databases (Naturemap, BA and EPBC).
The proportion of the task achieved and further work which might be needed.	Level 1 Survey complete. Further work may be required once the final transport corridor option is chosen.
Timing/weather/season/cycle.	The area had received above average rainfall in 2011, but there had been little in 2012 prior to the March survey. During the survey period conditions were generally cool to warm, with several overcast days and occasional very light showers; these conditions were considered suitable for the survey.
Disturbances (e.g. fire, flood, accidental human intervention etc.), which affected results of survey.	No disturbances affected the survey.
Intensity. (In retrospect, was the intensity adequate?)	Survey intensity was adequate for the purpose of assessing habitat suitability and identifying areas likely to support conservation significant fauna.
Completeness (e.g. was relevant area fully surveyed).	Although the entire length of all three transport corridor options was flown over, several areas of interest i.e. salt lakes, along the eastern and western routes were not accessible for cultural reasons.
Resources (e.g. degree of expertise available in animal identification to taxon level).	All vertebrate species identified to species level where possible. All staff are competent to conduct animal identification to taxon level.

Remoteness and/or access problems.	Helicopters were used to overcome access difficulties. Some areas were inaccessible for cultural reasons (in respect to the Pila Nguru people), although the likely fauna values of these areas are discussed.
Availability of contextual (e.g. biogeographic) information on the region.	Some regional information was available and was consulted.

2.6 Impact Assessment

While some impacts are unavoidable during a development, of concern are long-term, deleterious impacts upon biodiversity. This is reflected in documents such as the Significant Impact Guidelines provided by DSEWPaC (see Appendix 4). Significant impacts may occur if:

- There is direct impact upon a VSA and the VSA is rare, a large proportion of the VSA is affected and/or the VSA supports significant fauna.
- There is direct impact upon conservation significant fauna.
- Ecological processes are altered and this affects large numbers of species or large proportions of populations, including significant species.

The impact assessment process therefore involves reviewing the fauna values identified through the desktop assessment and field investigations with respect to the project and impacting processes. The severity of impacts on the fauna assemblage and conservation significant fauna can then be quantified on the basis of predicted population change (Table 3).

The presentation of this assessment follows the general approach to impact assessment as given in Section 1.2, but modified to suit the characteristics of the site and the field investigations for the Cyclone deposit – Transport corridor options project. Key components to the general approach to impact assessment are addressed as follows:

Fauna values

This section presents the results of the desktop and field investigations in terms of key fauna values (described in detail in Appendix 1):

- Assemblage characteristics (uniqueness, completeness and richness) - based upon desktop assessment and the reconnaissance survey;
- Species of conservation significance – based upon desktop assessment and reconnaissance;
- Recognition of ecotypes or vegetation/substrate associations (VSAs) - based upon desktop assessment and reconnaissance;
- Patterns of biodiversity across the landscape - based upon desktop assessment and reconnaissance for general patterns;
- Ecological processes upon which the fauna depend - based upon desktop assessment and reconnaissance.

Impact assessment

This section reviews impacting processes (as described in detail in Appendix 2) with respect to the project and examines the potential effect of these impacts upon biodiversity of the alignment. It thus expands upon the Project Description (Section 1.3) and discusses the contribution of the project to impacting processes, and the consequences of this with respect to biodiversity. A major component of impact assessment is consideration of threats to species of conservation significance as these are a major and sensitive element of biodiversity. Therefore, the impact assessment includes the following:

- Review of impacting processes; will the proposal result in:
    - Habitat loss leading to population decline, especially for significant species;
    - Habitat loss leading to population fragmentation, especially for significant species;
    - Weed invasion occur and lead to habitat degradation;
    - Ongoing mortality;
    - Species interactions that adversely affect native fauna, particularly significant species;
    - Hydrological change;
    - Altered fire regimes; and
    - Disturbance (dust, light, noise).
- Summary of impacts upon significant species, and other fauna values.

The impact assessment concludes with recommendations based upon predicted impacts and designed to mitigate these.

Table 3. Assessment criteria of impacts upon fauna**.**

Impact Category	**Observed Impact**
Negligible	Effectively no population decline; at most few individuals impacted and any decline in population size within the normal range of annual variability.
Minor	Short-term population decline (recovery after end of project) within project area, no change in viability of conservation status of population. Where environment permanently altered, no change in viability or conservation status of population
Moderate	Permanent population decline, change in viability or conservation status of population considered unlikely
Major	Permanent population decline resulting in change in viability or conservation status of population
Critical	Taxon extinction

3 Results

3.1 Fauna assemblage

The desktop study identified 267 vertebrate fauna species as potentially occurring in the project area (see Table 4 and Appendix 5). Species extinct in the region are listed separately under Appendix 5. The presence of 72 of the expected species was confirmed during field investigations (indicated in Appendix 5; see also field results in Appendix 6, including data from motion-sensitive cameras, and annotated species list from field investigations in Appendix 7). The assemblage includes at least 30 species of conservation significance, which are discussed further in Section 3.2. Conservation significant invertebrate species are also considered in Section 3.2. Key features of the assemblage are:

- Uniqueness: The assemblage varies considerably along the length of the three transport corridor options, with higher diversity in the north compared to that recorded in the central Nullarbor, at the southern end of the routes. Although quite depauperate, the Nullarbor does support a unique fauna assemblage, due to its unique VSA's. Because of the size and shape of the project area, many of the species included in the predicted assemblage are only expected along part of the three routes.

- Completeness: The assemblage almost entirely lacks a major component i.e. medium sized ("critical weight range") mammals. These have declined across much of southern Australia due to factors such as predation by feral species (particularly the Red Fox and feral Cat) and altered fire regimes (Burbidge and McKenzie 1989). Despite this, the assemblage is otherwise substantially complete because the transport corridor options cover largely undisturbed environments.

- Richness: the richness of the assemblage is expected to vary considerably along the length of the three route options, with higher richness in the north and lower richness in the south. The fauna assemblage at specific locations is likely to be a subset of the project area's assemblage, determined by factors such as biogeography, vegetation, soils and fire history.

As a fauna value, the most important features of the assemblage are that it is substantially complete and contains several threatened species.

Table 4. Composition of vertebrate fauna assemblage recorded or expected to occur along the Transport corridor options.

Taxon	Number of native (and introduced) species expected.	Number of native (and introduced) species recorded.	Significant fauna expected		
			CS1	CS2	CS3
Frogs	5 (0)	0 (0)	0	0	0
Reptiles	91 (1)	8 (1)	3	1	2
Birds	140 (0)	53 (0)	12	6	0
Mammals	31 (5)	5 (5)	3	2	1
Total	267 (6)	66 (6)	18	9	3

3.2 Species of conservation significance

Details on species of conservation significance are presented in Table 6. The list includes five reptile species, at least 18 bird species but with the potential for additional migratory waterbirds and six mammal species. Some of these species are considered unlikely to be present or to occur only as vagrants, but some are expected to be resident or regularly present, with some of these recorded during field investigations. Further information on these is presented below. No known conservation significant invertebrate species are expected to occur in the project area, but there is potential for short range endemic invertebrate species to occur.

3.2.1 Conservation significance level 1

Woma. Possibly present throughout the northern sections of the transport corridor options where the VSA's are more suitable i.e. the sandplains of the Great Victoria Desert and the Carlisle Plain.

Figure 13.: Woma – (EcoLogical Australia (Rob Browne-Cooper))

South-West Carpet Python. Probably present throughout the northern sections of the transport corridor options where the VSA's are more suitable.

Giant Desert Skink. Possibly present throughout the northern sections of the transport corridor options where the VSA's are more suitable i.e. dunefields of the Great Victoria Desert.

Malleefowl. Known to occur in the Great Victoria Desert. Possibly present in sandplain areas in the northern sections of the study area but, if present, likely to be in very low densities.

Eastern Cattle Egret. Listed under the CAMBA and JAMBA agreements as a migratory species. May occur after cyclonic rainfall.

Peregrine Falcon. Probably present throughout the northern sections of the transport corridor options where the VSA's are more suitable. Likely to breed only where there are large trees that provide hollows, or old nests of other species (eg Australian Raven).

Common Greenshank, Wood Sandpiper, Common Sandpiper, Red-necked Stint, Curlew Sandpiper. All migratory waterbirds that may utilise salt-lakes and depressions within the study area during wet years.

Major Mitchell's Cockatoo. Probably a scarce resident of the Great Victoria Desert and northern edges of the Nullarbor.

Naretha Blue-bonnet. Resident of the Myall woodland bordering the Nullarbor Plain. Moderately common in this vegetation type during the March 2012 survey.

Night Parrot. Possibly visits the area during suitable conditions, utilising salt-lake margins and surrounds.

Rainbow Bee-eater. Summer breeding visitor throughout project area. May construct nesting burrows on the edge of tracks or in sand-dunes.

Crest-tailed Mulgara. Status unknown within the study area. There is taxanomic uncertainty between the Crest-tailed and Brush-tailed Mulgara's, with records of both from nearby to the project area. If one or both species are present, it is likely to be within the north of the project area, where areas of mature Spinifex were recorded.

Sandhill Dunnart. Possibly occurs within the dune fields at the northern end of the project area. Known to utilise areas of mature Spinifex grassland.

Marsupial Mole. Resident within dune fields at the northern end of the project area. Evidence, in the form of "moleholes", was recorded from within the Cyclone deposit during this survey.

3.2.2 Conservation significance level 2

Ramphotyphlops margaretae (blind snake). Possibly occurs in the northern section of the project area; known from areas to the west and north-west of the GVD Nature Reserve.

Australian Bustard. Probably a resident of the area, with numbers expected to increase during better seasons. Likely to occur over the entire project area, but more commonly in the north. One recorded from the Nullarbor during this survey and several seen during the September 2011 trip.

Figure 14.: Australian Bustard – (EcoLogical Australia (Rob Browne-Cooper))

Princess Parrot. Known to occur at least periodically in the region; likely to utilise dunefields vegetated with Spinifex and shrublands, such as those present in the northern end of the project area.

Striated Grasswren. Possibly occurs in the northern sections of the study area, in those VSA's with a high cover of Spinifex. Known to occur north of the project area, as a resident in the GVD.

Western (Thick-billed) Grasswren. Possibly occurs in the northern sections of the study area, in those VSA's with a high cover of Spinifex.

Nullarbor Quail-thrush. Endemic to the Nullarbor Plain; one recorded from a donga on the plain during the March 2012 survey.

Crested Bellbird. Resident of the GVD and Myall woodland bordering the northern edge of the Nullarbor Plain. The population within this region is not exposed to the same threats as the Wheatbelt population; it is the Wheatbelt population's decline, largely in response to land-clearing, on which the taxa's status is based.

Brush-tailed Mulgara. Status unknown within the study area. There is taxonomic uncertainty between the Crest-tailed and Brush-tailed Mulgara, with records of both

from nearby to the project area. If one or both species are present, it is likely to be within the north of the project area, where areas of mature Spinifex were recorded.

Central Long-eared Bat. Probably resident within the northern sections of the project area, utilising larger trees for roosting sites.

3.2.3 Conservation significance level 3

Hemiergis millewae (a skink lizard). Several small isolated populations west of the project area and with the main population to the east of the project area. Considering the limited amount of work conducted in the region, it is possible that the species does occur with the project area.

Nullarbor Bearded Dragon. Endemic to the Nullarbor Plain.

Southern Hairy-nosed Wombat. The south-eastern corner of the project area represents the western edge of the species distribution, although there are anecdotal records of the species near Loongana (the southern end of the western route).

3.2.4 Summary of species of conservation significance

Significant species expected to occur along the alignment include a number of particular interest. These are:

- Southern Marsupial Mole (or Itjari-itjari).
- Sandhill Dunnart.
- Great Desert Skink.
- Nullarbor Quail-thrush.
- Nullarbor Bearded Dragon.
- SRE invertebrates, particularly in any karst areas at the southern end of the project area.

Table 5. Conservation status of significant fauna species expected to occur in the study (based on desktop review and field investigation). See Appendix 3 for descriptions of conservation significance levels. Species recorded are indicated and the predicted status of each species in the project is also given (as per Section 2.4.1).

CONSERVATION STATUS		CS1				CS2	CS3	Status in Project area
COMMON NAME	**SPECIES NAME**	**EPBC**	**WA Act**	**JAMBA**	**CAMBA**			
REPTILES								
Woma	*Aspidites ramsayi*		S4					Probable Resident
South-western Carpet Python	*Morelia spilota imbricata*		S4			P4		Probable Resident
Great Desert Skink	*Liopholis* (*Egernia*) *kintorei*	VU	S1 (VU)					Probable Resident
A blind snake	*Ramphotyphlops margaretae*					P2		Possible Resident
A skink	*Hemiergis millewae*						+	Possible Resident
Nullarbor Bearded Dragon	*Pogona nullarbor*						+	Resident (Endemic to the Nullarbor)
BIRDS								
Malleefowl	*Leipoa ocellata*	VU/Mig	S1 (VU)					Possible Resident (at very low densities)
Eastern Cattle Egret	*Ardea ibis*	Mig	S2 (Mig)					Irregular Visitor
Peregrine Falcon	*Falco peregrinus*		S4					Probable Resident
Common Greenshank, Wood Sandpiper, Common Sandpiper, Red-necked Stint, Curlew Sandpiper	*Tringa nebularia* *Tringa glareola* *Actitis hypoleucos* *Calidris ruficollis* *Calidris ferruginea*	Mig	S2 (Mig)					Occasional visitors to the area (following suitable weather conditions)
Major Mitchell's Cockatoo	*Cacatua leadbeateri*		S4					Possible resident
Naretha Blue-bonnet	*Northiella haematogaster narethae*		S4					Resident (common in the Myall woodlands bordering the true Nullarbor Plain)
Night Parrot	*Pezoporus occidentalis*	EN	S1 (CR)					Possible irregular visitor

CONSERVATION STATUS		CS1				CS2	CS3	Status in Project area
COMMON NAME	**SPECIES NAME**	**EPBC**	**WA Act**	**JAMBA**	**CAMBA**			
Rainbow Bee-eater	*Merops ornatus*	Mig	S2 (Mig)					Regular visitor
Australian Bustard	*Ardeotis australis*					P4		Resident (seen throughout the project area)
Princess Parrot	*Polytelis alexandrae*					P4		Irregular visitor
Striated Grasswren	*Amytornis striatus striatus*					P4		Possible resident
Western (Thick-billed) Grasswren	*Amytornis textilis*					P4		Possible resident
Nullarbor Quail-thrush	*Cinclosoma alisteri*					P4		Resident (endemic to the Nullarbor)
Crested Bellbird (southern)	*Oreoica gutturalis gutturalis*					P4		Resident (recorded in northern sections of the alignment)
MAMMALS								
Crest-tailed Mulgara	*Dasycercus cristicauda*	VU	S1 (VU)					Possible Resident
Sandhill Dunnart	*Sminthopsis psammophila*	EN	S1 (EN)					Probable Resident
Marsupial Mole	*Notoryctes typhlops*	EN	S1 (EN)					Resident (evidence found within the Cyclone deposit area)
Brush-tailed Mulgara	*Dasycercus blythi*					P4		Possible Resident
Inland Greater Long-eared Bat	*Nyctophilus major tor*					P4		Probable Resident
Southern Hairy-nosed Wombat	*Lasiorhinus latifrons*						+	Resident (known from areas south of the study area)
INVERTEBRATES								
SRE invertebrates							+	Some rare/unusual VSAs have features suitable for SRE species

3.3 Vegetation and Substrate Associations

The three transport corridor options for the Cyclone deposit traverse a range of land systems, soils, vegetation and even climates. Despite this, much of the route passes through VSAs that are extensive and broadly similar, with only a few locations with distinctive Associations. Six VSAs that provide habitat for fauna were identified during the site reconnaissance and are described below.

Mallee Eucalypt woodland over mixed shrubland and spinifex hummock grassland on red sand dunes (Figure 3 and Figure 4). This VSA was very extensive across the northern parts of the project area, covering much of the GVD and some areas of the northern Nullarbor Plain. It is expected that a number of conservation significant mammal species would preferentially utilise the dunes as corridors to move through the landscape. Traditional landscape burning practices undertaken by the local Pila Nguru people have ensured a range of fire ages are well represented across the extent of this VSA. This would aid in maintaining an intact assemblage of fauna species across the landscape.

- *Conservation Significance*: this VSA is expected to support a range of conservation significant species including Woma, Malleefowl, Princess Parrot, Sandhill Dunnart, Marsupial Mole, Brush-tailed/Crest-tailed Mulgara.

Sheoak (*Casuarina pauper*) woodland with mixed understorey on shallow calcareous loams (Figure 5 and Figure 6). This VSA is widespread across the northern section of the study area. Some areas support low breakaways, but the areas geology precludes the formation of deeper caves within these breakaways.

- *Conservation Significance*: likely to support a rich diversity of species, but not expected to be a preferred habitat for conservation significant fauna species.

Gypsum salt lakes with low samphire (Figure 7). There are numerous small isolated lakes spread across the study area along with several larger lake systems e.g. Carlisle, Shell and Forrest Lakes. Although these larger lake systems were within the impact area of two of the transport corridor options, they are culturally significant for the Pila Nguru people and consequently weren't visited during the March 2012 survey. This VSA often occurs in association with the Sheoak Woodland VSA.

- *Conservation Significance*: this VSA may support several conservation significant fauna including Night Parrot and Slender-billed Thornbill. This VSA is also significant due to its restricted occurrence.

Myall/Mulga woodland with mixed understorey on shallow calcareous soils (Figure 8). Widespread through the middle of the study area, as a band

between the GVD and Nullarbor Plain. Myall (*Acacia papyrocarpa*) appears to be the more dominant towards the Nullarbor Plain, whilst Mulga (*Acacia aneura*) is more dominant towards the GVD. The understorey is dominated by various chenopod and grass species.

- *Conservation Significance*: This VSA appears to be preferred by Naretha Blue-bonnets and may provide habitat for several other conservation significant fauna species e.g. Nullarbor Quail-thrush, Nullarbor Bearded Dragon.

Nullarbor Plain – a mosaic of low shrublands and grasslands on thin calcareous soils underlain by limestone (Figure 9). An extensive VSA, covering much of the NUL2 sub-bioregion and parts of the NUL1 sub-bioregion. This VSA is notable for its complete lack of any trees over such an extensive area.

- *Conservation Significance*: this VSA supports two endemic, conservation significant fauna species i.e. Nullarbor Quail-thrush and Nullarbor Bearded Dragon.

Dongas (Figure 10). These depressions, found in large numbers in the northern parts of the Nullarbor Plain, are notable for the tall shrublands/low open woodlands they support in comparison to the surrounding VSA of the Nullarbor Plain low shrubland/grassland mosaic. The Dongas vary in size with some between 10-150 metres in diameter recorded during the March 2012 survey. Although they collectively support a range of plant species, each Donga is usually dominated by one or perhaps two plant species.

- *Conservation Significance*: these areas may support higher densities of the Nullarbor endemic conservation significant fauna (e.g. Nullarbor Quail-thrush and Nullarbor Bearded Dragon) than the surrounding Nullarbor Plain and some are known to support a range of waterbird species when inundated (Brooker *et. al.* 1979).

3.3.1 Summary of Vegetation and Substrate Associations

Six broad VSAs occur along the alignment. Of these, Mallee Eucalypt woodlands on red sand dunes and Sheoak woodlands on calcareous soils are widespread across the northern parts of the project area, covering much of the GVD subregions. Gypsum salt lakes are scattered throughout the GVD, with several larger lake systems in the north-west and north-east. An extensive band of Myall/Mulga woodland runs through the middle of the study area, forming a northern edge to the Nullarbor Plain. The Nullarbor Plain is dominated by a mosaic of low shrublands and grasslands, with dongas scattered throughout.

The gypsum salt lakes of the GVD and the dongas of the Nullarbor Plain are the most restricted VSAs.

Although not recorded during the reconnaissance survey, there is potential for karst features in the southern end of the study area, with numerous caves known from the Nullarbor bioregion. These caves are recognised for their unique assemblages of troglodytes and stygofauna (Barton *et al.* 2002).

Figure 15.: Mallee Eucalypt woodland over mixed shrubland and spinifex hummock grassland on red sand dunes. Photo taken @ 52 J 438730 6723974.

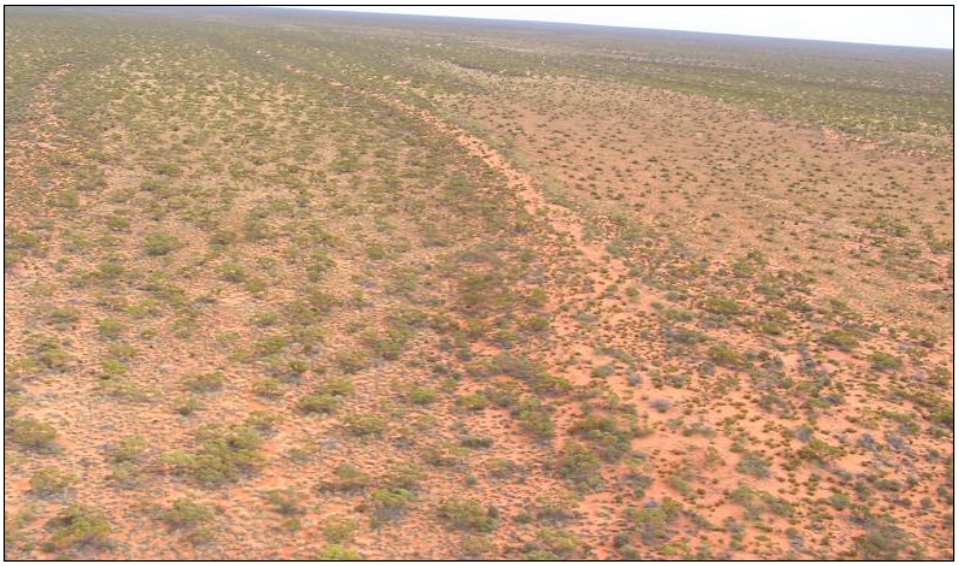

Figure 16.: Mallee Eucalypt woodland over mixed shrubland and spinifex hummock grassland on red sand dunes. Photo taken between 52 J 452722 6791011 and 52 J 434644 6748421. Note the three fire ages visible across the landscape i.e. oldest in the top right corner, younger vegetation on the left half of the picture and the youngest in the middle on the right side.

Figure 17.: Sheoak (*Casuarina pauper*) woodland with mixed understorey on shallow calcareous loams. Photo taken @ 52 J 455115 6795258.

Figure 18.: Sheoak (*Casuarina pauper*) woodland with mixed understorey on shallow calcareous loams. Photo taken @ 52 J 438730 6723974.

Figure 19.: Gypsum salt lakes with low samphire. Photo taken @ 52 J 455115 6795258.

Figure 20.: Myall woodland with mixed understorey on shallow calcareous soils. Photo taken @ 52 J 425495 6642492.

Figure 21.: Nullarbor Plain – a mosaic of low shrublands and grasslands. Photo on left @ 52 J 285417 6697217, middle @ 52 J 311004 6576992 and right @ 52 J 285938 6684056.

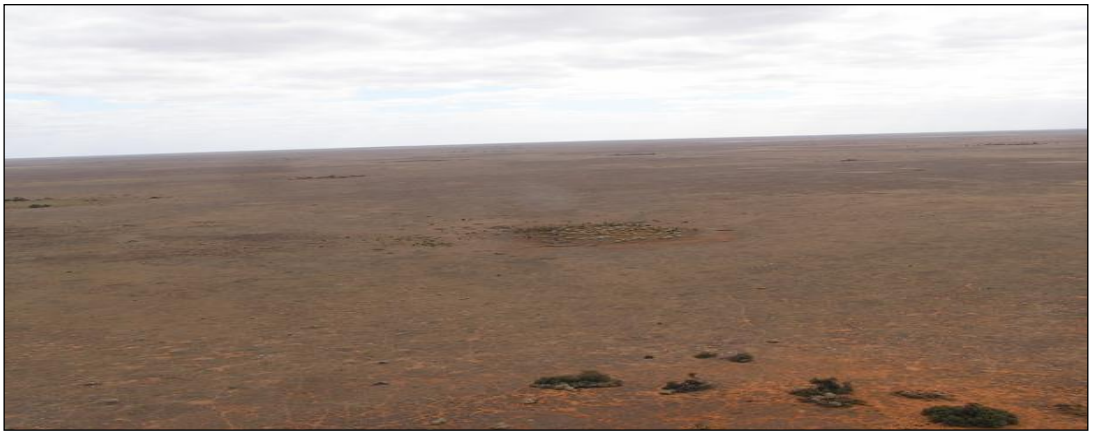

Figure 22.: Donga in centre of photo with numerous others in the background. Photo taken between 52 J 318850 6767028 and 52 J 500404 6644523.

3.4 Patterns of biodiversity and other field observations

The fauna assemblage can be expected to vary between VSA's, but as a broad overview it is expected to decrease in richness across a north-south gradient, with higher species diversity expected in the GVD and lower species diversity expected on the Nullarbor Plain.

- Mallee Eucalypt woodlands on sand dunes are expected to have a rich overall species with a variety of reptiles (especially fossorial species), woodland birds and numerous mammals, including conservation significant species.
- Sheoak woodlands and the Myall/Mulga woodlands are likely to support a rich bird fauna, but a limited number of reptile and mammal species.
- Although gypsum salt lakes are expected to support a limited number of fauna species, the assemblage is likely to be unique, including several reptiles and bird species that preferentially utilise this VSA.
- The shrublands and grasslands of the Nullarbor Plain are known to support a poor diversity of fauna (McKenzie and Robinson, 1987), possibly exacerbated by the overabundance of Feral Rabbits and their direct impact on vegetation/soil degradation.
- The dongas of the Nullarbor Plain are expected to support higher densities of fauna than the surrounding plain, but again these areas have been significantly degraded by overabundant Feral Rabbits. Some dongas may support waterbirds during periods of inundation.
- There is potential for karst formations in the Nullarbor bioregion, which would need to be avoided by the transport corridor.

The expected fauna assemblages correlated with the limited data collected during the March 2012 survey. It should be noted that changing climatic conditions may dramatically alter the fauna assemblage e.g. flooding from cyclonic rains may introduce a suite of waterbird/migratory shorebird species to VSA's where they are generally not recorded.

3.5 Key ecological processes in the project area

The Cyclone Deposit transport corridor options project area is extensive and diverse; the nature of the landscape and the fauna assemblages do indicate several ecological processes that may be important. These include:

Landscape permeability – the ability of fauna to move through the landscape. Two potential impacts from the proposed transport corridor options include the disruption of linear habitats that may form fauna corridors e.g. sand-dunes, and altering traditional fire regimes as maintained by the Pila Nguru people.

Some fauna species e.g. Marsupial Moles, Sandhill Dunnarts, Great Desert Skink, are expected to utilise sand dunes as fauna corridors. Consequently, any disruption to the sand dunes has the potential to disrupt the movement of fauna, and ultimately genes, through the landscape.

The traditional fire regimes maintained by the Pila Nguru have created a mosaic of different fire ages within the VSA's of the GVD. This mosaic effect was recognised by Pianka (1996) as a factor in maintaining the diversity of reptiles within the GVD. Care should be taken in any alteration of the current burning regime, as there is potential for long-term impacts to the VSA's and fauna assemblages of the region.

Local hydrology – although the Nullarbor and GVD regions are both considered arid, receiving an average annual rainfall of 150 – 200mm, they do periodically receive cyclonic rainfall which can result in some poorly drained areas being inundated. These areas may be utilised by a variety of waterbird/migratory shorebird species and potentially SRE invertebrates as well. The construction and placement of any transport corridor will need to account for these irregular inundations and ensure that local drainage is not impeded or otherwise altered.

Fauna interactions (introduced predators and herbivores). Introduced species, both predators and herbivores, are a major factor in the decline and local extinction of some mammal and bird species (Burbidge and McKenzie, 1998). Within the context of the current project this includes European Red Fox, Feral Cat, Feral Rabbits and Dromedary Camels; the former three species are all recognised as "Threatening Processes" under the EPBC act. Construction of the transport corridor may aid the movement of the Fox and Camel through the landscape (Mahon *et. al.* 1998; pers obs); both species are known to readily utilise roads move through the landscape.

Habitat degradation due to weed invasion. The proposed transport corridor options cover areas that currently have limited vehicle traffic. With the construction of a transport corridor and associated vehicle movements, comes the risk of introducing a variety of weed species into these areas, some of which have the potential to significantly alter the VSA's of the area thereby impacting the fauna assemblage.

3.6 Summary of fauna values

Fauna values through the Cyclone Deposit transport corridor options project area can be summarised as follows:

Fauna assemblage. Varied richness, decreasing along a north-south gradient, but substantially intact except for the loss of a suite of medium-size mammal species. Primarily Eremeaen (arid), but with some Bassian (Mediterranean) influences.

Species of conservation significance. This list includes five reptile species, at least 18 bird species (but with the potential for additional migratory waterbirds) and six mammal species, with the possibility of some Short Range Endemic (SRE) invertebrates). Species of note are the Southern Marsupial Mole (or Itjari-itjari), Sandhill Dunnart, Great Desert Skink, Nullarbor Quail-thrush, Nullarbor Bearded Dragon and potential SRE invertebrates, particularly in any karst areas at the southern end of the project area.

Vegetation and Substrate Associations. Generally widespread except for Gypsum salt lakes in the GVD and Dongas on the Nullarbor Plain. Karst areas may be present within the southern end of the project area.

Patterns of biodiversity. As a general rule, species richness decreases along a north-south gradient within the project area. The VSA's of the GVD in the north have higher species richness than those of the Nullarbor Plain in the south. The fauna assemblages of the Gypsum salt lakes (of the GVD) and Dongas (of the Nullarbor Plain) are not expected to be species rich, but are likely to be unique and potentially include several conservation significant species.

Key ecological processes. Main processes affecting the fauna assemblage along the alignment include landscape permeability (disruption of linear habitats utilised by fauna for movement, and traditional landscape burning regimes), local hydrology, fauna interactions (introduced predators and herbivores) and habitat degradation due to weed invasion.

4 Impact assessment

As outlined in section 1.3, the three transport corridor options allow for the transportation of mineral resource south from the Cyclone deposit to the Trans-Australia Railway Line. The three options are between 229km and 405km in length, with most, if not all, of the chosen route being a newly constructed transport corridor. The sorts of impacts upon fauna that can be expected as a result of the construction, presence and maintenance of the transport corridor are: habitat loss, habitat fragmentation (eg. disruption of linear habitats i.e. sand dunes, that are utilised by some fauna species as corridors for movement through the landscape), alteration to local hydrology, change in level of access by people/vehicles (affects disturbance, fire, weeds), and altered movement and abundance of introduced fauna along transport corridors. Impacting processes are discussed below and summarised in Table 6. Impacts on key fauna values are summarised in Table 7. Impact categories as per Table 3.

4.1 Loss of habitat leading to population decline

The area of habitat loss is small in any one location because the footprint is long and narrow, and most of the VSA's are widespread. Those VSA's that are not widespread i.e. Gypsum salt lakes and Dongas, should be easily avoided. Therefore, population declines due to direct habitat loss are expected to be Negligible to Minor. Little or no effect of habitat loss upon significant species expected.

4.2 Loss of habitat leading to population fragmentation

The transport corridor options, regardless of which options is chosen, will pass through dunefields, likely crossing numerous east-west orientated dunes. These dunes are potentially utilised by Great Desert Skink, Marsupial Moles and Sandhill Dunnarts (all CS1 species) as corridors allowing movement through the landscape. By disrupting the dunes, the transport corridor has the potential to locally disrupt the movement of these species through the landscape (referred to as landscape permeability). However, regardless of the type of transport corridor constructed, it is likely that any impact to fauna will be Minor.

4.3 Degradation of habitat due to weed invasion

The development of any transport corridor is likely to result in an increase in the weed diversity/density along the length of the route. There are already numerous weed species along the Trans-Australia Railway Line, based on Naturemap species lists for the Forrest area, and any increase in vehicle movement from these areas has the potential to aid the spread of these weeds. These weeds have the potential to alter VSAs within the study area, with unknown severity. The impact of weed invasion is expected to be Minor, or possibly Moderate where weeds dramatically alter VSAs within the project area.

4.4 Ongoing mortality

With the construction and operation of the transport corridor, there is potential for species to be impacted by ongoing mortality from roadkills. This has the potential to impact conservation significant species e.g. Woma, Malleefowl and Nullarbor Quail-thrush. For such species, the loss of only one or two individuals could be significant. The effects of increased mortality on such species could be Moderate.

4.5 Species interactions

Species interactions include effects of feral species, especially predators but also feral herbivores. The transport corridor is unlikely to impact feral Cat and/or Rabbit numbers, but it may aid in the movement of Foxes and Feral Camels through the project area, allowing them to easier access a broader area. This has the potential to impact native fauna through increased predation (foxes), alteration of VSAs (camels) and competition for food resources (foxes and camels). Overall, species interactions are anticipated to have Minor impact upon biodiversity.

4.6 Hydrological change

Hydrological impacts are expected to be localised as the project area has limited surface drainage, much of it terminating in either Gypsum salt lakes (in the GVD) or Dongas (on the Nullarbor). Both of these VSAs being uncommon within the landscape and therefore considered conservation significant. Drainage along the chosen transport route will need to be considered to ensure these VSAs are not adversely impacted, especially during periods of inundation. Impacts of hydrological change are expected to be Negligible or Minor.

4.7 Altered fire regimes

The current fire regime, as maintained by the Pila Nguru people, has created a mosaic of different fire ages across the range of vegetation types within the GVD section of the study area. It is expected that this mosaic effect has aided a range of fauna species, including conservation significant species, to maintain a viable population within the region. Although there is potential for conflict between maintaining the traditional burning regime and operation of the Cyclone deposit and associated transport corridor, it is expected that the area of land affected by such a situation would be minimal. As such the impacts of altered fire regimes are therefore anticipated to be Negligible to Minor.

4.8 Disturbance

Construction and operation of the transport corridor will result in an increase in disturbance, dust and light along the length of the corridor. Due to the narrow footprint of the transport corridor and widespread nature of the VSAs to be affected, the impacts of such an increase in disturbance, dust and light are expected to be Minor.

4.9 Summary of impacts across the project area

Impacts are summarised in Table 6 and Table 7. Most processes are expected to have only negligible or minor impacts, the exceptions being increased mortality (roadkill affecting significant fauna; moderate) and habitat degradation due to weed invasion (weeds spreading along the length of the transport corridor and altering VSAs, thereby affecting significant fauna; moderate). Impacts are generally considered to be only negligible or minor, even upon the majority of significant species (see Table 5) because of the long, narrow footprint and the widespread nature of most VSAs to be impacted.

Table 6. Summary assessment of impacting processes and the possible effects of the proposed development upon fauna values.

Impacting process	Impact
Habitat loss leading to population decline	**Negligible** to **Minor**. A long narrow footprint, with minimal impact to restricted VSAs expected. Little or no impact upon significant species anticipated.
Population fragmentation and disruption of movement and gene flow due to habitat fragmentation	**Minor.** Although the transport corridor will bisect habitats, it is not expected to disrupt the movement of most species through the landscape. Care should be taken to minimise impacts on sand dunes, which are likely to be utilised by several CS1 as corridors for movement through the landscape. Any such impacts to CS1 species are expected to be localised.
Increased mortality leading to population decline; e.g. due to ongoing roadkill	**Moderate**. Operation of the transport corridor is likely to result in roadkills, which could impact some CS1 species e.g. Woma, Malleefowl and Nullarbor Quail-thrush. For these species, loss of several individuals could be significant.
Habitat degradation due to weed invasion	**Minor** to **Moderate.** High potential for spread of weeds with vehicle movement along the newly created transport corridor. Appropriate hygiene practices will reduce this risk. Potential for any weeds that do establish in new areas to alter the VSAs, potentially impacting conservation significant fauna species within those VSAs.
Hydrological change	**Negligible** to **Minor**. Care to be taken around restricted VSAs where alteration to drainage could locally impact conservation significant fauna species.
Species interactions due to feral or over-abundant native species	**Minor**. Construction of the transport corridor is expected to aid the movement of introduced predators (e.g. fox) and herbivores (e.g. camels) through the project area, potentially increasing their impacts, both direct and indirect, upon conservation significant fauna.

Changes in fire regime	**Negligible** to **Minor**. Any alterations to the current fire regime are expected to impact minimal areas of land, therefore impacts will be localised.
Effects of disturbance, dust and light	**Minor.** Although disturbance and associated effects will increase, impacts are expected to be minimal.

Table 7. Summary of possible impacts upon key fauna values.

Fauna Value	Impacts from proposal	Significance of impacts
Fauna assemblage	Small loss of habitat	Negligible
VSAs	Small losses and generally of widespread VSAs. Restricted VSAs should be easily avoided, thereby minimising impacts.	Negligible
Southern Marsupial Mole	Some impacts to sand-dunes may have local impacts on the movement of this species	Minor
Sandhill Dunnart	Some impacts to sand-dunes may have local impacts on the movement of this species. There is potential for increased predation in areas adjacent to the chosen haul road option.	Minor
Great Desert Skink	Some impacts to sand-dunes may have local impacts on the movement of this species. There is potential for increased predation in areas adjacent to the chosen haul road option.	Minor
Nullarbor Quail-thrush	Potential for increased mortality from road-kills, which could impact viability of local populations	Moderate
Nullarbor Bearded Dragon	Minimal loss of habitat	Negligible
SRE Invertebrates	If chosen route impacts karst areas in the Nullarbor bioregion it may consequently impact associated SRE Invertebrates. Hence such areas should be avoided.	Minor to Moderate

4.10 Comparison of impacts between the three transport corridor options

The three haul road options cover the same VSA's across their length, with the main differences being:

- The length of the transport corridor option (between 229 and 405km);
- The extent of representation of different VSAs within the footprint of the three transport corridor options; and
- The existing land-uses and cultural values (e.g. GVD-NR, cultural significance for the Pila Nguru) and potential conflicts with the construction and operation of a transport corridor.

The various details, including issues and impacts, for each of the three transport corridor options are provided below.

Western Route (405km long)

Impact to VSAs. The gypsum salt lake VSA is strongly represented within this corridor option i.e. Shell and Carlisle Lake systems. All other VSAs have similar representation relative to other corridor options.

Land-use conflicts. Whilst this route avoids the GVD-NR, it does cross the Shell and Carlisle Lake systems, both considered culturally significant by the Pila Nguru people.

Fauna impacts. Because this route skirts the northern and western boundaries of the GVD-NR it is 60-75% longer than the other routes and consequently has a much larger footprint. Initial and ongoing impacts from the transport corridor will be larger than the other routes due to the increased length. The two lake systems it crosses are also considered conservation significant (as well as culturally significant).

Central Route (252km long)

Impact to VSAs. The gypsum salt lake VSA is poorly represented within this corridor option i.e. several small un-named lakes. All other VSAs have similar representation relative to other corridor options.

Land-use conflicts. The route crosses through the middle of the GVD-NR, thereby impacting the area's conservation value.

Fauna impacts. This route is of medium length relative to the other corridor options, 37% shorter than the western route and 10% longer than the eastern route. Therefore direct impacts associated with the footprint of the transport corridor are expected to intermediate of the other two options.

Eastern Route (229km long)

Impact to VSAs. The gypsum salt lake VSA is well represented within this corridor option i.e. Forrest Lake system. All other VSAs have similar representation relative to other corridor options.

Land-use conflicts. The route follows the WA/SA border, with some potential impacts to the GVD-NR (WA) and the Mamungari Conservation Park (SA) both of which abut the border for part of this option's length. Additionally, this route also impacts Forrest lakes, an area considered culturally significant by the Pila Nguru people.

Fauna impacts. The route is the shortest option, being 9-43% shorter than the other options and as such, the direct impacts from creating the corridor will be less than the other options. The option does currently cross through the Forrest lake system which is conservation significant due to the unique fauna assemblage it may support.

5 Recommendations

Recommendations for the minimisation of impacts can be drawn from the review of impacting processes.

- Habitat loss leading to population decline and/or population fragmentation. Minimise where possible, particularly where restricted VSAs are impacted. In this respect, the shorter options (i.e. the central and eastern) will have a smaller footprint and reduced impacts, compared to the western option.

- Degradation of habitat due to weed invasion. Vehicle hygiene to minimise transport of weeds into uncontaminated areas.

- Ongoing mortality. Roadkill likely to be the most significant source of ongoing mortality and difficult to regulate. Speed limits may be beneficial if locations of regular crossings by species such as Malleefowl are identified.

- Species interactions. Changes in the abundance of introduced predators and/or herbivores should be monitored. Where possible, these species should be controlled, in consultation with DEC, DAFWA (Dept, of Food and Agriculture, Western Australia) and the local Pila Nguru people, particularly if an increase in their densities is recorded.

- Hydrological change. Design the transport corridor to ensure local drainage patterns are not altered.

- Altered fire regimes. Ensure, where possible, that the chosen transport option will not interfere with the current fire regime, as conducted by the Pila Nguru people.

- Disturbance. As a precaution, light, noise and dust should be minimised during construction and operation of the transport corridor.

The Central and Eastern options are significantly shorter than the Western option; if chosen, they will significantly reduce the transport corridor's footprint. The Eastern option currently passes through the conservation (and culturally) significant Forrest lakes system. A variation of the Eastern option that passes west of the Forrest lake system before heading east to the border and southwards on its current route could potentially minimise all impacts.

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Appendix 1. Explanation of fauna values.

Fauna values are the features of a site and its fauna that contribute to biodiversity, and it is these values that are potentially at threat from a development proposal. Fauna values can be examined under the five headings outlined below. It must be stressed that these values are interdependent and should not be considered equal, but contribute to an understanding of the biodiversity of a site. Understanding fauna values provides opportunities to predict and therefore mitigate impacts.

Assemblage characteristics.

Uniqueness. This refers to the combination of species present at a site. For example, a site may support an unusual assemblage that has elements from adjacent biogeographic zones, it may have species present or absent that might be otherwise expected, or it may have an assemblage that is typical of a very large region. For the purposes of impact assessment, an unusual assemblage has greater value for biodiversity than a typical assemblage.

Completeness. An assemblage may be complete (ie. has all the species that would have been present at the time of European settlement), or it may have lost species due to a variety of factors. Note that a complete assemblage, such as on an island, may have fewer species than an incomplete assemblage (such as in a species-rich but degraded site on the mainland).

Richness. This is a measure of the number of species at a site. At a simple level, a species rich site is more valuable than a species poor site, but value is also determined, for example, by the sorts of species present.

Vegetation/substrate associations (VSAs)

VSAs combine broad vegetation types, the soils or other substrate with which they are associated, and the landform. In the context of fauna assessment, 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 since these may not incorporate soil and landform, and recognise floristics to a degree that VSAs do not. Vegetation types may also not recognise minor but often significant (for fauna) structural differences in the environment. VSAs also do not necessarily correspond with soil types, but may reflect some of these elements.

Because VSAs provide the habitat for fauna, they are important in determining assemblage characteristics. For the purposes of impact assessment, VSAs can also provide a surrogate for detailed information on the fauna assemblage. For example, rare, relictual or restricted VSAs should automatically be considered a significant

fauna value. Impacts may be significant if the VSA is rare, a large proportion of the VSA is affected and/or the VSA supports significant fauna. The disturbance of even small amounts of habitat in a localised area can have significant impacts to fauna if rare or unusual habitats are disturbed.

Patterns of biodiversity across the landscape

This fauna value relates to how the assemblage is organised across the landscape. Generally, the fauna assemblage is not distributed evenly across the landscape or even within one VSA. There may be zones of high biodiversity such as particular environments or ecotones (transitions between VSAs). There may also be zones of low biodiversity. Impacts may be significant if a wide range of species is affected even if most of those species are not significant *per se*.

Species of conservation significance

Species of conservation significance are of special importance in impact assessment. 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 *Western Australian Wildlife Conservation Act 1950* (Wildlife Conservation Act). In addition, the Western Australian DEC recognises priority levels, while local populations of some species may be significant even if the species as a whole has no formal recognition. Therefore, three broad levels of conservation significance can be recognised and are used for the purposes of this report and are outlined below. A full description of the conservation significance categories, schedules and priority levels mentioned below is provided in Appendix 3.

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

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 uses a series of Schedules to classify status, 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, as many colonies of waterbirds. The Western Australian Department of Environmental Protection, now DEC (2000), used this sort of interpretation to identify significant bird species in the Perth metropolitan area as part of the Perth Bushplan.

Many of the invertebrate species considered to be short range endemics (SREs) also fall within the CS3 category, as they have no legislative or published recognition and their significance is based on interpretation of distribution information. 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).

Introduced species

In addition to these conservation levels, species that have been introduced (INT) are indicated throughout the report. Introduced species may be important to the native fauna assemblage through effects by predation and/or competition.

Ecological processes upon which the fauna depend

These are the processes that affect and maintain fauna populations in an area and as such are very complex; for example, populations are maintained through the dynamic of mortality, survival and recruitment being more or less in balance, and these are affected by a myriad of factors. The dynamics of fauna populations in a project may be affected by processes such as fire regime, landscape patterns (such as fragmentation and/or linkage), the presence of feral species and hydrology. Impacts may be significant if processes are altered such that fauna populations are adversely affected, resulting in declines and even localised loss of species. Threatening processes as outlined below are effectively the ecological processes that can be altered to result in impacts upon fauna.

Appendix 2. Explanation of threatening processes

Potential impacts of proposed developments upon fauna values can be related to threatening processes. This is recognised in the literature and under the EPBC Act, in which threatening processes are listed (see Appendix 4). Processes that may impact fauna values are discussed below. Rather than being independent of one another, processes are complex and often interrelated. They are the mechanisms by which fauna can be affected by development. Impacts may be significant if large numbers of species or large proportions of populations are affected.

Loss of habitat affecting population survival

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.

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 also affect movement of small, terrestrial species. Fragmented populations may not be sustainable and may be sensitive to effects such as reduced gene flow.

Degradation of habitat due to weed invasion leading to population decline

Weed invasion can occur as a result of development and if this alters habitat quality, can lead to effects similar to habitat loss.

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 ((Scheick & Jones 1999; Clevenger & Waltho 2000; Jackson & Griffin 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.

Species interactions, including predation and competition

Changes in species interactions often occur with development. Introduced species, including the feral Cat, Fox and Rabbit may have adverse impacts upon native species and development can alter their abundance. In particular, some mammal species are very 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 & McKenzie 1989). Introduced grazing species, such as the Rabbit, Goat, Camel and domestic livestock, can also degrade habitats and deplete vegetation that may be a food source for other species.

Changes in the abundance of some native species at the expense of others, due to the provision of fresh watering points, can also be a concern. (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. Common, water-dependent birds were found to out-compete some less common, water-independent species. Over-abundant native herbivores, such as kangaroos, can also adversely affect less abundant native species through competition and displacement.

Hydroecology

Interruptions of hydroecological processes can have major effects because they underpin primary production in ecosystems and there are specific, generally rare habitats that are hydrology-dependent. Fauna may be impacted by potential changes to groundwater level and chemistry and altered flow regime. These changes may alter vegetation across large areas and may lead to habitat degradation or loss. Impacts upon fauna can be widespread and major.

Changes to flow regime across the landscape may alter vegetation and may lead to habitat degradation or loss, affecting fauna. 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.

Fire

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 in fire regime, whether to more frequent or less frequent fires, may be significant to some fauna. Impacts of severe fire may be devastating to species already occurring at low densities or to species requiring long unburnt habitats to survive. Fire management may be considered the responsibility of managers of large tracts of land.

Dust, light, noise and vibration

Impacts of dust, light, noise and vibration upon fauna are difficult to predict. Some studies have demonstrated the impact of artificial night lighting on fauna, with lighting affecting fauna behaviour more than noise ((Rich & Longcore 2006)). Effects can 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 very large numbers of insects has been observed around some remote mine sites and attracts other fauna, notably native and introduced predators (M.Bamford pers. obs). 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 & Longcore 2006). Artificial night lighting may also lead to disorientation of migratory birds. Aquatic habitats and open habitats such as grasslands and dunes may be vulnerable to light spill.

Appendix 3. 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* and the Western Australian *Wildlife Conservation Act*.

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.

Schedules used in the *WA Wildlife Conservation Act*

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

WA Department of Conservation and Land Management Priority species (species not listed under the Conservation Act, 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 4. Ecological and threatening processes identified under legislation and in the literature.

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.

Threatening processes (EPBC Act)
Under the EPBC Act (1999), 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 federal 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 km2 (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*); and
- The reduction in the biodiversity of Australian native fauna and flora due to the red imported fire ant, *Solenopsis invicta*.

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.

In addition to the above processes, the DSEWPaC has produced Significant Impact Guidelines that provide criteria for the assessment of the significance of impacts. These criteria provide a framework for the assessment of significant impacts. The criteria are listed below.

Will the proposed action lead to a long-term decrease in the size of a population.
Will the proposed action will reduce the area of occupancy of the species.
Will the proposed action fragment an existing population.
Will the proposed action adversely affect habitat critical to the survival of a species.
Will the proposed action will disrupt the breeding cycle of a population.
Will the proposed action modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.
Will the proposed action result in introducing invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat.
Will the proposed action introduce disease that may cause the species to decline.
Will the proposed action will interfere with the recovery of the species.

Appendix 5. Species lists derived from database searches and field investigations.

See Methods for an explanation of Status. In the Records column, "+" denotes those species recorded in the field.

Table 8. Frogs that may be present in the project area.

Species		Status	Record
Hylidae			
Main's Frog	*Cyclorana maini*		
Myobatrachidae			
	Neobatrachus aquilonius		
Kunapulari's Frog	*Neobatrachus kunapulari*		
	Neobatrachus sutor		
	Pseudophyrne occidentalis		
	Number of frog species expected: 5 **Number of frog species recorded: 0**		

Table 9. Reptiles that may be present in the project area.

Species		Status	Record
Gekkonidae (geckoes)			
Fat-tailed Gecko	*Diplodactylus conspicillatus*		
	Diplodactylus granariensis		
	Diplodactylus pulcher		
	Diplodactylus stenodactylus		
	Gehyra purpurascens		
Tree Dtella	*Gehyra variegata*		
Asian House Gecko	*Hemidactylus frenatus*	INT.	+
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)			
	Delma australis		
Butler's Legless-lizard	*Delma butleri*		
	Delma fraseri/petersoni		
Burton's Legless-Lizard	*Lialis burtonis*		
Western Hooded Scaleyfoot	*Pygopus nigriceps*		

Species		Status	Record
Southern Scaleyfoot	*Pygopus lepidopodus*		
Agamidae (dragons)			
Long-nosed Tree-Dragon	*Amphibolurus longirostris*		+
Mulga Dragon	*Caimanops amphiboluroides*		
	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*		+
Western Netted Dragon	*Ctenophorus reticulatus*		
	Diporiphora winnecki		
Thorny Devil	*Moloch horridus*		+
Western Bearded Dragon	*Pogona minor*		
Nullarbor Bearded Dragon	*Pogona nullarbor*		
	Tympanocryptis houstoni		
Scincidae (skink lizards)			
	Cryptoblepharus australis		
	Cryptoblepharus buchananii		
	Cryptoblepharus plagiocephalus		
	Ctenotus atlas		
	Ctenotus ariadnae		
	Ctenotus brooksi		
	Ctenotus calurus		
	Ctenotus dux		
	Ctenotus grandis		
	Ctenotus greeri		
	Ctenotus helenae		
	Ctenotus leae		
	Ctenotus leonhardii		
	Ctenotus orientalis		
	Ctenotus pantherinus		
	Ctenotus piankai		
	Ctenotus quattuordecimlineatus		
	Ctenotus regius		
	Ctenotus schomburgkii		
Slender Blue-tongue	*Cyclodomorphus melanops*		
Broad-banded Sand Swimmer	*Eremiascincus richardsonii*		

Species		Status	Record
	Hemiergis millewae	CS3	
	Lerista bipes		
	Lerista desertorum		
	Lerista labialis		
	Lerista muelleri		
	Lerista picturata		
	Lerista rhodonoides		
	Lerista taeniata		
Desert Skink	*Liopholis inornata*		
Great Desert Skink	*Liopholis kintorei*	CS1	
	Liopholis striata		
Grey's Skink	*Menetia greyii*		+
	Morethia adelaidensis		
	Morethia boulengeri		
	Morethia butleri		
	Morethia obscura		
	Proablepharus reginae		
Central Blue-tongue	*Tiliqua multifasciata*		
Western Blue-tongue	*Tiliqua occipitalis*		
Bobtail	*Tiliqua rugosa*		+
Varanidae (monitors or goannas)			
Short-tailed Pygmy Monitor	*Varanus brevicauda*		
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		
	Ramphotyphlops margaretae	CS2	
	Ramphotyphlops waitii		
Boidae (pythons)			
Woma	*Aspidites ramsayi*	CS1	
Carpet Python (SW Subsp.)	*Morelia spilota imbricata*	CS1	
Elapidae (front-fanged snakes)			
Desert Death Adder	*Acanthophis pyrrhus*		
Narrow-banded Shovel-nosed Snake	*Brachyurophis fasciolatus*		
Southern Shovel-nosed Snake	*Brachyurophis semifasciata*		

Species		Status	Record
Yellow-faced Whipsnake	*Demansia psammophis*		
Moon Snake	*Furina ornata*		
Monk Snake	*Parasuta monachus*		
Mulga Snake	*Pseudechis australis*		+
Ringed Brown Snake	*Pseudonaja modesta*		
Gwardar	*Pseudonaja nuchalis*		
Jan's Banded Snake	*Simoselaps bertholdi*		
Number of reptile species expected: 93 **Number of reptile species recorded: 9**			

Table 10. Birds that may be present in the project area.

Species		Status	Record
Dromaiidae (Emu)			
Emu	*Dromaius novaehollandiae*		
Megapodiidae (Megapodes)			
Malleefowl	*Leipoa ocellata*	CS1	
Phasianidae (Pheasants, Fowl & Allies)			
Stubble Quail	*Coturnix pectoralis*		+
Anatidae (Ducks, Geese & Swans)			
Black Swan	*Cygnus atratus*		
Australian Shelduck	*Tadorna tadornoides*		
Pink-eared Duck	*Malacorhynchus membranaceus*		
Maned Duck	*Chenonetta jubata*		
Pacific Black Duck	*Anas superciliosa*		
Grey Teal	*Anas gracilis*		
Podicipedidae (Grebes)			
Australasian Grebe	*Tachybaptus novaehollandiae*		
Hoary-headed Grebe	*Poliocephalus poliocephalus*		
Threskiornithidae (Ibises, Spoonbills)			
Australian White Ibis	*Threskiornis molucca*		
Straw-necked Ibis	*Threskiornis spinicollis*		
Ardeidae (Herons, Bitterns)			
White-faced Heron	*Egretta novaehollandiae*		
Eastern Cattle Egret	*Ardea ibis*	CS1	
Pelecanidae (Pelicans)			
Australian Pelican	*Pelecanus conspicillatus*		
Accipitridae (Kites, Hawks & Eagles)			
Square-tailed Kite	*Lophoictinia isura*		

Species		Status	Record
Black-shouldered Kite	*Elanus axillaris*		+
Whistling Kite	*Haliastur sphenurus*		
Spotted Harrier	*Circus assimilis*		+
Brown Goshawk	*Accipiter fasciatus*		
Collared Sparrowhawk	*Accipiter cirrocephalus*		
Wedge-tailed Eagle	*Aquila audax*		+
Little Eagle	*Hieraaetus morphnoides*		
Falconidae (Falcons)			
Nankeen Kestrel	*Falco cenchroides*		
Australian Hobby	*Falco longipennis*		+
Brown Falcon	*Falco berigora*		+
Peregrine Falcon	*Falco peregrinus*	CS1	+
Otididae (Bustards)			
Australian Bustard	*Ardeotis australis*	CS2	+
Turnicidae (Buttonquail)			
Little Button-quail	*Turnix velox*		
Recurvirostridae (Stilts, Avocets)			
Black-winged Stilt	*Himantopus himantopus*		
Banded Stilt	*Cladorhynchus leucocephalus*		
Red-necked Avocet	*Recurvirostra novaehollandiae*		
Scolopacidae (Sandpipers and Stints)			
Common Greenshank	*Tringa nebularia*	CS1	
Wood Sandpiper	*Tringa glareola*	CS1	
Common Sandpiper	*Actitis hypoleucos*	CS1	
Red-necked Stint	*Calidris ruficollis*	CS1	
Curlew Sandpiper	*Calidris ferruginea*	CS1	
Charadriidae (Plovers)			
Banded Lapwing	*Vanellus tricolor*		
Red-kneed Dotterel	*Erythrogonys cinctus*		
Inland Dotterel	*Peltohyas australis*		
Red-capped Plover	*Charadrius ruficapillus*		
Black-fronted Dotterel	*Elseyornis melanops*		
Laridae (Gulls, Terns)			
Silver Gull	*Chroicocephalus novaehollandiae*		
Gull-billed Tern	*Gelochelidon nilotica*		
Whiskered Tern	*Chlidonias hybrida*		
Columbidae (Pigeons, Doves)			
Common Bronzewing	*Phaps chalcoptera*		+

Species		Status	Record
Crested Pigeon	*Ocyphaps lophotes*		?
Cacatuidae (Cockatoos)			
Major Mitchell's Cockatoo	*Lophochroa leadbeateri*	CS1	
Galah	*Eolophus roseicapilla*		+
Cockatiel	*Nymphicus hollandicus*		
Psittacidae (Parrots)			
Australian Ringneck	*Barnardius zonarius*		+
Naretha Blue-bonnet	*Northiella haematogaster narethae*	CS1	+
Mulga Parrot	*Psephotus varius*		+
Bourke's Parrot	*Neopsephotus bourkii*		
Scarlet-chested Parrot	*Neophema splendida*		
Budgerigar	*Melopsittacus undulatus*		
Night Parrot	*Pezoporus occidentalis*	CS1	
Princess Parrot	*Polytelis alexandrae*	CS2	
Cuculidae (Cuckoos)			
Horsfield's Bronze Cuckoo	*Chrysococcyx basalis*		
Black-eared Cuckoo	*Chrysococcyx osculans*		
Pallid Cuckoo	*Cacomantis pallidus*		
Tytonidae (Barn Owls)			
Eastern Barn Owl	*Tyto delicatula*		?
Strigidae (Hawk Owls)			
Southern Boobook	*Ninox novaeseelandiae*		
Podargidae (Frogmouths)			
Tawny Frogmouth	*Podargus strigoides*		+
Caprimulgidae (Nightjars)			
Spotted Nightjar	*Eurostopodus argus*		+
Aegothelidae (Owlet-nightjars)			
Australian Owlet-nightjar	*Aegotheles cristatus*		+
Alcedinidae (Kingfishers)			
Red-backed Kingfisher	*Todiramphus pyrrhopygius*		
Meropidae (Bee-eaters)			
Rainbow Bee-eater	*Merops ornatus*	CS1	
Climacteridae (Australasian Treecreepers)			
White-browed Treecreeper	*Climacteris affinis*		
Rufous Treecreeper	*Climacteris rufus*		+
Maluridae (Australasian Wrens)			
Splendid Fairy-wren	*Malurus splendens*		
Variegated Fairy-wren	*Malurus lamberti*		+

Species		Status	Record
White-winged Fairy-wren	*Malurus leucopterus*		+
Rufous-crowned Emu-wren	*Stipiturus ruficeps*		
Striated Grass-wren	*Amytornis striatus*	CS2	
Western (Thick-billed) Grass-wren	*Amytornis textilis*	CS2	
Pardalotidae (Pardalotes)			
Striated Pardalote	*Pardalotus striatus*		
Red-browed Pardalote	*Pardalotus rubricatus*		
Acanthizidae (Australasian Warblers)			
Rufous Fieldwren	*Calamanthus campestris*		?
Redthroat	*Pyrrholaemus brunneus*		
Weebill	*Smicrornis brevirostris*		+
Western Gerygone	*Gerygone fusca*		
Inland Thornbill	*Acanthiza apicalis*		+
Chestnut-rumped Thornbill	*Acanthiza uropygialis*		+
Slender-billed Thornbill	*Acanthiza iredalei*		
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*		+
Slaty-backed Thornbill	*Acanthiza robustirostris*		+
Southern Whiteface	*Aphelocephala leucopsis*		+
Meliphagidae (Honeyeaters)			
Singing Honeyeater	*Lichenoctomus virescens*		+
Grey-headed Honeyeater	*Lichenostomus keartlandi*		
Grey-fronted Honeyeater	*Lichenostomus plumulus*		
Yellow-plumed Honeyeater	*Lichenostomus ornatus*		+
White-fronted Honeyeater	*Purnella albifrons*		
Yellow-throated Miner	*Manorina flavigula*		+
Spiny-cheeked Honeyeater	*Acanthagenys rufogularis*		+
Red Wattlebird	*Anthochaera carunculata*		
Grey Honeyeater	*Conopophila whitei*		
Pied Honeyeater	*Certhionyx variegatus*		
Black Honeyeater	*Sugomel nigrum*		
Crimson Chat	*Epthianura tricolor*		
Orange Chat	*Epthianura aurifrons*		+
Pomatostomidae (Australasian Babblers)			
White-browed Babbler	*Pomatostomus superciliosus*		+
Psophodidae (Quail-thrushes)			
Chestnut Quail-thrush	*Cinclosoma castanotum*		+
Nullarbor Quail-thrush	*Cinclosoma alisteri*	CS2	+
Chestnut-breasted Quail-thrush	*Cinclosoma castaneothorax*		+

Species		Status	Record
Cracticidae (Butcherbirds and Allies)			
Grey Butcherbird	*Cracticus torquatus*		+
Pied Butcherbird	*Cracticus nigrogularis*		+
Australian Magpie	*Gymnorhina tibicen*		+
Grey Currawong	*Strepera versicolor*		+
Artamidae (Woodswallows)			
Masked Woodswallow	*Artamus personatus*		
White-browed Woodswallow	*Artamus superciliosus*		
Black-faced Woodswallow	*Artamus cinereus*		
Dusky Woodswallow	*Artamus cyanopterus*		
Little Woodswallow	*Artamus minor*		
Campephagidae (Cuckoo-shrikes)			
Ground Cuckoo-shrike	*Coracina maxima*		
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*		+
White-winged Triller	*Lalage tricolor*		
Neosittidae (Sittellas)			
Varied Sittella	*Daphoenositta chrysoptera*		+
Pachycephalidae (Whistlers and Allies)			
Grey Shrike-thrush	*Colluricincla harmonica*		+
Gilbert's Whistler	*Pachycephala inornata*		+
Rufous Whistler	*Pachycephala rufiventris*		
Crested Bellbird (wheatbelt subsp.)	*Oreoica g. gutturalis*	CS2	+
Rhipiduridae (Fantails)			
Willie Wagtail	*Rhipidura leucophrys*		+
Grey Fantail	*Rhipidura albiscapa*		
Monarchidae (Monarchs)			
Magpie-lark	*Grallina cyanoleuca*		+
Corvidae (Crows and Ravens)			
Torresian Crow	*Corvus orru*		
Little Crow	*Corvus bennetti*		+
Petroicidae (Australasian Robins)			
Hooded Robin	*Melanodryas cucullata*		+
Jacky Winter	*Microeca fascinans*		+
Red-capped Robin	*Petroica goodenovii*		+
Hirundinidae (Swallows, martins)			
White-backed Swallow	*Cheramoeca leucosterna*		
Welcome Swallow	*Hirundo neoxena*		+
Fairy Martin	*Petrochelidon ariel*		

Species		Status	Record
Tree Martin	*Petrochelidon nigricans*		
Megaluridae (Grassbirds and allies)			
Rufous Songlark	*Cincloramphus mathewsi*		
Brown Songlark	*Cincloramphus cruralis*		
Dicaeidae (Flowerpeckers)			
Mistletoebird	*Dicaeum hirundinaceum*		
Estrildidae (Finches & Allies)			
Zebra Finch	*Taeniopygia guttata*		
Motacillidae (Wagtails, Pipits)			
Australian Pipit	*Anthus australis*		+
Number of bird species expected: 140 **Number of bird species recorded: 53**			

Table 11. Mammals that may be present in the project area.

Species		Status	Record
Tachyglossidae (echidna)			
Echidna	*Tachyglossus aculeatus*		
Dasyuridae (carnivorous marsupials)			
Kultarr	*Antechinomys laniger*		
Crest-tailed Mulgara	*Dasyurus cristcauda*	CS1	
Brush-tailed Mulgara	*Dasyurus blythi*	CS2	
Ride's Ningaui	*Ningaui ridei*		
Mallee Ningaui	*Ningaui yvonneae*		
Fat-tailed Dunnart	*Sminthopsis crassicaudata*		
Gilbert's Dunnart	*Sminthopsis gilberti*		
Hairy-footed Dunnart	*Sminthopsis hirtipes*		
Ooldea Dunnart	*Sminthopsis ooldea*		
Sandhill Dunnart	*Sminthopsis psammophila*	CS1	
Notoryctidae (Marsupial Moles)			
Southern Marsupial Mole	*Notoryctes typhlops*	CS1	+ [1]
Vombatidae (Wombats)			
Southern Hairy-nosed Wombat	*Lasiorhinus latifrons*	CS3	
Burramyidae (Pygmy-possum)			
Western Pygmy Possum	*Cercartetus concinnus*		
Macropodidae (kangaroos)			
Euro	*Macropus robustus*		
Western Grey Kangaroo	*Macropus fuliginosus*		+

Species		Status	Record
Red Kangaroo	*Macropus rufus*		+
Molossidae (freetail bats)			
Inland Freetail Bat	*Mormopterus* aff. *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*		
Central Long-eared Bat	*Nyctophilus major tor* (formerly *N. timoriensis*)	CS2	
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	+
Mitchell's Hopping Mouse	*Notomys mitchelli*		+[2]
Spinifex Hopping Mouse	*Notomys alexis*		+[2]
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 **Number of mammal species recorded: 10**			

[1]: numerous holes believed to belong to this species were recorded within sand-dune country within the Cyclone Deposit area.
[2]: numerous photos of Hopping-Mice were taken with the motion sensitive cameras, however the exact species is unable to be confirmed i.e *Notomys alexis* and *N.mitchelli* are both possible within the area.

Table 12. Species considered locally extinct within the project area

Species		Status
Dasyuridae (carnivorous marsupials)		
Chuditch	*Dasyurus geoffroii*	CS1 – Vulnerable
Peramelidae (Bandicoots and Bilbies)		
Desert Bandicoot	*Perameles eremiana*	CS1 – Extinct
Pig-footed Bandicoot	*Chaeropus ecaudatus*	CS1 – Extinct
Golden Bandicoot	*Isoodon auratus*	CS1 – Vulnerable
Western Barred Bandicoot	*Perameles bougainville*	CS1 – Endangered
Greater Bilby	*Macrotis lagotis*	CS1 – Vulnerable
Potoroidae (Potoroos and Bettongs)		
Burrowing Bettong	*Bettongia leseur*	CS1 - Vulnerable
Brush-tailed Bettong	*Bettongia pencillata*	CS1 - Endangered
Macropodidae (Kangaroos and Wallabies)		
Mala (Rufous Hare Wallaby)	*Lagorchestes hirsutus*	CS1 – Endangered?
Crescent Nail-tailed Wallaby	*Onychogalea lunata*	CS1 – Extinct
Muridae (rodents)		
Greater Stick-nest Rat	*Leporillus conditor*	CS1 - Vulnerable
Lesser Stick-nest Rat	*Leporillus apicalis*	CS1 - Extinct
Dusky Hopping Mouse	*Notomys fuscus*	CS1 - Endangered
Plains Rat	*Pseuodmys australis*	CS1 - Vulnerable
Djoongari (Shark Bay Mouse)	*Pseudomys fieldi*	CS1 - Vulnerable

Appendix 6. Field data, including fauna records and site descriptions.

6.1 Motion Camera Locations and Records

Camera	Location	Site Photo	Start-End Date	Site Description	Photo Descriptions
Aud #1	52 J 452726 6790981		22nd – 26th March	Small ledge with ancient stick-nest rat nest remains.	No photos taken.
Aud #2	52 J 434656 6748374		24th – 26th March	Dune crest.	180 photos taken, 106 with animals. Most photos show hopping mice (*Notomys* sp.) some with both large & small individuals, probably adult *N. mitchellii* and juvenile but possibly *N. mitchellii* & *N. alexis*. One cat (*Felis catus*) also.

Camera	Location	Site Photo	Start-End Date	Site Description	Photo Descriptions
Aud #4	52 J 474635 6811916		24th – 26th March	Mole trench (M1T1).	525 photos taken; 507 photos were just black indicating a fault with camera.
Aud #5	52 J 494997 6794664		23rd – 26th March	Small ledge in breakaway.	1192 photos taken, with 1037 showing hopping mice (*Notomys* sp.) some with large & smal individuals probably adult *N. mitchellii* and juvenile but possibly *N. mitchellii* & *N. alexis*. A few show a small portion of an unidentifiable macropod.

Camera	Location	Site Photo	Start-End Date	Site Description	Photo Descriptions
Aud #6	52 J 494515 6794005		23rd – 26th March	Plain near lake with large reptile scats.	237 photos taken, with 187 including fauna. Most photos show hopping mice (*Notomys* sp.) some with large & smal individuals probably adult *N. mitchellii* and juvenile but possibly *N. mitchellii* & *N. alexis*. 1 cat (*Felis catus*) & 1 fox (*Vulpes vulpes*) also.
Aud #7	52 J 455057 6795277		24th – 26th March	Small ledge with ancient stick-nest rat nest remains.	No photos taken.

6.2 Locations, descriptions and fauna records from on-ground foot traverses

* species recorded near site whilst in flight.

Date	Haul Road Option	Co-ordinates for Location	Site description	Fauna Records	
22-Mar	West01	52 J 374226 6792217	Broad dune swale with mow Mallee Eucalypt over Spinifex on sand	*Ctenophorus isolepis* Singing Honeyeater	Yellow-throated Miner Dromedary Camel Prints
23-Mar	East01	52 J 495247 6794697	Open Sheoak Woodland with mixed shrubs and grasses on calcareous gravel. A small breakaway surrounding a sumpland.	Spiny-cheeked Honeyeater Singing Honeyeater Black-faced Woodswallow	Yellow-throated Miner Splendid Fairy-wren Red-capped Robin
23-Mar	East02	52 J 500141 6727697	Open Myall/Acacia woodland over chenopod shrubs on calcareous gravels and some gilgai soils.	Nankeen Kestrel Crested Pigeon Inland Thornbill Singing Honeyeater Grey Butcherbird Goat/Sheep? Droppings Rabbit droppings	Mulga Parrot Variegated Fairy-wren Chestnut-rumped Thornbill Yellow-throated Miner Black-faced Woodswallow Camel droppings
23-Mar	East03	52 J 500404 6644523	Donga with mixed shrubs (on Nullarbor Plain).	Stubble Quail Wedge-tailed Eagle* Australian Ringneck* Yellow-throated Miner Orange Chat Nullarbor Quail-thrush Australasian Pipit Dingo*	Spotted Harrier Nankeen Kestel Mulga Parrot Singing Honeyeater Willie Wagtail Little Crow Rabbit
23-Mar	East04	52 J 500238 6613444	Low chenopod shrubland on skeletal calcareous soils (on Nullarbor Plain).	Singing Honeyeater	Rabbit
24-Mar	Central01	52 J 423133 6627238	Donga with mixed shrubs (on Nullarbor Plain). Degraded by camels and rabbits.	Wedge-tailed Eagle Brown Falcon Variegated Fairy-wren Singing Honeyeater Black-faced Woodswallow Rabbit	Nankeen Kestrel Hobby Falcon Inland Thornbill Willie Wagtail Australasian Pipit Feral Cat

Date	Haul Road Option	Co-ordinates for Location	Site description	Fauna Records	
24-Mar	Central02	52 J 425495 6642492	Open Myall woodland over bluebush shrubland (the first tongue of trees heading north from the Nullarbor Plain).	Wedge-tailed Eagle Nankeen Kestrel Variegated Fairy-wren Singing Honeyeater Willie Wagtail Grey Butcherbird Australasian Pipit	Black-shouldered Kite Naretha Blue Bonnet Yellow-rumped Thornbill Red-capped Robin Crested Bellbird Black-faced Woodswallow
24-Mar	Central03	52 J 432189 6678864	Open Myall woodland over mixed Acacia and low bluebush shrubland on calcareous loams.	Nankeen Kestrel Naretha Blue Bonnet Spiny-cheeked Honeyeater Yellow-throated Miner Australian Magpie	Mulga Parrot Australian Ringneck Singing Honeyeater White-browed Babbler
24-Mar	Central04	52 J 438136 6734693	Eucalpyt woodland over shrubs and grasses on sand/loam	*Ctenophorus cristatus* Yellow-plumed Honeyeater Rabbit	Yellow-throated Miner Dromedary Camel
24-Mar	Central05	52 J 434644 6748421	Eucalpyt Mallee woodland over mixed shrubs and Spinifex on red sand dunes	Variegated Fairy-wren Chestnut-rumped Thornbill Yellow-plumed Honeyeater Willie Wagtail	Inland Thornbill Spiny-cheeked Honeyeater Jacky Winter Grey Shrike-thrush
25-Mar	West02	52 J 282329 6707176	Open Myall woodland over open bluebush shrubland	Wedge-tailed Eagle White-winged Fairy-wren Singing Honeyeater Hooded Robin Australian Magpie Australian Magpie	Naretha Blue Bonnet Slaty-backed Thornbill Yellow-throated Miner Willie Wagtail Black-faced Woodswallow Richards Pipit
25-Mar	West03	52 J 285417 6697217	Low saltbush shrubland on skeletal soils	No foot traverse	
25-Mar	West04	52 J 285938 6684056	Occasional saltbush over open grassland.	No foot traverse	
25-Mar	West05	52 J 303014 6619386	Open saltbush shrubland over open grassland	Brown Falcon	Stubble Quail
25-Mar	West06	52 J 311004 6576992	Donga with open *Muehlenbeckia* shrubland over low grasses	No foot traverse	

Date	Haul Road Option	Co-ordinates for Location	Site description	Fauna Records	
25-Mar	Central06	52 J 433224 6690940	Open Mulga/Acacia tall shrubland over low saltbush shrubland.	*Menetia greyii*	Mulga Parrot
				White-winged Fairy-wren	Yellow-throated Miner
				Spiny-cheeked Honeyeater	Singing Honeyeater
				Willie Wagtail	Grey Butcherbird
				Black-faced Woodswallow	Euro
25-Mar	Central07	52 J 438730 6723974	Open Sheoak woodland on calcareous loam, with open Mulga woodland along drainage lines	Brown Falcon	Chestnut-rumped Thornbill
				Singing Honeyeater	Australian Magpie
				Dromedary Camel & Rabbit droppings	
25-Mar	Central08	52 J 437767 6727269	Drainage sump with mixed Acacia woodland/shrubland, bluebush shrubland and low grassland on calcareous gravely loams and gilgai soils	Southern Whiteface	Singing Honeyeater
				Hooded Robin	Willie Wagtail
				Black-faced Woodswallow	Varied Sittella
25-Mar	Central09	52 J 455115 6795258	*Casuarina pauper* woodland between small breakaway and small salt lake	*Ctenophorus nuchalis*	Chestnut-rumped Thornbill
				Slaty-backed Thornbill	Singing Honeyeater
				Willie Wagtail	Australasian Pipit
25-Mar	Central10	52 J 434526 6748253	Eucalpyt Mallee woodland over open shrubs and Spinifex grassland on red sand dunes	Brown Falcon	Mulga Parrot
				Australian Ringneck	Rufous Treecreeper
				Chestnut-rumped Thornbill	Weebill
				Yellow-throated Miner	Singing Honeyeater
				Hooded Robin	White-browed Babbler
				Crested Bellbird	Gilbert's Whistler
				Rufous Whistler	Grey Butcherbird

6.3 Marsupial Mole trench survey results.

Trench location and dimensions

Trench & Transect No. (Code)	Co-ordinates (UTM, WGS '84)	Location within dune (Height of trench within dune system)	Mole holes per trench	Dimensions of trench (mm)		
				Length	Depth	Width
Trench 1 - South Transect **(M1T1)**	52 J 474638 6811911	Lower slope (1 metre)	0			
Trench 2 - South Transect **(M1T2)**	52 J 474640 6811893	Mid-slope (3 metres)	1	1200	700	500
Trench 3 - South Transect **(M1T3)**	52 J 474669 6811849	Upper-slope (4 metres)	2	1000	700	400
Trench 1 - North Transect **(M2T1)**	52 J 473742 6813759	Lower slope (1.5 metres)	8	1050	800	400
Trench 2 - North Transect **(M2T2)**	52 J 473744 6813775	Mid-slope (2 metres)	3	1100	800	400
Trench 3 - North Transect **(M2T3)**	52 J 473732 6813805	Upper-slope (5 metres)	2	1500	800	320

Trench vegetation details

Trench Code	Roots within soil profile L Large >10mm thick M Medium 1-10mm thick F Fine <1mm thick			Vegetation		
	Depth within trench			Description	Fire age (years)	% cover
	0-15cm	15-35cm	35-60cm			
M1T1				Myrtaceous shrubs and spinifex	6-10yrs	
M1T2	1*L, 2*M, 50*F	0*L, 6*M, 43*F	0*L, 5*M, 13*F	Myrtaceous shrub, Acacia and spinifex	6-10yrs	35%<1m 5%>1m
M1T3	1*L, 7*M, 150*F	1*L, 6*M, 50*F	0*L, 5*M, 15*F	Myrtaceous shrubs (*Senna* sp., *Eremophila* sp.) and *Acacia* over spinifex.	6-10yr	30%<1m 10%1>m
M2T1	2*L, 3*M, 70*F	0*L, 4*M, 60*F	0*L, 5*M, 40*F	Eucalypt mallee and mixed shrubs over spinifex.	25+	60%<1m 10%>1m
M2T2	0*L, 4*M, 55*F	0*L, 13*M, 70*F	1*L, 13*M, 30*F	Eucalypt mallee and mixed shrubs over spinifex.	25+	25%<1m 5%>1m
M2T3	1*L, 5*M, 45*F	1*L, 1*M, 20*F	0*L, 4*M, 15*F	Eucalypt mallee and mixed shrubs over spinifex	25+	

Molehole details

Trench Code	No. of Moleholes	Minimum Diameter (mm)	Maximum Diameter (mm)	Angle (from face of trench wall)	Clarity*	Confidence*	Age*	Depth from surface (mm)
M1T1	0 of 0	-	-	-	-	-	-	-
M1T2	1 of 1	37	38	90	3	3	3	250
M1T3	1 of 2	42	44	90	3	3	3	140
M1T3	2 of 2	39	39	90	2	3	3	250
M2T1	1 of 8	41	41	90	3	3	3	270
M2T1	2 of 8	43	46	90	3	3	3	450
M2T1	3 of 8	36	44	90	3	3	3	660
M2T1	4 of 8	41	68	45	3	3	3	490
M2T1	5 of 8	42	52	60	3	3	3	500
M2T1	6 of 8	40	41	90	3	3	3	480
M2T1	7 of 8	41	43	90	3	3	3	470
M2T1	8 of 8	42	44	90	3	3	3	320
M2T2	1 of 3	37	43	90	2	3	2	300
M2T2	2 of 3	47	49	90	3	3	3	420
M2T3	3 of 3	35	41	75	3	3	1-3?	420
M2T3	1 of 2	36	55	30	3	3	3	300
M2T3	2 of 2	42	43	90	3	3	3	320

Appendix 7. Annotated species list for surveys conducted along the Cyclone Deposit Transport Corridor Options.

REPTILES

1. *Nephurus levis*	One caught near Diatreme Camp.
2. *Hemidactylus frenatus*	One caught around Diatreme caravan (at the camp).
3. *Menetia greyii*	One seen in Acacia woodland.
4. *Tiliqua rugosa*	One seen by Brett Dennis (helicopter pilot) at the southern end of western route.
5. *Amphibolurus longirostris*	A photo of one taken from around camp during the field survey.
6. *Ctenophorus nuchalis*	Numerous individuals seen across the project area.
7. *Ctenophorus cristatus*	Several individuals seen, mainly in the Mallee woodland/sand-dune VSA.
8. *Moloch horridus*	Several individuals seen along the road west of Tjuntjuntara.
9. *Varanus gouldii*	Several seen across the project area and in camp.
10. *Pseudechis australis*	Several seen by botanists; one in mallee/spinifex in dunes, northern end of central line.

BIRDS

11. Malleefowl	None seen, but traditional owners indicate they do occur nearby.
12. Stubble Quail	One seen in a Donga on the Nullarbor Plain.
13. Wedge-tailed Eagle	Very common on the Nullarbor Plain and moderately so elsewhere.
14. Spotted Harrier	One seen hunting over the Nullarbor Plain.
15. Black-shouldered Kite	Uncommon, but one group of six seen in Myall Woodland on the edge of the Nullarbor Plain.
16. Brown Falcon	Common across the Nullarbor Plain, less so elsewhere.
17. Hobby Flacon	One seen in Myall Woodland on the edge of the Nullarbor Plain.
18. Nankeen Kestrel	Common across the Nullarbor Plain, less so elsewhere.
19. Peregrine Falcon	One seen hunting over the Tjuntjuntjara entrance road, near Western transport corridor option
20. Australian Bustard	One seen in flight over the eastern road option, just north of the Aboriginal Business Rd.
21. Crested Pigeon	One possibly heard on the edge of the Nullarbor Plain, on the eastern transport corridor option.
22. Galah	Abundant at Tjunutjuntjara.
23. Australian Ringneck	Uncommon; pairs seen occasionally across site.
24. Naretha Blue Bonnet	A pair seen in Myall Woodland on the edge of the Nullarbor Plain; ~20 seen feeding on Acacia sp. seed in a donga. Several groups of 2-4 seen in freshly burnt areas near Tjutjuntjara

25. Mulga Parrot	Uncommon; groups of 1-4 four seen in woodland/dongas throughout the site.
26. Tyto spp. Owl?	One seen by Diatreme staff around camp, prior to fieldtrip.
27. Barn Owl	Several seen on cutline, north of the Transline.
28. Tawny Frogmouth	A pair seen in mallee woodland on Diatreme.
29. Spotted Nightjar	One seen in north section of Cyclone deposit.
30. Australian Owlet-nightjar	One heard near camp early morning.
31. Varied Sitella	Uncommon; several seen in open Acacia woodland over saltbush.
32. Rufous Treecreeper	Several seen in Mallee/spinifex woodland over dunes.
33. White-winged Fairy-wren	Common in Dongas on the Nullarbor Plain.
34. Variegated Fairy-wren	Common within more wooded areas of the Nullarbor Plain and GVD.
35. Inland Thornbill	Moderately common in woodland areas, often in association with Chestnut-rumped Thornbills.
36. Chestnut-rumped Thornbill	Moderately common in woodland areas, often in association with Inland Thornbills.
37. Yellow-rumped Thornbill	One group seen in Myall Woodland on the edge of the Nullarbor Plain.
38. Slaty-backed Thornbill	Uncommon; one group seen in open Acacia woodland over saltbush.
39. Southern Whiteface	Uncommon; one group seen in open Acacia woodland over saltbush.
40. Weebill	Several seen in Mallee/spinifex woodland over dunes.
41. Spiny-cheeked Honeyeater	Uncommon; isolated individuals across the site.
42. Yellow-throated Miner	Common in wooded areas across the site.
43. Singing Honeyeater	Very common throughout the study area.
44. Yellow-plumed Honeyeater	Common in areas of flowering Eucalypts.
45. Orange Chat	Several young/females seen in a bluebush Donga at southern end of the eastern transport corridor option.
46. Jacky Winter	Group of three seen in open Mallee woodland (central line).
47. Red-capped Robin	Occasional birds seen in woodland areas.
48. Hooded Robin	Uncommon; two males seen separately in open Acacia woodland on the edge of the Nullarbor Plain.
49. White-browed Babbler	Groups seen in dongas and woodland areas throughout site.
50. Nullarbor Quail-thrush	One seen in a bluebush donga at southern end of the eastern line.
51. Chestnut Quail-thrush	One seen in open Mulga woodland between camp and Cyclone deposit.
52. Grey Shrike-thrush	One seen in Mallee woodland on central line.
53. Gilbert's Whistler	One seen in Mallee woodland on central line.
54. Crested Bellbird	Several seen and heard, usually in association with open woodland habitats of the northern study areas.
55. Willie Wagtail	Moderately common throughout the site, in dongas and woodlands.
56. Australian Magpie-lark	Several seen and heard around Tjunjuntjara community.

57. Black-faced Cuckoo-shrike	A pair seen flying over Tjuntjuntjara.
58. Black-faced Woodswallow	Uncommon; groups of 2-8 in dongas and woodland areas across the site.
59. Grey Butcherbird	Uncommon; individuals seen across the site in woodland areas.
60. Pied Butcherbird	Several seen between Diatreme and the cutline.
61. Australian Magpie	Uncommon; singles and pairs seen across the site.
62. Little Crow	Occasional flocks of 8-10 birds seen, usually on the Nullarbor Plain.
63. Australasian Pipit	Seen occasionally on the Nullarbor Plain and the edge of dongas.
64. Welcome Swallow	Several seen around Forrest airport.

MAMMALS

65. Red Kangaroo	Uncommon; several seen on the Nullarbor Plain and open areas of the GVD.
66. Western Grey Kangaroo	Uncommon; several seen in the GVD and outskirts of the Nullarbor Plain.
67. White-striped Free-tail	Common; heard regularly at night during the survey.
68. Mitchell's/Spinifex Hopping-Mouse	Common; Numerous photos of Notomys taken using motion sensitive cameras, however exact species is unknown.
69. Southern Marsupial Mole	Moderately common; several old burrows recorded within trenches.
70. Feral Cat	Uncommon photos taken at two different locations using motion sensitive cameras and one seen in nest in tall Acacia in a Donga on the Nullarbor
71. European Fox	Uncommon; one set of prints recorded from a track within the deposit area.
72. Feral Camel	Common; groups of 3-7 recorded regularly throughout the study area
73. Dingo/Dog	Common; individuals and small groups recorded from across the Nullarbor.
74. House Mouse	Abundant; up to 20 caught at camp each evening during the survey.
75. European Rabbit	Abundant; high density of warrens recorded from the Nullarbor and numerous latrines recorded from VSAs within the GVD.