Yeelirrie
Terrestrial Vertebrate Fauna Review

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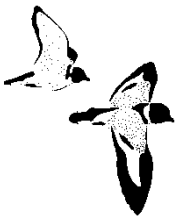

21st April 2015

Executive Summary

Background

Cameco Australia Pty Ltd (Cameco) proposes to develop the Yeelirrie Uranium Project, located approximately 420 km north of Kalgoorlie-Boulder, 70 km south-west of Wiluna and 110 km north-west of Leinster in the Murchison region of Western Australia. Cameco acquired the Yeelirrie Project in 2012 from BHP Biliton (BHP) and is in the process of reviewing the Environmental Review and Management Programme (ERMP) and related documents previously prepared for the Project.

As part of the environmental impact assessment, Bamford Consulting Ecologists (BCE) conducted detailed vertebrate fauna assessments of the Yeelirrie project area in 2009 and 2010 (BCE, 2011a; 2011b) and included desktop reviews, database searches and field investigations within the project area and outside to provide some regional context. This approach is consistent with guidelines and recommendations set out by the Western Australian Environmental Protection Authority (EPA, 2002; 2004). Cameco commissioned BCE to conduct a review of the historic fauna survey reports completed at Yeelirrie to confirm the following:

- The methods, reports and findings meet current guidelines and requirements;
- Conservation rankings of significant species are current;
- To identify and discuss any new issues that might have arisen since the previous work was completed in 2009, including information about species and new conservation rankings.

In 2015, a second desktop assessment (including relevant database searches) was conducted to update the initial desktop assessment. A site inspection targeting conservation significant fauna was also conducted in March 2015 and focussed on searches for Malleefowl, Slender-billed Thornbill, Striated Grasswren, Black-flanked Rock-wallabies and the Shield-backed Trapdoor Spider.

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.

Vertebrate Fauna Assemblage

The expected fauna assemblage developed by BCE (2011a) at Yeelirrie has been updated to reflect changes in taxonomy, nomenclature and revisions of the *Wildlife Conservation Act 1950*, and new records in the general region. The fauna assemblage is expected to be composed of 295 species, including: 11 frog, 88 reptile, 157 bird, 30 native mammal and nine introduced mammal species. Thirty-five of the species expected to occur in the region are of conservation significance and includes two reptile species, 27 bird species and six mammal species. Ten conservation significant species were confirmed by BCE during surveys. The project area supports (or is expected to support) resident populations of the Malleefowl, Black-flanked Rock-Wallaby, Brush-tailed Mulgara, Australian Bustard, Peregrine Falcon, Rainbow Bee-eater, Bush Stone-curlew and Striated Grasswren.

Malleefowl

One Malleefowl mound was recorded within the project area by BCE during the field surveys (BCE, 2011a). A recently used mound (due to the presence of eggshell fragments) was recorded amongst closed Acacia shrubland, approximately 2 km north of the resource area and will be impacted as a result of the project. The Malleefowl Preservation Group has conducted regular (annual) monitoring of Malleefowl mounds at Yeelirrie since 2000. Two active mounds were recorded in 2013 and none in 2014, indicating an extant population persists in the area. Most known Malleefowl mounds are situated away from the uranium orebody, within stands of dense Mulga woodland.

Black-flanked Rock-Wallaby

The Black-flanked Rock-Wallaby was known to occur in the region with several anecdotal reports of the species along the Barr Smith Range. BCE recorded a large number of rock-wallaby scats from a cave within the Barr Smith Range, approximately 40km east of the uranium resource (BCE, 2011a). While not expected to occur within habitats associated with the uranium orebody, the species may persist in the extensive rocky habitats to the north and south.

Slender-billed Thornbill

The Slender-billed Thornbill has not been recorded at Yeelirrie despite a number of bird surveys conducted in the area by BCE and historical surveys conducted by previous land managers. As a result a resident population appears unlikely.

Brush-tailed Mulgara

The Brush-tailed Mulgara was recorded extensively across the Yeelirrie project area (BCE, 2011a and during the 2015 inspection). It was most abundant within sandplain sites dominated by spinifex (and

was absent from calcrete habitats). A total of 154 burrow systems was recorded in 842 ha of search area, equating to 0.18 burrows/ha; 86 burrows were active (0.1 burrows/ha, BCE, 2011a).

Australian Bustard

The Australian Bustard was recorded throughout the Yeelirrie project area, particularly associated with spinifex sandplain. It was seen in both 2009/2010 (BCE, 2011a) and in March 2015. It is a widespread species across much of the northern half of Australia.

Peregrine Falcon

The Peregrine Falcon was recorded along a cliff ledge in the Barr Smith Range in 2009 (BCE, 2011a). The study area is likely to lie within the foraging territory of a pair.

Rainbow Bee-eater

Recorded throughout the study area in both 2009/2010 (BCE, 2011a) and in March 2015. While of high conservation significance because of its listing as a migratory species, it is widespread across Australia and frequently uses disturbed environments.

Striated Grasswren

While not recorded during surveys, there are three records of this species at Yeelirrie, including approximately 5 km south of the uranium orebody (BirdLife Australia, 2015). This location was visited in March 2015 and while the environment appeared suitable no birds were observed. This species has a highly patchy and fragmented distribution due to a reliance on mature spinifex grassland (Garnett *et al.*, 2011) and can be difficult to detect. Given the Birdlife record and the apparent suitability of the vegetation, it is likely to occur on the spinifex sandplains adjacent to the orebody.

Additional conservation significant fauna species are expected however only as irregular visitors or vagrants. For example, a number of migratory waterbirds may occasionally use seasonal natural wetlands, and could utilise artificial waterbodies associated with the project. Desktop studies identified nine introduced fauna species as potentially occurring in the Yeelirrie project area. Six species were recorded by BCE during field surveys.

Vegetation and Substrate Associations (VSAs)

Eight VSAs were identified across the project area and surrounding landscape. Mixed Shrubs over Spinifex Sandplain, Hardpan Mulga, Calcrete and Calcrete Outwash dominant most of the disturbance footprint with much smaller areas of rocky breakaway also included.

Impact Assessment

Potential impacts on the general vertebrate fauna assemblage are likely to be greater in the *E. gypsophila* woodland subset of the Calcrete habitat, which has a higher proportional representation in the study area. Ecological processes affecting the fauna assemblage include changes to hydrology, fire regimes, feral species and interactions with native species, habitat degradation due to weed

invasion and connectivity. Other impacts include bioaccumulation and migratory species consuming water from the evaporation pond. The assessment identified that impacts upon fauna are likely to be Minor or less. This is due to the site's location within a largely intact landscape; a landscape expected to contain large areas of the same VSAs as those present within the survey area. With appropriate management, there is likely to be some localised, long-term reduction in population size of a range of common species, but no loss of species or fauna assemblage viability.

Recommendations

Loss of habitat / habitat fragmentation

- Minimise removal of large trees;
- Minimise the disturbance footprint, especially in the calcrete VSA;
- Clearly delineate areas to be cleared;
- Where possible, protect environments and locations that support conservation significant fauna;
- Rehabilitate any cleared areas not needed after construction;
- Undertake pre-clearance fauna surveys as there is likely to be a large lag time between approval and development and to identify important fauna areas. These will also enable a revision of the impact assessment to account for any administrative / legislative changes;
- Protect large, hollow-bearing trees where possible.

Habitat Management

- Maintain the Yeelirrie lease as livestock-free as part of the site's environmental management. This would be a significant and positive step towards the management and rehabilitation of fauna habitats;
- Decommission stock watering points to reduce the availability of artificial watering points for aggressive species away from the mine area.

Species interactions

- Develop a feral animal management plan.

Hydrological changes

- Develop an understanding of the surface and sub-surface drainage and possible effects of human activities upon groundwater in order to identify the potential for hydrological changes that could potentially impact fauna habitats;
- Manage artificial waterbodies (evaporation ponds) to minimise impacts upon migratory waterbirds from potentially toxic waterbodies;
- Implement measures to minimise disruption to surface water and groundwater flows as described the ERMP.

Habitat degradation due to weed invasions

- Develop a weed management/hygiene plan.

Changes in fire regime

- Develop a fire management plan (which includes regard for the ecological role of fire) to preserve habitat for fire sensitive species.

Dust, noise, light and disturbance

- Minimise the production of dust, noise and light spill; especially where these may affect adjacent bushland. Establish long-term fauna monitoring sites to assess the impacts of these to monitor trends and identify areas of concern to dictate management.

Management of Tailings Evaporation Pond

- Undertake an ecological risk assessment of the evaporation pond;
- Implement a water quality monitoring programme and adapt fauna management strategies (e.g. bird deterrents) based on the outcomes of the programme;
- Monitor bird visitation of the evaporation pond and report fauna deaths;
- Fence off the evaporation pond from terrestrial mammals to minimise exposure during the initial period when the water is palatable.

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1 Introduction

1.1 Background

Cameco Australia Pty Ltd (Cameco) proposes to develop the Yeelirrie Uranium Project, centred on a large, shallow uranium deposit located in the Murchison region of Western Australia. The site is situated approximately 420 km north of Kalgoorlie-Boulder, 70 km south-west of Wiluna and 110 km north-west of Leinster (see Figure 1). The uranium deposit was discovered in 1972 by Western Mining Corporation (WMC) and has since had extensive exploration work conducted by WMC and more recently by BHP Billiton (BHP).

BHP commissioned an environment impact assessment of the Yeelirrie Project, and developed a detailed Environmental Review and Management Programme (ERMP, BCE, 2011a). As part of the environmental impact assessment, Bamford Consulting Ecologists (BCE) conducted a detailed vertebrate fauna assessment of the Yeelirrie Project Area during 2009 and 2010 (BCE, 2011a and 2011b).

Cameco acquired the Yeelirrie Project in 2012 and plans to develop the uranium mine. As a result, Cameco is in the process of reviewing the Yeelirrie ERMP and related documents previously prepared for the Yeelirrie Project (by BHP), with the intention of submitting a revised environmental impact assessment (Public Environmental Review or PER). As part of this process, Cameco commissioned BCE to conduct a fauna review of the Yeelirrie Project and address matters relating to fauna as follows:

- Review the historic reports of fauna surveys completed at Yeelirrie to confirm:
    - The methods, reports and findings meet current guidelines and requirements;
    - Conservation rankings of significant species are current;
    - To identify and discuss any new issues that might have arisen since the previous work was completed in 2009, including information about species, new conservation rankings, etc.
- Undertake consultation with the relevant state agencies (DPaW and the OEPA) to determine adequacy and the position with the statistical approach (such as species accumulation curves) on SREs;
- Undertake a desktop determination of significant SRE fauna, particularly *Idiosoma* sp.;
- Provide advice to Cameco of any gaps, including any new field work that may be required to finalise the studies (and conduct these studies);
- Prepare a standalone report that would be attached to the PER as an appendix alongside the field study reports that discusses the fauna review, updates and summarises the findings;
- Review ERMP fauna section and incorporate new findings as required;
- Rewrite the ERMP fauna section to reflect Cameco's new section structure.

In addressing these matters, BCE will produce:

- A revised vertebrate fauna report updated with a 2015 site visit;
- A summary and update of the invertebrate report based upon work done by Ecologia (2011a) and BCE in 2015;
- A review of the fauna section of the ERMP, including any new findings.

This document is the revised vertebrate fauna report.

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;
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- The review of **impacting processes** such as:
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  - 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.

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 (EPA, 2002; EPA, 2004).

1.3 Description of the Yeelirrie Project Area

The Yeelirrie project is located on Yeelirrie Station and forms part of the Shire of Wiluna (Figure 1). The proposed Yeelirrie development is situated within a wide, flat and long drainage valley that is characterised by extensive sand plains flanked by granite breakaways. The resource area is primarily situated in the centre of the project, along a paleo-drainage line, and is approximately 9 km in length and approximately 1.5 km wide.

Cameco has indicated the footprint proposed by BHP in the initial ERMP is indicative of the updated development. Cameco proposes one alteration – the inclusion of a 50 ha evaporation pond (see Figure 2). The disturbance envelope also includes mine infrastructure (such as the metallurgical plant and ore stockpiles), which will closely surround the resource. Mine infrastructure located further afield include: the quarry; the accommodation camp; associated access roads and borefield, and pipeline corridors. Collectively, the resource area and infrastructure components form the indicative project footprint (disturbance envelope, see Figure 1).

The project area lies within the Eastern Murchison subregion of the Murchison Bioregion (Thackway and Cresswell, 1995; McKenzie *et al.,* 2003). The proposed pit area lies across three main land types and five land systems. It is centred on calcrete drainage plains with mixed halophytic and non-halophytic shrublands (Cunya, Melaleuca, Mileura) and flanked by sand plains with Spinifex hummock grasslands (Bullimore) and Mulga Shrublands on hardpan (Yanganoo). The nominated uranium resource lies within the trunk valley of the ancient Yeelirrie paleodrainage system. Soil landscape systems have been described by DC Blandford & Associates (2009) within the project area.

BCE conducted a vertebrate fauna assessment of the Yeelirrie area in 2009 and 2010 (BCE, 2011a). As part of this, a desktop review was undertaken to gather regional data and included database searches covering approximately 50 km from the resource area (Figure 2). The focus of field investigations was on the resource area and its immediate surrounds. However, some work was undertaken outside these areas to provide regional context or to target significant species.

Figure 1. Location of the Yeelirrie project.

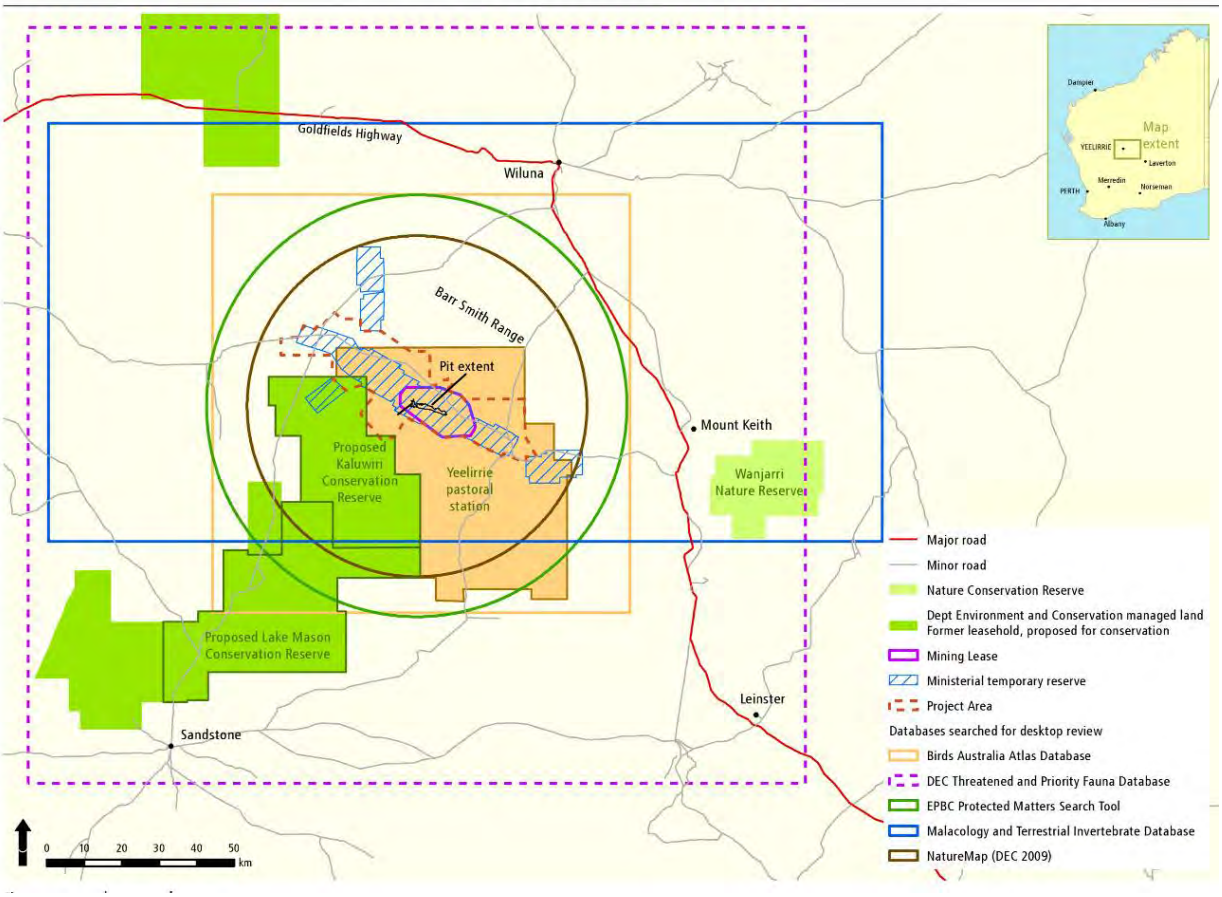
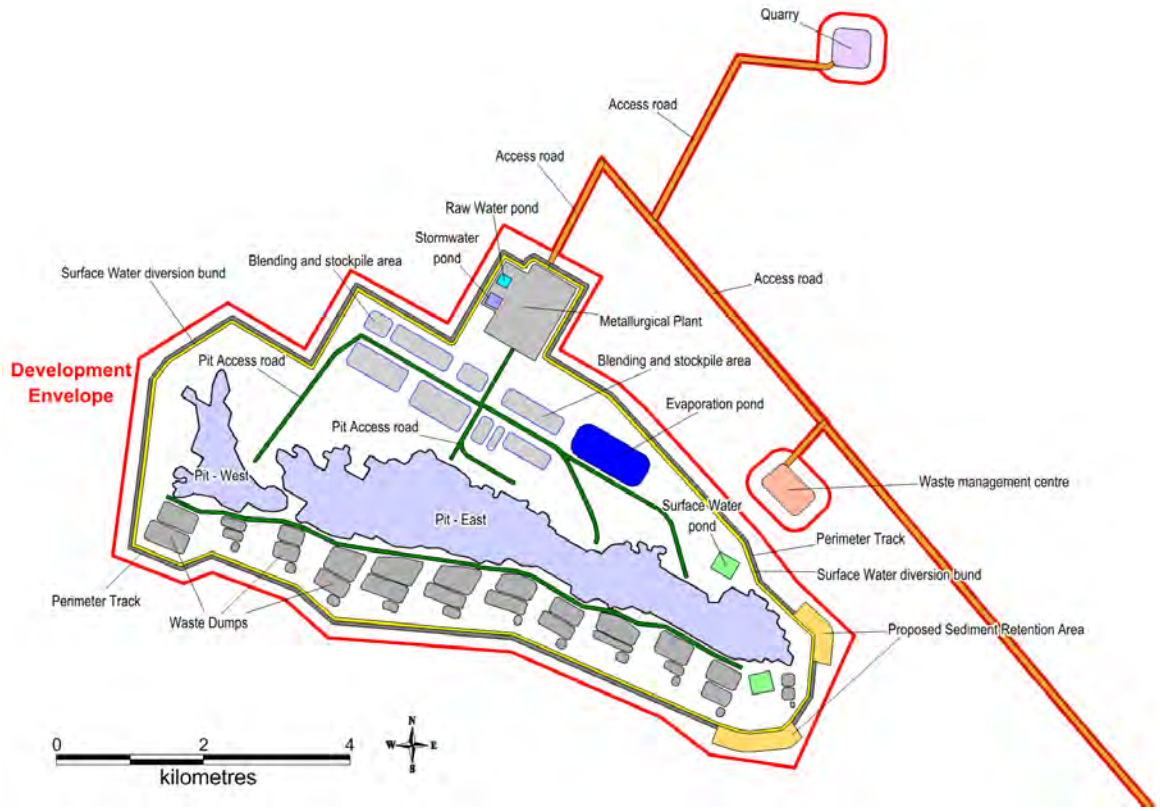


Figure 2. The Yeelirrie project disturbance envelope.



2 Methods

2.1 Desktop Assessment

2.1.1 Sources of Information

As part of the fauna review, a second desktop assessment was conducted for the Yeelirrie area. This builds on and updates the initial desktop assessment of the Yeelirrie project area was conducted by BCE (2011a). Information used for the desktop assessment has been re-assessed to develop an updated fauna assemblage that accounts for administrative and legislative changes (eg. changes in conservation status or taxonomy). Relevant fauna databases were re-visited and recent regional survey work was consulted (eg. BCE, 2014, BCE, 2011a). Sources of information used to update the Yeelirrie Desktop assessment are listed in Table 1.

Table 1. Sources of information used for the desktop assessment.

Database	Type of records held on database	Year / Area searched
NatureMap (DPaW, 2015)	Records in the WAM and DPaW databases. Includes historical data and records on Threatened and Priority species in WA.	Site plus 40 km buffer. Searched January 2015.
BirdLife Australia Atlas Database (Birdlife Australia, 2015)	Records of bird observations in Australia, 1998-2014.	One degree square containing site. Searched January 2015.
EPBC Protected Matters (DotE, 2015)	Records on matters of national environmental significance protected under the EPBC Act.	Site plus 40 km buffer. Searched January 2015.
Atlas of Living Australia (ALA)	Records held in Australian Museums and government departments.	Yeelirrie project area, surrounds, January 2015.
Vertebrate Fauna Assessment Yeelirrie Project - Baseline Report	Detailed Fauna Assessment of the Yeelirrie Project Area, conducted by BCE in 2009 and 2010	2009 – 2010 – Yeelirrie
Fauna Assessment of the Rosslyn Hill Mine	Detailed Fauna Survey conducted by BCE in late 2014.	2014 – Rosslyn Hill mining, 70 km north of Yeelirrie.
Fauna Assessment at Wiluna West (KLA, 2012)	Detailed Fauna Survey conducted by KLA in late 2011.	2011 – Wiluna West project, approximately 40 km north of Yeelirrie
Fauna Assessment at Wiluna Uranium Project (Outback Ecology, 2011)	Detailed Fauna Survey for Toro Energy Limited Wiluna Uranium Project	2011 – Wiluna.
Fauna Assessment of Lorna Glen (DPaW, 2015, Cowan, 2008)	Species recorded on Lorna Glen station which contains several habitats similar to those found at Yeelirrie (J. Turpin, pers. obs.)	2008 - 2014

2.1.2 Previous Fauna Surveys

BCE conducted detailed fauna assessments of the Yeelirrie project area during 2009 and 2010 (BCE, 2011a). Additionally, a historical list of fauna recorded at Yeelirrie has also been compiled (anon, 1978). Other fauna surveys conducted in the region include at Rosslyn Hill (70km north of the project area, BCE 2014) and near Wiluna (KLA, 2012, Outback Ecology, 2011). Where available, the results of these assessments were drawn upon to develop this fauna review.

2.1.3 2015 Site Visit

BCE conducted an additional fauna assessment of the Yeelirrie area during March 2015 in conjunction with a review of the findings of the original 2009 fauna assessment. The site inspection was conducted from the 13th till 18th March 2015 by Dr Mike Bamford and Jeff Turpin. The objective of the assessment centred on a review of conservation significant fauna and their expected occurrence within the Yeelirrie area. As a result, the field assessment included:

- Targeted searches for conservation significant fauna, particularly the Shield-backed Trapdoor Spider (including collection of specimens for DNA analysis to confirm species);
- A review of the expected status of the EPBC listed Slender-billed Thornbill in the project area and an assessment of habitat and occurrence within and outside the project area;
- A review of conservation significant fauna previously recorded in the Yeelirrie area by both BCE and others (eg. updates on Birds Australia databases). This included an assessment of suitable habitat and visiting previous records of Malleefowl, Slender-billed Thornbill, Striated Grasswren and rock-wallabies;
- Collect rock-wallaby scats for DNA analysis.

2.1.4 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 Fauna of Western Australia 2014*. The authorities used for each vertebrate group were: amphibians (Doughty and Ellis, 2014a), reptiles (Doughty and Ellis, 2014b), birds (Johnstone, 2013), and mammals (How *et al*. 2013). 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.

2.1.5 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 survey 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 survey area, meant that it was highly unlikely that these species would be present. Some are also known to be regionally extinct. In general, however, species returned by the desktop review process are considered to be potentially present in the survey area whether or not they were recorded during field surveys, and whether or not the survey area is likely to be important for them. 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. Species returned from databases but excluded from species lists are presented in Appendix 7.

Interpretation of species lists generated through the desktop review included assigning an expected status within the survey 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 survey area;
- Regular migrant or visitor: species that occur within the survey area regularly in at least moderate numbers, such as part of annual cycle;

- Irregular Visitor: species that occur within the survey 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 survey area in at least moderate numbers and for some time;
- Vagrant: species that occur within the survey area unpredictably, in small numbers and/or for very brief periods. Therefore, the survey area is unlikely to be of importance 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 survey area.

2.1.6 Legislation

Conservation significant fauna are protected under relevant state and federal legislation (EPBC Act, Wildlife Conservation Act – see Appendices 1 - 3). The latest editions of such legislation were consulted to update fauna the assemblage of any changes. This included:

- Schedule 1 of the Wildlife Conservation (Specially Protected Fauna) Notice 2014 released on 2 December 2014;
- EPBC Act – database review conducted January 2015.

2.4 Impact Assessment

The impact assessment process for the BHP Yeelirrie ERMP is described in detail in BCE (2011b). 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 Vegetation/Substrate Association (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.

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. 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 information from the site inspection;
- Species of conservation significance – based upon desktop assessment and site inspection;
- Recognition of ecotypes or VSAs - based upon desktop assessment and site inspection;
- Patterns of biodiversity across the landscape - based upon desktop assessment and site inspection;
- Ecological processes upon which the fauna depend - based upon desktop assessment and site inspection.

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 Section 1.2 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 that leads 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.

2.4.1 Criteria for Impact Assessment

The significance of impacts can be related to proportional decline in regional populations of a species or a type of environment. Significance is thus contextual. For example, the EPA (2004) suggests that the availability of fauna habitats within a radius of 15km can be used as a basis to predict low, moderate or high impacts. In this case, a high impact is where the impacted environment and its component fauna are rare (<5% of the landscape within a 15km radius or within the Bioregion), whereas a low impact is where the environment is widespread (10% of the local landscape). In a similar way, under the Ramsar Convention, a wetland that regularly supports 1% of a population of a waterbird species is considered to be significant. These sorts of values are suitable when considering large proposed developments in extensive environments, as is the case with the Yeelirrie project. Impacts can then be described as follows:

- Negligible: Effectively no population decline or other change in the immediate area.
- Minor: Population decline of <1% in the immediate area.
- Moderate: Permanent population decline 1-10% in the immediate area.
- Major: Permanent population decline >10% in the immediate area.
- Critical: Taxon extinction in the immediate area.

Note that for a few species there is guidance for the assessment of impact significance and this is referred to as necessary.

3 Results

3.1 Vertebrate Fauna Assemblage

3.1.1 Overview of the Fauna Assemblage

The fauna assemblage of the Yeelirrie project area was generated and updated using previous reports in the area (BCE, 2011a, 2014) and in conjunction with a review of the relevant fauna databases, literature, current legislation and a site inspection during 2015. BCE (2011) conducted a desktop study and several field surveys to generate a list of the vertebrate fauna species expected (or recorded) within the Yeelirrie project area. This list was reviewed and updated (subsequent to the 2015 site inspection) to account for any legislative or taxonomic changes.

The vertebrate fauna assemblage is expected to be composed of 295 species, including: 11 frog, 88 reptile, 157 bird, 30 native mammal and nine introduced mammal species (see Table 2, Appendix 5). Thirty-five of the species expected to occur in the region are of conservation significance. Some species, such as the Night Parrot, are unlikely to be extant but have been included in species lists based on previous records, distribution and suitable habitat. Ten conservation significant species were confirmed at Yeelirrie by BCE.

Appendix 5 lists the updated fauna assemblage expected and conservation significant fauna are summarised in Table 3. The expected fauna assemblage developed by BCE (2011a) at Yeelirrie has been updated to reflect changes in taxonomy, nomenclature and revisions of the *Wildlife Conservation Act 1950*, and new records in the general region. These changes include:

- The addition of one frog species (*Notaden nichollsi*, recorded by BCE 70km north);
- The removal of *Dasycercus cristicauda* from the expected list - there is ongoing discussion about the taxonomic validity and distribution of this species, but at a recent workshop run by the Department of Parks and Wildlife, there was almost consensus that it is only the Priority 4 *D. blythi* that occurs in the Pilbara and Murchison;
- Nomenclature changes (updates) of 14 species (two frogs, seven reptiles, four birds and one mammal);
- Addition of regional records as several surveys have been conducted in the region since the 2009-2010 surveys in Yeelirrie by BCE (eg. BCE, 2014). New records of conservation significant fauna include the P4 Striated Grasswren and Long-tailed Dunnart;
- CS1 fauna increased to 21 species - upgraded status of the Grey Falcon to Vulnerable under the Wildlife Conservation Act, and added the Night Parrot (CS1) to the list of potentially occurring conservation significant fauna;
- Changed the status of the Greater Bilby from locally extinct to vagrant as there have been some recent regional records (BCE, 2014);
- Revision of the Long-tailed Dunnart to Priority 4;
- Revision of the Bush Stone-curlew from CS2 (Prioirty 4) to CS3 (Locally significant);
- Removal of Desert Mouse from CS3;
- The status of Black-flanked Rock-Wallaby remains “resident” assuming the same disturbance footprint proposed by BHP, which indicated some disturbance to rocky habitats associated with the Barr Smith Range (eg. quarries for access roads).

Overall, the assemblage of vertebrate fauna expected to occur reflects the transition zone from the Murchison to the arid interior. This assemblage contains both species typical of the Murchison area

(e.g. Woolley's Pseudantechinus, Stripe-tailed Monitor) and species typical of the central deserts (e.g. Striated Grasswren), and some more typical of the south-west (such as the Grey Currawong, Regent Parrot, Malleefowl). As a result, a diverse fauna assemblage is expected to occur within the study area where ranges of species with predominantly southern, eastern or northern distributions overlap. Consequently, some fauna species expected in the region occur near the extreme edge of their range. As a fauna value, the site's assemblage is likely to be typical for the region, however contains species near the edge of their range and contains several restricted or habitat limited species (such as Long-tailed Dunnart).

Key features of the fauna assemblage expected in the survey area are:

- Uniqueness: The assemblage is likely to be typical of the region, however due to the project's location (on the edge of bio-geographic zones) reflects the transition zone from the Murchison to the arid interior, and some fauna species expected occur near the extreme edge of their range. Previous assessments have confirmed a diverse assemblage.
- Completeness: The assemblage is likely to be relatively complete but with the loss of some mammal species (eg. critical weight range species), although some significant species may persist (e.g. Black-flanked Rock-Wallaby). Many of the species expected may only utilise the area occasionally, when conditions are suitable (eg. nomadic or migratory birds).
- Richness: The assemblage is likely to vary annually and seasonally according to climatic conditions. The assemblage is considered to be moderately rich, as expected for a semi-arid area. Due to a range of substrates within the study area a diverse assemblage is expected; bird diversity will be seasonally variable and waterbirds will be poorly represented except as occasional visitors when seasonal waterbodies flood or may be associated with any artificial waterbody arising from the development.

Table 2. Composition of vertebrate fauna assemblage expected to occur within the survey area

Taxon	Number of species expected	Number Recorded by BCE	Significant fauna expected		
			CS1	CS2	CS3
Frogs	11	4	0	0	0
Reptiles	88	49	1	0	1
Birds	157	94	19	3	5
Native Mammals	30	21	2	3	1
Introduced Mammals	9	5	-	-	-
Total	**295**	**173**	**22**	**6**	**7**

3.1.2 Species of Conservation Significance

Details on species of conservation significance recorded or expected to occur in the survey area (even as vagrants) are presented in Table 3. This list includes two reptile species, 27 bird species and six mammal species. The suite of significant species includes many that are expected to occur only as vagrants or irregular visitors (Table 3), and thus for which the site is of low importance, except where it may have value for connectivity. The project area is likely to be important for several significant species which are

expected to occur there in resident populations or may utilise the project area during foraging or breeding. These species are discussed below.

Malleefowl

One Malleefowl mound was recorded within the project area by BCE during the field surveys (BCE, 2011a). A recently used mound (due to the presence of eggshell fragments) was recorded amongst closed Acacia shrubland on the northern sandplain, at 790 511E, 6 992 350N, approximately 2 km north of the resource area. Additionally, the Malleefowl Preservation Group has conducted regular (annual) monitoring of Malleefowl mounds at Yeelirrie since 2000, with recent surveys conducted in 2013 and 2014 (Benshemesh 2008, MPG, 2014). Two active mounds were recorded in 2013 and none in 2014, indicating an extant population persists in the area. Most known Malleefowl mounds are situated away from the uranium orebody, within stands of dense Mulga woodland. A cluster of monitored mounds is located close to the project area, including approximately 10km north of the orebody and 20km south of the orebody (see Figure 3). Suitable habitat for this species does occur within the project area and due to the presence of at least one recently active mound within the project area, and several nearby, a resident population is clearly present.

At the periphery of a species' range, environmental conditions are typically stressful and populations are comparatively small and isolated (Scoble, 2011). Yeelirrie lies near the northern limit of the Malleefowl's range (although a small population is known to the north at Lorna Glen, J. Turpin, pers. obs.). As such, the population at Yeelirrie is likely to be somewhat isolated and vulnerable to environmental change.

Black-flanked Rock-Wallaby

The Black-flanked Rock-Wallaby was known to occur in the region with several anecdotal reports of the species along the Barr Smith Range. BCE recorded a large number of rock-wallaby scats from a cave within the Barr Smith Range, approximately 40km east of the uranium resource (BCE 2011a). Several scats were collected during the 2015 assessment and forwarded to Australian Wildlife Forensic Services. Genetic analysis (White 2015) confirmed the species identification as the Black-flanked Rock-Wallaby (*Petrogale lateralis*), and most likely the sub-species *P. l. lateralis*.

The Black-flanked Rock-Wallaby relies on behavioural (occupying caves and exhibiting nocturnal foraging activity) rather than physiological responses for survival during adverse conditions (Bradshaw *et al.*, 2001; King and Bradshaw, 2008). As a result, sites containing permanent water (such as along the Barr Smith Range) can be important for the species in the arid zone, allowing animals to occupy sub-optimal habitat with inferior thermal refuge (Pearson, 2012). While much of the rocky habitat along the Barr Smith Range appears marginal, the presence of scattered waterholes in association with caves and rock crevices may allow the species to persist. While not expected to occur within habitats associated with the uranium orebody, the species may persist in the extensive rocky habitats to the north and south. The assumed status of Black-flanked Rock-Wallaby remains "resident" assuming the same disturbance footprint proposed by BHP, which indicated some disturbance to rocky habitats associated with the Barr Smith Range (eg. quarries for access roads).

Slender-billed Thornbill

The Slender-billed Thornbill has not been recorded at Yeelirrie despite a number of bird surveys conducted in the area by BCE and historical surveys conducted by previous land managers. As a result a resident population appears unlikely. While habitat potentially suitable for the species occurs at

Yeelirrie (dense tall chenopod shrubland) such habitat appears marginal and lacks the samphire elements of chenopod shrublands known to support the species in the region (eg. Lake Way, Lake Annean). During the March 2015 site visit, a site where the species had been recorded in 1978 was visited and was found to support a quite different chenopod shrubland from that found at Yeelirrie. This site, a salt lake near Sir Samuel, had extensive low, dense samphire shrubland with occasional taller patches, whereas the chenopod shrubland at Yeelirrie was very patchy with tall clumps but extensive open areas (see plates 1 and 2 below).

Plate 1. Salt lake near Sir Samuel, illustrating chenopod shrubland approximately where the Slender-billed Thornbill was recorded in 1978.

Plate 2. Chenopod shrubland at Yeelirrie, searched (unsuccessfully) for the Slender-billed Thornbill.

Brush-tailed Mulgara

The Brush-tailed Mulgara was recorded extensively across the Yeelirrie project area (BCE, 2011a and during the 2015 inspection). It was most abundant within sandplain sites dominated by spinifex (and was absent from calcrete habitats). A total of 154 burrow systems was recorded in 842 ha of search area, equating to 0.18 burrows/ha; 86 burrows were active (0.1 burrows/ha, BCE 2011a). Suitable habitat for the Brush-tailed Mulgara comprises approximately 69.9 % (69,840 ha) of the total project area (see BCE 2011a) and there may be approximately 6,984 active burrow systems within this area (using the burrow densities observed at Yeelirrie). Brush-tailed Mulgara are generally considered to be solitary, with males and females found in the same burrow only during the mating season (van Dyck and Strahan 2008). Therefore, the Project area may support several thousand Brush-tailed Mulgara.

Australian Bustard

The Australian Bustard was recorded throughout the Yeelirrie project area, particularly associated with spinifex sandplain. It was seen in both 2009/2010 (BCE 2011a) and in March 2015. It is a widespread species across much of the northern half of Australia.

Peregrine Falcon

The Peregrine Falcon was recorded along a cliff ledge in the Barr Smith Range in 2009 (BCE 2011a). The study area is likely to lie within the foraging territory of a pair.

Rainbow Bee-eater

Recorded throughout the study area in both 2009/2010 (BCE 2011a) and in March 2015. While of high conservation significance because of its listing as a migratory species under the EPBC Act, it is widespread across Australia and frequently uses disturbed environments.

Striated Grasswren

While not recorded during the BCE surveys, there are three records of this species at Yeelirrie, including approximately 5 km south of the uranium orebody (BirdLife Australia 2015). This location was visited in March 2015 and while the environment appeared suitable no birds were observed. This species has a highly patchy and fragmented distribution due to a reliance on mature spinifex grassland (Garnett *et al.*, 2011) and can be difficult to detect. Given the Birdlife record and the apparent suitability of the vegetation, it is likely to occur on the spinifex sandplains adjacent to the orebody.

Long-tailed Dunnart

The Long-tailed Dunnart favours rocky habitats and is likely to occur within the breakaway systems to the north and south of the Yeelirrie orebody area. It was recorded on hills near Wiluna in November 2014 (BCE 2014).

Migratory Waterbirds

Ten waterbirds listed as Migratory under the EPBC may periodically utilise the project area during migration. Several species have been recorded in the region and may utilise seasonal or artificial waterbodies associated with the project (eg. the 50 ha evaporation pond proposed by Cameco). The potential interaction of migratory waterbirds and the proposed evaporation pond is discussed in Appendix 5. During the March 2015 site inspection there were several seasonal wetlands present as a result of recent rains, but no migratory waterbird species were observed.

Inland Greater Long-eared Bat

This species was recorded by BCE during the previous field surveys (BCE, 2011a) and may rely on tree hollows within the *E. gypsophila* woodland subset of the Calcrete VSA.

Conservation Significance Level 3 Fauna

Eight species are considered to be of local conservation significance (CS3) due to restricted ranges (*Aprasia picturata*), because they are considered uncommon in the region (Grey Honeyeater, Rufous-crowned Emu-wren, Scarlet-chested Parrot, Square-tailed Kite, Kultarr), or because they occur in the area near range limits (Regent Parrot). The Buh Stone-curlew was recorded at several sites at Yeelirrie (BCE, 2011a). It occurs both within habitats associated with the uranium orebody and along drainage systems near rocky habitats associated with the Barr Smith Range.

Vagrants / Irregular Visitors

Several species are listed as vagrants or irregular visitors and are thus not expected to depend on environments within the project area. Eight species are discussed below.

The Night Parrot is included as potentially occurring due to the presence of suitable habitat and historical records. However an extant population has not been confirmed for the region.

The Greater Bilby is also included on the potential list as there are anecdotal records of the species further north (eg. Rosslyn Hill near Wiluna, BCE 2014), and the species is thriving at the DPaW managed Lorna Glen (J. Turpin, pers. obs.), approximately 180 km north-west of the project area. The Greater Bilby has a large home range and individuals can disperse widely (Southgate *et al.* 2007). As such, while no sign of Bilbies were recorded by BCE during field surveys, suitable habitat (spinifex sandplains) is

extensive at Yeelirrie and it is feasible that individuals may move through the area currently, or in the near future.

The status of the Great Desert Skink is listed as Unknown, as while no evidence of the species was recorded by BCE, there is potential for the species to occur at Yeelirrie, due to the extensive availability of suitable habitat (spinifex sandplains) and records nearby (at Wanjarri Nature Reserve, DPaW, 2015). The species has a clumped distribution which is influenced by fire regimes (McAlpin, 1997).

The Princess Parrot is considered an irregular visitor to the Yeelirrie area. It is an irregular visitor (sometimes at intervals of more than 20 years) to most sites in its range (Garnett and Crowley, 2000), and movements are largely unknown (Higgins, 1999). The species has been recorded at Wanjarri Nature Reserve (DPaW, 2015), however few other records exists for the region.

The Major Mitchell's Cockatoo was formerly more widespread and is patchily distributed across its range (BirdLife Australia, 2015). It has been formerly recorded at Yeelirrie, however BCE found no evidence of its occurrence and as such it is likely to be an irregular visitor.

The Grey Falcon has recently been upgraded to Vulnerable under the IUCN and Schedule 1 under the Wildlife Conservation Act. The species is infrequently recorded over much of arid and semi-arid Australia and occurs at low densities (BirdLife International, 2015). Regional records come from Wanjarri and Lorna Glen (DPaW, 2015). The distribution of the Grey Falcon is centred on inland drainage systems and nests are usually in the tallest trees along watercourses. At Yeelirrie it is likely to occur as an occasional visitor.

The Fork-tailed Swift is listed as migratory under the EPBC Act and was recorded at Yeelirrie during the 2015 field survey, with two sightings of several (and possibly the same) birds. It is a highly aerial species and largely independent of terrestrial environments. The Oriental Plover is also listed as a migratory species under the EPBC Act, but is unlikely to occur in the project area, except possibly as a vagrant. No evidence of this species was recorded during the surveys.

Table 3. Conservation status of significant fauna species expected to occur in survey area (based on desktop review) and their expected status in the study area. Species recorded by BCE at Yeelirrie are indicated with (X).

Common Name	Latin Name	Conservation Status				Expected status in project area	Local records	BCE 2011	BCE 2015
		EPBC	WCA	P	CS3				
Conservation Significance 1 (CS1)									
Malleefowl	*Leipoa ocellata*	Vul	S1			Resident	Yeelirrie	X	
Black-flanked Rock-Wallaby	*Petrogale lateralis*	Vul	S1			Resident	Albion Downs	X	X
Rainbow Bee-eater	*Merops ornatus*	Mig	S3			Regular migrant	Yeelirrie	X	X
Fork-tailed Swift	*Apus pacificus*	Mig	S3			Irregular visitor	Yeelirrie		X
Peregrine Falcon	*Falco peregrinus*		S4			Resident	Yeelirrie	X	
Major Mitchell's Cockatoo	*Cacatua leadbeateri*		S4			Irregular visitor	Yeelirrie		
Grey Falcon	*Falco hypoleucos*		S1			Irregular visitor	Wanjarri		
Princess Parrot	*Polytelis alexandrae*	Vul		P4		Irregular visitor	Wanjarri		
Slender-billed Thornbill	*Acanthiza iredalei*	Vul				Irregular visitor	Lake Way		
Night Parrot	*Pezoporus occidentalis*	CrE	S1			Vagrant	None recent		
Great Desert Skink	*Liopholis kintorei*	Vul	S1			Unknown	Wanjarri		
Greater Bilby	*Macrotis lagotis*	Vul	S1			Vagrant	Wiluna		
Eastern Great Egret	*Ardea modesta*	Mig	S3			Irregular visitor	Yeelirrie		
Common Sandpiper	*Acitis hypoleucos*	Mig	S3			Irregular visitor	Meekatharra		
Common Greenshank	*Tringa nebularia*	Mig	S3			Irregular visitor	Cue		
Marsh Sandpiper	*Tringa stagnatalis*	Mig	S3			Irregular visitor	Cue		
Wood Sandpiper	*Tringa glareola*	Mig	S3			Irregular visitor	Cue		
Red-necked Stint	*Calidris ruficollis*	Mig	S3			Irregular visitor	Cue		
Sharp-tailed Sandpiper	*Calidris acuminate*	Mig	S3			Irregular visitor	Yeelirrie		
Curlew Sandpiper	*Calidris ferruginea*	Mig	S3			Irregular visitor	Lake Austin		
Black-tailed Godwit	*Limosa limosa*	Mig	S3			Irregular visitor	Yeelirrie		
Oriental Plover	*Charadrius veredus*	Mig	S3			Vagrant	None, but returned from EPBC search		
Conservation Significance 2 (CS2)									
Australian Bustard	*Ardeotis australis*			P4		Resident	Yeelirrie	X	X
Striated Grasswren	*Amytornis s. striatus*			P4		Resident	Yeelirrie		
Brush-tailed Mulgara	*Dasycercus blythi*			P4		Resident	Yeelirrie	X	X
Long-tailed Dunnart	*Sminthopsis longicaudata*			P4		Resident	Rosslyn Hill		
Inland Long-eared Bat	*Nyctophilus major tor*			P4		Resident	Yeelirrie	X	
Conservation Significance 3 (CS3)									
Bush Stone-curlew	*Burhinus grallarius*				X	Resident	Yeelirrie	X	X
Square-tailed Kite	*Lophoictinia isura*				X	Resident	Yeelirrie	X	
Scarlet-chested Parrot	*Neophema splendida*				X	Irregular Visitor	Wanjarri		
Regent Parrot	*Polytelis anthopeplus*				X	Vagrant	Wanjarri		
Grey Honeyeater	*Conopohila whitei*				X	Resident	Wanjarri		
Rufous-crowned Emu-wren	*Stipiturus ruficeps*				X	Resident	Wanjarri		
Kultarr	*Antechinomys laniger*				X	Resident	Mount Keith		
legless-lizard	*Aprasia picturata*				X	Resident	Wiluna		

See Appendix 4 for descriptions of conservation significance levels. Species recorded are indicated and the predicted status of each species in the survey area is also given (as per Section 3.1.4).

EPBC Act listed species: Vul = Vulnerable, End = Endangered, CrE = Critically Endangered, Mig = Migratory.

WC Act listed species: S1 – S4 = Schedule 1 – 4, DpaW Priority Species: P1 – P5 = Priority 1 – 5.

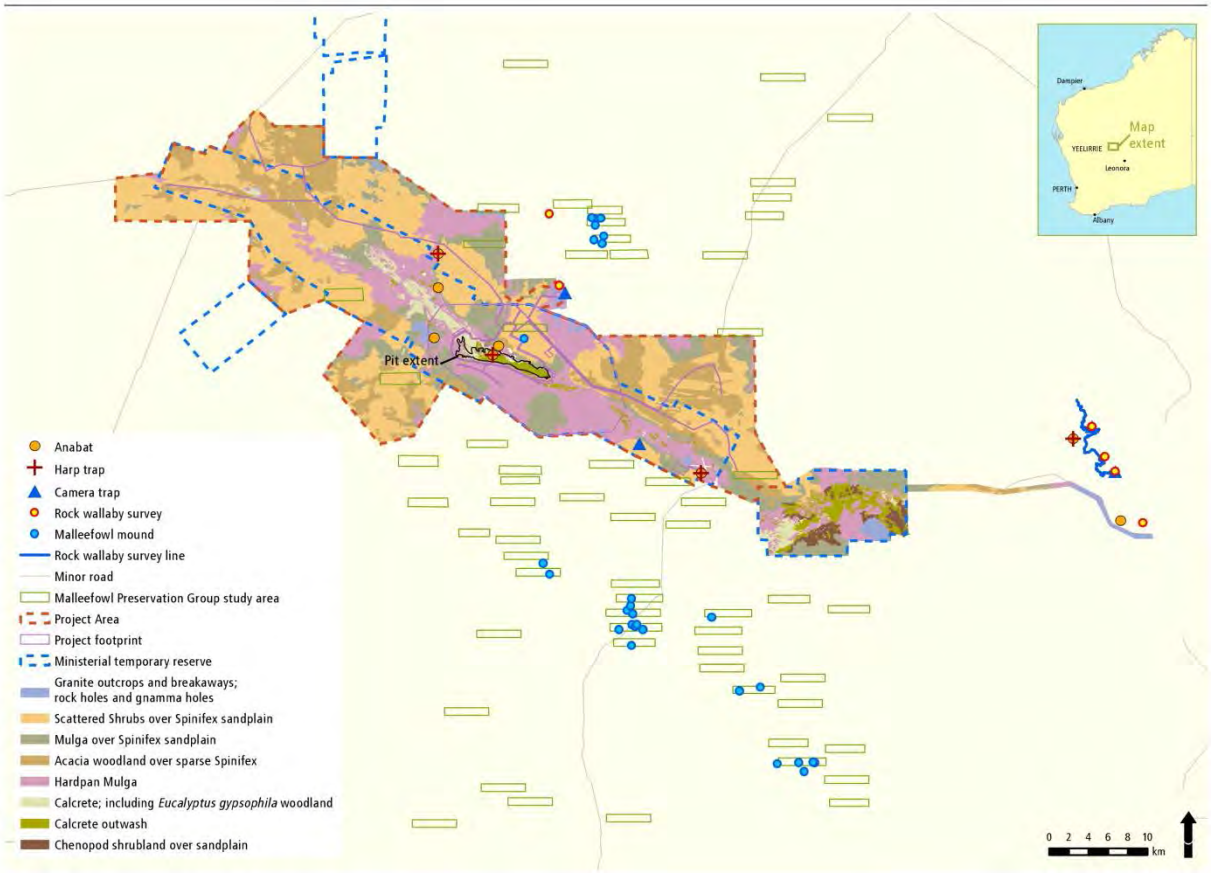
3.1.3 *Introduced / Feral Species*

The desktop study identified nine introduced fauna species as potentially occurring in the Yeelirrie project area (Table 4). Six species were recorded by BCE during the field surveys. Note that the European Red Fox is considered absent by the caretakers at Yeelirrie and would appear to be very uncommon. Wild Dogs/Dingoes appear to be common and those seen have been of a consistent appearance, suggesting that the population in the area is reasonably pure; ie not cross-bred with domestic dogs. There is a current debate that proposes Dingoes may have a role in suppressing introduced predators such as the Red Fox (Dickman *et. Al.*, 2009, compared with Allen *et al.* 2014), and thus with a history in Australia of over 3,500 years, they should perhaps be considered native at least in an ecological sense.

Table 4. Introduced fauna species expected to occur (based on desktop review and field surveys).

Common Name	Latin Name	Expected Status
MAMMALS		
Dog/Dingo	*Canis lupus dingo*	Confirmed Resident
Feral Cat	*Felis catus*	Confirmed Resident
House Mouse	*Mus musculus*	Resident
Rabbit	*Oryctolagus cuniculus*	Confirmed resident
European Red Fox	*Vulpes vulpes*	Confirmed resident
Donkey	*Equus asinus*	Resident
Horse	*Equus caballus*	Resident
Camel	*Camelus 18cuminate18s*	Confirmed visitor
Goat	*Capra hircus*	Resident
Cattle	*Bos taurus*	Confirmed visitor (from neighbouring stations)

Figure 3. Conservation Significant fauna recorded across the Yeelirrie project.



3.2 Vegetation and Substrate Associations (VSAs)

BCE (2011a) describes eight major VSAs (distinct environments that provide habitat for fauna) occurring across the Yeelirrie project area (Figure 4):

- Granite Outcrops and Breakaways. Supporting mixed shrubland on gravelly/sand. Some areas of chenopod shrubland on heavier soil also present;
- Hardpan Mulga. Mulga woodland with poorly-developed understorey on hard loam soils;
- Calcrete. Low calcrete rises with Eucalypt open woodland (variable) over a sparse shrubland;
- Calcrete Outwash. Clayey-loam and clay flats, subject to occasional inundation with some open claypans. Vegetation includes Acacia open shrubland, sometimes with thickets of *Melaleuca xerophila*, and chenopod shrub-heaths;
- Chenopod Shrubland over Sandplain. These shrublands occur in sandy soils on the margins of playas in the southeast of the project area;
- Spinifex Sandplain. Sandplains dominated by Triodia hummock grasslands and scattered shrubs with areas of open Acacia/Eucalypt woodland;
- Mulga over Spinifex Sandplain. Mulga woodland over Spinifex on sandy-loam soils; and
- Acacia woodland over sparse Spinifex. Areas of dense Acacia woodland with or without a Spinifex understorey of variable density.

Areas of each VSA within the project area are given in Table 5 (BCE, 2011a). The original disturbance footprint proposed by BHP was centred on the calcrete and calcrete outwash VSAs (467 and 615 ha respectively) and extended on the adjacent sandplain and hardpan mulga (1431 and 835 ha). Minor areas of granite outcrop / breakaway were proposed for disturbance (15 ha), and the sandplains supporting chenopod shrubland (in the south-east) occurred outside the proposed disturbance. While BHP proposed to disturb some areas of VSA, some important VSA areas were proposed to be included within a Yeelirrie Conservation Area as part of the management and preservation of the site's biodiversity (see Table 5).

Table 5. Areas of VSAs within the project area.

VSA type	Project area (ha)	Disturbance Footprint (ha)	VSA included in proposed conservation area
Granite Outcrops and Breakaways	1,866	17 (0.9%)	
Mixed Shrubs over Spinifex Sandplain*	69,840	821 (1.2%)	Yes
Hardpan Mulga	21,230	738 (3.5 %)	Yes
Calcrete	2,819	216 (7.7%)	Yes
Calcrete Outwash	3,095	548 (17.7%)	Yes
Chenopod Shrubland over Sandplain	1215	0 (0%)	
Bare and disturbed (not considered further in this study)	150	NA	

* Three VSAs not clearly defined by vegetation types so combined for the purposes of area calculation; all have spinifex in common.

Figure 4. Vegetation and Substrate Associations across the Yeelirrie project.

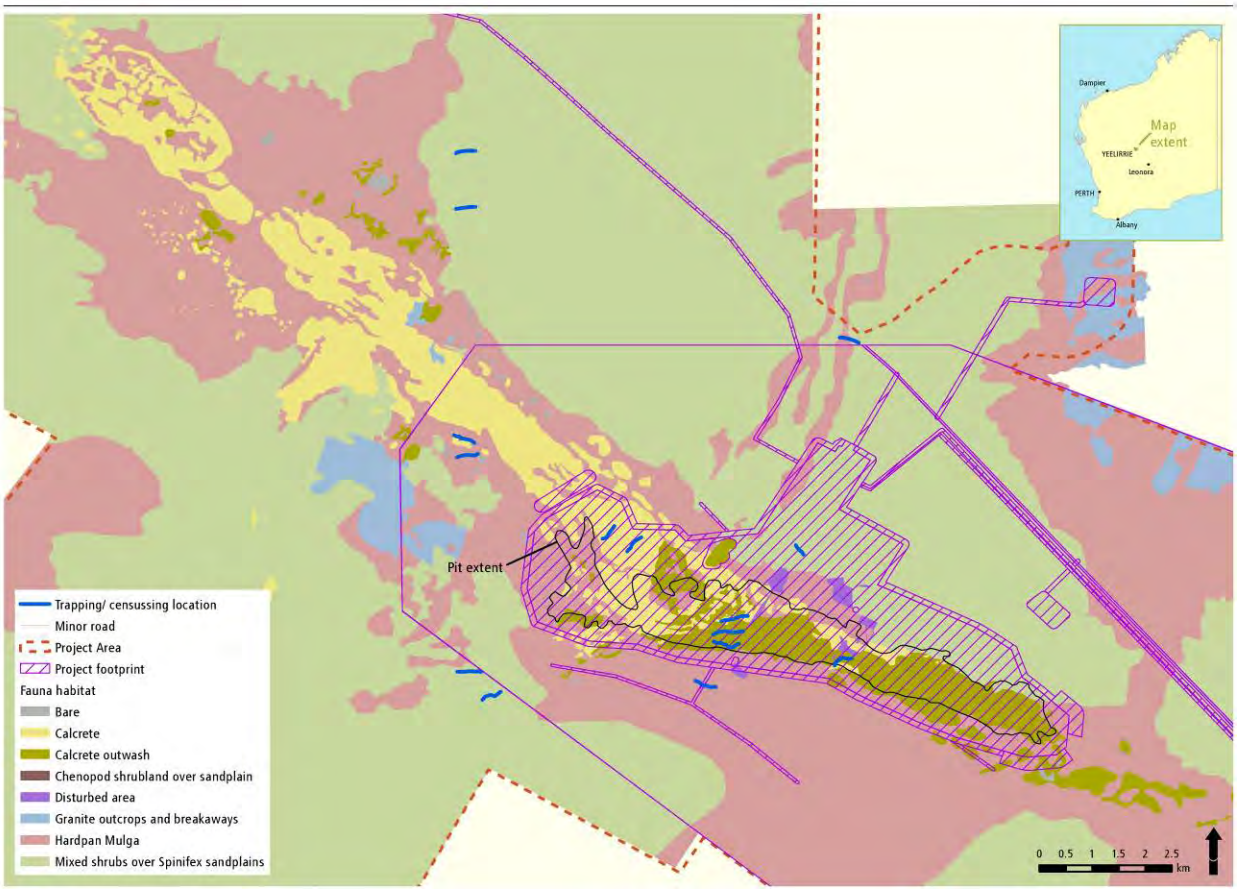
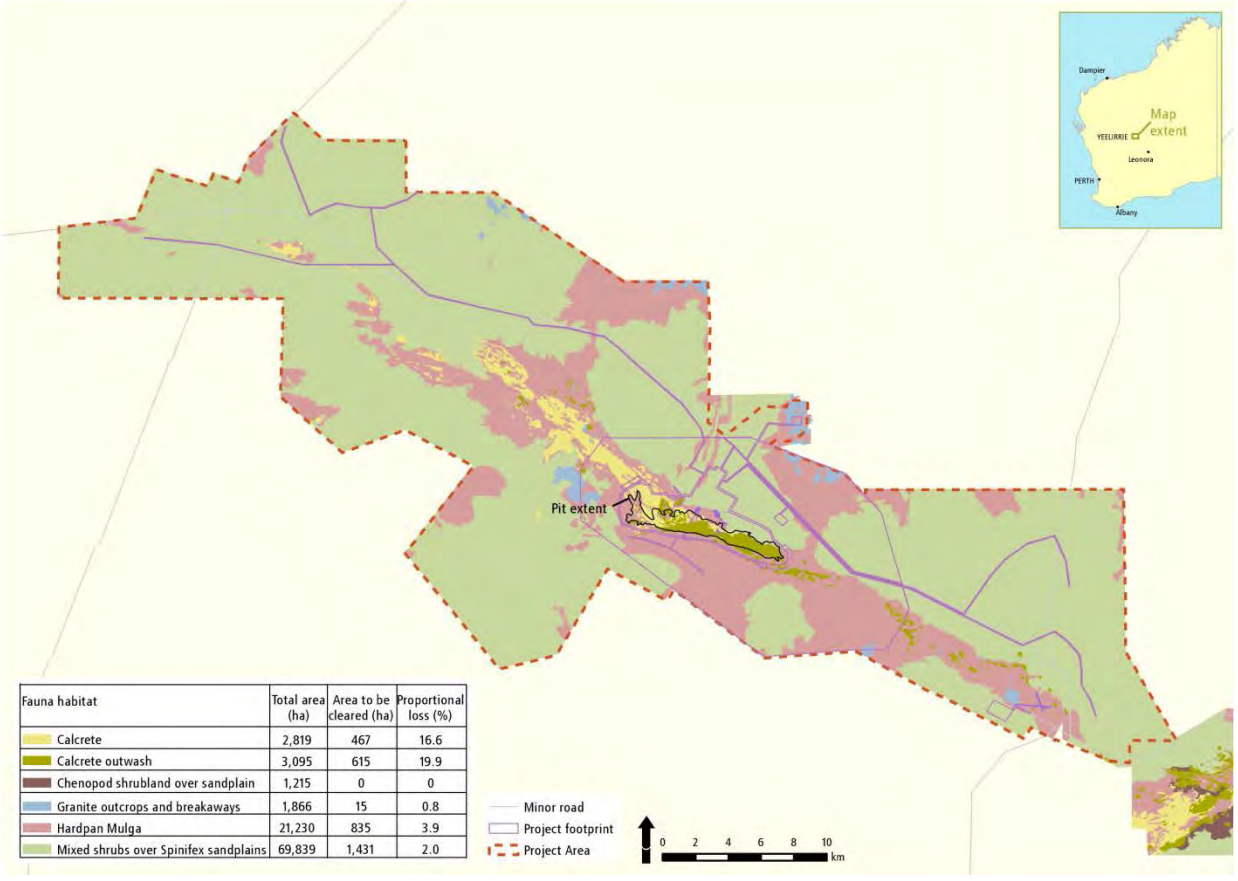


Figure 5. Vegetation and Substrate Associations across the wider Yeelirrie area.



Fauna habitat	Total area (ha)	Area to be cleared (ha)	Proportional loss (%)
Calcrete	2,819	467	16.6
Calcrete outwash	3,095	615	19.9
Chenopod shrubland over sandplain	1,215	0	0
Granite outcrops and breakaways	1,866	15	0.8
Hardpan Mulga	21,230	835	3.9
Mixed shrubs over Spinifex sandplains	69,839	1,431	2.0

3.3 Patterns of Biodiversity

Investigating patterns of biodiversity can be complex and are often beyond the scope even of level 2 investigations. However BCE (2011a) observed some overall trends at Yeelirrie during the 2009 – 2010 field work. Important patterns of distribution are:

- High reptile species richness and abundance in spinifex sandplain VSA;
- High bird species richness and abundance in VSAs including Mulga; and
- High bird and reptile species richness and abundance in *E. gypsophila* woodland subset of the Calcrete VSA.

The fauna assemblage varied in its distribution across the VSA types. Reptile species richness and abundance were highest on spinifex sandplain and in part of the calcrete VSA where *Eucalyptus gypsophila* formed an open woodland. Bird species richness and abundance were highest in this *E. gypsophila* woodland and in the two VSAs containing Mulga. With the exception of the *E. gypsophila* woodland subset of the Calcrete VSA, most of these VSAs are extensive outside the fauna study area. The rocky breakaways and outcrops away from the orebody support restricted species (such as the Black-flanked Rock-Wallaby, Long-tailed Dunnart, Woolley's Pseudantechinus) and the seasonal wetlands (playas) are likely to support irregular visits of migratory waterbirds.

3.4 Ecological Processes

The nature of the landscape and the fauna assemblage indicate some of the ecological processes that may be important for ecosystem function (see Appendix 4 for descriptions and other ecological processes). These include:

Local hydrology. The orebody is situated on a major paleo-drainage line which supports a series of seasonal wetlands. Several of the VSAs present (such as those associated with calcrete) may be reliant upon groundwater and the local hydrology will be important for all VSAs. The installation of artificial waterbodies has important implications for migratory waterbirds (see Appendix 5).

Fire. While some habitats associated with the orebody may burn infrequently (eg. Chenopod shrublands), the adjacent spinifex grasslands are highly flammable and mulga communities are fire sensitive. Spinifex grasses are highly flammable and are able to withstand high intensity fires by regenerating quickly from seed and rootstock following a fire event (Latz 1995). Mulga, however, is highly sensitive to fire and can be permanently removed by high intensity fires (mature Mulga trees and seedlings readily succumb to moderately intense fire and generally do not resprout). High intensity fires, repeat fire events or the lack of rainfall following a fire can deplete Mulga seed supply and cause long-term change (Bradstock *et al.*, 2012). In the absence of traditional burning regimes adopted by indigenous Australians, large areas of fire-sensitive Mulga (including the associated animals and plants) can be replaced by spinifex dominated communities (Bradstock *et al.*, 2012).

The project area will be prone to fire in dry weather and while appropriate fire regimes can benefit biodiversity, inappropriate regimes can lead to a loss of biodiversity. Some fauna species expected in the project area are sensitive to fire as they rely on long-unburnt environments to survive (eg. Striated Grasswren, Malleefowl). A mosaic burning regime is known to benefit biodiversity and can also aid in the control of unplanned wildfires. Rocky areas can also act as fire refuges and allow for the

development of fire-sensitive environments over time (eg. Callitris woodland along the Barr Smith Range).

Feral species and interactions with over-abundant native species. The fauna assemblage has already been impacted by feral species with the loss of some mammals due to feral predators, and the possible decline of the significant fauna (such as Malleefowl) due to grazing by domestic and feral animals. Increased human activity within bushland areas often results in an increase in the abundance of feral species. Feral fauna should be managed to reduce impacts on native fauna species. Threatened fauna (such as Malleefowl, Rock-Wallabies) would benefit from the control of feral fauna (eg. Feral cat, goat, fox). In addition, livestock have historically caused significant degradation to vegetation at Yeelirrie, particularly around permanent water. Yeelirrie has been destocked however cattle from neighbouring properties were recorded widely across the lease (during 2015). As a result of recent rainfall several seasonal wetlands supported small numbers of cattle.

Habitat degradation due to weed invasion. There was little evidence of weed invasion in most VSAs across the site but increasing human activity has the potential to increase habitat degradation through weed invasion. This in turn will impact on fauna when vegetation density changes. Weed management practises should be implemented as part of environmental management.

Connectivity and landscape permeability. The orebody lies on a major paleo-drainage line and is likely to have a connectivity function for fauna moving along it (to the north-west and south-east). This may be important for species inhabiting the *Eucalyptus gypsophila* woodland or the associated chenopod shrublands. Other VSAs occurring away from the orebody (such as spinifex sandplains and mulga) are widespread across the landscape.

3.5 Summary of Fauna Values

Fauna values within the study area can be summarised as follows:

Fauna assemblage. The vertebrate fauna assemblage is expected to be composed of 295 species, of which BCE (2011a) recorded 173 fauna species at Yeelirrie. The assemblage is considered to be relatively intact, within a relatively intact, largely uncleared landscape, although a number of species are likely to have been impacted by long-term pastoralism (e.g. Malleefowl) and feral predators (e.g. Bilby).

Species of conservation significance. A total of 35 species of conservation significance are expected to be present at least occasionally within the project area. Ten conservation significant species were recorded by BCE (2011a). The VSAs within the project area support (or are expected to support) resident populations of the Brush-tailed Mulgara, Malleefowl, Black-flanked Rock-Wallaby, Rainbow Bee-eater, Peregrine Falcon, Australian Bustard, Bush Stone-curlew and Striated Grasswren. Additional conservation significant fauna species are expected however only as irregular visitors or vagrants. For example, a number of migratory waterbirds may occasionally use seasonal natural wetlands, and could utilise artificial waterbodies associated with the project.

Vegetation and Substrate Associations (VSAs). Eight VSAs were identified across the project area and surrounding landscape. Mixed Shrubs over Spinifex Sandplain, Hardpan Mulga, Calcrete and Calcrete Outwash dominant most of the disturbance footprint with much smaller areas of rocky breakaway also included. The uranium orebody sits under the calcrete habitats, which are regionally uncommon

although are not restricted to the project area. Potential impacts on the general vertebrate fauna assemblage are likely to be greater in the *E. gypsophila* woodland subset of the Calcrete habitat, which has a higher proportional representation in the study area. Other VSAs in the project area, such as the mulga and spinifex sandplains are considered widespread.

Patterns of biodiversity. Biodiversity is likely to be spread across the VSAs, with the most significant areas for fauna considered to be the spinifex sandplains, *Eucalyptus gypsophila* woodland associated with the calcrete substrate and rocky breakaways.

Key ecological processes. One of the dominant ecological processes currently affecting the fauna assemblage in the project area is hydrology, with other processes including fire, feral species and interactions with native species, habitat degradation due to weed invasion and connectivity. Long-unburnt habitats are important for species such as the Malleefowl and Striated Grasswren.

4 Impact Assessment

4.1 Overview of Impacts

The following sections examine possible impacts upon fauna values based upon the impacting or threatening processes outlined in Appendix 2. Impacts upon significant species are summarised in Table7. Impacts are considered to be mostly Minor or Negligible. Impact criteria are outlined in Table 3. Recommendations relating to impacts are made in Section 6.

4.1.1 Loss of habitat leading to population decline

Some loss of habitat is inevitable but can be minimised through controls during clearing. Rehabilitation of disturbed areas may also be implemented as soon as possible after clearing. The small area of impact in relation to the surrounding landscape means that loss of habitat is unlikely to have long-term adverse impacts upon fauna populations in the region. The *E. gypsophila* woodland subset of the Calcrete habitat would be impacted and is an area of high species richness and abundance, but the vertebrate assemblage does not appear unique or to contain species not found elsewhere in the area. For example, much of the species richness and abundance is due to species attracted by the concentration of Eucalypt canopy, leaf-litter and possibly tree-hollows. These features are found in other habitats but the consequence may be a localised decline in population size of otherwise common species.

4.1.2 Loss of habitat leading to population fragmentation

Some landscape features within the project area may have a connectivity function for fauna, aiding them to move through the landscape. Therefore, impacts upon these features could disrupt this movement, facilitating population fragmentation. For example, the remaining patches of *E. gypsophila* woodland would be fragmented and this may affect the ability of some fauna species to move across the landscape.

4.1.3 Degradation of habitat due to weed invasion

Weed invasion of the project area is currently minimal. Further impacts from weeds can be minimised by maintaining reasonable hygiene measures.

4.1.4 Ongoing mortality

Increased mortality is inevitable during clearing operations and from ongoing activities, such as roadkill due to animals being struck by vehicles, or birds striking infrastructure and fauna attracted into production areas (eg. In search of food, such as death of insects underneath lights, or water). In general, areas to be cleared are small within the context of the regional landscape so mortality during clearing is likely to represent only small proportions of regional populations. For common species, levels of mortality are unlikely to be significant in a conservation sense, but there are welfare issues. However, the viability of species that occur at low population densities in areas adjacent to the project Area may be compromised by ongoing mortality. For example, if a population of Malleefowl or Black-flanked Rock-Wallaby was present in the project area, roadkill could be a concern. The mortality of migratory waterbirds attracted to toxic waterbodies is of concern and requires management – see Appendix 5.

4.1.5 Species interactions

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 and 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.

Existing stock watering points have been decommissioned as part of the site's environmental management, however the development would inevitably provide some opportunities for access to fresh water (e.g. from garden reticulation or water from air-conditioners). Changes in the abundance of some native species at the expense of others, due to the provision of fresh watering points, can be a concern. Harrington (2002) found the presence of artificial fresh water points 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.

4.1.6 Hydroecology

Interruptions of hydroecological processes are a concern where VSAs may be impacted, resulting in impacts to fauna species. The two Mulga habitats are likely to be reliant on surface and sub-surface flows that may be altered by clearing, earthworks and drainage management. The *E. gypsophila* woodland is also almost certainly reliant on groundwater. As a result, habitat degradation may occur beyond the clearing footprint.

4.1.7 Altered fire regimes

While the biota of the region is probably adapted to a particular fire regime, it is likely this regime has already been altered since European settlement. Utilising a mosaic burning regime is likely to benefit both native flora and fauna, and aid in the control of unplanned wildfires. Mulga in particular is sensitive to fire, while biodiversity in spinifex grasslands can be altered by changes in the fire regime. Although not part of the mining process, mining activities can lead to a change in the fire regime.

4.1.8 Disturbance

Impacts of dust, light, disturbance and noise upon fauna are considered likely. This may impact fauna if there is an increase in artificial lighting in the project area. For example, mortality of insects was noted around existing operations due to insects being attracted to lights; the consequence of such mortality is not understood but on a precautionary basis should be minimised. Recent work around Olympic Dam has found off-site impacts on bird assemblages related to disturbance (John Read, pers. Comm.).

4.1.9 Bioaccumulation

Bioaccumulation of heavy metals and radionuclides within the environment may occur in both the short and long-term. Heavy metals and radionuclides may enter the environment through seepage of contaminants from tailings facilities or dispersal of radioactive dust. An organism may accumulate heavy metals through direct ingestion, inhalation or ingestion of contaminated organisms. While heavy metals occur naturally in the environment, they become a concern for fauna when their environmental

concentration increases to the extent that the capacity of a species to regulate the internal concentration of metals is lost.

4.1.10 Summary of impacts

Impacts upon key fauna values are summarised in Tables 6 and 7 and are mostly considered to be Minor or less. This is due to the site's location within a largely intact landscape; a landscape expected to contain large areas of the same VSAs as those present within the survey area. With appropriate management, the combination of the above factors is likely to result in a localised, long-term reduction in population size of a range of common species, but no loss of species or fauna assemblage viability. As such, the residual impact is categorised as minor for most fauna values. Habitat degradation as a result of weed incursion and/or fire, and the activities of feral fauna may also be of some concern. Management measures listed in Table 6 are expanded on in Section 6.

Table 6. Impact assessment of conservation significant species expected to occur in the survey area.

Common Name	Status	Habitat	Occurrence	Management	Residual Impact
Conservation Significance 1 (CS1)					
Malleefowl	Vulnerable	Dense Acacia	Resident	Habitat preservation, fire/feral management, signpost to avoid roadkill	Minor
Black-flanked Rock-Wallaby	Vulnerable	Breakaways, Barr Smith Range	Resident	Habitat preservation, fire/feral management, signpost to avoid roadkill	Minor
Rainbow Bee-eater	Migratory	Sandplain	Regular migrant	Protect nest sites during earthworks and road maintenance	Negligible
Fork-tailed Swift	Migratory	Aerial	Irregular visitor	None – aerial species	Negligible
Peregrine Falcon	S1	Cliffs, woodland	Resident	Maintain breeding sites if found	Negligible
Major Mitchell's Cockatoo	S1	*E. gypsophila*	Irregular visitor	Maintain breeding sites if found	Negligible
Grey Falcon	Vulnerable	Open plains	Irregular visitor	Maintain breeding sites if found	Negligible
Princess Parrot	Vul, P4	*E. gypsophila*	Irregular visitor	Maintain breeding sites if found	Negligible
Slender-billed Thornbill	Vulnerable	Chenopods	Irregular visitor or possible resident	Habitat preservation	Negligible
Night Parrot	CrE	Sandplain	Vagrant	Possibly fire and feral fauna management	Negligible
Great Desert Skink	Vulnerable	Sandplain	Unknown	Habitat preservation, fire/feral management	Minor
Greater Bilby	Vulnerable	Sandplain	Vagrant	Habitat preservation, fire/feral management	Minor
Great Egret	Migratory	Wetlands	Irregular visitor	Management of waterbodies	Minor
Common Sandpiper	Migratory	Wetlands	Irregular visitor	Management of waterbodies	Minor
Common Greenshank	Migratory	Wetlands	Irregular visitor	Management of waterbodies	Minor
Marsh Sandpiper	Migratory	Wetlands	Irregular visitor	Management of waterbodies	Minor
Wood Sandpiper	Migratory	Wetlands	Irregular visitor	Management of waterbodies	Minor

Common Name	Status	Habitat	Occurrence	Management	Residual Impact
Red-necked Stint	Migratory	Wetlands	Irregular visitor	Management of waterbodies	Minor
Sharp-tailed Sandpiper	Migratory	Wetlands	Irregular visitor	Management of waterbodies	Minor
Curlew Sandpiper	Migratory	Wetlands	Irregular visitor	Management of waterbodies	Minor
Black-tailed Godwit	Migratory	Wetlands	Irregular visitor	Management of waterbodies	Minor
Oriental Plover	Migratory	Wetlands	Vagrant	Management of waterbodies	Minor
Conservation Significance 2 (CS2)					
Australian Bustard	P4	Sandplains	Resident	None – widespread	Negligible
Striated Grasswren	P4	Sandplains	Resident	Habitat preservation, fire/feral management	Minor
Brush-tailed Mulgara	P4	Sandplains	Resident	Habitat preservation, fire/feral management	Minor
Long-tailed Dunnart	P4	Rocky areas	Resident	Habitat preservation, fire/feral management	Minor
Central Long-eared Bat	P4	*E. gypsophila*	Resident	Retain tree hollows	Minor
Conservation Significance 3 (CS3)					
Bush Stone-curlew	CS3	Shrublands	Resident	Habitat preservation, fire/feral management	Minor
Square-tailed Kite	CS3	Woodlands	Resident	None	Negligible
Scarlet-chested Parrot	CS3	Mallee sandplains	Irregular Visitor	Habitat preservation	Minor
Regent Parrot	CS3	Woodlands	Vagrant	Retain tree hollows	Negligible
Grey Honeyeater	CS3	Mulga	Resident	None	Negligible
Rufous-crowned Emu-wren	CS3	Sandplains	Resident	fire/feral management	Minor
Kultarr	CS3	Open plains	Resident	None	Negligible
legless-lizard	CS3	Sandplains	Resident	None	Negligible

Table 7. Potential impacts upon key fauna values, including conservation significant species.

Fauna Value	Nature and Significance of Impact		Suggested Action
	Potential Impacts	Significance	
Fauna assemblage	• Increased mortality; • Loss of habitat; and • Species interactions.	Minor as impacts very localized in a regional context	• Minimise impact footprint; • Rehabilitate where possible; • Manage ongoing mortality; • Monitor / manage impacts from artificial waterbodies
VSAs	• Loss of habitat; • Altered hydroecology; and • Habitat degradation through weed invasion or altered fire regimes.	Minor as these are widespread in the region except Calcrete VSA	• Minimise footprint especially in Calcrete VSA; and • Monitor vegetation condition;

Fauna Value	Nature and Significance of Impact		Suggested Action
	Potential Impacts	Significance	
Significant fauna	• Ongoing mortality; • Loss of habitat; and • Species interactions.	Minor as impacts localized but consideration needed for Malleefowl, Black-flanked Rock-Wallaby	• Minimise footprint; • Habitat preservation – retain / manage areas of important for conservation; • Monitor important populations of conservation significant fauna; • Retain tree hollows • Manage feral species as required. • Monitor / manage impacts from artificial waterbodies
Patterns of biodiversity	The most significant VSAs in terms of biodiversity, such as watercourses and areas of spinifex on sandy-loam soil, are largely outside areas of direct impact. The most-impacted VSA is low in biodiversity within the context of the region, although rocky hills and watercourses within the VSA may be of interest for some taxa.	Minor as impacts very localized	• Minimise footprint where possible. • Monitor / manage impacts from artificial waterbodies
Ecological processes	• Potential impacts on hydrology; and • Some possible impacts on fire regimes and feral predators.	Minor but changes to hydrology could be a concern.	• Management to prevent any impacts to local hydrology; and • Manage fire and feral species where necessary.

5 Conclusions

Cameco commissioned BCE to conduct a review of the historic fauna survey reports completed at Yeelirrie to confirm the following:

- The methods, reports and findings meet current guidelines and requirements;
- Conservation rankings of significant species are current;
- To identify and discuss any new issues that might have arisen since the previous work was completed in 2009, including information about species and new conservation rankings.

BCE conducted detailed vertebrate fauna assessments of the Yeelirrie project area in 2009 and 2010 (BCE, 2011a; 2011b) and included desktop reviews, database searches and field investigations within the project area and outside to provide some regional context. This approach is consistent with guidelines and recommendations set out by the Western Australian Environmental Protection Authority (EPA, 2002; 2004). In 2015, a second desktop assessment (including relevant database searches) was conducted to update the initial desktop assessment. A site inspection targeting conservation significant fauna was also conducted in March 2015 and focussed on searches for Malleefowl, Slender-billed Thornbill, Striated Grasswren, Black-flanked Rock-wallabies and the Shield-backed Trapdoor Spider.

The vertebrate fauna assemblage is expected to be composed of 295 species, including: 11 frog, 88 reptile, 157 bird, 30 native mammal and nine introduced mammal species. BCE (2011a) recorded 173 fauna species at Yeelirrie. Thirty-five of the species expected to occur in the region are of conservation significance and includes two reptile species, 27 bird species and six mammal species. Ten conservation significant species were confirmed by BCE during surveys. Desktop studies identified nine introduced fauna species as potentially occurring in the Yeelirrie project area. Six species were recorded by BCE during the field surveys.

Eight VSAs were identified across the project area and surrounding landscape. Mixed Shrubs over Spinifex Sandplain, Hardpan Mulga, Calcrete and Calcrete Outwash dominant most of the disturbance footprint with much smaller areas of rocky breakaway also included. The VSAs within the project area support (or are expected to support) resident populations of the Brush-tailed Mulgara, Malleefowl, Black-flanked Rock-Wallaby, Rainbow Bee-eater, Peregrine Falcon, Australian Bustard, Bush Stone-curlew and Striated Grasswren. Additional conservation significant fauna species are expected however only as irregular visitors or vagrants. For example, a number of migratory waterbirds may occasionally use seasonal natural wetlands, and could utilise artificial waterbodies associated with the project.

Potential impacts on the general vertebrate fauna assemblage are likely to be greater in the *E. gypsophila* woodland subset of the Calcrete habitat, which has a higher proportional representation in the study area. Ecological processes affecting the fauna assemblage include changes to hydrology, fire regimes, feral species and interactions with native species, habitat degradation due to weed invasion and connectivity.

The assessment identified that impacts upon fauna are likely to be Minor or less. This is due to the site's location within a largely intact landscape; a landscape expected to contain large areas of the same VSAs as those present within the survey area. With appropriate management, there is likely to be some localised, long-term reduction in population size of a range of common species, but no loss of species or fauna assemblage viability. Management recommendations are provided in Section 6.

6 Recommendations

Section 4 (Impact Assessment) identified several potential adverse impacts that may occur from the disturbance to the survey area. While impacts are expected to be mostly Negligible to Minor, any reduction in impacts is desirable.

Management strategies are recommended below to reduce the potential impacts of this development on fauna species.

Loss of habitat / habitat fragmentation

- Minimise removal of large trees;
- Minimise the disturbance footprint, especially in the calcrete VSA;
- Clearly delineate areas to be cleared;
- Where possible, protect environments and locations that support conservation significant fauna;
- Rehabilitate any cleared areas not needed after construction;
- Undertake pre-clearance fauna surveys as there is likely to be a large lag time between approval and development and to identify important fauna areas. These will also enable a revision of the impact assessment to account for any administrative / legislative changes;
- Protect large, hollow-bearing trees where possible.

Habitat Management

- Maintain the Yeelirrie lease as livestock-free as part of the site's environmental management. This would be a significant and positive step towards the management and rehabilitation of fauna habitats.
- Decommission stock watering points to reduce the availability of artificial watering points for aggressive species away from the mine area.

Species interactions

- Develop a feral animal management plan.

Hydrological changes

- Develop an understanding of the surface and sub-surface drainage and possible effects of human activities upon groundwater in order to identify the potential for hydrological changes that could potentially impact fauna habitats
- Manage artificial waterbodies (evaporation ponds) to minimise impacts upon migratory waterbirds from potentially toxic waterbodies.
- Implement measures to minimise disruption to surface water and groundwater flows as described the ERMP

Habitat degradation due to weed invasions

- Develop a weed management/hygiene plan.

Changes in fire regime

- Develop a fire management plan (which includes regard for the ecological role of fire) to preserve habitat for fire sensitive species.

Dust, noise, light and disturbance

- Minimise the production of dust, noise and light spill; especially where these may affect adjacent bushland. Establish long-term fauna monitoring sites to assess the impacts of these to monitor trends and identify areas of concern to dictate management.

Further studies

There are several opportunities for further work at Yeelirrie:

- The record of the Black-flanked Wallaby is of interest and the species is likely to be restricted to the rocky landscapes to the north of the orebody. Government agencies may require further information on the distribution and abundance of this species.
- Work at other mine operations (e.g. Olympic Dam) suggests indirect impacts on bird assemblages up to several kilometres from operations. There is potential for Cameco to monitor birds (and other groups) to assess such indirect impacts from the proposed development and potentially develop mitigation measures.
- If a delay of several years or more occurs before development takes place, the fauna assemblage should be reassessed to account for any changes in conservation listings, and some targeted surveys of significant fauna should be undertaken.

7 References

Allen, B.L., Lundie-Jenkins, G., Burrows, N.D., Engeman, R.N., Fleming, P.J.S. and Leung, L. K.-P. (2014). Does lethal control of top predators release meso-predators? A re-evaluation of three Australian case studies. Ecological Management and Restoration 15: 1-5.

Anon. (1978). Unpubl. Species list for Yeelirrie Project area from 1978 ERMP.

Bamford Consulting Ecologists (2011a). Vertebrate Fauna Assessment: Yeelirrie Project Baseline Report. Unpubl. Report to URS Australia Pty Ltd, by Bamford Consulting Ecologists, Kingsley.

Bamford Consulting Ecologists (2011b). Fauna Assessment of the Yeelirrie Fauna Study Area Impact Assessment Report. Unpubl. Report to URS Australia Pty Ltd, by Bamford Consulting Ecologists, Kingsley.

Bamford Consulting Ecologists (2014). Rosslyn Hill Project Proposed Priority Expansion Areas Fauna Assessment October 2014. Unpubl. Report to Strategen, by Bamford Consulting Ecologists, Kingsley.

Bamford Consulting Ecologists (2014). Impact of Pit Void Lakes on Fauna . Unpubl. Report to Cameco Pty Ltd, by Bamford Consulting Ecologists, Kingsley.

Barrett, G., Silcocks, A., Barry, S., Cunningham, R. and Poulter, R. (2003). *The new atlas of Australian birds*. Melbourne: Birds Australia.

Benshemesh, J., S. Dennings, C. Danzi, and A. Sanders. (2008). Malleefowl searches at Yeelirrie station in arid Western Australia: a valuable collaboration between industry and volunteers. In: Davies S.J.J.F. (ed) Katanning National Malleefowl Forum 2007. School of Environmental Biology Bulletin No.28, Curtin University of Technology, Perth WA.

Birdlife Australia (2015). Birdata Database. www.birdata.com.au (accessed January 2015).

BirdLife International (2015). IUCN Red List for birds. Downloaded from http://www.birdlife.org on 24/01/2015.

Blakers, M., Davies, S.J.J.F. and Reilly, P.N. (1984). The Atlas of Australian Birds. Royal Australasian Ornithologists Union. Melbourne University Press.

Bradstock RA, Williams RJ, Gill AM (2012). Flammable Australia: fire regimes, biodiversity and ecosystems in a changing world. CSIRO Publishing.

Calver, M., Lymbery, A., McComb, J. and Bamford, M. (2009). *Environmental Biology*. Cambridge University Press, Melbourne.

Christidis, L. and Boles, W. E. (2008). *Systematics and Taxonomy of Australian Birds*. CSIRO Publishing, Collingwood, Victoria.

Churchill, S. (2008). *Australian Bats*. Reed New Holland Press, Sydney.

Cowan M (2008). Australian biodiversity assessment, (2008). Annex 2.3, examples of trends in significant species and communities: small mammals and reptiles of Lorna Glen ex-pastoral station. Department of Environment and Conservation, Kensington, WA.

Department of the Environment (2015). EPBC Protected Matters Search Tool. (accessed January 2015).

Department of the Environment (2014b). Key Threatening Processes. http://www.environment.gov.au/cgi-bin/sprat/public/publicgetkeythreats.pl (accessed May 2014).

Department of Parks and Wildlife (WA) (2015). NatureMap Database. http://naturemap.dec.wa.gov.au/default.aspx (accessed January 2015).

DEWHA. (2009a). Advice to the Minister for the Environment, Heritage and the Arts from the Threatened Species Scientific Committee (the Committee) on Amendment to the list of Threatened Species under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act). Department of the Environment, Water, Heritage and the Arts, Canberra, Australia.

DEWHA.(2010). Survey guidelines for Australia's threatened birds. Department of the Environment, Water, Heritage and the Arts, Canberra, Australia.

Dickman CR, Glen AS & Letnic M (2009). Reintroducing the dingo: can Australia's conservation wastelands be restored? In: MW Hayward & MJ Somers (eds). *Reintroduction of top order predators*. Pp. 238-269. Wiley-Blackwell, London.

Doughty, P. and Ellis, R. (2014a). Checklist of the Amphibians of Western Australia. Department of Terrestrial Zoology, Western Australian Museum, Welshpool, Western Australia.

Doughty, P. and Ellis, R. (2014b). Checklist of the Reptiles of Western Australia. Department of Terrestrial Zoology, Western Australian Museum, Welshpool, Western Australia.

Environmental Protection Authority (2002). Terrestrial Biological surveys as an Element of Biodiversity Protection. Position Statement No. 3. Environmental Protection Authority, Perth, Western Australia.

Environmental Protection Authority. (2004). Guidance for the assessment of environmental factors: Terrestrial fauna surveys for environmental impact assessment in Western Australia. No. 56. Environmental Protection Authority, Perth, Western Australia.

Environmental Protection Authority and Department of Environment and Conservation (2010). Technical Guide – Terrestrial Vertebrate Fauna surveys for Environmental Impact Assessment (eds B.M. Hyder, J. Dell and M.A Cowan). Perth, Western Australia.

Environment Australia.(2000). Revision of the Interim Biogeographic Regionalisation for Australia (IBRA) and Development of Version 5.1 – Summary Report. Environment Australia, Department of Environment and Heritage, Canberra, Australian Capital Territory.

Garnett, S., Szabo, J. and Dutson, G. (2011). *The Action Plan for Australian Birds* 2010.CSIRO Publishing.

Harvey, M. (2002). Short-range Endemism amongst the Australian fauna: examples from non-marine environments. *Invertebrate Systematics*, 16: 555-570.

Higgins, P. J. (Ed.) (1999). Handbook of Australian, New Zealand and Antarctic Birds. Volume 4: Parrots to Dollarbird. Oxford University Press, Melbourne, Australia.

How, R. A., Cooper, N. K. and Bannister, J. L. (2013). Checklist of the Mammals of Western Australia. Department of Terrestrial Zoology, Western Australian Museum, Welshpool, Western Australia.

Johnstone, R. E. (2013). Checklist of the Birds of Western Australia. Department of Terrestrial Zoology, Western Australian Museum, Welshpool, Western Australia.

Johnstone, R.E. and Storr, G.M. (1998). *Handbook of Western Australian Birds* Vol 1 – Non-passerines (Emu to Dollarbird).Western Australian Museum, Perth.

Johnstone, R.E. and Storr, G.M. (2004). *Handbook of Western Australian Birds*. Vol 2: Passerines (Blue-winged Pitta to Goldfinch). Western Australian Museum, Perth.

King, J. M., and Bradshaw, S.D. (2008). Comparative water metabolism of Barrow Island macropod marsupials: Hormonal versus behavioural-dependent mechanisms of body water conservation. General and Comparative Endocrinology, 155, 378-385.

KLA (2012). Spring Fauna Assessment – C3, C4 and Bowerbird, Wiluna West Project. Unpublished report. Keith Lindbeck and Associates, Perth.

Latz, P.K. (1995). Bushfires and Bushtucker: Aboriginal plant use in Central Australia . Alice Springs, IAD Press.

McAlpin, S. (1997). *Conservation of the Great Desert Skink,* Egernia kintorei*, at Uluru – Kata Tjuta National Park, N.T*. Page(s) 1-63. Canberra: ANCA.

Mace, G. and Stuart, S. (1994). Draft IUCN Red List Categories, Version 2.2.Species; Newsletter of the Species Survival Commission.IUCN – The World Conservation Union. No. 21-22: 13-24.

Menkhorst, P. and Knight, F. (2001). *A Field Guide to the Mammals of Australia*. Oxford University Press, Melbourne.

Outback Ecology (2011). Toro Energy Limited Wiluna Uranium Project: Terrestrial Fauna Assessment 2010. Unpublished report, 2011. Outback Ecology Services, Jolimont, WA.

Pearson, D. J. (2012). Recovery Plan for five species of rock-wallabies: black-flanked rock-wallaby (Petrogale lateralis), Rothschild's rock-wallaby (Petrogale rothschildi), short-eared rock-wallaby (Petrogale brachyotis), monjon (Petrogale burbidgei) and nabarlek (Petrogale concinna). Department of Environment and Conservation, Perth.

Read, J.L. (1999). A strategy for minimizing waterfowl deaths on toxic waterbodies. Journal of Applied Ecology, 36, 345–350.

Sample, B. E., D.M. Opresko, and G.W. Suter, (1996). Toxicological Benchmarks for Wildlife: 1996 Revision, ES/ER/TM-86/R3, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Soule, M. E., Mackey, B. G., Recher, H. F., Williams, J. E., Woinarski, J. C. Z., Driscoll, D., Dennison, W. C. and Jones, M. E. (2004). The role of connectivity in Australian conservation. *Pacific Conservation Biology*10: 266-279.

Southgate, R., R. Paltridge, P. Masters & S. Carthew (2007). Bilby distribution and fire: A test of alternative models of habitat suitability in the Tanami Desert, Australia. Ecography. 30:759-776

Storr, G.M., Smith, L.A. and Johnstone, R.E. (1983). *Lizards of Western Australia*. II. Dragons and Monitors. W.A. Museum, Perth.

Storr, G.M., Smith, L.A. and Johnstone, R.E. (1990). *Lizards of Western Australia*. III. Geckoes and Pygopodids. W.A. Museum, Perth.

Storr, G.M., Smith, L.A. and Johnstone, R.E. (1999). *Lizards of Western Australia*. I. Skinks. Revised Edition. W.A. Museum, Perth.

Storr, G.M., Smith, L.A. and Johnstone, R.E. (2002). *Snakes of Western Australia*. W.A. Museum, Perth.

Tyler, M.J., Smith, L.A. and Johnstone, R.E. (2000). *Frogs of Western Australia*. W.A. Museum, Perth.

U. S. Department of Energy Environmental Office (2005). Remediation of the Moab Uranium Mill Tailings, Grand and San Juan Counties, Utah, Final Environmental Impact Statement, Volume II Appendices A–H, U. S. Department of Energy, United States of America.

Van Dyck, S. and Strahan, R. (Eds.) (2008). *Mammals of Australia*.3rd Edition. Australian Museum, Sydney.

Western Australian Museum (2014). Checklists of the Fauna of Western Australia. Unpublished checklist. Last updated April 2014. Western Australian Museum, Perth.

White, N. (2015). DNA identification of sample WF15-01-1 (Yeelirrie). Australian Wildlife Forensic Services, Curtin University, Bentley.

Wilson S, Swan G (2008). *A Complete Guide to Reptiles of Australia*. Second edition. New Holland Publishers (Australia), Sydney

8 Appendices

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 (i.e. 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 Department of Environment and Conservation (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 4.

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 Convention on the Conservation of Migratory Species of Wild Animals (CMS; also referred to as the Bonn Convention). The Wildlife Conservation Act uses a series of Schedules to classify status, but also recognizes the IUCN categories and ranks species within the Schedules using the categories of Mace and Stuart (1994).

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 may colonies of waterbirds. The Western Australian Department of Environmental Protection, now DpaW, used this sort of interpretation to identify significant bird species in the Perth metropolitan area as part of the Perth Bushplan (DEP 2000).

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 5). 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 several medium-sized mammals in eastern Australia (Dufty 1989; Jones 2000). Increased mortality due to roadkill is often more prevalent in habitats that have been fragmented (Scheick and Jones 1999; Clevenger and Waltho 2000; Jackson and 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, Red 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 Red Fox, and to a lesser extent the feral Cat (Burbidge and 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 (Gill *et al.* 1981; Fox 1982; Letnic *et al.* 2004; Bamford and Roberts 2003). It is also one of the factors that has contributed to the decline and local extinction of some mammal and bird species (Burbidge and McKenzie 1998). 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. In terms of conservation management, it is not fire *per se* but the fire regime that is important, with evidence that infrequent, extensive and intense fires adversely affect biodiversity, whereas frequent fires that cover small areas and are variable in both season and intensity can enhance biodiversity. 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 and 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 and 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 1999* and the Western Australian *Wildlife Conservation Act 1950*.

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 1950*

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 Environment and Conservation Priority species (species not listed under the *Wildlife Conservation Act 1950*, 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, 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 20 key threatening processes listed by the federal Department of the Environment (DotE 2014b):

- Competition and land degradation by rabbits.
- Competition and land degradation by unmanaged goats.
- Dieback caused by the root-rot fungus (*Phytophthora cinnamomi*).
- Incidental catch (bycatch) of Sea Turtle 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.
- Invasion of northern Australia by Gamba Grass and other introduced grasses.
- Land clearance.
- Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants.
- 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.

- Novel biota and their impact on biodiversity.
- Predation by European red fox.
- Predation by exotic rats on Australian offshore islands of less than 1000 km^2 (100,000 ha).
- Predation by feral cats.
- Predation, Habitat Degradation, Competition and Disease Transmission by Feral Pigs.
- Psittacine Circoviral (beak and feather) Disease affecting endangered psittacine species.
- The biological effects, including lethal toxic ingestion, caused by Cane Toads (*Bufo marinus*).
- The reduction in the biodiversity of Australian native fauna and flora due to the red imported fire ant, *Solenopsis invicta* (fire ant).

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— such as altered flow regimes affecting riparian vegetation; and
- Pollution.

In addition to the above processes, 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 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 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 interfere with the recovery of the species?

Appendix 5. Fauna expected to occur in the survey area (Table 8 to Table 11).

These lists are derived from the results of database and literature searches and from previous field surveys conducted in the Yeelirrie area. These are:

- Species listed under fauna databases – NatureMap (DpaW, 2015), Birdata (BirdLife Australia, 2015), Atlas of Living Australia (ALA, 2014) or EPBC Protected Matters Search (DotE, 2015), or from the literature;
- Local Records – historical fauna records from Yeelirrie* (anon, 1978) or from Wanjarrie Nature Reserve (WJ) (DpaW, 2015) or recorded by BCE at Rosslyn Hill (RH) (70km north of Yeelirrie, BCE 2014) ;
- Species recorded at Yeelirrie by BCE during the initial field surveys (BCE 2011);
- Species recorded at Yeelirrie by BCE during the 2015 site inspection (BCE 2015);

Table 8. Frog species expected to occur in the survey area.

Species		Status	Source	Local Records	BCE 2011	BCE 2015
HYLIDAE (Tree frogs)						
Cyclorana maini	Main's Frog		**Lit**	**WJ**	**X**	**X**
Cyclorana platycephala	Water-holding Frog		**Lit**	**WJ**	**X**	**X**
Litoria rubella	Desert Tree Frog		**Lit**	**WJ**	**X**	**X**
LIMNODYNASTIDAE (Burrowing Frogs)						
Platyplectrum spenceri	Spencer's Frog			**WJ**		
Neobatrachus aquilonius	Northern Burrowing Frog		**DpaW**	**WJ**		
Neobatrachus kunapalari	Kunapalari Frog			**RH**		
Neobatrachus sudellae	Trilling Frog			**WJ**		
Neobatrachus sutor	Shoemaker Frog		**DpaW**			
Neobatrachus wilsmorei	Wilsmore's Frog		**Lit**			
Notaden nichollsi	Desert Spadefoot			**RH**		
MYOBATRACHIDAE (Ground frogs)						
Pseudophryne occidentalis	Western Toadlet		**DpaW**		**X**	
Total Species Expected: 11 **Total Species Recorded: 4**				**8**	**4**	**3**

Table 9. Reptile species expected to occur in the survey area.

Species		Status	Source	Local Records	BCE 2011	BCE 2015
CHELUIDAE (freshwater tortoise)						
Chelodina steindachneri	Flat-shelled Tortoise		**ALA**			
CARPHODACTYLIDAE (knob-tailed geckoes)						
Nephrurus vertebralis	Midline Knob-tail		**WJ**	*	**X**	
Nephrurus wheeleri	Southern Banded Knob-tail			**RH**		
Underwoodisaurus milii	Barking Gecko		**Lit**			
DIPLODACTYLIDAE (ground geckoes)						
Diplodactylus conspicillatus	Fat-tailed Gecko		**WJ**	*	**X**	
Diplodactylus granariensis rex	Goldfields Stone Gecko				**X**	
Diplodactylus pulcher	Western Saddled Ground Gecko			**WJ**	**X**	
Diplodactylus squarrosus	Mottled Ground Gecko			**WJ**		
Diplodactylus stenodactylus	Pale-snouted Ground Gecko		**Lit**			
Oedura marmorata	Marbled Velvet Gecko		**Lit**			
Rhynchoedura ornata	Beaked Gecko			**WJ**	**X**	
Strophurus assimilis	Thorn-tailed Gecko		**ALA**			
Strophurus elderi	Jewelled Gecko			**WJ**	**X**	
Strophurus strophurus	Western Ring-tailed Gecko			**WJ**	**X**	
Strophurus wellingtonae	Western Shield Spiny-tailed Gecko			**WJ**	**X**	
GEKKONIDAE (geckoes)						
Gehyra purpurascens	Purple Arid Dtella		**Lit**			
Gehyra 47cuminat	Spotted Rock Dtella			*		
Gehyra variegata	Variegated Dtella		**WJ**	*	**X**	**X**
Heteronotia binoei	Bynoe's Gecko		**WJ**	*	**X**	
PYGOPODIDAE (legless lizards)						
Aprasia picturata		**CS3**	**Lit**			
Delma butleri	Unbanded Delma		**DpaW**	**RH**	**X**	
Delma nasuta	Long-nosed Delma		**DpaW**		**X**	
Delma petersoni				**WJ**		
Lialis burtonis	Burton's Legless Lizard		**DpaW**	*	**X**	
Pygopus nigriceps	Western Hooded Scaly-foot		**DpaW**	**RH**	**X**	
AGAMIDAE (dragon lizards)						
Amphibolurus longirostris	Long-nosed Dragon			**WJ**		
Ctenophorus caudicinctus	Ring-tailed Dragon		**DpaW**	*	**X**	**X**
Ctenophorus isolepis	Military Dragon		**DpaW**	*	**X**	**X**
Ctenophorus nuchalis	Central Netted Dragon		**DpaW**	*	**X**	**X**
Ctenophorus reticulatus	Western Netted Dragon		**WJ**	*		
Ctenophorus salinarum	Claypan Dragon		**Lit**			

Species		Status	Source	Local Records	BCE 2011	BCE 2015
Ctenophorus scutulatus	Lozenge-marked Dragon		DpaW	RH	X	X
Diporiphora (Caimanops) amphiboluroides	Mulga Dragon		Lit			
Moloch horridus	Thorny Devil		DpaW	*	X	
Pogona minor	Western Bearded Dragon		DpaW	*	X	
Tympanocryptis cephala	Earless Pebble Dragon			WJ		
VARANIDAE (monitors or goannas)						
Varanus brevicauda	Short-tailed Monitor			WJ		
Varanus caudolineatus	Stripe-tailed Monitor		DpaW	RH	X	X
Varanus eremius	Desert Pygmy Monitor			WJ	X	
Varanus giganteus	Perentie		DpaW	*	X	
Varanus gouldii	Sand Goanna		WJ	*	X	
Varanus panoptes	Yellow-spotted Monitor		DpaW	RH	X	X
Varanus tristis	Black-headed Monitor			*		
EGERNIIDAE (part skinks)						
Egernia depressa	Pygmy Spiny-tailed Skink		DpaW	*	X	X
Egernia formosa	Goldfields Crevice Skink			WJ		
Liopholis inornata	Desert Skink			*	X	X
Liopholis kintorei	Great Desert Skink	CS1	EPBC	WJ		
Liopholis striata	Night Skink			WJ	X	
Tiliqua occipitalis	Western Blue-tongue		DpaW	*	X	
Tiliqua multifasciata	Centralian Blue-tongue		DpaW	*	X	X
EUGONGYLIDAE(part skinks)						
Cryptoblepharus buchananii	Fence Skink		DpaW	RH	X	
Cryptoblepharus plagiocephalus	Fence Skink				X	
Eremiascincus richardsonii	Broad-banded Sand-swimmer		DpaW	*	X	X
Menetia greyii	Common Dwarf Skink		DpaW	*	X	X
Morethia butleri	Woodland Dark-flecked Morethia		DpaW		X	
SPHENOMORPHIDAE (part skinks)						
Ctenotus ariadnae			DpaW		X	
Ctenotus calurus				WJ		
Ctenotus dux			Lit			
Ctenotus grandis			DpaW	*	X	
Ctenotus hanloni			DpaW		X	
Ctenotus helenae	Clay Soil Ctenotus		DpaW	*	X	
Ctenotus leonhardii	Leonhardi's Ctenotus		DpaW	*	X	
Ctenotus pantherinus	Leopard Skink		DpaW	RH	X	
Ctenotus quattuordecimlineatus				WJ		
Ctenotus schomburgkii	Barred Wedge-snout Ctenotus		DpaW	*	X	

Species		Status	Source	Local Records	BCE 2011	BCE 2015
Ctenotus severus	Stern Rock Ctenotus		Lit			
Ctenotus uber	Spotted Ctenotus			RH		
Lerista bipes				WJ		
Lerista desertorum			DpaW	*	X	
Lerista timida			WJ	*	X	
TYPHLOPIDAE (blind snakes)						
Anilios bicolor	Dark-spined Blind Snake				X	
Anilios hamatus	Northern Hook-snouted Blind Snake			WJ	X	
Anilios waitii	Beaked Blind Snake			WJ		
BOIDAE (pythons)						
Antaresia perthensis	Pygmy Python		Lit			
Antaresia stimsoni	Stimson's Python		Lit			
ELAPIDAE (front-fanged snakes)						
Acanthophis pyrrhus	Desert Death Adder		Lit			
Brachyurophis approximans	Northern Shovel-nosed Snake			RH		
Brachyurophis semifasciata	Southern Shovel-nosed Snake			WJ		
Brachyurophis fasciolata	Narrow-banded Shovel-nosed Snake		Lit			
Demansia psammophis	Yellow-faced Whip-Snake		Lit	RH		
Parasuta monachus	Monk Snake			WJ		
Pseudechis australis	Mulga or King Brown Snake			WJ		
Pseudechis butleri	Spotted Mulga Snake			WJ		
Pseudonaja modesta	Ringed Brown Snake			WJ	X	
Pseudonaja mengdeni	Gwardar		DpaW	*	X	X
Simoselaps bertholdi	Jan's Banded Snake		DpaW	RH	X	
Furina ornata	Moon Snake		Lit			
Suta fasciata	Rosen's Snake		WJ	*		
Total Species Expected: 88						
Total Species Recorded at Yeelirrie (BCE and anon): 53				29	49	13

Table 10. Bird species expected to occur in the survey area.

Species		Status	Source	Local Records	BCE 2011	BCE 2015
CASUARIIDAE (Cassowaries and emus)						
Dromaius novaehollandiae	Emu		**BA**	*	**X**	**X**
MEGAPODIIDAE (Megapodes)						
Leipoa ocellata	Malleefowl	**CS1**	**Lit**	*	**X**	
PHASIANIDAE (Pheasants and allies)						
Coturnix pectoralis	Stubble Quail		**Lit**			
ANATIDAE (swans and ducks)						
Cygnus atratus	Black Swan		**Lit**	*		
Tadorna tadornoides	Australian Shelduck		**Lit**	*	**X**	**X**
Anas superciliosa	Pacific Black Duck		**Lit**	*		
*Anas gracilis*l	Grey Teal		**Lit**	*		**X**
Chenonetta jubata	Australian Wood Duck		**Lit**	*		**X**
Malacorhynchus membranaceus	Pink-eared Duck		**Lit**			
Aythya australis	Hardhead		**Lit**			
PODICIPEDIDAE (grebes)						
Tachybaptus novaehollandiae	Australasian Grebe		**Lit**			
Poliocephalus poliocephalus	Hoary-headed Grebe		**Lit**	*		**X**
PHALACROCORACIDAE (cormorants)						
Phalacrocorax melanoleucos	Little Pied Cormorant		**BA**			
Phalacrocorax varius	Pied Cormorant		**Lit**			
Phalacrocorax sulcirostris	Little Black Cormorant		**Lit**			
ARDEIDAE (herons and egrets)						
Ardea novaehollandiae	White-faced Heron		**BA**	*		
Ardea pacifica	White-necked Heron		**Lit**	*		
Ardea modesta	Eastern Great Egret	**CS1**	**Lit**	*		
Nycticorax caledonicus	Nankeen Night-Heron		**Lit**			
THRESKIORNITHIDAE (ibis and spoonbills)						
Threskiornis molucca	Australian White Ibis		**Lit**	*		
Threskiornis spinicollis	Straw-necked Ibis		**Lit**	*		
ACCIPITRIDAE (Osprey, hawks and eagles)						
Elanus axillaris	Black-shouldered Kite		**Lit**			
Elanus scriptus	Letter-winged Kite		**Lit**	*		
Lophoictinia isura	Square-tailed Kite	**CS3**	**Lit**	*		
Hamirostra melanosternon	Black-breasted Buzzard		**Lit**	**RH**		
Milvus migrans	Black Kite		**Lit**			
Haliastur sphenurus	Whistling Kite		**BA**	*	**X**	**X**
Circus assimilis	Spotted Harrier		**Lit**		**X**	
Accipiter fasciatus	Brown Goshawk		**Lit**	*		
Accipiter cirrhocephalus	Collared Sparrowhawk		**Lit**	*	**X**	

Species		Status	Source	Local Records	BCE 2011	BCE 2015
Aquila audax	Wedge-tailed Eagle		BA	*	X	X
Hieraaetus morphnoides	Little Eagle		Lit	*	X	
FALCONIDAE (Falcons)						
Falco berigora	Brown Falcon		BA	*	X	X
Falco longipennis	Australian Hobby		BA	*	X	X
Falco hypoleucos	Grey Falcon	CS1	Lit			
Falco subniger	Black Falcon		Lit			
Falco peregrinus	Peregrine Falcon	CS1	BA	RH	X	
Falco cenchroides	Nankeen Kestrel		BA	*	X	X
RALLIDAE (Rails, gallinules and coots)						
Gallinula ventralis	Black-tailed Native-hen		Lit	*		
Fulica atra	Eurasian Coot		Lit	*		
OTIDIDAE (Bustards)						
Ardeotis australis	Australian Bustard	CS2	DpaW	*	X	X
TURNICIDAE (Button-quails)						
Turnix velox	Little Button-quail		Lit	*		
SCOLOPACIDAE (sandpipers)						
Limosa limosa	Black-tailed Godwit	CS1	Lit			
Tringa nebularia	Common Greenshank	CS1	Lit			
Tringa stagnatalis	Marsh Sandpiper	CS1	Lit			
Actitis hypoleucos	Common Sandpiper	CS1	Lit			
Tringa glareola	Wood Sandpiper	CS1	Lit			
Calidris ruficollis	Red-necked Stint	CS1	Lit			
Calidris 51cuminate	Sharp-tailed Sandpiper	CS1	Lit	*		
Calidris ferruginea	Curlew Sandpiper	CS1	Lit			
BURHINIDAE (Stone-curlews)						
Burhinus grallarius	Bush Stone-curlew	CS3	BA	*	X	X
RECURVIROSTRIDAE (stilts and avocets)						
Himantopus himantopus	Black-winged Stilt		Lit	*		
CHARADRIIDAE (Lapwings, plovers and dotterels)						
Erythrogonys cinctus	Red-kneed Dotterel		Lit	*		
Charadrius ruficapillus	Red-capped Plover		Lit	*		X
Charadrius veredus	Oriental Plover	CS1	EPBC			
Charadrius melanops	Black-fronted Dotterel		Lit	*		
Charadrius australis	Inland Dotterel		Lit			
Vanellus tricolor	Banded Lapwing		BA	*	X	X
LARIDAE (Gulls and terns)						
Gelochelidon nilotica	Gull-billed Tern					X
COLUMBIDAE (Pigeons and doves)						
Phaps chalcoptera	Common Bronzewing		BA	*	X	X
Ocyphaps lophotes	Crested Pigeon		BA	*	X	X

Species		Status	Source	Local Records	BCE 2011	BCE 2015
Geopelia cuneata	Diamond Dove		Lit	*		X
CACATUIDAE (Cockatoos)						
Eolophus roseicapilla	Galah		BA	*	X	X
Cacatua sanguinea	Little Corella		Lit	RH		
Cacatua leadbeateri	Major Mitchell's Cockatoo	CS1	Lit	*		
Nymphicus hollandicus	Cockatiel		Lit	*	X	X
PSITTACIDAE (Parrots)						
Barnardius zonarius	Australian Ringneck		BA	*	X	X
Psephotus varius	Mulga Parrot		BA	*	X	X
Melopsittacus undulatus	Budgerigar		BA	*	X	X
Neosephotus bourkii	Bourke's Parrot		BA	*		
Neophema elegans	Elegant Parrot		Lit	*	X	
Neophema splendida	Scarlet-chested Parrot	CS3	Lit	WJ		
Polytelis alexandrae	Princess Parrot	CS1	EPBC	WJ		
Polytelis anthopeplus	Regent Parrot	CS3	Lit	WJ		
Pezoporus occidentalis	Night Parrot	CS1	Lit			
CUCULIDAE (Old world cuckoos)						
Cuculus pallidus	Pallid Cuckoo		BA		X	
Chrysococcyx osculans	Black-eared Cuckoo		BA	RH		X
Chrysococcyx basalis	Horsfield's Bronze-Cuckoo		BA		X	X
STRIGIDAE (Hawk owls)						
Ninox novaeseelandiae	Southern Boobook		Lit	*	X	
TYTONIDAE (Barn owls)						
Tyto alba	Barn Owl		Lit	*		
PODARGIDAE (Australian frogmouths)						
Podargus strigoides	Tawny Frogmouth		Lit	*	X	
CAPRIMULGIDAE (Nightjars and allies)						
Eurostopodus argus	Spotted Nightjar		BA	*	X	X
AEGOTHELIDAE (Owlet-nightjars)						
Aegotheles cristatus	Australian Owlet-nightjar		BA	*	X	X
APODIDAE (Typical swifts)						
Apus pacificus	Fork-tailed Swift	CS1	Lit	*		X
HALCYONIDAE (Kingfishers)						
Todiramphus pyrrhopygia	Red-backed Kingfisher		Lit	*	X	
Todiramphus sanctus	Sacred Kingfisher		Lit	RH		
MEROPIDAE (Bee-eaters)						
Merops ornatus	Rainbow Bee-eater	CS1	Lit	*	X	X
CLIMACTERIDAE (Australo-Papuan treecreepers)						
Climacteris affinis	White-browed Treecreeper		BA			

Species		Status	Source	Local Records	BCE 2011	BCE 2015
MALURIDAE (Fairy-wrens, emu-wrens and grasswrens)						
Malurus splendens	Splendid Fairy-wren		BA	RH	X	X
Malurus lamberti	Variegated Fairy-wren		BA	RH	X	X
Malurus leucopterus	White-winged Fairy-wren		BA		X	X
Amytornis striatus striatus	Striated Grasswren	CS2	DPaW	WJ		
Stipiturus ruficeps	Rufous-crowned Emu wren.	CS3	Lit	WJ		
PARDALOTIDAE (Pardalotes, scrubwrens, thornbills and allies)						
Pardalotus rubricatus	Red-browed Pardalote		BA			
Pardalotus striatus	Striated Pardalote		BA	RH	X	
Calamanthus campestris	Rufous Fieldwren		Lit			X
Pyrrholaemus brunneus	Redthroat		BA	RH	X	X
Smicrornis brevirostris	Weebill		BA	RH	X	X
Gerygone fusca	Western Gerygone		BA	RH	X	
Acanthiza apicalis	Inland Thornbill		BA	RH	X	X
Acanthiza uropygialis	Chestnut-rumped Thornbill		BA	RH	X	X
Acanthiza robustirostris	Slaty-backed Thornbill		BA	RH	X	X
Acanthiza iredalei	Slender-billed Thornbill	CS1	Lit			
Acanthiza chrysorrhoa	Yellow-rumped Thornbill		BA	RH	X	X
Aphelocephala leucopsis	Southern Whiteface		BA	RH	X	X
MELIPHAGIDAE (Honeyeaters)						
Acanthagenys rufogularis	Spiny-cheeked Honeyeater		BA	RH	X	X
Manorina flavigula	Yellow-throated Miner		BA	RH	X	X
Lichenostomus virescens	Singing Honeyeater		BA	RH	X	X
Lichenostomus penicillatus	White-plumed Honeyeater		BA	RH	X	X
Lichenostomus plumulus	Grey-fronted Honeyeater		BA	RH		
Lichmera indistincta	Brown Honeyeater		BA		X	
Phylidonyris albifrons	White-fronted Honeyeater		BA		X	X
Conopophila whitei	Grey Honeyeater	CS3	Lit			
Certhionyx niger	Black Honeyeater		BA			
Certhionyx variegatus	Pied Honeyeater		BA			X
Epthianura tricolor	Crimson Chat		BA		X	X
Epthianura aurifrons	Orange Chat		Lit			
Epthianura albifrons	White-fronted Chat		Lit			
PETROICIDAE (Robins)						
Microeca leucophaea	Jacky Winter		BA		X	
Petroica goodenovii	Red-capped Robin		BA	RH	X	X
Melanodryas cucullata	Hooded Robin		BA	RH	X	
POMATOSTOMIDAE (Babblers)						
Pomatostomus temporalis	Grey-crowned Babbler		BA	RH	X	X
Pomatostomus superciliosus	White-browed Babbler		BA	RH	X	X

Species		Status	Source	Local Records	BCE 2011	BCE 2015
CINCLOSOMATIDAE (Quail-thrushes and allies)						
Psophodes occidentalis	Chiming Wedgebill		BA			
Cinclosoma castanotum	Chestnut Quail-thrush		BA			
Cinclosoma casteneothorax	Chestnut-breasted Quail-thrush		BA	RH	X	X
NEOSITTIDAE (Sitellas)						
Daphoenositta chrysoptera	Varied Sittella		BA	RH	X	X
PACHYCEPHALIDAE (Whistlers, shrike-thrushes and allies)						
Oreoica gutturalis	Crested Bellbird		BA	RH	X	X
Pachycephala rufiventris	Rufous Whistler		BA	RH	X	X
Colluricincla harmonica	Grey Shrike-thrush		BA	RH	X	X
DICRURIDAE (Monarchs, fantails and drongos)						
Grallina cyanoleuca	Magpie-lark		BA	RH	X	X
Rhipidura fuliginosa	Grey Fantail		Lit	RH	X	
Rhipidura f. albicauda	White-tailed Fantail		Lit			
Rhipidura leucophrys	Willie Wagtail		BA	RH	X	X
CAMPEPHAGIDAE (Cuckoo-shrikes and trillers)						
Coracina novaehollandiae	Black-faced Cuckoo-shrike		BA	*	X	X
Coracina maxima	Ground Cuckoo-shrike		BA	*	X	
Lalage sueurii	White-winged Triller		BA	*	X	
ARTAMIDAE (Woodswallows, butcherbirds and currawongs)						
Artamus personatus	Masked Woodswallow		Lit	RH	X	X
Artamus cinereus	Black-faced Woodswallow		BA	RH	X	X
Artamus minor	Little Woodswallow		BA			X
Cracticus torquatus	Grey Butcherbird		BA	RH	X	X
Cracticus nigrogularis	Pied Butcherbird		BA	RH	X	X
Gymnorhina tibicen	Australian Magpie		BA	RH	X	X
Strepera versicolor	Grey Currawong		BA	WJ	X	
CORVIDAE (Crows and allies)						
Corvus coronoides	Australian Raven		Lit			
Corvus bennetti	Little Crow		BA	RH	X	X
Corvus orru	Torresian Crow		BA	RH	X	X
PTILONORHYNCHIDAE (Bowerbirds)						
Chlamydera guttata	Western Bowerbird		BA	RH	X	X
MOTACILIDAE (Old world wagtails and pipits)						
Anthus novaeseelandiae	Australasian Pipit		BA	*	X	X
PASSERIDAE (Sparrows, weaverbirds, waxbills and allies)						
Taeniopygia guttata	Zebra Finch		BA	RH	X	X
DICAEIDAE (Flowerpeckers)						
Dicaeum hirundinaceum	Mistletoebird		BA	RH	X	X

Species		Status	Source	Local Records	BCE 2011	BCE 2015
HIRUNDINIDAE (Swallows and martins)						
Cheramoeca leucosternum	White-backed Swallow		BA	*	X	
Hirundo neoxena	Welcome Swallow		BA	*	X	
Hirundo nigricans	Tree Martin		BA	RH	X	
Hirundo ariel	Fairy Martin		Lit	*	X	
SYLVIIDAE (Old world warblers)						
Cinclorhamphus mathewsi	Rufous Songlark		Lit			
Cinclorhamphus cruralis	Brown Songlark		Lit			X
Total Species Expected: 157 **Total Species Recorded by BCE: 94 and anon (1978): 108**				110	82	71

Table 11. Mammal species expected to occur in the survey area.

Species		Status	Source	Local Records	BCE 2011	BCE 2015
TACHYGLOSSIDAE (Echidnas)						
Tachyglossus aculeatus	Echidna			RH	X	X
DASYURIDAE (Dasyurids)						
Dasycercus blythi	Brush-tailed Mulgara	CS2		WJ	X	X
Antechinomys laniger	Kultarr	CS3	DPaW	WJ		
Ningaui ridei	Wongai Ningaui		DPaW	WJ	X	
Pseudantechinus woolleyae	Woolley's Pseudantechinus			WJ	X	
Sminthopsis crassicaudata	Fat-tailed Dunnart			WJ		
Sminthopsis dolichura	Little Long-tailed Dunnart			WJ		
Sminthopsis hirtipes	Hairy-footed Dunnart		DPaW	WJ	X	
Sminthopsis longicaudata	Long-tailed Dunnart	CS2		RH		
Sminthopsis macruora	Stripe-faced Dunnart		DPaW	WJ	X	
Sminthopsis ooldea	Ooldea Dunnart		DPaW	WJ	X	
PERAMELIDAE (Bandicoots)						
Macrotis lagotis	Greater Bilby	CS1		RH#		
MACROPODIDAE (Kangaroos, wallabies)						
Macropus robustus	Euro, Biggada		DPaW	WJ	X	X
Macropus rufus	Red Kangaroo, Marlu		DPaW	WJ	X	X
Petrogale lateralis	Black-flanked Rock-Wallaby	CS1			Scats	Scats
EMBALLONURIDAE (Sheathtail bats)						
Saccolaimus flaviventris	Yellow-bellied Sheathtail-bat Bat			RH	X	
Taphozous hillli	Hill`s Sheathtail-bat		Lit	RH		
VESPERTILIONIDAE (Vespertillionid bats)						

Species		Status	Source	Local Records	BCE 2011	BCE 2015
Chalinolobus gouldii	Gould's Wattled Bat		DPaW	WJ	X	
Nyctophilus geoffroyi	Lesser Long-eared Bat		WAM	WJ	X	
Nyctophilus major tor	Inland Greater Long-eared Bat	CS2			X	
Scotorepens balstoni	Inland Broad-nosed Bat		DPaW	WJ	X	
Vespadelus baverstocki	Inland Forest Bat		Lit	WJ	X	
Vespadelus finlaysoni	Finlayson's Cave Bat		WAM	RH	X	
Vespadelus regulus	Southern Forest Bat		WAM	WJ		
MOLOSSIDAE (Freetail bats)						
Mormopterus sp. 3 (Adams *et al.* ,1988).	Inland Freetail-bat		DPaW		X	
Tadarida australis	White-striped Freetail-bat		WAM	WJ	X	
MURIDAE (Rats and mice)						
Mus musculus	House Mouse	INT	DPaW	WJ		
Notomys alexis	Spinifex Hopping-Mouse		DPaW	WJ	X	X
Pseudomys desertor	Desert Mouse	CS3	Lit	MK		
Pseudomys hermannsburgensis	Sandy Inland Mouse		DPaW	MK		
LEPORIDAE (Rabbits and hares)						
Oryctolagus cuniculus	Rabbit	INT	DPaW	RH	X	X
CANIDAE (Dogs and foxes)						
Canis lupus	Dog/Dingo		DPaW	RH	X	X
Vulpes vulpes	Red Fox	INT	Lit	RH	X	
FELIDAE (Cats)						
Felis catus	Cat	INT	Lit	RH	X	X
BOVIDAE (Horned ruminants)						
Bos taurus	Cattle	INT	Lit	RH		X
Capra hircus	Goat	INT	Lit			
EQUIDAE (horses)						
Equus asinus	Donkey	INT	Lit			
Equus caballus	Horse	INT	Lit			
CAMELIDAE (camels)						
Camelus dromedarius	Camel	INT	Lit		X	X
Native Species Expected: 30 **Native Species Recorded by BCE at Yeelirrie: 21** **Introduced Species Expected: 9** **Introduced Species Recorded by BCE at Yeelirrie: 5**				32	25	11

 # - an anecdotal record of the Greater Bilby was reported to BCE at Rosslyn Hill, 70km north of Yeelirrie.

Note MK = Mount Keith.

Appendix 6. Tailings Evaporation Pond

A 50 ha tailings evaporation pond is proposed by Cameco for the life of the Yeelirrie Uranium project. The development of the evaporation pond would establish a new and large artificial waterbody in an arid area and may attract numbers of waterbirds, potentially including conservation significant migratory waterbirds listed under the EPBC Act. Several such species have been recorded in the region (see Table 10).

The water initially sent to the pond is predicted to have mineral concentrations listed in Table 12 (provided by Cameco). However, it is important to note such levels are predicted to change over the life of the mine. Initially, the pH is predicted to be 10.64 (alkaline) with liquid tonnage expected to be 42632 t/ hr (at 1.07 t/m^3). Initially the water salinity is expected to be similar to seawater (but this is expected to change over time).

The evaporation pond has some potential to provide drinking water for wildlife. Marine waterbirds, including sandpipers and plovers, often live in environments where the only available drinking water is seawater but will drink water of lower salinity if available. If salinity stratification occurs, the surface layer of water may be palatable to some wildlife and the possibility exists of a lens of low salinity water forming at the surface following heavy rain, or from the accumulation of low salinity groundwater. Such water would have lower concentrations of contaminants and it is likely that stratification would be offset by mixing following rain, and by evapoconcentration at other times. If exceptional rainfall did create a layer of near-fresh water, this would occur at a time when numerous other and more attractive/accessible sources of fresh water would be available in the region, including the numerous claypans within the project area. In comparison to natural water bodies, evaporation ponds are expected to be characterised by steep banks, which lack shallow sandy shores, riparian vegetation (habitat) and shade, and therefore less attractive to fauna.

The Uranium concentration is expected to be 0.06 g/L (or 60 mg/L). The Uranium NOAEL (No Observable Adverse Impact Level) benchmark for drinking water for birds is 68.8 mg/L, and for mammals is 6.995 mg/L (Sample et al., 1996). Therefore for birds, at least initially, uranium concentrations are expected to be below NOAEL benchmarks although how concentrations change over time is not known.

Waterbird usage of the evaporation pond may occur early in the life of the lake when salinity and Uranium levels are low. Several deterrents are available to discourage waterbirds from using artificial waterbodies and may need to be considered as a part of environmental management. Bird deterrents are used at the Olympic Dam mine site, South Australia, where acidic liquid is stored. A rotating beacon with intermittent beam directed at a shallow angle across the water surface (in combination with gas guns) effectively discouraged most waterbirds (Read 1999). If bird deterrents or other barriers are employed in the first few years following closure, then visitation and the likelihood of contaminant transfer will be reduced. After this time, increasing salinity and the lack of biota may reduce visitation and consumption rates, and result in a low transfer of contaminants to the surrounding environment.

Recommendations include:

1. Undertake an ecological risk assessment of the evaporation pond;
2. Implement a water quality monitoring programme and adapt fauna management strategies (e.g. bird deterrents) based on the outcomes of the programme;
3. Monitor bird visitation of the evaporation pond and report fauna deaths; and
4. Fence off the evaporation pond from terrestrial mammals to minimise exposure during the initial period when the water is palatable.

Table 12. Predicted mineral concentrations within water sent to the Yeelirrie Evaporation Pond.

Item	g/L	Comment
NaCl	31.05	Similar to seawater. The maximum salinity that land birds can drink to maintain body weight ranges from 25% to 100% of seawater salinity (30 000 – 50 000 mg / L).
H	107.41	
C	4.82	
O	885.17	
Na	35.34	
Mg	1.33	
S	6.81	
Cl	21.59	
K	3.44	
Ca	0.54	
V	0.52	
Sr	0.23	
U	0.06	NOAEL benchmark for drinking water for birds is 68.8 mg/L, and for mammals is 6.995 mg/L (Sample *et al.*, 1996).