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9 July 2021

Department of Mines, Industry Regulation and Safety
Via: DMIRS online payment and application lodgement portal

Attention: DMIRS Resource and Environmental Compliance Division

To Whom it May Concern,

Re: Request to Amend Native Vegetation Clearing Permit CPS 3891/3

We write to request an amendment of Native Vegetation Clearing Permit (NVCP) CPS 3891/3 on behalf of the permit holder Australian Garnet (Australian Garnet).

1. PROPOSED AMENDMENT

The purpose of this NVCP amendment is to align the Purpose Permit boundary with tenement boundaries and to extend the boundary to allow for the construction and installation of a communications tower and infrastructure corridor outside the currently approved boundary. The amendment of the Purpose Permit boundary within Mining Lease M 70/1280 will also avoid surveyed Priority Flora species. The area within the Purpose Permit boundary will increase by 1.5 ha (from 144.4 ha to 145.9 ha). The area proposed to clear is not required to be amended.

Figure 1 shows the currently approved and amended boundary.

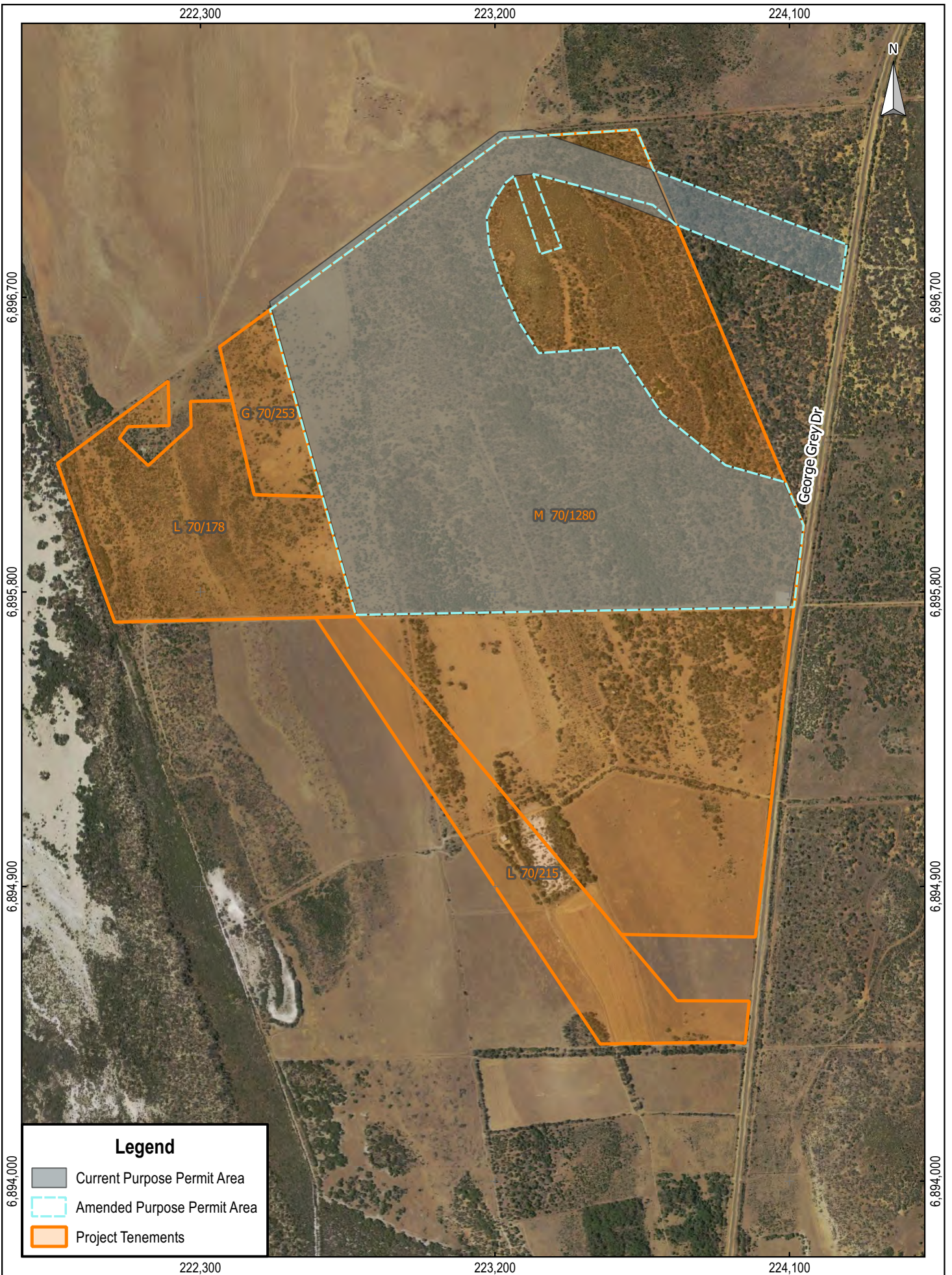
Table 1 provides a summary of the relevant tenements, all held by Australian Garnet.

Table 1: Butcherbird Manganese Project Tenements

Tenement	Area (ha)	Grant Date	Expiry Date
M 70/1280	262.4	19/08/2009	18/08/2030
M 70/1387	1308.65	12/03/2019	11/03/2040
L 70/134	7.85	23/07/2010	22/07/2031

Clearing in the additional area will be limited to a narrow disturbance footprint associated with an access track and power/optics infrastructure (approximately 12 m wide) and an area for the installation of a communications tower. No increase in the total area of vegetation permitted to be cleared under CPS 3891/3 is proposed.





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 Aerial: Landgate

0 250 500 m

Australian Garnet
 Balline Garnet Project
 NVCP Amendment (PCS
 3891/3)

Figure 1
**Purpose Permit Boundary
 Amendment**

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2. EXISTING ENVIRONMENT

At the time of the original Purpose Permit application the environmental baseline surveys provided, and information cited were from a Level 1 flora and fauna survey undertaken in September 2008 by Ecoscape Environmental Services (Ecoscape, 2008). No threatened flora, no priority flora, no Threatened Ecological Communities (TECs) or Priority Ecological Communities (PECs) were identified during the survey work.

Since those surveys and further amendments to CPS 3891, additional survey work has been undertaken at the Project location, including information which covers CPS 3891/3. More recent flora and vegetation, and fauna assessments include:

- A Level 2 Flora and Vegetation Survey conducted by Onshore Environmental in 2013 (Onshore, 2013; Attachment 1)
- A Level 1 Fauna and Habitat assessment conducted by Bamford Consulting Ecologists in 2013 (Bamford and McHarrie, 2013; Attachment 2).

The above surveys provide an increased level of detail regarding the environmental values of the project area which may provide additional but more specifically more recent information in the assessment of the proposed extension to the Purpose Permit boundary.

2.1 FLORA AND VEGETATION SURVEY

The Level 2 survey by Onshore (2013) assessed 15 vegetation quadrats and 163 relevé plots across the 1,736 ha Project area, predominantly in locations not cleared for agriculture (approximately 1,080 ha at the time of survey). The survey was conducted in accordance with the Environmental Protection Authority (EPA) Guidance Statement 51 for surveys pre-2016.

2.1.1 Vegetation and Communities

Approximately 656 ha of native vegetation was broken down into 19 Vegetation Associations (VA). The majority of vegetation recorded within the study area occurs on undulating low hills and ridges comprising limestone and sand. Vegetation is dominated by xerophytic plant taxa that have no reliance of groundwater to survive although a number of the vegetation associations were classed as potentially groundwater dependent (VA 1, 2, 3 and 15). These VAs are located on the south and west Project boundaries. Another VA (VA 4) was similar to WA-listed PEC 'Coastal sands dominated by *Acacia rostellifera*, *Eucalyptus oraria* and *Eucalyptus obtusiflora* (Priority 1)' but differs through dominance of mallee cover on sandy hillslopes. Neither VA 1, 2, 3, 4 or 15 are distributed in the Purpose Permit Application 3891/3 or this Amendment.

Refer to Figure 2 for an indication of the VAs distributed within the amended Purpose Permit boundary.

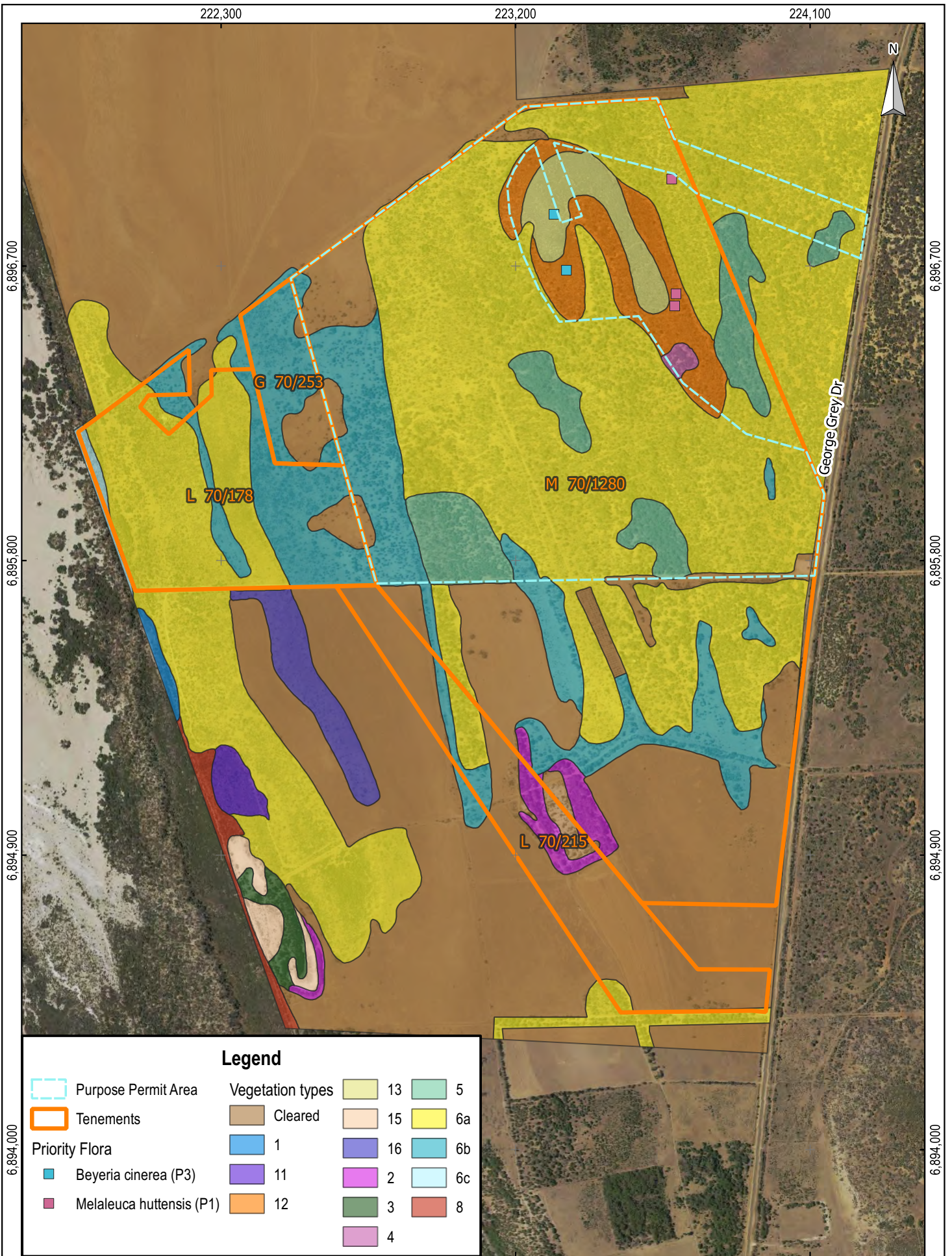
2.1.2 Conservation Significant Flora Species

None of the plant taxa recorded were Threatened Flora pursuant to Western Australia's *Biological Conservation Act 1950* (BC Act 2016; formerly the Wildlife Conservation Act 1950) or listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). There were four Priority Flora taxa, as defined by the State's Department of Biodiversity and Conservation and Attractions (DBCA), recorded from the study area. These were:

- *Melaleuca huttensis* (Priority 1)
- *Cryptandra glabriflora* (Priority 2)
- *Anthocercis intricata* (Priority 3)
- *Beyeria cinerea* subsp. *cinerea* (Priority 3)

The proposed amendment of the Purpose Permit boundary will result in none of the surveyed priority taxa being inside the Purpose Permit boundary.

Refer to Figure 2 for the Priority Flora locations in the amended Purpose Permit Area.



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Figure 2
**Vegetation Associations
 and Priority Flora Locations**

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2.2 FAUNA AND HABITAT ASSESSMENT

The desktop survey identified an assemblage of 187 vertebrate fauna species potentially occurring in the Balline area. This comprised of 10 frog, 64 reptile, 87 bird, 14 native mammal and eight introduced mammal species. However, because of the poor natural condition of the majority of the site and fragmentation of vegetation islands, many of these species may only be present infrequently or not at all.

Three fauna habitat types were identified within the Project area during the Level 2 survey. These habitats, termed Vegetation and Substrate Associations (VSAs) include:

- VSA1 - Cleared land/Pasture with generally low habitat value for native fauna.
- VSA2 - Acacia Shrubland to Tall Shrubland on yellow-brown sands, important for most native fauna still present in the area, providing habitat and connectivity across the landscape.
- VSA3 - Melaleuca Acacia Shrubland to Tall Shrubland on grey sand over limestone, important for most native fauna still present in the area, providing habitat and connectivity across the landscape. A potential SRE may be restricted to this VSA.

2.2.1 Conservation Significant Species

2.2.1.1 Vertebrates

A total of 30 terrestrial vertebrate fauna species were recorded during the field survey including four reptile, 20 bird, two native mammal and four introduced mammal species.

A White-browed Babbler (*Pomatostomus superciliosus superciliosus*), a Department of Environment Conservation (DEC, currently DBCA) listed Priority species at the time was detected during the field survey, and the presence of Carpet Python (*Morelia spilota*) was verified by a local landowner, although both species have since been de-listed. Accordingly, no terrestrial vertebrate species of current conservation significance were detected during the 2013 field survey, but a number of species were listed as expected to be residents in the Balline Area such as:

- Gilled Slender Blue-tongue (*Cyclodomorphus branchialis*) (Vulnerable under *Biodiversity Conservation (BC) Act 2016*). The presence of this species is based on an unpublished detection 70 km east of the project by Bamford Consulting Ecologists near Galena. The species was not identified in the NatureMap search performed for the survey.
- Stripe-sided Robust Slider (*Lerista axillaris*) (P2) which may be confined to patches of remnant vegetation.

2.2.1.2 Invertebrates

Bamford and McHarrie (2013) also included the Short-tongued Bee (*Neopasiphae simplicior*) as expected to potentially occur in the Project Area, with the Short-tongued Bee added due to a 1998 record in Port Gregory, approximately 20 km away in NatureMap. This species is Listed as Critically Endangered under the *Environment Protection and Biodiversity Conservation (EPBC) Act 1999* and Endangered under the *BC Act 2016*, although DAWE data indicates this species is localised south of the Perth Metropolitan in the vicinity of wetlands with specific flowering flora species not identified in the Balline area (*Lobelia tenuior*, *Goodenia filiformis* and *Angianthus preissianus*).

2.2.2 Short Range Endemics

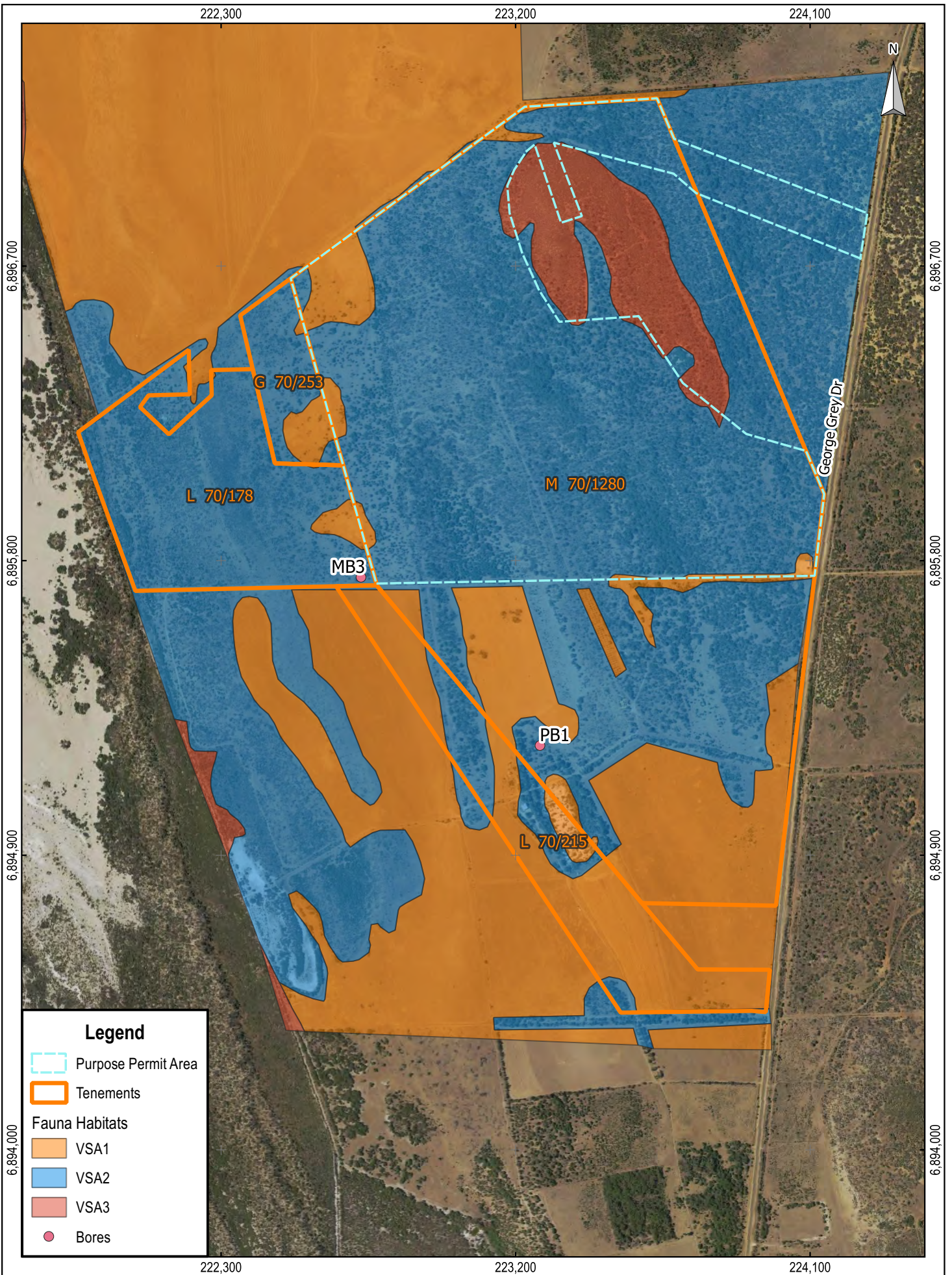
Short-range endemic (SRE) invertebrate sampling occurred as part of the Subterranean Fauna Pilot Survey conducted in December of 2009 (Goater and Knott, 2009; Attachment 3) and the Level 1 fauna survey conducted by Bamford Consulting Ecologists (Bamford and McHarrie 2013).

No short-range endemics were collected in litter sampling of Goater and Knott (2009), but three species of ground-dwelling spiders were collected in the sampling programme in bores PB1, PB3 and HUT4 as shown in Figure 3. One species of *Collembola* with surface affinities was recovered from four bores, which indicates a reasonably

widespread occurrence through the study area. Preliminary identification of the spiders collected suggests that none of the species appear to be cavernicolous (i.e., troglofauna) and it is thought probable that the species are widespread and of little conservation interest (Goater and Knott, 2009).

Sampling conducted during Bamford and McHarrie (2013) collected an isopod (slater) described by Phoenix Environmental (2013) as *Buddelundia* '81'. Phoenix Environmental concluded it was likely an SRE. This species was located in VSA3 which will be largely unimpacted by the Project, although less so given the boundary extension requested as part of this amendment i.e., proposed location of the communications tower and the infrastructure corridor (refer to Figure 3).

Habitats located in the Project area were not specifically assessed against those associated with SREs e.g., sheltered habitats and microclimates facing south-west aspects as discussed in EPA's Technical Guidance document, *Sampling of short-range endemic invertebrate fauna*, (2016) but a habitat isolate, limestone outcropping, is found within VSA3. As discussed above VSA3 will still not be greatly impacted.



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 Grid: GDA94 / MGA zone 50
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Figure 3

Fauna Habitat

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3. ASSESSMENT AGAINST 10 CLEARING PRINCIPLES

The 10 Clearing Principles outlined in Schedule 5 of the *EP Act 1986* were assessed for the proposed extension to the permit boundary by 1.5 ha. Apart from the communication tower area, all other changes of the permit area boundaries i.e., alignment with the tenement boundaries are considered negligible and consistent with the initial assessment (CPS 3891/1). Furthermore, the amendment of boundaries to tenements is in the best interest of future applications and on-going permit management on the project.

Outcomes, additional discussion, potential impacts, and the subsequent management and mitigation measures associated with the amendment to the Purpose Permit boundary for the proposal are listed in Table 2.

Table 2: Additional Area Assessment Against the Clearing Principles

Principle	Clearing Principle	Outcome	Discussion and Potential Impacts	Additional Management and Mitigation Measures
a	Native vegetation should not be cleared if it comprises a high level of biological diversity.	Unlikely to be at variance	Biological diversity is not significantly different to other areas locally or regionally. No Threatened flora or fauna are located within the amendment area.	No additional measures are proposed.
b	Native vegetation should not be cleared if it comprises the whole or a part of, or is necessary for the maintenance of, a significant habitat for fauna indigenous to Western Australia.	Unlikely to be at variance	<p>The extension of the Purpose Permit boundary extends into VSA3, a fauna habitat that is associated with a higher likelihood of supporting potential SRE fauna such as the isopod <i>Buddelundia</i> '81'. The extent of clearing within VSA3 will be limited to an infrastructure corridor (approximately 12 m wide) and the construction and installation of a communications tower. Although the amended boundary extends south across the full extent of VSA3s north to south area at that location, with potential to disrupt connectivity of fauna within the habitat type, the footprint itself will be relatively narrow.</p> <p>The overall area of VSA3 identified through Bamford and McHarrie (2013) is approximately 110 ha, and the area to be impacted forms part of a 20-ha area.</p> <p>The relatively small amount of clearing within the additional boundary area is likely to have a negligible impact on any species populations associated with this habitat type as a whole and a low local impact due to the small scale of the works required.</p>	No additional measures are proposed.
c	Native vegetation should not be cleared if it includes, or is necessary for the continued existence of, rare flora.	Not at variance	<p>Site specific surveys have not identified any Threatened Flora Species present within or adjacent to the approved or proposed amended Purpose Permit Area although there are four Priority Flora species identified locally.</p> <p>No mapped Priority Flora individuals are to be impacted due to the amended boundary. The Priority 1 <i>Melaleuca huttensis</i> is</p>	Current mapped Priority Flora locations will be avoided in the amended Purpose Permit boundary.

Principle	Clearing Principle	Outcome	Discussion and Potential Impacts	Additional Management and Mitigation Measures
			avoided near the boundary of M 70/1280 and L 70/134, while a Priority 3 <i>Beyeria cinerea</i> subsp. <i>Cinerea</i> location has not been included in the amended boundary.	
d	Native vegetation should not be cleared if it comprises the whole or a part of, or is necessary for the maintenance of, a Threatened Ecological Community (TEC).	Not at variance	No Threatened Ecological Communities (TEC) listed under the <i>Environmental Protection and Biodiversity Conservation Act 1990 (EPBC Act)</i> , or <i>Biodiversity Conservation Act 2016 (BC Act)</i> were identified within a 50 km search radius and none of VAs of the approved or amended Purpose Permit Area show similarities to TECs or Priority Ecological Communities (PEC).	No additional measures are proposed.
e	Native vegetation should not be cleared if it is significant as a remnant of native vegetation in an area that has been extensively cleared.	At variance	A review of the comprehensive, adequate and representative (CAR) Reserve System for Western Australia (Government of Western Australia, 2010) indicates that 46.17% of the pre-European vegetation remains in the Geraldton Hills IBRA Sub Region Name. The proposal was previously considered at variance to this Principle in its 3891/1 assessment and there has been no reduction of clearing of native vegetation (90 ha) requested therefore this Principle remains unchanged.	No additional measures are proposed.
f	Native vegetation should not be cleared if it is growing in, or in association with, an environment associated with a watercourse or wetland.	Not at variance	There are no watercourses or wetlands within or nearby the approved or amended area. There are no permanent surface water bodies in the Project area, although a low-lying claypan, as indicated by the cleared area enclosed by VA2 in Figure 2 fills for a small number of days during heavy rainfall events (site communications). This is located over 1 km away from the boundary extension.	No additional measures are proposed.
g	Native vegetation should not be cleared if the clearing of the vegetation is likely to cause appreciable land degradation.	Unlikely to be at variance	The extension to the boundary reaches the crest of a dun, the rationale behind the installation of the communications tower at this location. As indicated by the VSA3 description this area comprises grey sand over limestone and the location is also associated with the	Implement Dust Management Plan for clearing, mining and construction.

Principle	Clearing Principle	Outcome	Discussion and Potential Impacts	Additional Management and Mitigation Measures
			<p>limestone ridge (in the north-east of the study area) which generates higher surface water run-off rates.</p> <p>The area is likely maintained as the dune crest due to the more stable properties of the underlying limestone relative to the surrounding deep yellow-brown sands although this may be offset by a greater vulnerability to wind erosion but should be managed by the Dust Management Plan in place for the Project's clearing activities and future developments.</p> <p>Detailed assessment of the resource and soil characteristics (currently unpublished) confirm no acid sulfate soils or other deleterious soils are located within the Project area.</p>	
h	Native vegetation should not be cleared if the clearing of the vegetation is likely to have an impact on the environmental values of any adjacent or nearby conservation areas.	Unlikely to be at variance	The amendment area is not within a conservation area or DWER managed lands and is no closer to Utcha Well Nature Reserve than the approved application area (approximately 2.7 km south), nor would clearing in the 1.5 ha area be expected to significantly impact connectivity to the nature reserve.	No additional measures are proposed.
i	Native vegetation should not be cleared if the clearing of the vegetation is likely to cause deterioration in the quality of surface or underground water.	Unlikely to be at variance	<p>There are no permanent surface water bodies in the Project area, although a low-lying claypan, as indicated by the cleared area enclosed by VA2 in Figure 2 fills for a small number of days during heavy rainfall events (site communications).</p> <p>The proposed extension to the boundary is located on the crest of the dune associated with the limestone ridge (in the north-east of the study area). The ridge generates higher surface water run-off rates than the surrounding yellow-brown sands although as run-off reaches the sands, infiltration rates are quite rapid (approximately 12 mm/hr), and surface water flows are not expected to reach the low-lying claypan located over 1 km to the south.</p>	Implement Dust Management Plan for clearing, mining and construction.

Principle	Clearing Principle	Outcome	Discussion and Potential Impacts	Additional Management and Mitigation Measures
			Detailed assessment of the resource and soil characteristics (currently unpublished) confirm no acid sulfate soils or other deleterious soils are located within the Project area. Clay/fines content of the soils are limited to approximately 4% (currently unpublished) and are not expected to be mobilised from clearing conducted in the 1.5 ha amendment area.	
j	Native vegetation should not be cleared if clearing the vegetation is likely to cause, or exacerbate, the incidence of flooding.	Unlikely to be at variance	Even with the amendment area exhibiting higher surface water run-off rates, the low volume of clearing required for an infrastructure corridor and communications tower, in conjunction with general low rainfall and high infiltration rates of the surrounding yellow-brown sands clearing is not expected to cause, exacerbate or increase the frequency of flooding.	No additional measures are proposed.

4. CONCLUSION

It is considered unlikely that there will be a significant impact on the conservation status of relevant fauna species in VSA3 as a result of clearing vegetation for an infrastructure corridor and communications tower. The minor 1.5 ha extension of the Purpose Permit boundary is also not expected to amount to significant variances in clearing against the Clearing Principals, even in the instance of *Clearing Principal e* because the initial 90 ha clearing requested has not changed.

Please do not hesitate to contact me on 08 9226 3166, or via email: lboynton@mbsenvironmental.com.au should you have any queries regarding this application.

Yours sincerely
MBS Environmental



Leo Boynton
Senior Environmental Scientist

Attachment 1 - Onshore (2013). Level 2 Flora and Vegetation Survey. Balline Garnet Project
Attachment 2 - Bamford and McHarrie (2013). Fauna Impact Assessment (Level 1). Balline Garnet Project.
Attachment 3 - Goater, S and Knott, B (2009). Subterranean Fauna Pilot Survey, December 2009. Haddington Resources Limited.

5. REFERENCES

Government of Western Australia. (2010). CAR Analysis Report 2009. Accessed June 2021. WA Department of Environment and Conservation, Perth, <https://www2.landgate.wa.gov.au/slip/portal/services/files/carreserveanalysis2009.xls>

**ATTACHMENT 1: ONSHORE (2013). LEVEL 2 FLORA AND
VEGETATION SURVEY. BALLINE GARNET PROJECT.**

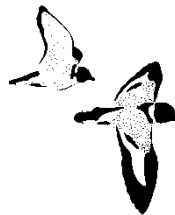
Balline Garnet Project - Fauna Assessment



Project area from the south, showing remnant native vegetation
and extensive paddocks (M. Bamford)

Prepared for: Pemaco Services
PO Box 4232
Mosman Park,
WA, 6012

Prepared by: Mike Bamford and Claudia McHarrie
M.J. & A.R. Bamford Consulting Ecologists
23 Plover Way
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9th December 2013

Executive summary

As part of Environmental Impact Assessment for the development of the Balline Garnet Project, Bamford Consulting Ecologists (BCE) was commissioned by Pemaco Services to conduct a Level 1 fauna assessment (desktop review and site inspection) within the Balline area (tenement M70/1280 and associated infrastructure footprint) – termed the “project area”. 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 vegetation/substrate associations (VSAs) that provide habitat for fauna, particularly those that are rare, unusual and/or support significant fauna;
 - Patterns of biodiversity across the landscape;
 - Ecological processes upon which the fauna depend.
- The review of **impacting processes** such as:
 - Habitat loss leading to population decline;
 - Habitat loss leading to population fragmentation;
 - Degradation of habitat due to weed invasion leading to population decline;
 - Ongoing mortality from operations;
 - Species interactions including feral and overabundant native species;
 - Hydrological change;
 - Altered fire regimes; and
 - Disturbance (dust, light, noise).
- The **recommendation** of actions to mitigate impacts.

The fauna investigations were based on a desktop assessment and a site reconnaissance survey in September 2013. The desktop survey identified an assemblage of 187 vertebrate fauna species potentially occurring in the Balline area. This comprised 10 frog, 64 reptile, 87 bird, 14 native mammal and eight introduced mammal species. However, many of these species may be present infrequently because of the condition of the site. A total of 30 fauna species was recorded during the field survey: four reptile, 23 bird, two native mammal and four introduced mammal species. Six vertebrate species of conservation significance fauna species were recorded during the field survey, and three invertebrate species possibly of conservation significance were recorded during the survey or on previous surveys.

Key **fauna values** are:

Fauna assemblage. Depauperate because of extensive clearing. Remnant vegetation on shallow soils over limestone is distinctive, may be regionally uncommon and thus may have a locally unusual (albeit species-poor) fauna assemblage.

Species of conservation significance. These include three reptile species, 17 bird species, one amphibian species and two terrestrial invertebrates. Two species of subterranean fauna were also found in the groundwater of the site, and one probably SRE terrestrial invertebrate was confirmed; these may be of local conservation significance. Vertebrate species of note are the Southern Sandhill Frog, Carpet Python, the skinks *Cyclodomorphus branchialis* and *Lerista axillaris*. However, extensive clearing of the site means that most of these species are expected only rarely and/or as vagrants. The presence of a suite of locally significant birds reliant on remnant native vegetation is of conservation interest.

Vegetation and Substrate Associations. Most of the project area consists of paddocks used for livestock grazing. Remnants of native vegetation can be divided into Acacia Shrubland to Tall Shrubland on yellow-brown sands, and *Melaleuca cardiophylla* Shrubland to tall shrubland on shallow grey sands over limestone, with extensive limestone outcropping. This vegetation associated with limestone close to the surface occurs largely in the west, but also on the hilltop in the southern block. Both these VSAs are extensively cleared to the north and south. Approximately 0.3% of native vegetation within a 15km radius of the centre-point of project area may be cleared as part of the proposed development.

Patterns of biodiversity. Biodiversity is likely to occur in VSA2 and VSA3 which comprise remnant patches of Acacia shrubland and Acacia Melaleuca shrubland, respectively. These VSAs are likely to be important for most of the native fauna assemblage present in the study area.

Key Ecological Processes. Because of extensive clearing, connectivity between remnants of native vegetation is likely to be important for biodiversity maintenance. With regard to connectivity, the project area lies between Kalbarri National Park to the north, and Utcha Well Nature Reserve to the south, so may provide connectivity for wildlife moving between these two conservation areas. The coastal unallocated crown land provides uninterrupted but narrow linkage between the two reserves. Degradation of remnants by domestic livestock is of concern.

Impacts upon fauna include:

- Potential loss and further fragmentation of habitat; and
- Possible hydrological change.

In addition, there may be some positive impacts such as reduced grazing in remnants and the potential to enhance linkage through rehabilitation.

Recommendations relate to impacts and include:

- Rehabilitation after mining and possibly improvement of linkage through planting habitat corridors between remnants;
- Restrict access of livestock to remnants where possible;
- Minimising vegetation clearing; and
- Taking a precautionary approach to minimise impacts through changes in hydrology.

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1 Introduction

1.1 Introduction

As part of Environmental Impact Assessment for development of the Balline Garnet Project, Bamford Consulting Ecologists (BCE) was commissioned by Pemaco Services to conduct a Level 1 fauna assessment, consistent with EPA Guidance, (desktop review and site inspection) within the Balline area – termed the “project area”. A level 1 fauna assessment is required to identify the fauna values of a site so that impacts upon these from any proposed development can be assessed and, where possible, minimised.

1.2 General Approach to Fauna Impact Assessment

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

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

Descriptions and background information on these values and processes can be found in Appendices 1 to 4. Based on this impact assessment process, the objectives of investigations are to: identify fauna values; review impacting processes with respect to these values and the proposed development; and provide recommendations to mitigate these impacts.

1.3 Description of Survey Area

The Balline survey area is comprised of tenement M70/1280, L70/134 and associated infrastructure footprints, and is located approximately 35km south of Kalbarri and 460km north of Perth. It lies in a region extensively cleared for agriculture, but with large tracts of uncleared land to the north, east and south (Figures 1 and 2). Some of these areas of uncleared vegetation are within conservation areas (Kalbarri National Park to the north and Utcha Well Nature Reserve to the south, see Figure 1). The site contains remnant patches of *Acacia rostellifera* thicket and *Melaleuca cardiophylla* heath (Ecoscape 2009), and these patches are part of a network that may provide connectivity for fauna between the larger areas of native vegetation to the north, east and south (Figure 2).

The total area of the site is about 1176ha, of which about 426ha supports remnant native vegetation in four blocks: an area in the north, two patches in the centre and a large area in the south (Figure 2). Part of this southern block has been previously disturbed but is now regenerating although has high levels of weed invasion. The remainder is cleared agricultural land.

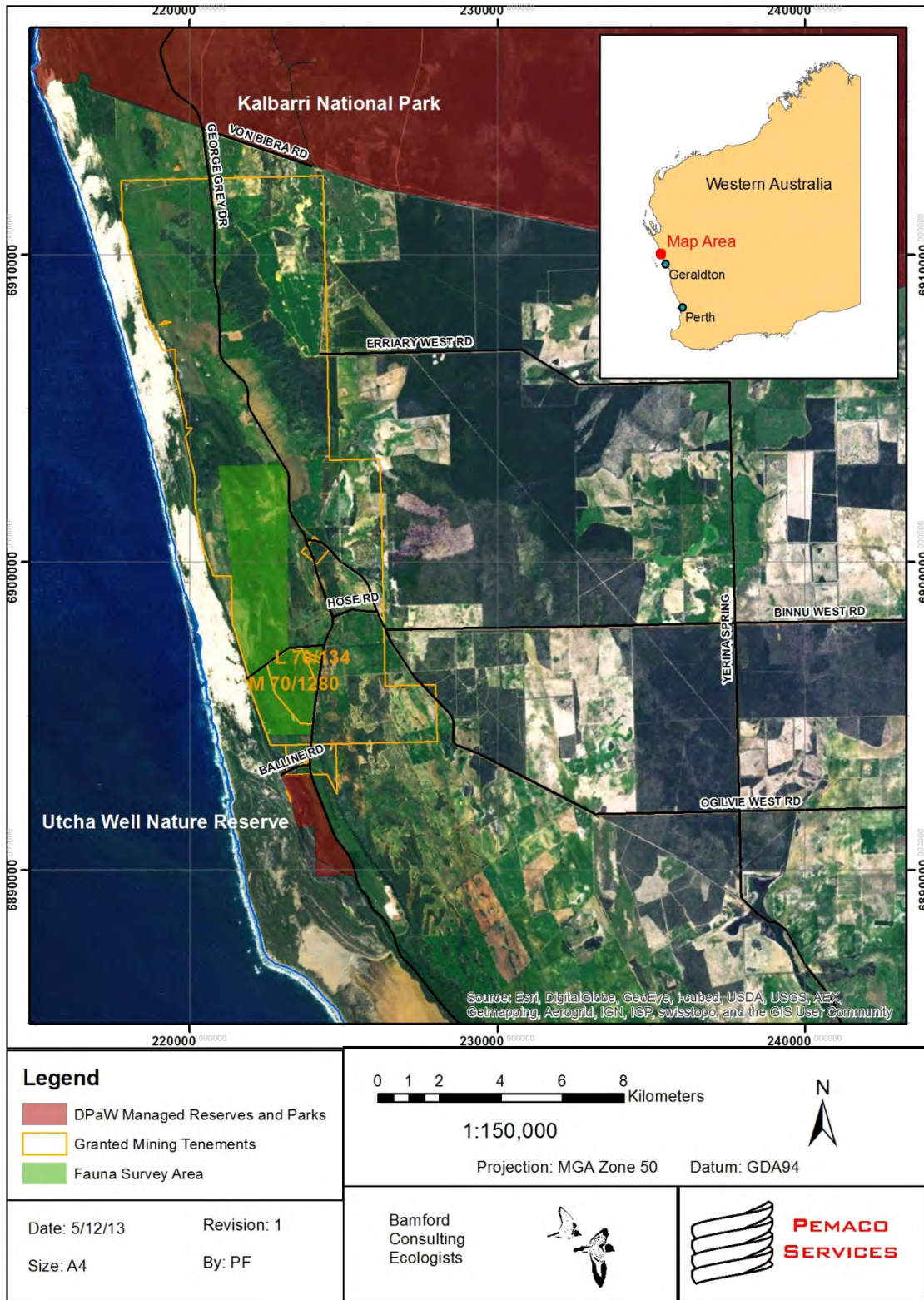


Figure 1. Location of project area.

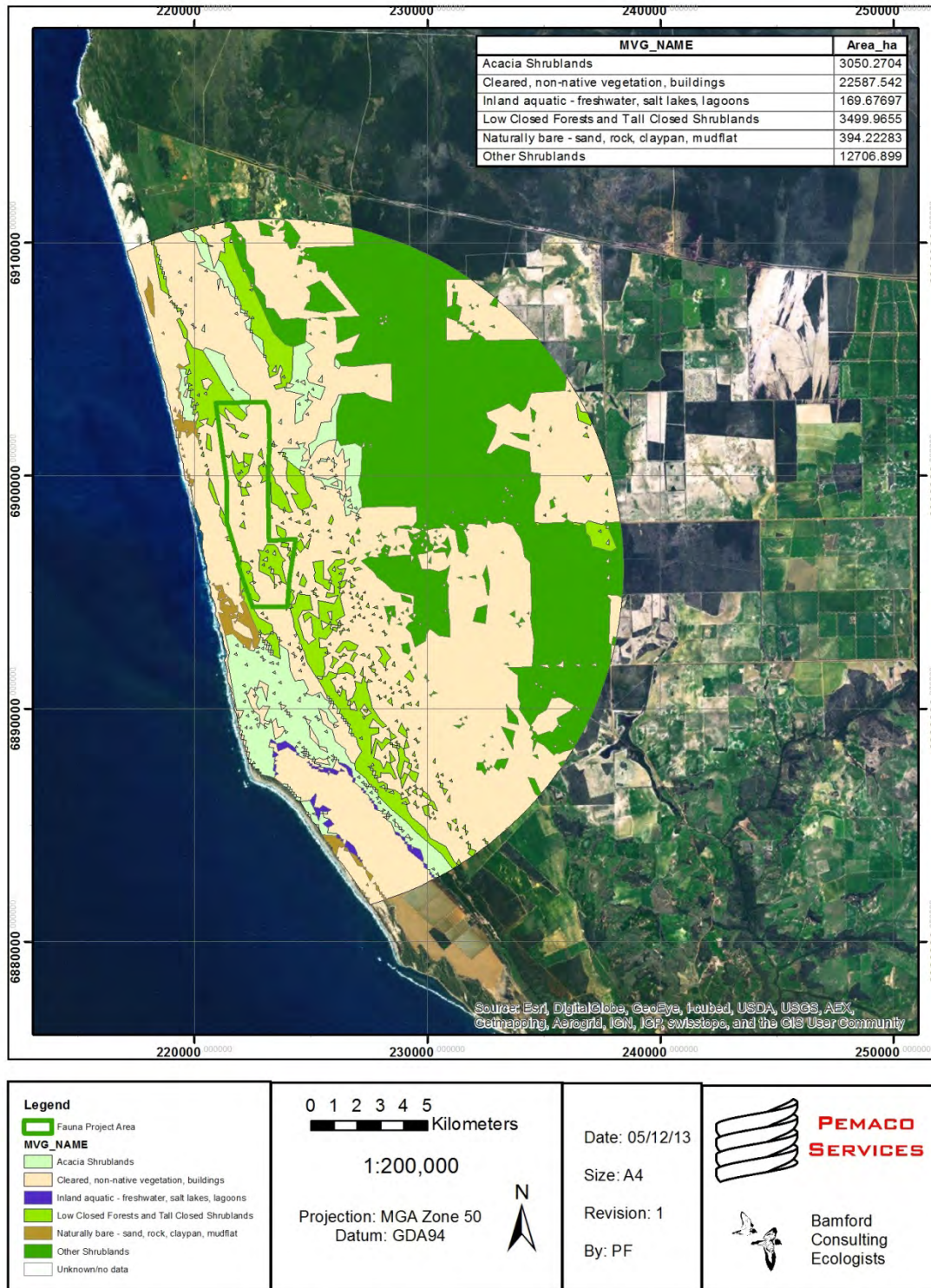


Figure 2. The extent of remnant native vegetation within a 15km radius of the project area.

2 Background

2.1 Regional Description

The Interim Biogeographic Regionalisation of Australia (IBRA) (Environment Australia, 2000) has identified 26 bioregions in Western Australia (Figure 2). Bioregions are classified on the basis of climate, geology, landforms, vegetation and fauna (Thackway and Cresswell, 1995). IBRA Bioregions are affected by a range of different threatening processes and have varying levels of sensitivity to impact (EPA, 2004).

The Balline survey area lies in the Geraldton Sandplains Bioregion and the Geraldton Hills Subregion (DSEWPaC 2013b), although it is probably atypical of these areas with distinctive near-coastal soils and vegetation.



Figure 3. IBRA Subregions in Western Australia.

Note the project area lies in GS2 (Geraldton Hills) IBRA subregion.

The Geraldton Hills subregion is characterised by “sand heaths with emergent Banksia and Actinostrobos, York Gum woodlands on alluvial plains, proteaceous heath and Acacia shrubs on limestones. The climate is Warm semi-arid to Mediterranean with 400-500mm of rainfall annually, and the subregional area is 2,242,033 ha.”(Desmond and Chant 2001)

The dominant land use in this subregion is dry-land agriculture and smaller areas of conservation, grazing native pastures, UCL and Crown Reserves. Desmond and Chant (2001) describe the Geraldton Hills Subregion as having areas of relatively high ecosystem or species diversity.

2.2 Vegetation Units

Beard (1972, 1976) mapped the Geraldton Hills region including the Balline survey area. The vegetation community in the area is mostly Shrubland; *Acacia rostellifera* thicket.

3 Methods

3.1 Overview

The methods used in these investigations are based upon the general approach to fauna investigations for impact assessment as outlined in Section 1.2 and EPA Guidance Statement 56, and with reference to Appendices 1 to 4. Thus, the impact assessment process involves the identification of fauna values, review of impacting processes and preparation of mitigation recommendations.

In addition, the approach to fauna impact assessment was carried out with reference to guidelines and recommendations set out by the Western Australian Environmental Protection Authority (EPA) on fauna surveys and environmental protection, and Commonwealth biodiversity legislation (EPA 2002; EPA 2004). The EPA proposes two levels of investigation that differ in the approach to field investigations, Level 1 being a review of data and a site reconnaissance to place data into the perspective of the site, and Level 2 being a literature review and intensive field investigations (e.g. trapping and other intensive sampling). The level of assessment recommended by the EPA is determined by the size and location of the proposed disturbance, the sensitivity of the surrounding environment in which the disturbance is planned, and the availability of pre-existing data.

As the proposed Balline Garnet Project is in bankable feasibility stage, Pemaco Services requested a Level 1 fauna assessment of the area. A Level 1 fauna assessment consists of a desktop study and basic ground-truthing through a reconnaissance survey.

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

- Desktop assessment. The purpose of the desktop review is to produce a species list that can be considered to represent the vertebrate fauna assemblage of the project area based on unpublished and published data using a precautionary approach.
- Field investigations. The purpose of the field investigations is to gather information on this assemblage: confirm the presence of as many species as possible (with an emphasis on species of conservation significance), place the list generated by the desktop review into the context of the environment of the project area, collect information on the distribution and abundance of this assemblage, and develop an understanding of the project area's ecological processes that maintain the fauna. Note that field investigations cannot confirm the presence of an entire assemblage, or confirm the absence of a species. This requires far more work than is possible in the EIA process. For example, in an intensive trapping study, How and Dell (1990) recorded in any one year only about 70% of the vertebrate species found over three years. In a study spanning over two decades, Bamford (2010b) has found that the vertebrate assemblage varies over time and space, meaning that even complete sampling at a set of sites only defines the assemblage of those sites at the time of sampling.
- Impact assessment. Determine how the fauna assemblage may be affected by the proposed development based on the interaction of the project with a suite of ecological and threatening processes.

3.2 Desktop Assessment

3.2.1 Sources of information

Information on the fauna assemblage of the project area was drawn from a wide range of sources. These included state and federal government databases and results of regional studies. Databases accessed were the DEC Naturemap (incorporating the Western Australian Museum's FaunaBase and the DEC Threatened and Priority Fauna Database), BirdLife Australia's Atlas Database (BA), the EPBC Protected Matters Search Tool and the BCE database (Table 1). Information from the above sources was supplemented with species expected in the area based on general patterns of distribution. Sources of information used for these general patterns were:

- Frogs: Tyler *et al.* (2000);
- Reptiles: Storr *et al.* (1983); Storr *et al.* (1990); Storr *et al.* (1999); Storr *et al.* (2002) and Wilson & Swan (2008);
- Birds: Blakers *et al.* (1984); Johnstone and Storr (1998, 2004) and Barrett *et al.* (2003); and
- Mammals: Menkhorst & Knight (2001); Strahan (2004); Churchill (2008); and Van Dyck and Strahan (2008).

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

Database	Type of records held on database	Area searched
NatureMap (DPaW 2013)	Records in the WAM and DPaW databases. Includes historical data and records on Threatened and Priority species in WA.	28° 01' 10"S, 114° 10' 53"E – plus 40 km buffer
BirdLife Australia Atlas Database	Records of bird observations in Australia, 1998-2013.	Species list for one degree cell containing: 28° 01' 10"S, 114° 10' 53"E
EPBC Protected Matters	Records on matters of national environmental significance protected under the EPBC Act.	28° 01' 10"S, 114° 10' 53"E – plus 40 km buffer

3.2.2 Previous Fauna Surveys

A Level 1 fauna and flora investigation of the survey area was conducted by Ecoscape (2009); this was based upon a literature review and ground-truthing. A Subterranean Fauna Survey of the site was conducted by Goater and Knott (2009), using digital imaging and net sampling.

3.2.3 *Nomenclature and taxonomy*

As per the recommendations of EPA (2004a), the nomenclature and taxonomic order presented in this report are based on the Western Australian Museum's (WAM) *Checklist of the Vertebrates of Western Australia 2008*. The authorities used for each vertebrate group were: amphibians (Doughty and Maryan 2010a), reptiles (Doughty and Maryan 2010b), birds (Christidis and Boles 2008), and mammals (How *et al.* 2009). 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.

3.2.4 *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 6.

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.

3.3 Field survey

3.3.1 Overview

The field survey included several components:

- targeted searching for conservation significant fauna;
- opportunistic fauna observations; and
- habitat assessment.

3.3.2 Dates and Personnel

The Balline survey area was assessed on the 14th September 2013 by Dr Michael Bamford (B.Sc. Hons. Ph.D.) and Ms Amanda Bamford (B.Sc. Hons.). This fauna assessment document was prepared by Ms Claudia McHarrie (B.Sc. Hons.) and Dr Mike Bamford.

3.3.3 Vegetation and Substrate Associations

Vegetation and Substrate Associations (VSAs) throughout the survey area were assessed during the desktop review and as part of the field investigations. Within the Balline survey area, each major VSA was visited to develop an understanding of major fauna habitat types present and to assess the likelihood of conservation significant species being present in the area.

3.3.4 Targeted searching for conservation significant species

Significant species recorded during the desktop assessment include several that can be found by searching for evidence of their activities (e.g. scats, tracks, diggings, burrows) or listening for their call. Searching for evidence of significant fauna was therefore undertaken by walking through habitat considered suitable for such species, as well as searching for suitable nesting hollows for black-cockatoos.

3.3.5 Opportunistic observations

At all times, observations of fauna were noted when they contributed to the accumulation of information on the fauna of the site. These included such casual observations as birds or reptiles seen while travelling through the site.

3.4 Survey limitations

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

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

EPA Limitation	BCE Comment
Level of survey.	Level 1 (desktop study and reconnaissance survey). Survey intensity was deemed adequate due to the level of survey and the number of fauna surveys previously conducted in the region.
Competency/experience of the consultant(s) carrying out the survey.	The authors have had extensive experience in conducting desktop reviews and site inspections.
Scope. (What faunal groups were sampled and were some sampling methods not able to be employed because of constraints?)	As a level 1 survey, the scope was not to comprehensively sample fauna; the inspection was adequate to define fauna habitats and there was abundant desktop data on the fauna assemblage in the region.
Proportion of fauna identified, recorded and/or collected.	No specimens collected, all fauna observed identified.
Sources of information e.g. previously available information (whether historic or recent) as distinct from new data.	Sources include previous Ecoscape fauna survey of the site; databases (BA, DEC, WAM, EPBC)
The proportion of the task achieved and further work which might be needed.	Site inspection completed.
Timing/weather/season/cycle.	Site inspection conducted during September 2013. Conditions were mild, with 6.6mm rainfall recorded on the day of the survey
Disturbances (e.g. fire, flood, accidental human intervention etc.) which affected results of survey.	Significant clearing for agriculture, livestock grazing and weed invasion See description in Section 5.1.1
Intensity. (In retrospect, was the intensity adequate?)	Survey intensity was low (desktop study and site inspection) however was adequate to satisfy EPA guidelines.
Completeness (e.g. was relevant area fully surveyed).	Desktop study covered survey area and adjacent habitats. Site inspection covered all areas of the project.
Resources (e.g. degree of expertise available in animal identification to taxon level).	All species identified to taxon level.
Remoteness and/or access problems.	No access problems.
Availability of contextual (e.g. biogeographic) information on the region.	Extensive regional information was available and was consulted.

3.5 Presentation of results for Impact Assessment

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

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

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

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 vegetation/substrate associations (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 1.3 and discusses the contribution of the project to impacting processes, and the consequences of this with respect to biodiversity. A major component of impact assessment is consideration of threats to species of conservation significance as these are a major and sensitive element of biodiversity. Therefore, the impact assessment includes the following:

- Review of impacting processes; will the proposal result in:

- Habitat loss leading to population decline, especially for significant species;
 - Habitat loss leading to population fragmentation, especially for significant species;
 - Weed invasion 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.

3.5.1 Criteria for impact assessment

Impact assessment criteria are based on the severity of impacts on the fauna assemblage and conservation significant fauna, and were quantified on the basis of predicted population change (Table 3). Population change can be the result of direct habitat loss and/or impacts upon ecological processes.

The significance of population change is contextual. 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 is 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). Under the Ramsar Convention, a wetland that regularly supports 1% of a population of a waterbird species is considered to be significant. These provide some guidance for impact assessment criteria. In the following criteria (Table 3), the significance of impacts is based upon percentage population decline within a 15 km radius (effectively local impact) and upon the effect of the decline upon the conservation status of a recognised taxon (recognisably discrete genetic population, sub-species or species). Note that percentage declines can usually only be estimated on the basis of distribution of a species derived from the extent of available habitat.

Table 3. Assessment criteria of impacts upon fauna.

Impact Category	Observed Impact
Negligible	Effectively no population decline; at most few individuals impacted and any decline in population size within the normal range of annual variability.
Minor	Population decline temporary (recovery after end of project such as through rehabilitation) or permanent, but <1% within 15 km radius of centre-point of impact area (or within bioregion if this is smaller). No change in viability or conservation status of taxon.
Moderate	Permanent population decline 1-10% within 15 km radius. No change in viability or conservation status of taxon.
Major	Permanent population decline >10% within 15 km radius. No change in viability or conservation status of taxon
Critical	Taxon extinction within 15 km and/or change in viability or conservation status of taxon.

4 Results

4.1 Vertebrate Fauna

4.1.1 Overview of fauna assemblage

The desktop study identified 187 vertebrate fauna species as potentially occurring in the Balline survey area (see Table 4 and Appendix 6): 10 frogs, 64 reptiles, 87 birds, and 14 native and 8 introduced mammals. Note that this assemblage comes from databases and includes species that may occur occasionally on the site, but for which it is not important (such as birds that rarely fly overhead). The vertebrate assemblage includes at least 30 species of conservation significance ((Table 5), with a further 46 significant species returned from databases but which are not considered likely to occur in the project area (included in Appendix 6). In addition, one terrestrial invertebrate species of high conservation significance was returned from databases, while three invertebrate species that may be of local conservation significance were recorded. These are also listed in Table 5, and significant species are discussed further in Section 4.1.2.

While the assemblage is large, the site is extensively cleared and therefore many of the species expected to be present probably only occur infrequently and may not be reliant on the site. As a result, key features of the fauna assemblage expected in the project area are:

- **Uniqueness:** The assemblage is likely to be typical of the region, but may have some unusual elements because of the near-coastal vegetation and soils. The site inspection confirmed the presence of a number of bird species reliant upon remnant native vegetation (and thus absent from surrounding farmland).
- **Completeness:** The assemblage is likely to be incomplete because much of the site is cleared. The mobility of fauna means that many species could be recorded in the project area over time, but many of the records would be of vagrant individuals moving between nearby patches of native vegetation.
- **Richness:** The assemblage is likely to be depauperate because of the scarcity of intact native vegetation.

As a fauna value, the most important feature of the site's assemblage is that it is reliant upon remnant native vegetation in an otherwise agricultural landscape.

Table 4. Composition of vertebrate fauna assemblage expected to occur within the survey area
 (Values in parenthesis are numbers of introduced species included in the total. CS – Conservation Significant).

Taxon	Number of species expected	Number of species recorded	Significant fauna Expected (recorded)		
			CS1	CS2	CS3
Frogs	10	0	0	0	1 (0)
Reptiles	64	4	2 (0)	1 (0)	0
Birds	87	20	7 (0)	4 (0)	6 (0)
Native Mammals	14	2	0	0	0
Introduced Mammals	8	4			
CS Invertebrates	4	3	1 (0)	0	3 (3)
Total	187	33	10	5	10

Table 5. Conservation status of significant fauna species expected to occur in project area (based on desktop review and field investigation).

Common Name	Latin Name	Conservation Status			Expected status in project area
		CS1	CS2	CS3	
AMPHIBIANS					
Southern Sandhill Frog	<i>Arenophryne xiphorhyncha</i>			X	Resident?
REPTILES					
Carpet Python	<i>Morelia spilota</i>	S4			Resident
	<i>Cyclodomorphus branchialis</i>	S1			Resident
Stripe-sided Robust Slider	<i>Lerista axillaris</i>		P2		Resident
BIRDS					
Fork-tailed Swift	<i>Apus pacificus</i>	Mig, S3			Occasional visitor
Malleefowl	<i>Leipoa ocellata</i>	S1			Vagrant
Peregrine Falcon	<i>Falco peregrinus</i>	S4			Occasional visitor
Rainbow Bee-eater	<i>Merops ornatus</i>	Mig, S3			Regular visitor
Major Mitchell's Cockatoo	<i>Cacatua leadbeateri</i>	S4			Vagrant
White-browed Babbler (wheatbelt form)	<i>Pomatostomus superciliosus</i>		P4		Recorded in project area
Australian Bustard	<i>Ardeotis australis</i>		P4		Occasional visitor
Bush Stone-curlew	<i>Burhinus grallarius</i>				Vagrant
Crested Bellbird (wheatbelt form)	<i>Oreoica gutturalis</i>				Occasional visitor
Splendid Fairy-wren	<i>Malurus splendens</i>			X	Recorded in project area
Variiegated Fairy-wren	<i>Malurus lamberti</i>			X	Recorded in project area
White-winged Fairy-wren	<i>Malurus leucopterus</i>			X	Recorded in project area
Blue-breasted Fairy-wren	<i>Malurus pulcherrimus</i>			X	Regular visitor
Inland Thornbill	<i>Acanthiza apicalis</i>			X	Recorded in project area
White-browed Scrubwren	<i>Sericornis frontalis</i>			X	Recorded in project area
INVERTEBRATES					
Native Bee	<i>Neopasiphae simplicior</i>	Cr, S1			Resident?
Isopod (slater)	<i>Buddelundia "81"</i>			X	Recorded in project area
Subterranean crustacea	Ostracod and calanoid copepod			X	Recorded in project area

See Appendix 1 for descriptions of conservation significance levels. Species recorded are indicated and the predicted status of each species in the project is also given (as per Section 2.4.1).

EPBC Act listed species: V = Vulnerable, En = Endangered, Cr = Critically Endangered, Mig = Migratory.

WC Act listed species: S1 = Schedule 1, S3 = Schedule 3, S4 = Schedule 4, DEC Priority Species: P1 = Priority 1, P2 = Priority 2, P3 = Priority 3, P4 = Priority 4, P5 = Priority 5.

4.1.2 *Species of conservation significance*

Details on species of conservation significance returned from the database and expected (including those recorded) to occur in the project area (even as vagrants) are presented in Table 5. This list includes one amphibian species, three reptile species, 15 bird species and four invertebrate species. Further information on species that might be present, including observations from the site inspection, is presented below. Note that species extinct in the region and that may have been present historically on the basis of broad patterns of distribution have not been included (but are listed in Appendix 6).

Southern Sandhill Frog (*Arenophyrne xiphorhyncha*)

This species has a restricted distribution, occurring along the coast from Kalbarri National Park north to Shark Bay. It may occur in the sandy hills and ridges present within the survey area, which lies immediately to the south of Kalbarri National Park, but the project area may lie just south of the species' range.

Carpet Python (*Morelia spilota*)

This species is listed as CS1 and, if present in the survey area, is at the extreme north of its known range. It has been reported in the vicinity by local farmers and may be a resident of native vegetation in the project area.

Cyclodomorphus branchialis

This species may be present in the remnant vegetation of the project area. It has previously been recorded during a survey near Galena, approximately 70km east of the survey area (M. Bamford unpubl. data).

Stripe-sided Robust Slider (*Lerista axillaris*)

This species may be present in the project area, confined to patches of remnant vegetation.

Peregrine Falcon (*Falco peregrinus*)

This species is found in a variety of habitats, including rocky ledges, cliffs, watercourses, open woodland and acacia shrublands. The distribution of the Peregrine Falcon is often tied to the abundance of prey as this species predated heavily on other birds. The Peregrine Falcon lays its eggs in recesses of cliff faces, tree hollows or in large abandoned nests of other birds (Birds Australia 2012). Blakers *et al.* (1984) consider that Australia is one of the strongholds of the species, since it has declined in many other parts of the world. Though it is unlikely that Peregrine Falcons breed in the project area due to lack of nesting habitat, it is possible that a pair lives in the region and forages over the project area occasionally.

Australian Bustard (*Ardeotis australis*)

The Australian Bustard is nomadic and may range over very large areas, largely dependent on rainfall and hence food availability. It may be an occasional visitor to the project area.

Fork-tailed Swift (*Apus pacificus*) and Rainbow Bee-eater (*Merops ornatus*)

The Fork-tailed Swift is largely aerial but may over-fly the project area occasionally. The Rainbow Bee-eater is an abundant, ground-nesting species that catches insects on the wing over a range of environments. It is a summer, breeding visitor to the South-West of WA and is likely to be present annually in the project area.

Malleefowl (*Leipoa ocellata*)

No Malleefowl mounds were found during the field survey but the species is known to be present in the general region. The remnant vegetation within the site may be too small to support the species, but may allow for vagrant birds to move through the project area.

White-browed Babbler (western wheatbelt sub-species)

This species is listed as CS2 due to extensive clearing of habitat. It was recorded in the project area during the field survey, with one party found in the large area of remnant native vegetation in the south.

Major Mitchell's Cockatoo

Known from the general region but probably only present as a vagrant as there is no eucalypt woodland, its preferred habitat.

Bush Stone-curlew

This species is listed as CS2 due to extensive clearing of habitat and probably predation by Foxes. It was not recorded on the site during the field survey but may be a vagrant. There is probably too little continuous habitat to support this species.

Crested Bellbird (Wheatbelt sub-species)

This species is listed as CS2 due to habitat loss as a result of clearing for agriculture. It was not recorded on the site during the field survey and is very conspicuous due to its distinctive call. Therefore it is probably not resident but may be an occasional visitor.

CS3 Birds

The Splendid Fairy-wren, Variegated Fairy-wren, White-winged Fairy-wren, White-browed Scrubwren and Inland Thornbill were recorded during the site visit, and are listed as CS3 because they are likely to be restricted to native vegetation; thus populations may be locally significant where they occur.

Significant invertebrates

There is one terrestrial invertebrate of high conservation significance (CS1) that may be present in the project area, the native bee *Neopasiphae simplicior*. *Neopasiphae simplicior* is a short-tongued bee which utilises *Lobelia tenuior*, *Goodenia filiformis* and *Angianthus preissianus*. This species was not recorded in the project area during the survey but may be a resident. An isopod (slater) collected during the site inspection is the first known example of an undescribed species and has been described as *Buddelundia '81'* by Phoenix Environmental (2013), who concluded that it was likely to be a short range endemic (SRE and thus CS3). It was recorded only in areas of native vegetation where limestone was present on the surface (VSA 3, see Figure 3). Two species of subterranean crustacea were found in the superficial groundwater aquifer of the site, a species of ostracod and a calanoid copepod (Goater and Knott 2009). The distribution of these is unknown but they have to be assumed to be short range endemics because they occur in a restricted environment. They are thus of CS3.

4.1.3 Introduced / Feral Species

The desktop study identified six introduced fauna species as potentially occurring in the Balline survey area. Of these two were recorded on site and many of the other species are expected to be occasional visitors to the survey area. In addition, two species of domestic livestock were observed during the site inspection. While domestic and not included in databases, they have ecological impacts and were present in remnant native vegetation.

Table 6. Introduced fauna species expected to occur in project area (based on desktop review and field investigation).

Common Name	Latin Name	Expected status in project area
MAMMALS		
Red Fox	<i>Vulpes vulpes</i>	Recorded in project area
House Mouse	<i>Mus musculus</i>	Resident
Black Rat	<i>Rattus rattus</i>	Occasional visitor
Goat	<i>Capra hircus</i>	Occasional visitor
Cat	<i>Felis catus</i>	Resident
European Rabbit	<i>Oryctolagus cuniculus</i>	Recorded in project area
Domestic Sheep	<i>Ovis aries</i>	Recorded in project area
Domestic Cattle	<i>Bos taurus</i>	Recorded in project area

4.2 Summary of species of conservation significance

Significant species expected to be present at least occasionally within the project area include three reptiles, up to 15 birds, possibly two terrestrial invertebrates and two species of invertebrate stygofauna. Of greatest conservation interest are the Southern Sandhill Frog, Carpet Python, the skinks *Cyclodomorphus branchialis* and *Lerista axillaris*, and the CS3 birds. These species are restricted to native vegetation and therefore, are likely to be reliant on the remnant patches of vegetation remaining within the survey area. A possible SRE invertebrate, the slater *Buddelundia '81'*, may be restricted to areas where limestone is present on the surface. The two species of stygofauna were present in the superficial aquifer.

4.3 Vegetation and Substrate Associations (VSAs)

Three VSAs were identified during field investigations. These were:

- 1. Pasture. This is very extensive (see Figure 4) across the project area. It includes one small area that might be inundated for short periods in winter.
- 2. *Acacia rostellifera* Shrubland to Tall Shrubland on yellow-brown sands.
- 3. *Melaleuca cardiophylla* Shrubland to tall shrubland on shallow grey sands over limestone, with extensive limestone outcropping. This vegetation associated with limestone close to the surface occurs largely in the west, but also on the hilltop in the southern block.

The VSAs occurring within the survey area are described below. Their representation within the survey area and conservation significance for fauna is also listed.

- 1) Pasture.
 - a. Representation. Widespread and well-represented in cleared land in the region.
 - b. Conservation Significance for Fauna. Generally of low value as habitat.
- 2) *Acacia* Shrubland to Tall Shrubland on yellow-brown sands (Figures 5, 6 and 7).
 - a. Representation. Restricted to remnants in the study area, with patches in the south, centre and north. Degraded by grazing where livestock not excluded. Restricted to near-coastal locations in region and extensively cleared.
 - b. Conservation Significance for Fauna. Important for most of the native fauna assemblage still present in the study area, providing habitat and connectivity across the landscape.
- 3) *Melaleuca* *Acacia* Shrubland to Tall Shrubland on grey sand over limestone (Figures 8 and 9).
 - a. Representation. Restricted to remnants in the study area, with patches in the west and on a low hill in the south. Degraded by grazing where livestock not excluded. Restricted to near-coastal locations in region and extensively cleared.
 - b. Conservation Significance for Fauna. Important for most of the native fauna assemblage still present in the study area, providing habitat and connectivity across the landscape. The probable SRE isopod *Buddelundia '81'* may be restricted to this VSA.

Detailed mapping of vegetation types and therefore VSAs outside the project area is not available, but the loss due to clearing of both natural VSAs within the region of the project area is probably similar to the general level of clearing. Within 15km of the project area, 47% of native vegetation remains (Figure 1). Remnant vegetation within the project area represents 2.0% of native vegetation within a 15km radius. The area of native vegetation to be cleared within the project area (132ha) represents 33% of native vegetation within the project area, but only 0.3% of native vegetation within a 15km radius.

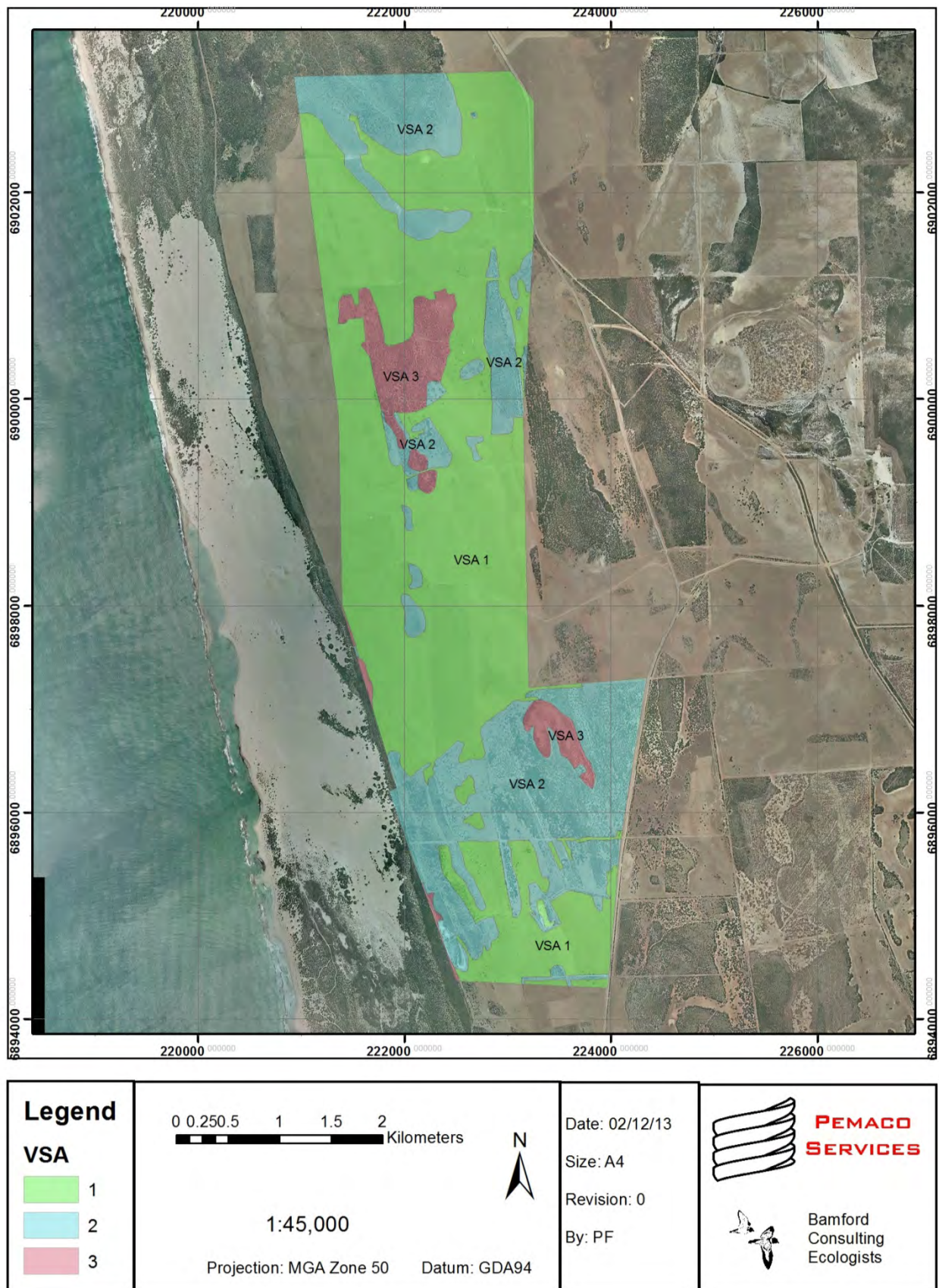


Figure 4. The distribution of Vegetation and Substrate Associations in the project area.



Figure 5. Acacia shrubland in remnant in north of project area.



Figure 6. Acacia shrubland badly degraded by livestock.



Figure 7. Acacia tall shrubland in sheltered valley in southern remnant.



Figure 8. Melaleuca shrubland with exposed limestone in western remnant.



Figure 9. View across large remnant in south from the west. Acacia shrubland in the foreground is tall and appears to be regrowth after past clearing, while the top of the hill in the background supports Melaleuca shrubland. Pasture lies to the left.

4.4 Patterns of biodiversity

Patterns of biodiversity can be interpreted from initial field observations and the characteristics of the VSAs described above, although intensive field investigations are required to provide detailed information. In a project area as extensively cleared as the Balline Garnett site, the key pattern of biodiversity is the importance of any remnant vegetation. There will be differences in biodiversity related to size, location, condition and type of remnant vegetation. For example, small and degraded remnants in the centre and north of the project area may have fewer species than the large remnant in the south, but they may have an important linkage function.

4.5 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 ground water of the site occurs within a superficial aquifer that is likely to be unconfined (Goater and Knott 2009) and therefore may be sensitive to changes associated with mining. A groundwater-dependent subterranean fauna assemblage is present.

Fire. The shrublands may be prone to fire in dry weather and while appropriate fire regimes can benefit biodiversity, inappropriate regimes can lead to a loss of biodiversity. This is a particular concern in a fragmented landscape when all of a fragment may be burnt at once.

Feral species and interactions with over-abundant native species. The fauna assemblage of the project areas has already been impacted by feral species (loss of a major component of the mammal fauna), and both feral and domestic herbivores are leading to degradation of native vegetation. Human activity has the potential to alter the abundance of feral species.

Habitat degradation due to weed invasion. The project area currently has high levels of weed invasion, exacerbated by livestock grazing.

Connectivity. Remnant vegetation in the project area may have a role in landscape connectivity for fauna, primarily between Kalbarri National Park in the north and Utcha Well Nature Reserve in the south, but also in an east-west direction, as uncleared native vegetation lies to the east (see Figures 1 and 2). Note that the remnant vegetation is fragmented but such fragments can be used as “stepping stones” for movement, particularly by birds. To some extent there is a corridor of native vegetation between the project area and the coastal sand-dunes, but this is narrow and may not support the same suite of species as remnant vegetation in the project area.

4.6 Summary of fauna values

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

Fauna assemblage. Depauperate due to extensive clearing. Remnant vegetation on shallow soils over limestone is distinctive, regionally uncommon and thus may have a locally unusual (albeit species-poor) fauna assemblage.

Species of conservation significance. A range of significant species may be present but in small numbers. Species of note are the Southern Sandhill Frog, Carpet Python, the skinks *Cyclodomorphus branchialis* and *Lerista axillaris*, a suite of CS3 (locally significant) birds and several invertebrates. All are likely to be associated with remnant native vegetation, with the isopod *Buddelundia '81'* possibly restricted to VSA 3.

Vegetation and Substrate Associations. Three VSAs were identified across the project area, of which only two are natural. Both the natural VSAs are extensively cleared in the region.

Patterns of biodiversity. Biodiversity is likely to be spread across the natural VSAs, VSA2 and VSA3. These VSAs are likely to be important for most of the native fauna assemblage present in the study area.

Key ecological processes. Main processes currently affecting the fauna assemblage in the project area include extensive clearing and grazing by domestic livestock degrading the remaining remnants of native vegetation.

5 Impact assessment

5.1 Overview of Impacts

As outlined in section 1.1, Pemaco Services is investigating the Balline Garnet Project survey area about 35 km south of Kalbarri, Western Australia. A level 1 fauna assessment identified the fauna values of this survey area. The following sections examine possible impacts upon these fauna values based upon the impacting or threatening processes outlined in Appendix 2. Impacts are summarised in Table 7. Impact criteria are outlined in Table 3. Recommendations relating to impacts are made in Section 6.

5.1.1 *Loss of habitat leading to population decline*

Disturbance of farmland would have little if any impact upon biodiversity, but direct loss in areas of remnant vegetation could lead to population declines. The southern remnant of native vegetation is the largest in the project area and part of this is targeted for mining, with existing approval to clear 90ha. Some of the vegetation targeted for clearing is regenerating following earlier disturbance, but it still provides habitat for fauna.

5.1.2 *Loss of habitat leading to population fragmentation*

Remnant vegetation in the project area may have a connectivity function for fauna. Therefore, impacts upon remnant vegetation could facilitate population fragmentation. The southern remnant of native vegetation is the largest in the project area and part of this is targeted for mining, and this may increase population fragmentation.

5.1.3 *Degradation of habitat due to weed invasion*

Weed invasion of the project area is currently high and is unlikely to be exacerbated by the proposed development if reasonable hygiene measures are employed.

5.1.4 *Ongoing mortality*

Direct mortality of common species during clearing is unavoidable but can be minimised (see recommendations below). Ongoing mortality would only be a concern if placement of roads and vehicle movements were such that they posed a risk to species such as the Carpet Python. This would occur if roads were placed through areas of remnant vegetation.

5.1.5 *Species interactions*

Feral species are a major conservation concern; two introduced species were detected and others are highly likely to be present. Foxes and feral cats are likely to be attracted by recent disturbance, possibly leading to increased local impacts on native fauna on the margins of disturbed areas. Inappropriate waste management may also attract foxes and feral cats, as well as native predators and scavengers, which may exacerbate localised impacts on other native fauna.

5.1.6 Hydroecology

Impacts upon groundwater are expected to be minimal. Mining activities will only reach below the water table in a small portion of the total area to be mined. As such, there is no reason to expect that there will be adverse impacts upon any subterranean fauna that may be present, and no effect on deep-rooted plants that may depend upon groundwater. Surface water appears only to be transient in the project area.

5.1.7 Altered fire regimes

While the biota of the region is probably adapted to a particular fire regime, a succession of fires, especially in a fragmented landscape, could lead to local extinction. Activities in the project area are a potential source of fire although this can be managed.

5.1.8 Disturbance

Impacts of dust, light, disturbance and noise upon fauna are expected to be likely as processing operations will run 24 hours a day. This may impact fauna if there is an increase in artificial lighting in the project area.

5.1.9 Summary of impacts

Impacts upon key fauna values are summarised in Table 7 and are considered to be Minor or less. This is due to the site being extensively cleared and to the impact footprint being small. However, there is some concern with localised loss of habitat due to mining in the southern remnant of native vegetation which can be expected to lead to localised population declines and could affect fauna movements through the area. Offsite impacts from fire and feral fauna on adjacent areas of bushland may also be of some concern. Recommendations made in this table are expanded in Section 6.

Table 7. Summary of potential impacts upon key fauna values that are expected to occur in the survey area.

Criteria for significance of impacts are outlined in Section 3.5.1.

Fauna Value	Nature and Significance of Impact		Action required
	Potential Impacts	Significance	
Fauna assemblage	Loss of fauna in areas of remnant vegetation (mostly in southern block)	Minor as impacts very localized in a regional context	Minimise impact footprint on remnant vegetation and rehabilitate where possible.
VSAs	Loss of remnant vegetation (VSAs 2 and 3) mainly in southern block.	Minor as these are moderately widespread in the region	Minimise footprint, avoid remnant vegetation where possible
Significant fauna	Risk mainly to locally significant (CS3) birds with population decline due to habitat loss anticipated in the southern block of remnant vegetation	Minor as impacts very localized	Minimise footprint in remnant vegetation where possible.
Patterns of biodiversity	Proposed clearing lies mainly in natural VSAs (VSAs 2 and 3) that are locally important for biodiversity.	Minor as impacts very localized	Minimise footprint in remnant vegetation where possible.
Ecological processes	Some possible impacts on fire regimes and feral predators; impacts upon subterranean hydrology appear unlikely. Development may increase fragmentation of fauna populations.	Minor but fragmentation could be a concern.	Management to prevent off-site impacts. Rehabilitate to restore connectivity where possible. Potential exists to improve connectivity through planting of corridors in pasture areas.

6 Recommendations

Section 5 (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

- Minimise the disturbance footprint;
- Clearly delineate areas to be cleared;
- Where possible, rehabilitate post-disturbance to replace at least some lost habitat, and to enhance linkage.

Habitat fragmentation

- Minimise the disturbance footprint;
- Rehabilitation post-disturbance to enhance linkage.
- Plant native vegetation in unused parts of the survey area to provide additional linkage. This could include planting corridors through pasture areas.

Species interactions

- Discourage the presence of feral species, particularly the feral Cat and Fox, by the use of appropriate waste management procedures.

Hydrological changes

- Monitor groundwater levels to ensure these do not alter during mining.

Habitat degradation due to weed invasion

- Develop a weed management/hygiene plan. For example, vehicles visiting the site should be clear of weeds and should not have come from weed-infested agricultural land nearby.
- Fence remnants to exclude stock.

Changes in fire regime

- Develop a fire management plan. Of particular importance is prevention of unplanned fires in adjacent bushland.

Dust, noise, light and disturbance

- Minimise the production of dust, noise and light spill; especially where these may affect adjacent bushland.

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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 3.

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

Species listed under the EPBC Act are assigned to categories recommended by the International Union for the Conservation of Nature and Natural Resources (IUCN) and reviewed by Mace and Stuart (1994), or are listed as migratory. Migratory species are recognised under international treaties such as the China Australia Migratory Bird Agreement (CAMBA), the Japan Australia Migratory Bird Agreement (JAMBA), the Republic of South Korea Australia Migratory Bird Agreement (ROKAMBA), and/or the 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 DEC, 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 (phreatoicidan crustaceans), and Decapoda (freshwater crayfish). The poor understanding of the taxonomy of many of the short-range endemic species hinders their conservation (Harvey 2002).

Introduced species

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

Ecological processes upon which the fauna depend

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

Appendix 2. Explanation of threatening processes.

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

Loss of habitat affecting population survival

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

Loss of habitat leading to population fragmentation

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

Degradation of habitat due to weed invasion leading to population decline

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

Increased mortality

Increased mortality can occur during project operations; for example from roadkill, animals striking infrastructure and entrapment in trenches. Roadkill as a cause of population decline has been documented for 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. 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 4.	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).
Priority 5	

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 19 key threatening processes listed by the federal Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC 2011):

- Competition and land degradation by feral/unmanaged Goats (*Capra hircus*);
- Competition and land degradation by feral Rabbits (*Oryctolagus cuniculus*);
- Dieback caused by the root-rot fungus (*Phytophthora cinnamomi*);
- Incidental catch (bycatch) of Sea Turtles during coastal otter-trawling operations within Australian waters north of 28 degrees South;
- Incidental catch (or bycatch) of seabirds during oceanic longline fishing operations;
- Infection of amphibians with chytrid fungus resulting in chytridiomycosis;
- Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris;
- 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;
- Predation by exotic rats on Australian offshore islands of less than 1000 km² (100 000 ha);

- Predation by feral Cats (*Felis catus*);
- Predation by the European Red Fox (*Vulpes vulpes*);
- Predation, Habitat Degradation, Competition and Disease Transmission by Feral Pigs (*Sus scrofa*);
- Psittacine Circoviral (beak and feather) Disease affecting endangered psittacine species;
- The biological effects, including lethal toxic ingestion, caused by Cane Toads (*Bufo marinus*); and
- The reduction in the biodiversity of Australian native fauna and flora due to the imported Red Fire Ant, *Solenopsis invicta*.

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

- Vegetation clearing;
- Increasing fragmentation, loss of remnants and lack of recruitment;
- Firewood collection;
- Grazing pressure;
- Feral animals;
- Exotic weeds;
- Changed fire regimes;
- Pathogens;
- Changed hydrology—dryland salinity and salt water intrusion;
- Changed hydrology— 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 will reduce the area of occupancy of the species?
- Will the proposed action fragment an existing population?
- Will the proposed action adversely affect habitat critical to the survival of a species?
- Will the proposed action will disrupt the breeding cycle of a population?
- Will the proposed action modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?
- Will the proposed action result in introducing invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat?
- Will the proposed action introduce disease that may cause the species to decline?
- Will the proposed action will interfere with the recovery of the species?

Appendix 5. Fauna recorded or expected to occur in the Balline survey area (Tables 1 to 5).

These lists are derived from the results of database and literature searches and from previous field surveys conducted in the local area. Results do not include returned marine species. These are:

- BA = Birds Australia Database: searched September 2013; (Lit in this column = species likely to be present based upon interpretation of general literature).
- E = EPBC Protected Matters Search Tool: searched September 2013;
- N = NatureMap Database: searched September 2013;
- Balline = Found in the project area during the site inspection.

TABLE 1. Significant Invertebrates expected to occur and recorded in the Balline survey area.

Common Name	Species Name	Status	E	N	Balline
Native Bee	<i>Neopasiphae simplicior</i>	CS1		X	
Ostracod crustacean	NA	CS3			X
Copepod crustacean	<i>Calanoidae</i>	CS3			X
Isopod (slater)	<i>Buddelundia '81'</i>	CS3			X
Total Species	1	CS = 4			

TABLE 2. Frogs expected to occur and recorded in the Balline survey area.

Common Name	Species Name	Status	E	N	Balline
Myobatrachidae					
Southern Sandhill Frog	<i>Arenophryne xiphorhyncha</i>	CS3		X	
Squelching Froglet	<i>Crinia insignifera</i>			X	
Moaning Frog	<i>Heleioporus eyrei</i>			X	
Western Spotted Frog	<i>Heleioporus albopunctatus</i>			X	
Sand Frog	<i>Heleioporus psammophilus</i>			X	
Western Banjo Frog	<i>Limnodynastes dorsalis</i>			X	
Turtle Frog	<i>Myobatrachus gouldii</i>			X	
Kunapalari Frog	<i>Neobatrachus kunapalari</i>			X	
Humming Frog	<i>Neobatrachus pelobatooides</i>			X	
	<i>Neobatrachus wilsmoreii</i>				
Total Species	10	CS=1			

TABLE 3. Reptiles expected to occur and recorded in the Balline survey area.

Common Name	Species Name	Status	E	N	Balline
Agamidae					
Long-nosed Water Dragon	<i>Amphibolurus longirostris</i>			X	
Southern Heath Dragon	<i>Ctenophorus adelaidensis</i>			X	
Shark Bay Heath Dragon	<i>Ctenophorus butlerorum</i>			X	
Spotted Military Dragon	<i>Ctenophorus maculatus</i>			X	X
Central Netted Dragon	<i>Ctenophorus nuchalis</i>			X	
Western Netted Dragon	<i>Ctenophorus reticulatus</i>			X	
	<i>Ctenophorus scutulatus</i>			X	
Thorny Devil	<i>Moloch horridus</i>			X	
Dwarf Bearded Dragon	<i>Pogona minor</i>			X	
Diplodactylidae					
	<i>Diplodactylus ornatus</i>			X	
	<i>Diplodactylus pulcher</i>			X	
Carphodactylidae					
	<i>Nephrurus levis</i>			X	
Gekkonidae					
Clawless Gecko	<i>Crenadactylus ocellatus</i>			X	
	<i>Gehyra variegata</i>			X	X
Bynoe's Gecko	<i>Heteronotia binoei</i>			X	
	<i>Lucasium alboguttatum</i>			X	
	<i>Strophurus spinigerus</i>			X	
Pygopodidae					
	<i>Aprasia repens</i>			X	
	<i>Aprasia smithi</i>			X	
	<i>Delma australis</i>			X	
	<i>Delma grayii</i>			X	
	<i>Lialis burtonis</i>			X	
Keeled Legless Lizard	<i>Pletholax gracilis</i>			X	
Common Scaly Foot	<i>Pygopus lepidopodus</i>			X	
Scincidae					
	<i>Cryptoblepharus buchananii</i>			X	
	<i>Ctenotus australis</i>			X	
	<i>Ctenotus fallens</i>			X	
Leopard Ctenotus	<i>Ctenotus pantherinus</i>			X	
	<i>Ctenotus schomburgkii</i>			X	
	<i>Cyclodomorphus branchialis</i>	CS1	MB recorded Galena		
	<i>Cyclodomorphus celatus</i>			X	
King's Skink	<i>Egernia kingii</i>			X	
Broad-banded Sand Swimmer	<i>Eremiascincus richardsonii</i>			X	
Stripe-sided Robust Slider, skink	<i>Lerista axillaris</i>	CS2, P2		X	
	<i>Lerista connivens</i>			X	
	<i>Lerista elegans</i>			X	
	<i>Lerista lineopunctulata</i>			X	

	<i>Lerista macropisthopus</i>			X	
	<i>Lerista micra</i>			X	
	<i>Lerista planiventralis</i>			X	
	<i>Lerista praepedita</i>			X	
	<i>Menetia greyii</i>			X	
	<i>Menetia surda</i>			X	
	<i>Morethia butleri</i>			X	
	<i>Morethia lineoocellata</i>			X	
Western Bluetongue	<i>Tiliqua occipitalis</i>			X	
	<i>Tiliqua rugosa</i>			X	X
Varanidae					
	<i>Varanus caudolineatus</i>		MB recorded Eurardy		
Bungarra or Sand Monitor	<i>Varanus gouldii</i>			X	
Racehorse Monitor	<i>Varanus tristis</i>			X	
Typhlopidae					
	<i>Ramphotyphlops australis</i>			X	
	<i>Ramphotyphlops leptosoma</i>			X	
Boidae					
Carpet Python	<i>Morelia spilota</i>	CS1	Reported by landowner		
Stimson's Python	<i>Antaresia stimsoni</i>			X	
Elapidae					
	<i>Brachyuropis semifasciatus</i>			X	
Yellow-faced Whipsnake	<i>Demansia psammophis</i>			X	
Bardick	<i>Echiopsis curta</i>			X	
Black-naped Snake	<i>Neelaps bimaculatus</i>			X	
	<i>Parasuta gouldii</i>			X	
Mulga Snake	<i>Pseudechis australis</i>			X	
Western Brown Snake	<i>Pseudonaja mengdeni</i>			X	X
Ringed Brown Snake	<i>Pseudonaja modesta</i>			X	
Jan's Banded Snake	<i>Simoselaps bertholdi</i>			X	
West Coast Banded Snake	<i>Simoselaps littoralis</i>			X	
Total Species	64	CS = 3			4

TABLE 4. Birds expected to occur and recorded in the Balline survey area.

Common Name	Species Name	Status	BA	E	N	Balline
Casuariidae						
Emu	<i>Dromaius novaehollandiae</i>		X		X	X
Megapodiidae						
Malleefowl	<i>Leipoa ocellata</i>	CS1			X	
Phasianidae						
Stubble Quail	<i>Coturnix pectoralis</i>				X	
Columbidae						
Domestic Pigeon	<i>Columba livia</i>				X	
Diamond Dove	<i>Geopelia cuneata</i>				X	
Peaceful Dove	<i>Geopelia striata</i>				X	
Crested Pigeon	<i>Ocyphaps lophotes</i>				X	X
Common Bronzewing	<i>Phaps chalcoptera</i>				X	
Laughing Turtle-Dove	<i>Streptopelia senegalensis</i>	Introduced			X	X
Podargidae						
Tawny Frogmouth	<i>Podargus strigoides</i>				X	
Apodidae						
Fork-tailed Swift	<i>Apus pacificus</i>	CS1			X	
Accipitridae						
Collared Sparrowhawk	<i>Accipiter cirrocephalus</i>				X	
Brown Goshawk	<i>Accipiter fasciatus</i>				X	
Wedge-tailed Eagle	<i>Aquila audax</i>				X	
Little Eagle	<i>Aquila morphnoides</i>				X	
Spotted Harrier	<i>Circus assimilis</i>				X	
Whistling Kite	<i>Haliastur sphenurus</i>				X	
Black-breasted Buzzard	<i>Hamirostra melanosternon</i>				X	
Black-shouldered Kite	<i>Elanus axillaris</i>		X			
Falconidae						
Brown Falcon	<i>Falco berigora</i>				X	
Nankeen Kestrel	<i>Falco cenchroides</i>		X		X	
Australian Hobby	<i>Falco longipennis</i>				X	
Peregrine Falcon	<i>Falco peregrinus</i>	CS1			X	
Otididae						
Australian Bustard	<i>Ardeotis australis</i>	CS2, P4			X	
Burhinidae						
Bush Stone-curlew	<i>Burhinus grallarius</i>	CS2			X	
Charadriidae						
Banded Lapwing	<i>Vanellus tricolor</i>				X	
Psittacidae						
Major Mitchell's Cockatoo	<i>Cacatua leadbeateri</i>	CS1			X	
Cockatiel	<i>Nymphicus hollandicus</i>				X	

Cuculidae						
Fan-tailed Cuckoo	<i>Cacomantis flabelliformis</i>		X		X	
Pallid Cuckoo	<i>Cacomantis pallidus</i>		X		X	
Horsfield's Bronze Cuckoo	<i>Chalcites basalis</i>		X			
Shining Bronze Cuckoo	<i>Chalcites lucidus</i>		X			
Strigidae						
Boobook Owl	<i>Ninox novaeseelandiae</i>				X	
Halcyonidae						
Red-backed Kingfisher	<i>Todiramphus</i>		Lit			
Sacred Kingfisher	<i>Todiramphus sanctus</i>				X	
Meropidae						
Rainbow Bee-eater	<i>Merops ornatus</i>	CS1	X		X	
Maluridae						
Variegated Fairy-wren	<i>Malurus lamberti</i>	CS3	X		X	X
White-winged Fairy-wren	<i>Malurus leucopterus</i>	CS3	X		X	X
Blue-breasted Fairy-wren	<i>Malurus pulcherrimus</i>	CS3			X	
Splendid Fairy-wren	<i>Malurus splendens</i>	CS3	X		X	X
Acanthizidae						
Inland Thornbill	<i>Acanthiza apicalis</i>	CS3			X	X
Yellow-rumped Thornbill	<i>Acanthiza chrysorrhoa</i>		X			X
Rufous Fieldwren	<i>Calamanthus campestris</i>				X	
Redthroat	<i>Pyrrholaemus brunneus</i>				X	
Pardalotidae						
Southern Whiteface	<i>Aphelocephala leucopsis</i>				X	
Striated Pardalote	<i>Pardalotus striatus</i>				X	
White-browed Scrubwren	<i>Sericornis frontalis</i>	CS3	X		X	X
Meliphagidae						
Spiny-cheeked Honeyeater	<i>Acanthagenys rufogularis</i>				X	X
Red Wattlebird	<i>Anthochaera carunculata</i>				X	
White-fronted Chat	<i>Epthianura albifrons</i>				X	
Orange Chat	<i>Epthianura aurifrons</i>				X	
Crimson Chat	<i>Epthianura tricolor</i>				X	
Singing Honeyeater	<i>Lichenostomus virescens</i>		X			X
Brown Honeyeater	<i>Lichmera indistincta</i>				X	
Yellow-throated Miner	<i>Manorina flavigula</i>				X	
White-cheeked Honeyeater	<i>Phylidonyris niger</i>		X			
White-plumed Honeyeater	<i>Ptilotula penicillatus</i>				X	
White-fronted Honeyeater	<i>Purnella albifrons</i>				X	
Pomatostomidae						
White-browed Babbler (wheatbelt)	<i>Pomatostomus superciliosus superciliosus</i>	CS2			X	X
Psophodidae						
Chiming Wedgebill	<i>Psophodes occidentalis</i>				X	
Campephagidae						

White-winged Triller	<i>Lalage sueurii</i>		Lit			
Black-faced Cuckoo-shrike	<i>Coracina novaehollandiae</i>				X	
Pachycephalidae						
Grey Shrike-thrush	<i>Colluricincla harmonica</i>				X	X
Golden Whistler	<i>Pachycephala pectoralis</i>		X		X	
Rufous Whistler	<i>Pachycephala rufiventris</i>				X	X
Crested Bellbird (wheatbelt)	<i>Oreoica gutturalis gutturalis</i>	CS2			X	
Artamidae						
Black-faced Woodswallow	<i>Artamus cinereus</i>				X	
Masked Woodswallow	<i>Artamus personatus</i>		X			
Grey Currawong	<i>Strepera versicolor</i>		X			
Pied Butcherbird	<i>Cracticus nigrogularis</i>		X			
Australian Magpie	<i>Cracticus tibicen</i>				X	X
Grey Butcherbird	<i>Cracticus torquatus</i>				X	X
Rhipiduridae						
Grey Fantail	<i>Rhipidura fuliginosa</i>				X	
Willie Wagtail	<i>Rhipidura leucophrys</i>				X	X
Corvidae						
Little Crow	<i>Corvus bennetti</i>				X	
Australian Raven	<i>Corvus coronoides</i>		X			X
Monarchidae						
Magpie-lark	<i>Grallina cyanoleuca</i>				X	
Petroicidae						
Southern Scrub-robin	<i>Drymodes brunneopygia</i>				X	
Western Yellow Robin	<i>Eopsaltria australis</i>				X	
Jacky Winter	<i>Microeca fascinans</i>				X	
Hooded Robin	<i>Petroica cucullata</i>				X	
Red-capped Robin	<i>Petroica goodenovii</i>				X	
Megaluridae						
Rufous Songlark	<i>Cincloramphus mathewsi</i>				X	
Timaliidae						
Silvereye	<i>Zosterops lateralis</i>		X		X	X
Estrildidae						
Zebra Finch	<i>Taeniopygia guttata</i>				X	
Nectariniidae						
Mistletoebird	<i>Dicaeum hirundinaceum</i>				X	X
Motacillidae						
Australasian Pipit	<i>Anthus novaeseelandiae</i>		X			
Total Species	87	CS = 17				20

TABLE 5. Mammals expected to occur and recorded in the Balline survey area.

Common Name	Species Name	Status	E	N	Balline
Tachyglossidae					
Echtdna	<i>Tachyglossus aculeatus</i>				X
Canidae					
Dingo/wild dog	<i>Canis lupus</i>			X	
Red Fox	<i>Vulpes vulpes</i>	Introduced			X
Dasyuridae					
Fat-tailed Dunnart	<i>Sminthopsis crassicaudata</i>			X	
Little long-tailed Dunnart	<i>Sminthopsis dolichura</i>			X	
White-tailed Dunnart	<i>Sminthopsis granulipes</i>			X	
Hairy-footed Dunnart	<i>Sminthopsis hirtipes</i>			X	
Peramelidae					
Macropodidae					
Western Grey Kangaroo	<i>Macropus fuliginosus</i>			X	X
Euro	<i>Macropus robustus</i>			X	
Muridae					
House Mouse	<i>Mus musculus</i>	Introduced		X	
Ash-grey Mouse	<i>Pseudomys albocinereus</i>			X	
Black Rat	<i>Rattus rattus</i>	Introduced		X	
Vespertilionidae					
Lesser Long-eared Bat	<i>Nyctophilus geoffroyi</i>			X	
Finlayson's Cave Bat	<i>Vespadelus finlaysoni</i>			X	
Pteropodidae					
Little Red Flying-fox	<i>Pteropus scapulatus</i>			X	
Molossidae					
White-striped Freetail-bat	<i>Tadarida australis</i>			X	
Tarsipedidae					
Honey Possum	<i>Tarsipes rostratus</i>			X	
Bovidae					
Sheep (domestic)	<i>Ovis aries</i>	Introduced			X
Cattle (domestic)	<i>Bos Taurus</i>	introduced			X
Goat	<i>Capra hircus</i>	Introduced			
Felidae					
Cat	<i>Felis catus</i>	Introduced			
Leporidae					
European Rabbit	<i>Oryctolagus cuniculus</i>	Introduced			X
Total Species	22	CS = 0 Int = 8			6

Appendix 6. Vertebrate species returned in database searches but unlikely to be found in the project area.

Database searches often return species that, despite being found nearby, are unlikely to be present in the survey area due to lack of suitable habitat (e.g. aquatic species) or ecological barriers preventing them from reaching the area (e.g. island species). There are also some errors, out-of-date Latin names, zoo specimens and subtleties of distribution that are not recognised in databases. Note some species listed below (notably birds) could occur as vagrants but the project area would be of no importance to them.

Common Name	Latin Name	Status	BA	E	N
Invertebrates					
Shield-backed Trapdoor Spider	<i>Idiosoma nigrum</i>	CS1			X
Graceful Sunmoth	<i>Synemon gratiosa</i>	CS2, P4			X
Amphibians					
Slender Tree Frog	<i>Litoria adelaidensis</i>				X
Motorbike Frog	<i>Litoria moorei</i>				X
Bleating Froglet	<i>Crinia pseudinsignifera</i>				X
Crawling Toadlet	<i>Pseudophryne guentheri</i>				X
Reptiles					
Sea-snake	<i>Disteira major</i>				X
Sea-snake	<i>Hydrophis elegans</i>				X
Oblong Tortoise	<i>Chelodina colliei (oblonga)</i>				X
	<i>Lerista kendricki</i>				X
Birds					
Western Wattlebird	<i>Anthochaera lunulata</i>				X
Slender-billed Thornbill	<i>Acanthiza iredalei</i>	CS1		X	
Chestnut-rumped Thornbill	<i>Acanthiza uropygialis</i>				X
Western Gerygone	<i>Gerygone fusca</i>		X		X
Weebill	<i>Smicrornis brevirostris</i>				X
Swamp Harrier	<i>Circus approximans</i>				X
Common Sandpiper	<i>Actitis hypoleucos</i>	CS1			X
Ruddy Turnstone	<i>Arenaria interpres</i>	CS1	X		
Sharp-tailed Sandpiper	<i>Calidris acuminata</i>	CS1			X
Sanderling	<i>Calidris alba</i>	CS1			X
Curlew Sandpiper	<i>Calidris ferruginea</i>	CS1			X
Red-necked Stint	<i>Calidris ruficollis</i>	CS1			X
Long-toed Stint	<i>Calidris subminuta</i>	CS1			X
Great Knot	<i>Calidris tenuirostris</i>	CS1			X
Bar-tailed Godwit	<i>Limosa lapponica</i>	CS1			X
Black-tailed Godwit	<i>Limosa limosa</i>	CS1			X
Little Curlew	<i>Numenius minutus</i>	CS1			X
Whimbrel	<i>Numenius phaeopus</i>	CS1			X
Red-necked Phalarope	<i>Phalaropus lobatus</i>	CS1			X
Grey-tailed Tattler	<i>Tringa brevipes</i>	CS1			X
Wood Sandpiper	<i>Tringa glareola</i>	CS1			X
Common Greenshank	<i>Tringa nebularia</i>	CS1			X
Marsh Sandpiper	<i>Tringa stagnatilis</i>	CS1			X
Grey Teal	<i>Anas gracilis</i>				X

Balline Garnet Project - Fauna Impact Assessment

Australasian Shoveler	<i>Anas rhynchos</i>				X
Pacific Black Duck	<i>Anas superciliosa</i>				X
Hardhead	<i>Aythya australis</i>				X
Musk Duck	<i>Biziura lobata</i>				X
Australian Wood Duck	<i>Chenonetta jubata</i>				X
Black Swan	<i>Cygnus atratus</i>				X
Pink-eared Duck	<i>Malacorhynchus membranaceus</i>				X
Australian Shelduck	<i>Tadorna tadornoides</i>				X
Fairy Tern	<i>Sternula nereis</i>	CS1	X		
Eastern Great Egret	<i>Ardea modesta</i>	CS1			X
White-necked Heron	<i>Ardea pacifica</i>	CS1			X
Australasian Bittern	<i>Botaurus poiciloptilus</i>	CS1		X	
Eastern Reef Egret	<i>Egretta sacra</i>				X
Nankeen Night Heron	<i>Nycticorax caledonicus</i>				X
Little Woodswallow	<i>Artamus minor</i>				X
Carnaby's Black-Cockatoo	<i>Calyptorhynchus latirostris</i>	CS1		X	X
Greater Sand Plover	<i>Charadrius leschenaultii</i>	CS1			X
Lesser Sand Plover	<i>Charadrius mongolus</i>	CS1			X
Red-capped Plover	<i>Charadrius ruficapillus</i>				X
Grey Plover	<i>Pluvialis squatarola</i>	CS1			X
Banded Stilt	<i>Cladorhynchus leucocephalus</i>				X
Black-winged Stilt	<i>Himantopus himantopus</i>				X
Red-necked Avocet	<i>Recurvirostra novaehollandiae</i>				X
Lesser Noddy	<i>Anous tenuirostris</i>	CS1		X	X
Silver Gull	<i>Chroicocephalus novaehollandiae</i>				X
Pacific Gull	<i>Larus pacificus</i>				X
White-bellied Sea Eagle	<i>Haliaeetus leucogaster</i>	CS1		X	X
Sooty Oystercatcher	<i>Haematopus fuliginosus</i>		X		X
Pied Oystercatcher	<i>Haematopus longirostris</i>				X
Common Peafowl	<i>Pavo cristatus</i>	Introduced			X
Southern Royal Albatross	<i>Diomedea epomophora</i>	CS1		X	
Amsterdam Albatross	<i>Diomedea exulans amsterdamensis</i>	CS1		X	
Tristan Albatross	<i>Diomedea exulans exulans</i>	CS1		X	
Wandering Albatross	<i>Diomedea exulans sensu lato</i>	CS1		X	
Indian Yellow-nosed Albatross	<i>Thalassarche carteri</i>	CS1		X	X
Shy Albatross	<i>Thalassarche cauta cauta</i>	CS1		X	X
White-capped Albatross	<i>Thalassarche cauta steadi</i>	CS1		X	X
Black-browed Albatross	<i>Thalassarche melanophris</i>	CS1		X	X
Campbell Albatross	<i>Thalassarche melanophris impavida</i>	CS1		X	X
Eurasian Coot	<i>Fulica atra</i>				X
Buff-banded Rail	<i>Gallirallus philippensis</i>				X
Australian Spotted Crake	<i>Porzana fluminea</i>		X		X
Spotless Crake	<i>Porzana tabuensis</i>		X		X
Southern Giant-Petrel	<i>Macronectes giganteus</i>	CS1		X	
Northern Giant-Petrel	<i>Macronectes halli</i>				X

Slender-billed Prion	<i>Pachyptila belcheri</i>				X
Soft-plumaged Petrel	<i>Pterodroma mollis</i>	CS1		X	
Little Grassbird	<i>Megalurus gramineus</i>		X		X
Australian Pelican	<i>Pelecanus conspicillatus</i>				X
Great Cormorant	<i>Phalacrocorax carbo</i>				X
Little Black Cormorant	<i>Phalacrocorax sulcirostris</i>				X
Pied Cormorant	<i>Phalacrocorax varius</i>		X		X
Ruff	<i>Philomachus pugnax</i>	CS1			X
Yellow-billed Spoonbill	<i>Platalea flavipes</i>				X
Australian White Ibis	<i>Threskiornis molucca</i>				X
Straw-necked Ibis	<i>Threskiornis spinicollis</i>				X
Great Crested Grebe	<i>Podiceps cristatus</i>				X
Hoary-headed Grebe	<i>Poliiocephalus poliocephalus</i>				X
Australasian Grebe	<i>Tachybaptus novaehollandiae</i>				X
Gull-billed Tern	<i>Sterna nilotica macrotarsa</i>				X
Crested Tern	<i>Thalasseus bergii</i>		X		
Mammals					
Woylie	<i>Bettongia penicillata ogilbyi</i>	CS1; locally extinct		X	
Chuditch	<i>Dasyurus geoffroii</i>	CS1; locally extinct			X
Quenda	<i>Isoodon obesulus</i>	CS2, locally extinct			X
Tammar Wallaby	<i>Macropus eugenii</i>	CS1; locally extinct			X
Spinifex Hopping-mouse	<i>Notomys alexis</i>				X
Common Brushtail Possum	<i>Trichosurus vulpecula</i>	Locally extinct			X
Feral Pig	<i>Sus scrofa</i>	Introduced		X	
Total Number of Species	102	CS = 46			

**ATTACHMENT 2: BAMFORD AND MCHARRIE (2013). FAUNA
IMPACT ASSESSMENT (LEVEL 1). BALLINE GARNET PROJECT.**



Balline Garnet Project Level 2 Flora and Vegetation Survey

**Prepared for Australian Garnet Pty Ltd
November 2013**



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Executive Summary

Onshore Environmental Consultants Pty Ltd (Onshore Environmental) was commissioned by Australian Garnet Pty Ltd (Australian Garnet) to complete a one season Level 2 flora and vegetation survey of the Menari Mineral Sands Deposit within the Balline Project Area, herein referred to as the study area. The study area covered 1,736 ha of which approximately 1,080 ha is currently cleared for agriculture.

The survey was completed between the 5th and 11th October 2013 with a total of 15 quadrats and 163 releve plots assessed. A total number of 151 plant taxa (including varieties and subspecies) from 54 families and 116 genera were recorded from the study area by Onshore Environmental during October 2013. Species representation was greatest among the Poaceae, Asteraceae, Fabaceae, Chenopodaceae and Myrtaceae families.

Following intensive quadrat sampling and extensive ground truthing of the study area none of the plant taxa recorded were gazetted as Threatened Flora (T) pursuant to subsection (2) of section 23F of the *Wildlife Conservation Act 1950* (WC Act), or listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

There were four Priority flora taxa (as defined by DPaW) recorded from the study area; *Melaleuca huttensis* (Priority 1), *Cryptandra glabriflora* (Priority 2), *Anthocercis intricata* (Priority 3) and *Beyeria cinerea* subsp. *cinerea* (Priority 3).

There were 24 introduced (weed) species recorded from the study area. None of the weeds are listed as Declared Pests under the *Biosecurity and Agriculture Management Act 2007* (BAM Act).

Vegetation within the study area was described and mapped as 19 vegetation associations. The vegetation associations were classified into sixteen Broad Floristic Formations on the basis of canopy structure. None of the vegetation associations from the study area were affiliated with any Commonwealth listed TECs. However, Vegetation association 4 does show similarities to the State listed PEC 'Coastal sands dominated by *Acacia rostellifera*, *Eucalyptus oraria* and *Eucalyptus obtusiflora* (Priority 1)'.

A large proportion of the study area has been historically cleared for agriculture and vegetation condition was subsequently mapped as completely degraded. The larger area of remnant vegetation was rated as good, with smaller sections rated as very good or degraded. The major disturbances recorded within the study area were related to historical agriculture, specifically clearing of native vegetation, establishment of annual pasture and seasonal crops, grazing by domestic stock, and introduction of weeds and feral animals such as rabbits.

The majority of vegetation recorded within the study area occurs on undulating low hills and ridges comprising limestone and sand. Associated vegetation is dominated by xerophytic plant taxa that have no reliance of groundwater to survive. Vegetation associations 1, 2, 3 and 15 occur on exposed limestone clay loam flats situated at the lowest position in the landscape, close to the coastline in the south-west sector of the study area, and where depth to groundwater is at its shallowest. Given the salinity of groundwater from monitoring bores closest to

coast and at the very top of the water table is in the range 4,000 - 7,000 mg/L TDS, it is likely that Vegetation associations 1, 2, 3 and 15 have interaction with this groundwater at least seasonally during the year.

Currently, flora and vegetation values of significance within the study area include the four Priority flora taxa; *Melaleuca huttensis* (Priority 1), *Cryptandra glabriflora* (Priority 2), *Anthocercis intricata* (Priority 3) and *Beyeria cinerea* subsp. *cinerea* (Priority 3), as well as Vegetation association 4 which is closely affiliated with a State listed PEC.

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1.0 Introduction

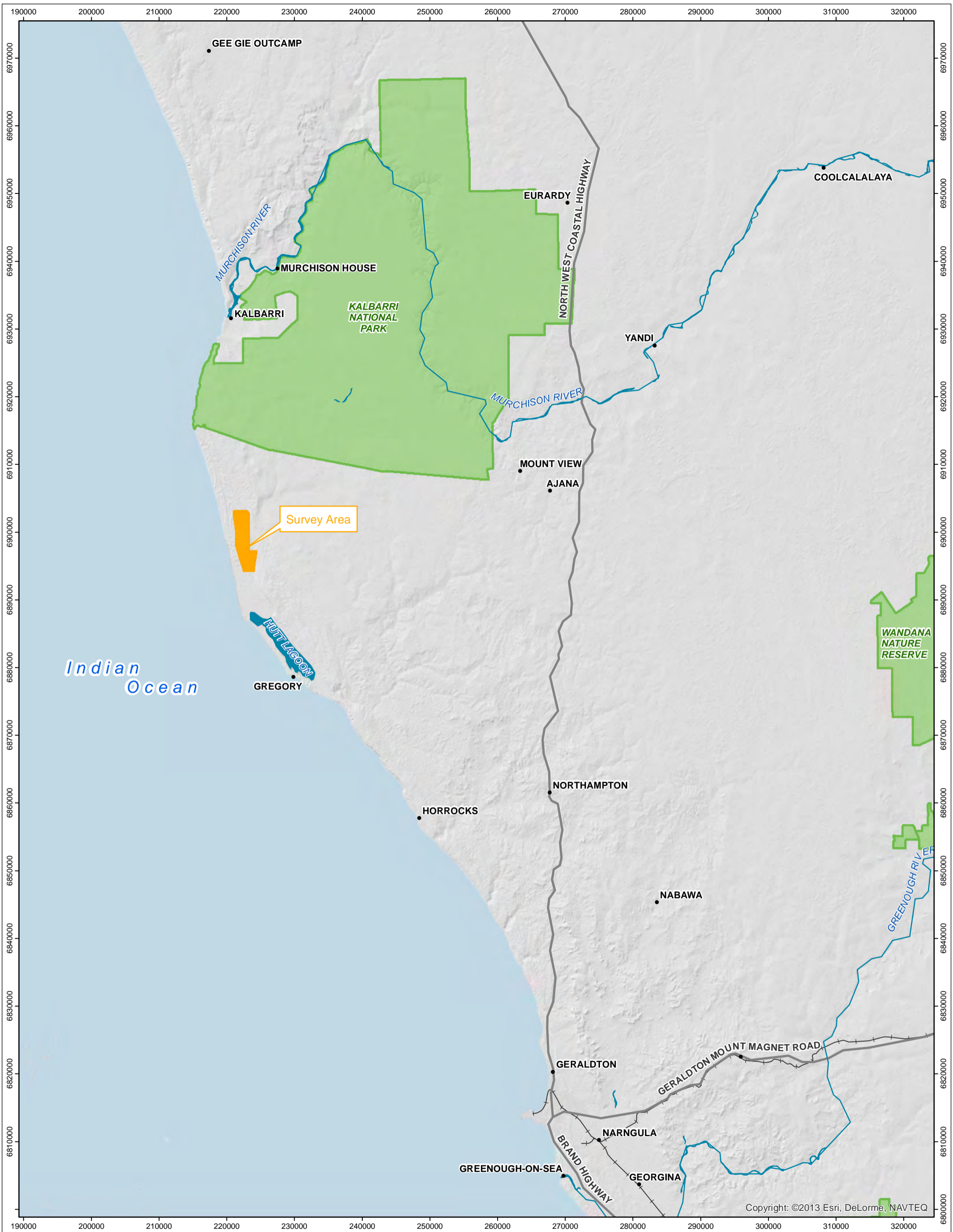
1.1 Preamble

Onshore Environmental was commissioned by Australian Garnet to undertake a Level 2 flora and vegetation survey of the Menari Mineral Sands Deposit, which forms part of the Balline Project, situated approximately 35 km south of Kalbarri in the Mid-West region of Western Australia (Figure 1). The 1,736 ha study area occurs on privately owned farmland of which approximately 1,080 ha has been previously cleared for agriculture and the remaining 675 ha comprises disjunct remnant vegetation.

1.2 Previous Surveys

There are five previous flora and vegetation surveys completed within a 100 km radius of the study area that are publically available. These surveys are listed below and described in more detail in Section 3.1.1:

- Ecoscape (2009) *Haddington Resources Balline Level 1 Flora and Fauna assessment*;
- GHD (2011) *City of Geraldton-Greenough Report for Lots 3012 and 3013 Olive Street, Geraldton Flora and Fauna Survey*;
- Ecoscape (2010) *Geraldton Regional Flora and Vegetation Survey*;
- Ecologica (2010) *Oakajee Port and Rail OPR Rail Development Vegetation and Flora Assessment*; and
- Northern Agricultural Catchment Council (2010), *Dongara to Cape Burney Coastal Vegetation Survey*.



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BALLINE
REGIONAL LOCATION

0 5 10 15 20
Kilometers

1:500,000

Datum: GDA94
Projection: MGA Zone 50

ONSHORE
ENVIRONMENTAL

ONSHORE ENVIRONMENTAL CONSULTANTS		Date:	09/12/2013
Sheet Size:		A3	Status:
Drawn by	Requested by	Internal Reference	
GSM	DB	Kalbarri_LOC_20131113	

Legend

- Survey Area
- Nature Conservation Reserve
- Watercourses
- Roads
- Railways

1.3 Climate

The climate of the Mid-west comprises mild wet winters and warm to hot dry summers. Annual rainfall totals are relatively consistent decreasing from 350 mm on the coast to 275 mm at the eastern margin of the survey area. Average maximum summer temperatures range between 31°C to 35°C and winter maximum temperatures range from 22°C and 30°C (Figure 2). Prevailing winds are easterly to southerly.

Rainfall was below average for the six months prior to the October field survey, with the June 2013 total significantly lower than the long term average (Figure 2, BOM 2013a).

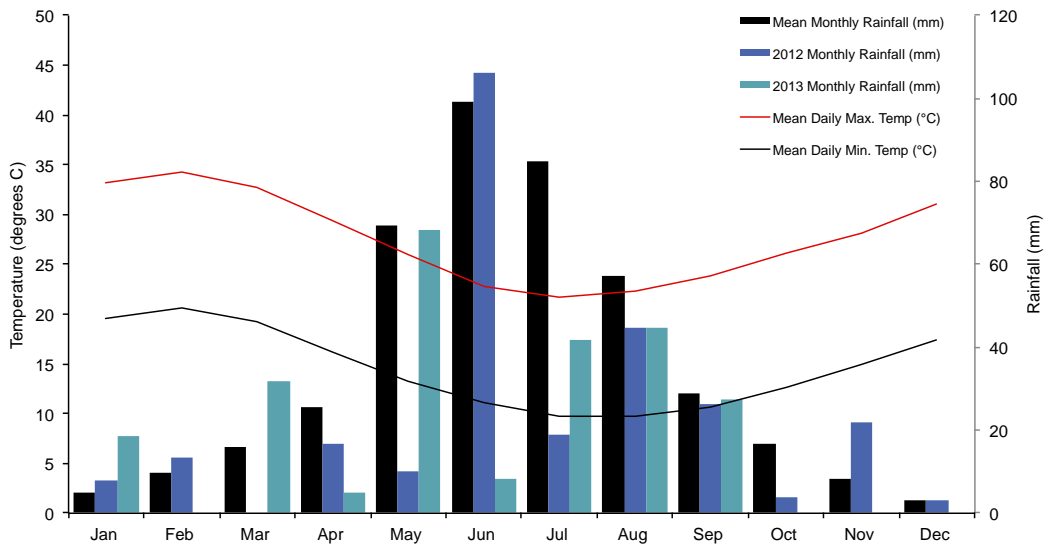


Figure 2 Rainfall data recorded from Balline for 2012 and 2013. Long term average rainfall for Balline (1930-2012) and climatic data is for Kalbarri from 1970 to 2013 (BOM 2013a, 2013b).

1.4 Biogeographic Regions

The latest version of the Interim Biogeographic Regionalisation for Australia (IBRA) describes a system of 89 'biogeographic regions' (bioregions) and 419 subregions covering the entire Australian continent (Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) 2013). Bioregions are defined on the basis of climate, geology, landform, native vegetation and fauna information. The bioregions and subregions are the reporting unit for status of native ecosystems and their level of protection in the National Reserve System (DSEWPaC 2013).

The study area lies within the Geraldton Hills subregion of the Geraldton Sandplains bioregion. The bioregion consists of endemic rich, proteaceous scrub-heaths on undulating sand plains mesas and coastal sands and limestones. Outwash plains and drainage lines have extensive stands of York Gum and Jam woodlands. Sandplains, alluvial plains and coastal limestones dominate the Geraldton Hills subregion. The vegetation includes heaths of *Banksia* and *Actinostrobus*, York gum woodlands and *Acacia* species. The climate is semi-arid to Mediterranean and the subregional area is 2,242,033 ha (Desmond and Chant 2001).

1.5 Existing Land Use

The primary land use in the Balline area is agriculture which extends across 79% of the subregion. Dry-land agriculture is the dominant practice with a smaller extent utilized for grazing native pastures. Conservation areas, unallocated crown land and Crown Reserves are less prominent land uses (Desmond and Chant 2001).

1.6 Soils

Tille (2006) collated the most recent and detailed mapping of Western Australia's rangelands and arid interior into a hierarchy of soil-landscape mapping units. The study area lies within the Carnarvon Province. The Carnarvon Province occupies approximately 92,475 km² (3.7% of Western Australia) and includes the towns of Carnarvon, Denham, Kalbarri, Useless Loop, Horrocks, Port Gregory and Gascoyne Junction. Areas of sand plain have deep red sands with some yellow sands occurring in the south. Interdune flats are comprised of red sandy earths, red shallow sands and red/brown non-cracking clays. Alluvial plains are mostly comprised of deep red sandy duplexes with some red/brown non-cracking clays, red shallow sandy duplexes, red loamy earths and red sandy earths. Red deep sands are also common on alluvial plains typically occurring on sandy banks and rises. Red deep sandy duplexes, red sandy earths and red shallow loams, occur on stony plains, with some red shallow sandy duplexes and red/brown non-cracking clays. Red sandy earths, red loamy earths and red shallow loams dominate the wash plains and the hilly terrain has stony soils with red shallow sandy duplexes, red loamy earths and red shallow sands. Calcareous shallow loams and calcareous loamy earths occur on the calcrete plains with calcareous deep sands and red deep sands on the coastal dunes. Salt lake soils cover the bed of Lake MacLeod.

The Carnarvon Province is comprised of seven soil landscape zones:

- Muggon Zone;
- Port Gregory Zone;
- Kalbarri Sandplain Zone;
- Yalbalgo Sandplain Zone;
- Victoria Red Sandplain Zone;
- Lower Gascoyne Alluvial Plains Zone; and
- Wandagee-Byro Plains and Hills Zone.

The study area lies within the Port Gregory Zone. This zone is described as coastal plains, sand plains, alluvial plains and sea cliffs. The area consists of limestone and sand with cretaceous sedimentary rocks of the Carnarvon basin covered by red shallow sands, deep sands, stony soils and calcareous deep sands. Some yellow deep sands and yellow / brown shallow sands also occur. The vegetation consists of coastal scrub-heath of *Banksia*, *Acacia* and *Hakea* with some *Acacia* thickets.

1.7 Geology

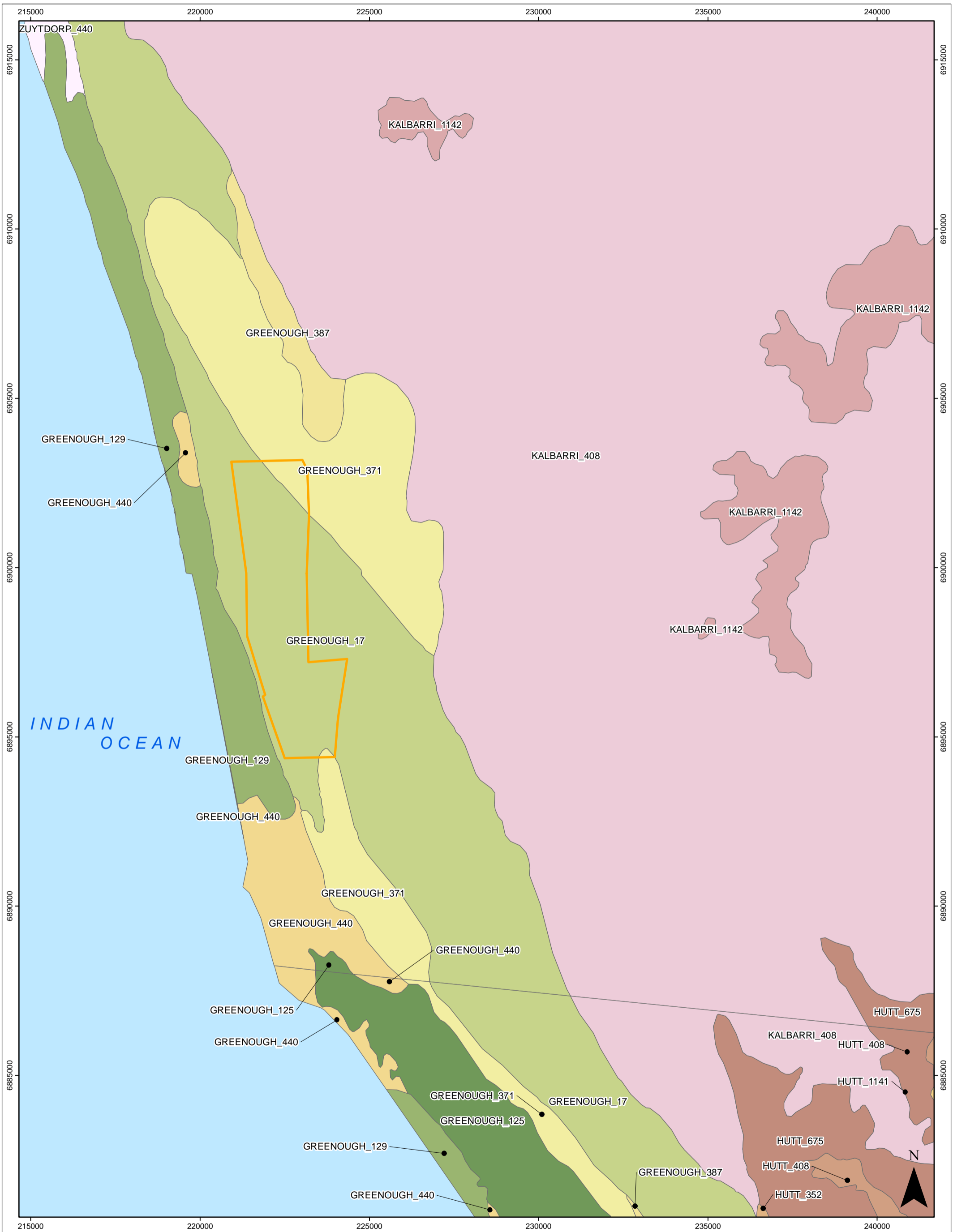
The ancient continental Western Shield dominates the geology of Western Australia. The study area lies close to the border between the southern end of the Carnarvon Basin and the northern end of the Perth Basin. The area includes some exposed Permian/Silurian siltstone and Jurassic sandstones (Desmond and Chant 2001). The Ordovician Tumblagooda Sandstone outcrops lie to the south of the Murchison River, on the Gascoyne Platform. There is also Jurassic sandstone and conglomerate, and Triassic shale and siltstone in the area (Tille 2006).

1.8 Flora and Vegetation

The study area is located within the Irwin Botanical District of the South-west Botanical Province (Beard 1990). Vegetation was broadly mapped as *Acacia - Casuarina* Thickets and Scrub, and mapped more specifically as two units; Low Forest of *Acacia rostellifera* (Greenough 371) and *Acacia rostellifera* Thicket (Greenough 17) on dunes (Figure 3). The remaining Pre-European extent for each of the two vegetation association approximates 10% and 48% respectively, with less than ten percent of each association currently protected within conservation reserves (Table 1).

Table 1 Pre-European extent of vegetation associations that intersect the study area (as described by Beard 1975 and reviewed by Shepherd *et al.* 2002).

Vegetation Association	Description	Pre-Euro. Extent (ha)	Pre-Euro. Extent Remaining (ha)	% Remaining	Current Extent Protected for Conservation (ha)
Greenough 371	Low forest; <i>Acacia rostellifera</i>	32,816	3,499	10.66%	242 (7%)
Greenough 17	Shrublands; <i>Acacia rostellifera</i> thicket	16,865	8,179	48.50%	849 (10%)



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BALLINE

PRE EUROPEAN VEGETATION

0 1 2 3 4
Kilometers

1:100,000

Datum: GDA94
Projection: MGA Zone 50

ONSHORE ENVIRONMENTAL

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Sheet Size: A3

Drawn by: GSM

Requested by: DB

Date: 09/12/2013

Status: Draft

Internal Reference: Kalbarri_PreEuro_20131114

Legend

Survey Area

Pre-European Vegetation SYSTEM / VEG ASSOC

- GREENOUGH, 125
- GREENOUGH, 129
- GREENOUGH, 17
- GREENOUGH, 371
- GREENOUGH, 387
- GREENOUGH, 440
- HUTT, 1141
- HUTT, 352
- HUTT, 408
- HUTT, 675
- KALBARRI, 1142
- KALBARRI, 408
- ZUYTDORP, 440

2.0 Methodology

2.1 Legislation and Guidance Statements

The flora and vegetation survey was carried out in a manner that was compliant with the following Environmental Protection Authority (EPA) requirements for the environmental surveying and reporting of flora and vegetation in Western Australia:

- Environmental Protection of Native Vegetation in Western Australia: Clearing of Native Vegetation with Particular Reference to Agricultural Areas. Position Statement No. 2 (EPA 2000);
- Terrestrial Biological Surveys as an Element of Environmental Protection. Position Statement No. 3 (EPA 2002); and
- EPA Guidance for the Assessment of Environmental Factors: Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia No. 51 (EPA 2004a).

2.2 Desktop Searches

Three desktop searches were undertaken for information relating to rare flora Threatened Ecological Communities (TECs) and Priority Ecological Communities (PECs) previously collected or described within, or in close proximity to the study area (Wildlife Conservation (Rare Flora) Notice 2013, TEC List 2013 and PEC List 2013). The database search was extended beyond the immediate survey limits to place flora values into a local and regional context. The search criteria used was a 50 km radius around the central point of the study area: GDA94 Zone 50 J 227318E 6898038N. The State database search investigated three DPaW databases:

1. The DPaW Threatened Flora Database;
2. The DPaW Priority Flora List; and
3. The Western Australian Herbarium Specimen Database for priority species opportunistically collected in the area of interest.

A search of the EPBC Act Protected Matters database was undertaken (DSEWPac 2013) within a 10 km buffer of the study area (EPBC Act 1999 Protected Matters Tool 2013). A search of the International Union for Conservation of Nature (IUCN) database was also conducted (IUCN 2013).

2.3 Field Survey Methodology

2.3.1 Timing and Personnel

The single season field survey was completed between the 5th and 11th October 2013. Field work was undertaken by Principal Botanist with Onshore Environmental, Dr Jerome Bull.

2.3.2 Sampling of Study Sites

The survey involved systematic sampling using quadrats (referred to as study sites). The study sites were generally 10 m by 10 m, or an equivalent area (100 m²) along narrow associations such as minor drainage lines. The area sampled for each study site is standard for the South-West Bioregion.

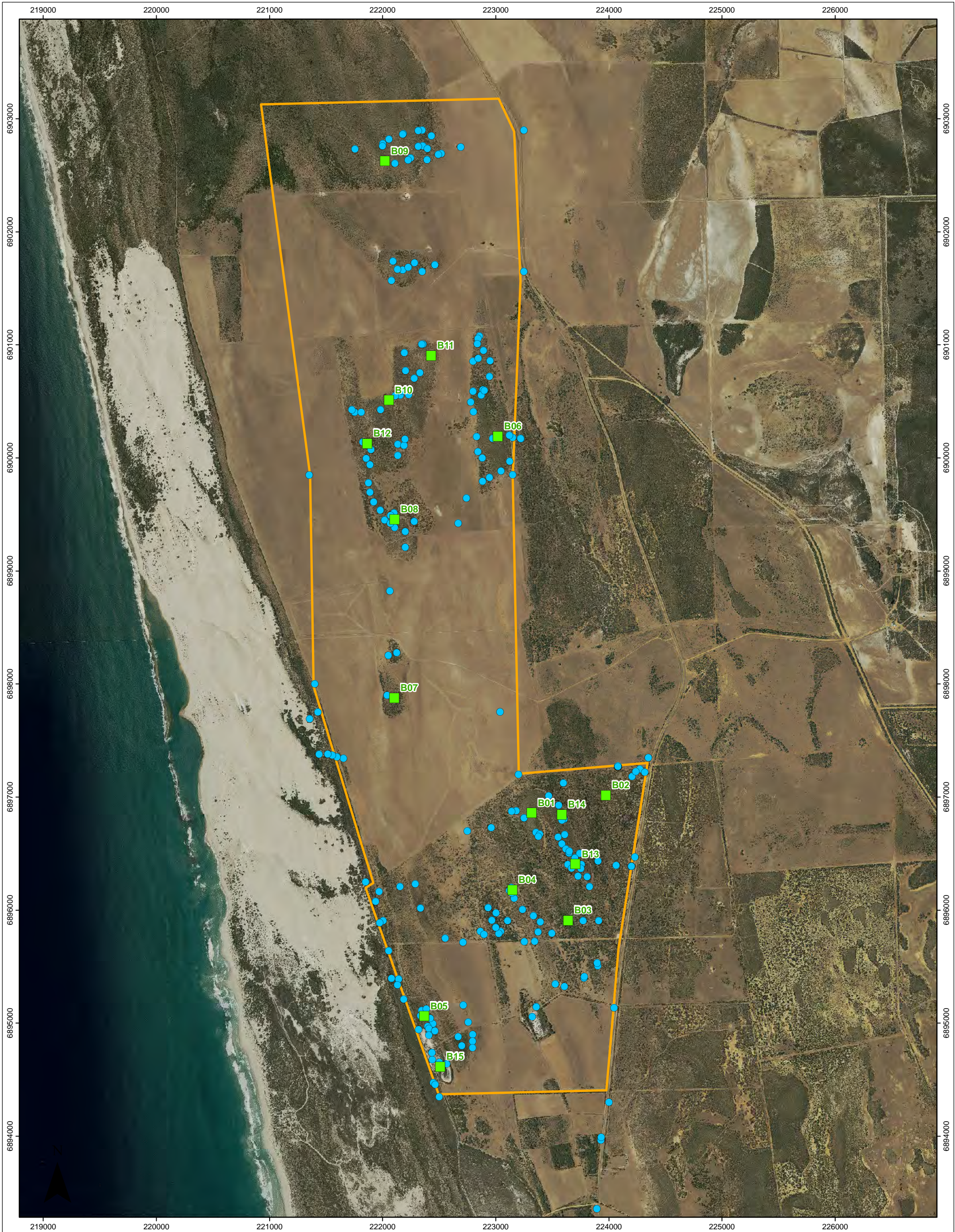
The number of study sites sampled was determined by the size and heterogeneity of each study area surveyed. A total of 15 quadrats were formally assessed within

the study area during the 2013 field survey. Vegetation descriptions were made at an additional 163 relevé sites to support vegetation mapping (Figure 4). Data was simultaneously collected on a range of other environmental parameters including:

- Landform and habitat;
- Aspect;
- Soil colour and soil type;
- Rock type;
- Slope (angle);
- Percentage of bare ground, logs, twigs and leaves;
- Vegetation condition;
- Disturbance (caused by fire, clearing, grazing etc.);
- Age since fire;
- Broad floristic formation;
- Vegetation association description; and
- Height and percentage ground cover provided by individual plant taxa.

Other parameters recorded for each study site were:

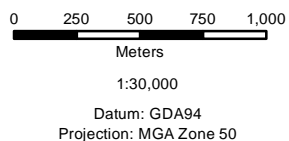
- Study site number and date of assessment;
- Names of the botanists undertaking the assessment;
- Location description using a waypoint - GPS coordinate (GDA94) using a handheld GPS; and
- Photograph number.



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BALLINE
SAMPLE LOCATIONS



Legend

- Vegetation Sample Sites
- Releve Locations
- Survey Area

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2.3.3 Targeted Surveys for Conservation Significant Flora

The entire study area was ground-truthed at less than 100 m intervals during the field assessment. This ground coverage provided the opportunity to record opportunistic locations for significant flora, and also undertake closer examination of specific landforms where flora of interest may be expected to occur.

2.3.4 Vegetation Association Mapping

The vegetation mapping utilised high-resolution aerial photography of the entire study area at a scale of 1:10,000, with definition of vegetation polygons based on contrasting shading patterns. The location of 15 quadrats (10 m x 10 m) and 163 relevé plots was overlaid on the aerial photography, and associated flora and vegetation data was used to provide vegetation association descriptions for the polygons defined. Ground-truthing of the study area, formal assessment quadrats and numerous relevé vegetation descriptions were made within selected vegetation polygons to confirm dominant structural layers and associated plant taxa.

Description of vegetation structure follows the height, life form and density classes of Specht (1970) as modified by Aplin (1979) (see Appendix 1). This is largely a structural classification suitable for broader scale mapping, but taking all ecologically significant strata into account. Vegetation condition for each of the sampling sites was determined using a recognised rating scale (based on Keighery 1994, see Appendix 2).

2.3.5 Vouchering

At least one voucher specimen was taken for each species collected to verify identification. Dr Eleanor Bennett confirmed specimen identifications at the Western Australian State Herbarium. Use was made of the Western Australian Herbarium for confirmation of species identification. Nomenclature follows Green (1985 and 1987), Paczkowska and Chapman (2000) and the Western Australian State Herbarium. Commonwealth and State conservation codes are outlined in Appendices 3 and 4.

2.3.6 Field Survey Constraints

The EPA Guidance Statement for Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia (EPA 2004) list twelve potential constraints that field surveys may encounter. These constraints are addressed in Table 2.

Table 2 Relevance of constraints, as identified by EPA (2004), to the flora and vegetation survey.

Constraint	Relevance
Scope	The scope was established by Onshore Environmental and Australian Garnet and is in compliance with relevant EPA Guidance Statements.
Proportion of flora collected and identified	The field survey was completed during optimum seasonal conditions which maximised the total flora recorded from the study area.
Sources of information	There were five previous flora and vegetation surveys identified during a desktop review of the region. One of the previous surveys covered part of the current study area and along with the other four surveys provides excellent regional context (Ecoscape 2009).
The proportion of the task achieved and further work which might be needed	All allocated tasks were achieved during the investigation. Some of the plant taxa were not flowering at the time of assessment and could not be identified to species level; an additional targeted survey would facilitate confirmation of these identifications.
Timing / weather / season / cycle	Rainfall for the six months preceding the field survey was below the long term average but sufficient to facilitate normal flowering cycles expected during Spring.
Disturbances, e.g. fire, flood	Disturbances within the study area include grazing of remnant vegetation by domestic stock and extensive establishment of introduced weed species. None of these disturbances affected the ability to complete the survey.
Intensity	Fifteen quadrats and 163 relevé plots were assessed during early October 2013 by Onshore Environmental. This represents an intensive Level 2 flora and vegetation survey given the relatively small size of the study area.
Completeness	Relevant tasks related to assessing flora and vegetation values within the study area were completed including vegetation association mapping and targeted surveys for weeds and species of conservation significance.
Resources	Appropriate resources were applied to surveying the study area during October 2013.
Access problems	The entire study area was accessed by vehicle and on foot, noting that vegetation mapping was facilitated by high-resolution aerial photography.
Availability of contextual information	Five previous flora and vegetation surveys were sourced within a 100 km radius of the study area, providing an extensive local database.
Experience levels	The Principal Botanist working on the survey has extensive experience completing flora and vegetation surveys throughout Western Australia.

3.0 Results

3.1 Literature Review

3.1.1 Previous flora and vegetation surveys within close proximity to the study area

The results from five previous flora and vegetation surveys undertaken within a 100 km radius of the study area are tabulated below (Table 3).

Table 3 Summary of significant flora and environmental weeds recorded during previous flora and vegetation surveys within, or in close proximity to, the study area.

Report	Company	Location	Field Survey	Significant Flora	Introduced Flora	TEC / PEC
Haddington Resources Balline Level 1 Flora and Fauna assessment	Ecoscope (2009)	Near Balline in the Shire of Northampton, 35km south of Kalbarri	27 th February 2008	None	<i>*Avena fatua</i> <i>*Bromus diandrus</i> , <i>*Hordeum leporinum</i> <i>*Rumex vesicarius</i> <i>*Carpobrotus edulis</i> , <i>*Brassica napus</i> , <i>*Geranium molle</i> , <i>*Lysimachia arvensis</i> , <i>*Hypochoeris glabra</i> , <i>*Sonchus oleraceus</i>	None
City of Geraldton-Greenough Report for Lots 3012 and 3013 Olive Street, Geraldton Flora and Fauna Survey	GHD (2011)	Lots 3012 and 3013 Olive Street, Mahomets Flats	April 2011	None	<i>*Tetragonia decumbent</i> , <i>*Schinus terebinthifolius</i> , <i>*Tropaeolum majus</i> , <i>*Phoenix dactylifera</i> , <i>*Washingtonia filifera</i> , <i>*Agave americana</i> , <i>*Hedyotis rhagadiloloides</i> , <i>*Helianthus annuus</i> , <i>*Lactuca serriola</i> , <i>*Reichardia tingitana</i> , <i>*Sonchus oleraceus</i> , <i>*Echium plantagineum</i> , <i>*Raphanus raphanistrum</i> , <i>*Opuntia</i> sp., <i>*Chenopodium</i> sp., <i>*Euphorbia terracina</i> , <i>*Lupinus cosentinii</i> , <i>*Medicago polymorpha</i> , <i>*Melilotus indicus</i> , <i>*Fumaria capreolata</i> , <i>*Malva parviflora</i> , <i>*Oxalis pes-caprae</i> , <i>*Avena barbata</i> , <i>*Bromus diandrus</i> , <i>*Ehrharta longifolia</i> , <i>*Ehrharta calycina</i> , <i>*Stenotaphrum secundatum</i> , <i>*Portulaca filifolia</i> , <i>*Lysimachia arvensis</i> , <i>*Lycium ferocissimum</i> , <i>*Tamarix aphylla</i>	None

Report	Company	Location	Field Survey	Significant Flora	Introduced Flora	TEC / PEC
Geraldton Regional Flora and Vegetation Survey	Ecoscope (2011)	424 km north of Perth on the Indian Ocean Coast Road, in the Mid-West region of Western Australia	March 2010	<i>Anthocercis intricata</i> (P3), <i>Caladenia hoffmanii</i> (T), <i>Diuris recurva</i> (P4), <i>Eucalyptus blaxellii</i> (T), <i>Grevillea triloba</i> (P3), <i>Hibbertia glomerosa</i> var. <i>bistrata</i> (P3), <i>Leucopogon</i> sp. Moresby Range (P3), <i>Thryptomene</i> sp. Moresby Range (P3), <i>Thryptomene stenophylla</i> (P2)	73 species in total with most common taxa including <i>*Avena barbata</i> , <i>*Brassica tournefortii</i> , <i>*Hypochaeris glabra</i> , <i>*Ehrharta longiflora</i> , <i>*Lycium ferocissimum</i>	None
Oakajee Port and Rail OPR Rail Development Vegetation and Flora Assessment	Ecologica (2010)	24 km north of Geraldton	Phase 1 April and August 2009. Phase 2 August and October 2009	55 Priority flora	62 species	Four Priority 1 PECs
Dongera to Cape Burney Coastal Vegetation Survey	Ecoscope (2010)	Geraldton Sandplains bioregion, GS2 - Geraldton Hills subregion	30th November and 4th December 2009	<i>Anthocercis intricata</i> (Priority 3)	<i>*Lysimachia arvensis</i> , <i>*Arctotheca calendula</i> , <i>*Avena barbata</i> , <i>*Brassica tournefortii</i> , <i>*Bromus diandrus</i> , <i>*Bromus rubens</i> , <i>*Carpobrotus edulis</i> , <i>*Carthamus lanatus</i> , <i>*Chenopodium murale</i> , <i>*Cynodon dactylon</i> , <i>*Ehrharta</i> sp., <i>*Euphorbia terracina</i> , <i>*Hordeum leporinum</i> , <i>*Hypochaeris glabra</i> , <i>*Lolium</i> sp., <i>*Lycium ferocissimum</i> , <i>*Mesembryanthemum crystallinum</i> , <i>*Parapholis incurva</i> , <i>*Petrohragia dubia</i> , <i>*Polypogon monspeliensis</i> , <i>*Reichardia tingitana</i> , <i>*Silene gallica</i> , <i>*Sonchus oleraceus</i> , <i>*Tetragonia decumbens</i> , <i>*Trachyandra divaricata</i> , <i>*Trifolium campestre</i> , <i>*Urospermum picroides</i> , <i>*Vulpia bromoides</i> , <i>*Vulpia myuros</i>	None

3.2 Desktop Review

3.2.1 Significant Flora Database Searches

There were 17 records identified from a search of the EPBC Act Protected Matters Database (DSEWPaC 2013) or the IUCN database (IUCN 2012) for a 50 km radius surrounding the study area (Table 4).

The DPaW database search (DPaW 2013) identified 112 Priority flora and 13 Threatened Flora within a 50 km radius surrounding the study area (Table 4).

Table 4 Significant flora species previously recorded from a 50 km search radius of the study area. SCC - State Conservation Code, FCC - Federal Conservation Code.

Species	SCC	FCC
<i>Acacia gelasina</i>	2	
<i>Acacia latipes</i> subsp. <i>licina</i>	3	
<i>Acacia leptospermoides</i> subsp. <i>obovata</i>	2	
<i>Acacia pelophila</i>	1	
<i>Acacia plautella</i>	3	
<i>Acacia ridleyana</i>	3	
<i>Acacia stereophylla</i> var. <i>cylindrata</i>	2	
<i>Acanthocarpus parviflorus</i>	3	
<i>Androcalva microphylla</i>	2	
<i>Anthocercis intricata</i>	3	
<i>Anthotroche myoporoides</i>	2	
<i>Arnocrinum drummondii</i>	3	
<i>Astroloma inopinatum</i>	1	
<i>Baeckea subcuneata</i>	2	
<i>Beyeria cinerea</i> subsp. <i>cinerea</i>	3	
<i>Beyeria gardneri</i>	3	
<i>Beyeria lepidopetala</i>	T	E
<i>Blackallia nudiflora</i>	3	
<i>Bossiaea calcicola</i>	3	
<i>Bossiaea inundata</i>	2	
<i>Caladenia barbarella</i>	T	E
<i>Caladenia bryceana</i> subsp. <i>cracens</i>	T	V
<i>Caladenia elegans</i>	T	E
<i>Caladenia hoffmanii</i>	T	E
<i>Caladenia wanosa</i>	T	V
<i>Calectasia browneana</i>	2	
<i>Calocephalus aevoides</i>	3	
<i>Calothamnus cupularis</i>	2	
<i>Calytrix ecalycata</i> subsp. <i>ecalycata</i>	3	
<i>Calytrix formosa</i>	3	
<i>Calytrix harvestiana</i>	2	
<i>Calytrix paucicostata</i>	2	
<i>Calytrix pimeleoides</i>	3	
<i>Calytrix purpurea</i>	2	
<i>Centrolepis cephaliformis</i> subsp. <i>murrayi</i>	3	
<i>Chamelaucium marchantii</i>	3	
<i>Cryptandra glabriflora</i>	2	

Species	SCC	FCC
<i>Dampiera</i> sp. Jurien (G. Lullfitz s.n. 10/7/1986)	2	
<i>Desmocladius biformis</i>	3	
<i>Dicrastylis micrantha</i>	3	
<i>Diuris drummondii</i>	T	V
<i>Diuris recurva</i>	4	
<i>Drakaea concolor</i>	T	V
<i>Drummondita ericoides</i>	T	E
<i>Enekbatus cristatus</i>	2	
<i>Eremophila microtheca</i>	4	
<i>Eremophila occidens</i>	2	
<i>Eucalyptus arachnaea</i> subsp. <i>arrecta</i>	3	
<i>Eucalyptus beardiana</i>	T	V
<i>Eucalyptus cuprea</i>	T	E
<i>Frankenia confuse</i>	2	
<i>Gastrolobium hamulosum</i>	T	E
<i>Gastrolobium propinquum</i>	3	
<i>Geleznovia</i> sp. Binnu (K.A. Shepherd & J. Wege KS 1301)	3	
<i>Geleznovia</i> sp. Red Bluff (A. Crawford ADC 597) PN	2	
<i>Grevillea costata</i>	3	
<i>Grevillea leucoclada</i>	3	
<i>Grevillea rogersoniana</i>	3	
<i>Grevillea stenomera</i>	2	
<i>Guichenotia impudica</i>	3	
<i>Hemiandra</i> sp. Kalbarri (D. Bellairs 1505)	2	
<i>Hemigenia pimelifolia</i>	2	
<i>Hibbertia spicata</i> subsp. <i>leptotheca</i>	3	
<i>Hypocalymma angustifolium</i> subsp. Hutt River (S. Patrick 2982)	T	?
<i>Hypocalymma longifolium</i>	T	V
<i>Isopogon uncinatus</i>	T	E
<i>Jacksonia velutina</i>	4	
<i>Keraudrenia saxatilis</i>	2	
<i>Lasiopetalum oldfieldii</i> subsp. <i>oldfieldii</i>	3	
<i>Lasiopetalum oppositifolium</i>	3	
<i>Lechenaultia chlorantha</i>	T	V
<i>Lepidobolus densus</i>	3	
<i>Lepidosperma rupestre</i>	4	
<i>Leucopogon psammophilus</i>	1	
<i>Liparophyllum congestiflorum</i>	4	
<i>Macarthuria intricata</i>	3	
<i>Malleostemon</i> sp. Hardabutt Rapids (D. Bellairs 1654A)	1	
<i>Malleostemon</i> sp. Kalbarri (L.A. Craven 7083)	2	
<i>Malleostemon</i> sp. Moonyoonooka (R.J. Cranfield 2947)	2	
<i>Malleostemon</i> sp. Yerina (S.J. Patrick 2728)	1	
<i>Melaleuca boeophylla</i>	2	
<i>Melaleuca huttensis</i>	1	
<i>Melaleuca oldfieldii</i>	2	
<i>Microcorys tenuifolia</i>	3	
<i>Millotia jacksonii</i>	2	
<i>Mirbelia corallina</i>	3	
<i>Murchisonia fragrans</i>	2	

Species	SCC	FCC
<i>Paracaleana alcockii</i>	2	
<i>Parmeliopsis macrospora</i>	3	
<i>Persoonia brachystylis</i>	2	
<i>Philotheca kalbarriensis</i>	2	
<i>Physopsis chrysophylla</i>	3	
<i>Pileanthus aurantiacus</i>	1	
<i>Pileanthus bellus</i>	3	
<i>Pityrodia viscida</i>	4	
<i>Platysace</i> sp. Kalbarri (D. & B. Bellairs 1383)	2	
<i>Psilotum nudum</i>	3	
<i>Pterostylis sinuata</i>	T	E
<i>Scaevola kallophylla</i>	4	
<i>Scaevola oldfieldii</i>	3	
<i>Scaevola</i> sp. Golden hairs (D. & B. Bellairs 1450 A)	1	
<i>Schoenus</i> sp. Kalbarri (K.R. Newbey 9352)	2	
<i>Scholtzia</i> sp. Ajana (T.A. Halliday 137)	3	
<i>Scholtzia</i> sp. Eradu (R.D. Royce 8016)	2	
<i>Scholtzia</i> sp. Eurardy (J.S. Beard 6886)	2	
<i>Scholtzia</i> sp. Folly Hill (M.E. Trudgen 12097)	2	
<i>Scholtzia</i> sp. Ross Graham Lookout (S. Maley 6)	2	
<i>Scholtzia</i> sp. Z-Bend (Bellairs-Kalflora 912a)	2	
<i>Stachystemon nematophorus</i>	T	V
<i>Stenanthemum divaricatum</i>	3	
<i>Stylidium torticarpum</i>	3	
<i>Thryptomene johnsonii</i>	2	
<i>Thryptomene</i> sp. Eagle Gorge (A.G. Gunness 2360)	2	
<i>Thryptomene</i> sp. Kalbarri limestone (D. & B. Bellairs 1652 A)	2	
<i>Thryptomene</i> sp. Wandana (M.E. Trudgen MET 22016)	3	
<i>Thryptomene stenophylla</i>	2	
<i>Thryptomene striata</i>	2	
<i>Thysanotus</i> sp. Kalbarri (D. & B. Bellairs 1523 A)	2	
<i>Triodia bromoides</i>	4	
<i>Triodia dielsii</i>	3	
<i>Verticordia capillaris</i>	4	
<i>Verticordia dasystylis</i> subsp. <i>kalbarriensis</i>	2	
<i>Verticordia densiflora</i> var. <i>roseostella</i>	3	
<i>Verticordia dichroma</i> var. <i>dichroma</i>	3	
<i>Verticordia dichroma</i> var. <i>syntoma</i>	3	
<i>Verticordia galeata</i>	2	
<i>Verticordia polytricha</i>	4	
<i>Verticordia x eurardyensis</i>	1	
<i>Wurmbea tubulosa</i>	T	E
<i>Xanthoparmelia norpraegnans</i>	2	

3.3 Flora Species

A total number of 151 plant taxa (including varieties and subspecies) from 54 families and 116 genera were recorded from the study area by Onshore Environmental during October 2013 (Appendix 5). Species representation was greatest among the Poaceae, Asteraceae, Fabaceae, Chenopodiaceae and Myrtaceae families (Table 5).

Table 5 Statistics for total flora recorded from within the study area.

Parameter	No.
No. Families	54
No. Genera	116
No. Species (incl. subspecies and varieties)	151
No. Native Species (incl. subspecies and varieties)	127
Threatened Flora	0
Priority Flora	4
No. Introduced Species	24
Speciose Families	
Poaceae	16
Asteraceae	12
Fabaceae	12
Chenopodiaceae	10
Myrtaceae	9
Malvaceae	6
Goodeniaceae	5
Euphorbiaceae	4
Convolvulaceae	4
Amaranthaceae	4
Solanaceae	4
Speciose Genera	
<i>Acacia</i> (Fabaceae)	5
<i>Melaleuca</i> (Myrtaceae)	4
<i>Ptilotus</i> (Amaranthaceae)	4
<i>Amyema</i> (Loranthaceae)	3
<i>Eucalyptus</i> (Myrtaceae)	3
<i>Goodenia</i> (Goodeniaceae)	3
<i>Austrostipa</i> (Poaceae)	3

3.4 Significant Flora

3.4.1 Threatened Flora

Following intensive quadrat sampling and extensive ground truthing of the study area none of the plant taxa recorded were gazetted as Threatened Flora (T) pursuant to subsection (2) of section 23F of the WC Act, or listed under the EPBC Act.

3.4.2 Priority Flora

There were four Priority flora taxa (as defined by DPaW) recorded from the study area (Figure 5, Appendix 6); *Melaleuca huttensis* (Priority 1), *Cryptandra glabriflora* (Priority 2), *Anthocercis intricata* (Priority 3) and *Beyeria cinerea* subsp. *cinerea* (Priority 3).

Melaleuca huttensis (Priority 1)

Melaleuca huttensis is an upright shrub to 3 m in height flowering white to grey cream-yellow between June and September (Plate 1). It has distinctive gnarled bark and occurs in light yellow or beige sand on lower slopes of undulating plains and on sandplains. It is restricted to the coastal strip of the Geradton Sandplains. Within the study area it was restricted to two points where plants occurred as scattered individuals approximating five plants per 100 m². Associated vegetation was described as Shrubland of *Rhagodia latifolia* var. *latifolia*, *Pimelea microcephala* and *Olearia* sp. indet. with High Open Shrubland of *Grevillea argyrophylla*, *Acacia rostelifera* and *Santalum spicatum* over Low Open Shrubland of *Melaleuca cardiophylla*, *Scholtzia* sp. Kalbarri (N. Hoyle 623) and *Diplopeltis petiolaris*.



Plate 1 *Melaleuca huttensis* (Priority 1) (photograph sourced from WAH)

Cryptandra glabriflora (Priority 2)

Cryptandra glabriflora is a low shrub reaching 0.5 m in height. It produces white or pink flowers between May to August and grows on gravelly soils on plains. Within the study area it was recorded at one location on a hillcrest. The vegetation association at this location was: Low Open Heath of *Scholtzia* sp. Kalbarri (N. Hoyle 623), *Olearia* sp. indet *Acanthocarpus preissii* over Open Shrubland of *Olearia* sp. indet *Pimelea microcephala*, *Anthocercis intricata* over Scattered Tussock Grassland of *Austrostipa elegantissima* and *Austrostipa crinita*.

Anthocercis intricata (Priority 3)

Anthocercis intricata is a dense spiny shrub reaching 3 m in height and flowering white or cream between June to September (Plate 2). It grows in sand or loam over limestone on consolidated sand dunes. Within the study area it was recorded at one location on a hillcrest. The vegetation association at this location was: Low Open Heath of *Scholtzia* sp. Kalbarri (N. Hoyle 623), *Olearia* sp. indet *Acanthocarpus preissii* over Open Shrubland of *Olearia* sp. indet *Pimelea microcephala*, *Anthocercis intricata* over Scattered Tussock Grassland of *Austrostipa elegantissima* and *Austrostipa crinita*.



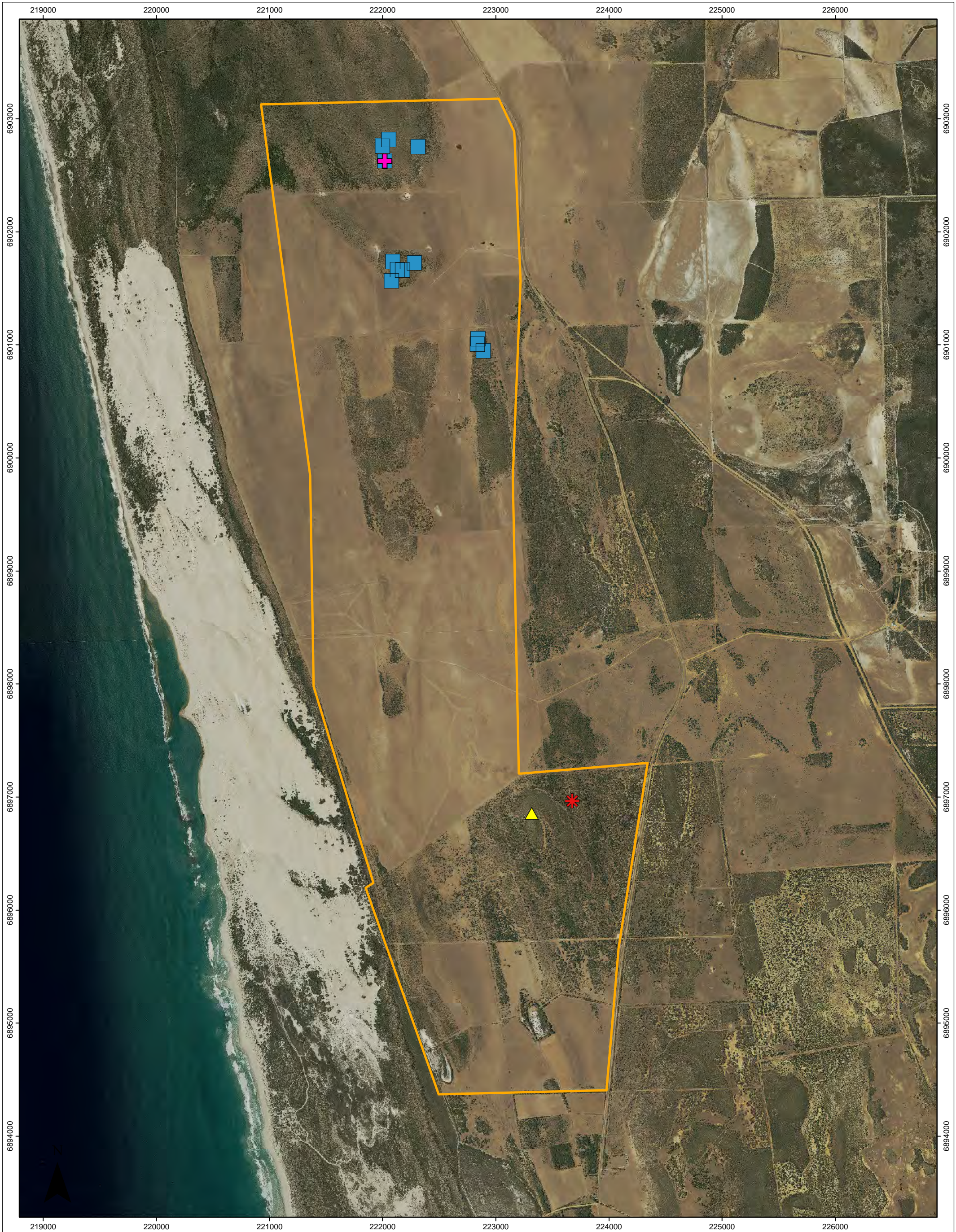
Plate 2 *Anthocercis intricata* (Priority 3) (photograph sourced from WAH)

Beyeria cinerea subsp. *cinerea* (Priority 3)

Beyeria cinerea subsp. *cinerea* is a prostrate, erect or spreading shrub reaching 0.5m in height (Plate 3). Flowers are green or yellow and appear from May to October. This species grows in grey/white or red sand on coastal limestones and dunes. Within the study area it was recorded at one location on a hillcrest. The vegetation association was: Low Closed Heath of *Melaleuca cardiophylla*, *Beyeria cinerea* subsp. *cinerea* over Very Open Herbs of **Brassica tournefortii* and **Lysimachia arvensis*.

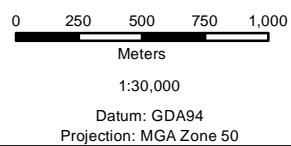


Plate 3 *Beyeria cinerea* subsp. *cinerea* (Priority 3) (photograph sourced from WAH)



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SIGNIFICANT FLORA



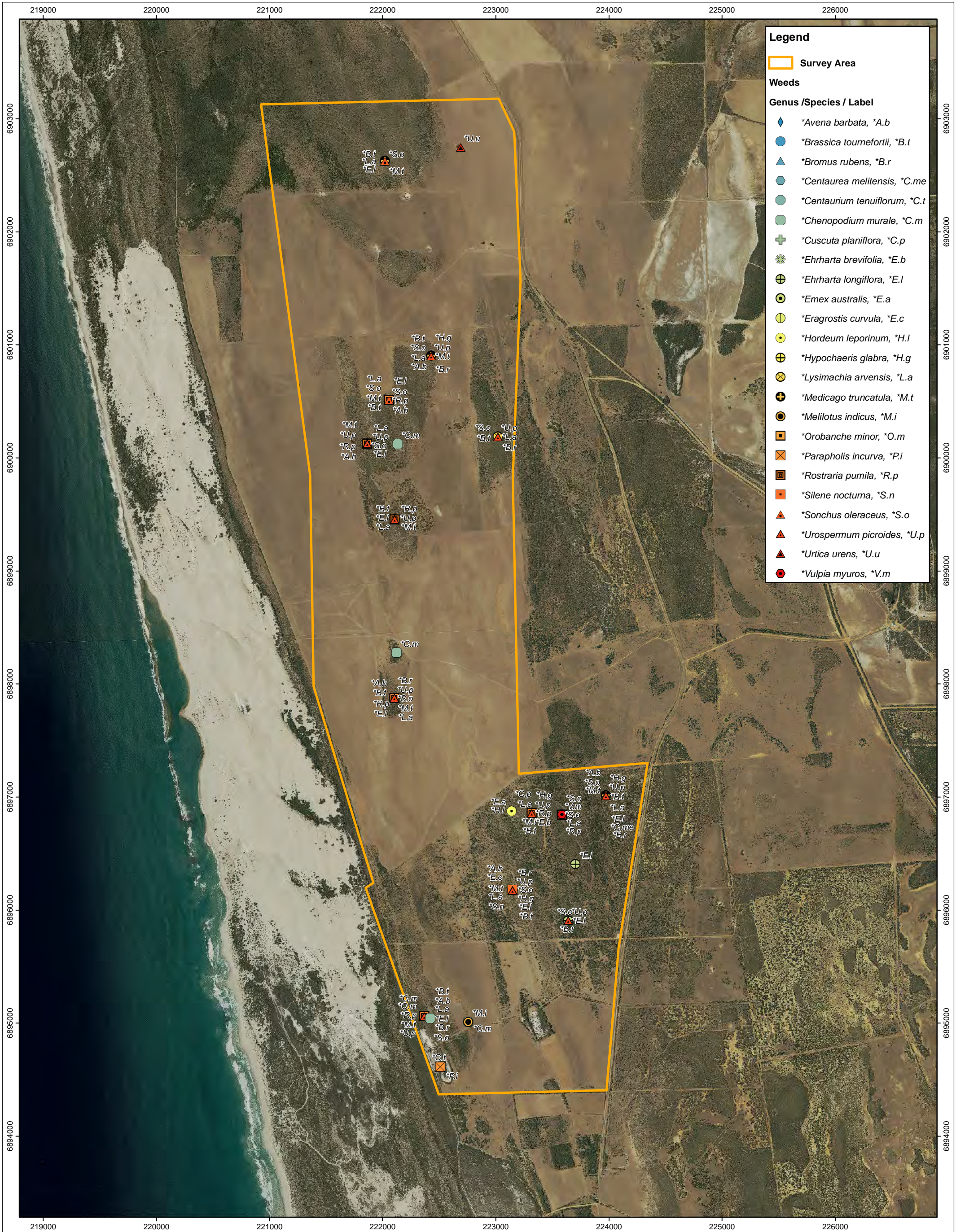
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- Survey Area
- Significant Flora**
- Genus/Species**
- ^Anthocercis intricata
- ^Beyeria cinerea subsp cinerea
- ^Cryptandra glabriflora
- ^Melaleuca huttensis

3.5 Introduced Flora

There were 24 introduced (weed) species recorded from the study area; **Avena barbata*, **Brassica tournefortii*, **Bromus rubens*, **Centaurea melitensis*, **Centaurium tenuiflorum*, **Chenopodium murale*, **Cuscuta planiflora*, **Ehrharta brevifolia* var. *cuspidata*, **Ehrharta longiflora*, **Emex australis*, **Eragrostis curvula*, **Hordeum leporinum*, **Hypochaeris glabra*, **Lysimachia arvensis*, **Medicago truncatula*, **Melilotus indicus*, **Orobancha minor*, **Parapholis incurva*, **Rostraria pumila*, **Silene nocturna*, **Sonchus oleraceus*, **Urospermum picroides*, **Urtica urens* and **Vulpia myuros* (Figure 6, Appendix 7). None of the introduced species are listed as Declared Pests under the BAM Act.



3.6 Threatened & Priority Ecological Communities

A search of the EPBC database confirmed there were no TECs previously recorded within or adjacent to, the study area. A search of the State database confirmed there were no previous TEC records for a 50 km radius around the study area.

In addition to TECs, DPaW has generated a list of PECs occurring in the Mid-West region of Western Australia. The list identifies communities that require further investigation prior to nomination for TEC status. The following PECs were identified to occur within 90 km radius of the study area (Figure 7):

Kalbarri ironstone community (Priority 1)

This community consists of winter wet, mallees and *Melaleucas* over herbs. It forms a dense shrubland when burnt and is surrounded by areas of sandplains. It occurs at Yerina Springs, north Eurardy Station, Z-bend loop and Junga Dam. *Eremophila microtheca*, a Threatened Flora occurs in this community. It is located approximately 10 km to the south east of the study area.

Shrublands of the Northampton area, dominated by Melaleuca species over exposed Kockatea Shale (Priority 1)

The Kockatea Shale PEC occurs in Port Gregory, west of Northampton approximately 25 km south-east of the study area. It consists of heath on breakaways and contains several Priority flora taxa including *Ptilotus chortophyllum* (P1), *Leucopogon* sp. Port Gregory, *Ozothamnus* sp. Northampton, *Gastrolobium propinquum* (P1) and *Ptilotus helichrysoides*. The geology of the area is unusual with outcropping of Kockatea Shale at the surface.

Plant assemblages of the Moresby Range system (Priority 1)

These plant assemblages include *Melaleuca megacephala* and *Hakea pycnoneura* thickets on stony slopes, *Verticordia* dominated low heath, and *Allocasuarina campestris* and *Melaleuca uncinata* thickets on superficial laterite. It occurs on the Moresby Range approximately 60 km to the south-east of the study area and is threatened by clearing for infrastructure.

Claypans with mid dense shrublands of Melaleuca lateritia over herbs (Priority 1)

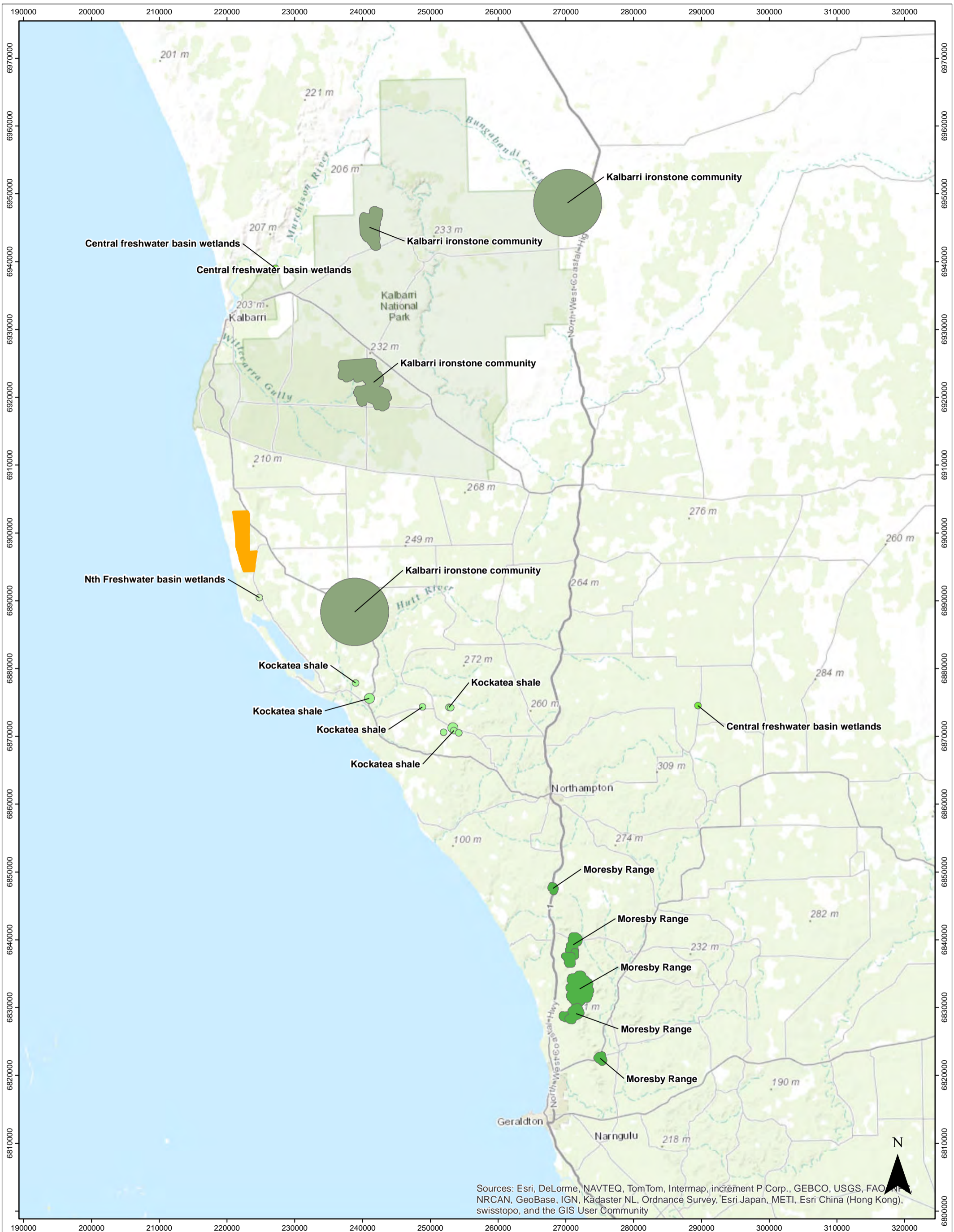
Claypans (predominantly basins) usually dominated by a shrubland of *Melaleuca lateritia* occurring both on the coastal plain and the adjacent plateau. These claypans are characterised by aquatic (*Hydrocotyle lemnoides* - Priority 4) and amphibious taxa (e.g. *Glossostigma diandrum*, *Villarsia capitata* and *Eleocharis keigheryi* - T). The community has previously been recorded approximately 5 km south of the study area with additional know locations to the north-east of Kalbarri.

None of the four PECs identified from the State communities database search occur within the study area, and none of the vegetation associations described and mapped from the study area have any affiliation with these PECs. However, Vegetation association 4 does have affiliations with a fifth PEC listed as occurring within the Mid-West region:

- Coastal sands dominated by *Acacia rostellifera*, *Eucalyptus oraria* and *Eucalyptus obtusiflora* (Priority 1).

Floristically, this community is similar to other *Acacia rostellifera* communities but is differentiated on structure, being dominated by mallee eucalypts. The community occurs on limestone ridges, in some swales in the coastal dunes

between Cape Burney and Dongara, on the Greenough Alluvial Flats on limestone soil and near Tarcoola Beach. Some very small occurrences have also been recorded on the limestone scarp north of the Buller River. Within the study area Vegetation association 4 is described as 'Mallee of *Eucalyptus fruticosa* and *Eucalyptus oraria* over Scattered High Shrubs of *Acacia rostellifera* and *Pittosporum ligustrifolium* over Scattered Low Shrubs of *Rhagodia latifolia* var. *latifolia*'. Vegetation is defined by the mallee cover which occurs on sandy hill slopes.



Sources: Esri, DeLorme, NAVTEQ, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, and the GIS User Community

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KALBARRI
TEC / PEC SEARCH RESULTS

1:500,000
Datum: GDA94
Projection: MGA Zone 50

ONSHORE ENVIRONMENTAL CONSULTANTS
Date: 09/12/2013
Sheet Size: A3 Status: Draft
Drawn by: GSM Requested by: DB Internal Reference: Kalbarri_PEC_TEC_20131028

Legend

Survey Area



TEC / PEC Search Results



- Central freshwater basin wetlands
- Kalbarri ironstone community
- Kockatea shale
- Moresby Range
- Nth Freshwater basin wetlands



3.7 Vegetation



A total of 19 vegetation associations were described and mapped within the study area (Figure 8, Table 6). The vegetation associations were classified into sixteen Broad Floristic Formations on the basis of canopy structure. Raw data for the 15 study sites is provided as Appendix 8.



Table 6 Vegetation associations described and mapped from the study area by Onshore Environmental.



BFF	Code	Final Vegetation Description	Photograph	Landform	Sites/ relevés	Condition
Casuarina Low Open Forest	1	Low Open Forest of <i>Casuarina obesa</i> over Low Shrubland of <i>Atriplex amnicola</i> , <i>Sarcocornia blackiana</i> and <i>Dissocarpus paradoxus</i> over Very Open Tussock Grass of <i>Sporobolus virginicus</i>		Limestone clay loam flats in leeward side of white sand dunes	RB150, RB151, RB152	Very Good
Eucalyptus Low Woodland	2	Low Woodland of <i>Eucalyptus camaldulensis</i> , <i>Eucalyptus sargentii</i> and <i>Casuarina obesa</i> over High Open Shrubland of <i>Acacia rostellifera</i> , <i>Melaleuca viminea</i> subsp. <i>viminea</i> and <i>Acacia saligna</i> subsp. <i>saligna</i> over Scattered Low Shrubs of <i>Atriplex amnicola</i>		Planted and partly rehabilitated vegetation adjacent to exposed limestone	RB33, RB39	Degraded



BFF	Code	Final Vegetation Description	Photograph	Landform	Sites/ relevés	Condition
Casuarina Low Woodland	3	Low Woodland of <i>Casuarina obesa</i> over Low Open Shrubland of <i>Sarcocornia blackiana</i> , <i>Frankenia pauciflora</i> and <i>Dissocarpos paradoxus</i>		Limestone clay loam flats	B15	Very Good
Eucalyptus Mallee	4	Mallee of <i>Eucalyptus fruticosa</i> and <i>Eucalyptus oraria</i> over Scattered High Shrubs of <i>Acacia rostellifera</i> and <i>Pittosporum ligustrifolium</i> over Scattered Low Shrubs of <i>Rhagodia latifolia</i> var. <i>latifolia</i>		Sandy hill slopes	B13, RB95, RB137, RB138	Very Good



BFF	Code	Final Vegetation Description	Photograph	Landform	Sites/ relevés	Condition
Acacia Closed Scrub	5	Closed Scrub of <i>Acacia rostellifera</i> over Very Open Annual Tussock Grassland of <i>Ehrharta longiflora</i> over Scattered Herbs of <i>Sonchus oleraceus</i> and <i>Brassica tournefortii</i>		Sandy swales between broad dunes, lower hill slopes	B3, RB24, RB25, RB34	Very Good
Acacia High Shrubland	6a	High Shrubland to Open Scrub <i>Acacia rostellifera</i> over Open Annual Tussock Grassland of <i>Avena barbata</i> , <i>Bromus rubens</i> and <i>Ehrharta longiflora</i> with Open Shrubland of <i>Rhagodia latifolia</i> var. <i>latifolia</i> , <i>Pimelea microcephala</i> and <i>Olearia</i> sp. indet.		Sandy hill slopes	B2, 4, 7, 10, 12	Good



BFF	Code	Final Vegetation Description	Photograph	Landform	Sites/ relevés	Condition
Acacia High Shrubland	6b	High Shrubland of <i>Acacia rostelifera</i> and <i>Alyogyne hakeifolia</i> over Open Annual Tussock Grassland of <i>Avena barbata</i> , and <i>Bromus rubens</i> over Open Herbland of <i>Brassica tournefortii</i> and <i>Medicago truncata</i>		Parkland cleared, sandy hill slopes	RB9,22,29	Degraded
Acacia High Shrubland	6c	High Shrubland of <i>Acacia rostelifera</i> over Open Shrubland of <i>Rhagodia latifolia</i> var. <i>latifolia</i> , <i>Olearia axillaris</i> and <i>Scaevola crassifolia</i> over Very Open Hummock Grassland of <i>Spinifex longifolius</i>		White sand dunes	RB88, RB90	Excellent

BFF	Code	Final Vegetation Description	Photograph	Landform	Sites/ relevés	Condition
Acacia High Shrubland	6d	High Shrubland of <i>Acacia rostellifera</i> over Shrubland <i>Olearia</i> sp. indet., <i>Pimelea microcephala</i> and <i>Zygophyllum fruticosum</i> over Low Shrubland of <i>Acanthocarpus preissii</i> , <i>Pimelea sessilis</i> and <i>Solanum oldfieldii</i>		Sandy hill slopes	RB98, RB104	Very Good
Melaleuca High Shrubland	7	High Shrubland of <i>Melaleuca cardiophylla</i> over Shrubland of <i>Diplolaena grandiflora</i> , <i>Rhagodia latifolia</i> var. <i>latifolia</i> and <i>Pimelea microcephala</i> over Very Open Herbs of <i>Brassica tournefortii</i>		Limestone hill crest (with boulders)	B8, RB82, RB124	Good

BFF	Code	Final Vegetation Description	Photograph	Landform	Sites/ relevés	Condition
Grevillea High Shrubland	8	High Shrubland of <i>Grevillea argyrophylla</i> , <i>Acacia rostellifera</i> and <i>Melaleuca cardiophylla</i> over Shrubland of <i>Pittosporum ligustrifolium</i> , <i>Rhagodia latifolia</i> var. <i>latifolia</i> and <i>Zygophyllum fruticosum</i> over Open Climbers of <i>Clematicissus angustissimus</i> , <i>Tetragonia implexicoma</i> and <i>Dioscorea hastifolia</i>		Sandplain (brown sands) in lee of white sand dunes	RB40, RB87	Very Good
Melaleuca Open Heath	9	Open Heath of <i>Melaleuca cardiophylla</i> and <i>Olearia</i> sp. indet. over Low Shrubland of <i>Comesperma scoparium</i> , <i>Scholtzia</i> sp. Kalbarri (N. Hoyle 623), and <i>Acanthocarpus preissii</i> over Very Open Herbland of <i>*Medicago truncata</i> , <i>*Brassica tournefortii</i> and <i>*Lysimachia avensis</i>		Limestone hill crest and slopes	B11, RB71, RB108	Very Good

BFF	Code	Final Vegetation Description	Photograph	Landform	Sites/ relevés	Condition
Olearia Open Heath	10	Open Heath of <i>Olearia</i> sp. indet. with High Open Shrubland of <i>Acacia rostellifera</i> over Low Open Shrubland of <i>Acanthocarpus preissii</i> and <i>Solanum oldfieldii</i>		Sandy hill slopes and swales (orange sands)	B6	Very Good
Pimelea Shrubland	11	Shrubland of <i>Pimelea microcephala</i> , <i>Olearia</i> sp. indet. and <i>Quoya loxocarpa</i> over Low Shrubland of <i>Quoya loxocarpa</i> , <i>Zygophyllum fruticosum</i> and <i>Tricoryne elatior</i> over Open Annual Tussock Grassland of <i>Avena barbata</i> , <i>Bromus rubens</i> and <i>Ehrharta longiflora</i>		Sandplain (orange sands)	B5	Good

BFF	Code	Final Vegetation Description	Photograph	Landform	Sites/ relevés	Condition
Rhagodia Shrubland	12	Shrubland of <i>Rhagodia latifolia</i> var. <i>latifolia</i> , <i>Pimelea microcephala</i> and <i>Olearia</i> sp. indet. with High Open Shrubland of <i>Grevillea argyrophylla</i> , <i>Acacia rostellifera</i> and <i>Santalum spicatum</i> over Low Open Shrubland of <i>Melaleuca cardiophylla</i> , <i>Scholtzia</i> sp. Kalbarri (N. Hoyle 623) and <i>Diplopeltis petiolaris</i>		Mid to lower limestone hill slopes	B14, RB134, RB141, RB145	Very Good
Melaleuca Low Closed Heath	13	Low Closed Heath of <i>Melaleuca cardiophylla</i> , <i>Melaleuca campanae</i> and <i>Cryptandra arbutiflora</i> over Very Open Herbs of <i>*Brassica tournefortii</i> and <i>*Lysimachia arvensis</i>		Limestone hill crest (unbroken ridge)	B1	Very Good

BFF	Code	Final Vegetation Description	Photograph	Landform	Sites/ relevés	Condition
Scholtzia Low Open Heath	14	Low Open Heath of <i>Scholtzia</i> sp. Kalbarri (N. Hoyle 623), <i>Comesperma scoparium</i> and <i>Acanthocarpos preissii</i> with Open Shrubland of <i>Olearia</i> sp. indet., <i>Acacia rostelifera</i> and <i>Pimelea microcephala</i> over Scattered Tussock Grass of <i>Austrostipa crinita</i>		Limestone hill crest and slopes	B9, RB103	Very Good
Sarcocornia Low Shrubland	15	Low Shrubland of <i>Sarcocornia blackiana</i> and <i>Frankenia pauciflora</i> with Scattered Low Trees of <i>Casuarina obesa</i>		Lower parts of limestone clay loam flats	RB41, RB149	Very Good

BFF	Code	Final Vegetation Description	Photograph	Landform	Sites/ relevés	Condition
*Avena Annual Tussock Grassland	16	Annual Tussock Grassland of <i>*Avena barbata</i> and <i>*Bromus rubens</i> over Open Herbland of <i>*Brassica tournefortii</i> and <i>*Medicago truncata</i> with Scattered High Shrubs of <i>Acacia rostellifera</i>		Sandy hill slopes	RB35,81	Completely Degraded

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**BALLINE
VEGETATION
MAPPING**



ONSHORE ENVIRONMENTAL CONSULTANTS		Date:	09/12/2013
Sheet Size:		A3	Status:
Drawn by GSM	Requested by DB	Internal Reference Kalbarri_Vegmap20131114	

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1:30,000
Datum: GDA94
Projection: MGA Zone 50

Legend

 Survey Area

Vegetation Mapping

Casuarina Low Open Forest

1 Low Open Forest of *Casuarina obesa* over Low Shrubland of *Atriplex amnicola*, *Sarcocornia blackiana*, *Dissocarpos paradoxus* over Very Open Tussock Grass of *Sporobolus virginicus*

Eucalyptus Low Woodland

2 Low Woodland of *Eucalyptus camaldulensis*, *Eucalyptus sargentii*, *Casuarina obesa* over High Open Shrubland of *Acacia rostellifera*, *Melaleuca viminea* subsp. *viminea*, *Acacia saligna* subsp. *saligna* over Scattered Low Shrubs of *Atriplex amnicola*

Casuarina Low Woodland

3 Low Woodland of *Casuarina obesa* over Low Open Shrubland of *Sarcocornia blackiana*, *Frankenia pauciflora*, *Dissocarpos paradoxus*

Eucalyptus Mallee

4 Mallee of *Eucalyptus fruticosa*, *Eucalyptus oraria* over Scattered High Shrubs of *Acacia rostellifera*, *Pittosporum ligustrifolium* over Scattered Low Shrubs of *Rhagodia latifolia* var. *latifolia*

Acacia Closed Scrub

5 Closed Scrub of *Acacia rostellifera* over Very Open Annual Tussock Grassland of *Ehrharta longiflora* over Scattered Herbs of *Sonchus oleraceus*, *Brassica tournefortii*

Acacia High Shrubland

6a High Shrubland to Open Scrub *Acacia rostellifera* over Open Annual Tussock Grassland of *Avena barbata*, *Bromus rubens*, *Ehrharta longiflora* with Open Shrubland of *Rhagodia latifolia* var. *latifolia*, *Pimelea microcephala*, *Olearia* sp. *indet.*

6b High Shrubland of *Acacia rostellifera*, *Alyogyne hakeifolia* over Open Annual Tussock Grassland of *Avena barbata*, *Bromus rubens* over Open Hermland of *Brassica tournefortii*, *Medicago truncata*

6c High Shrubland of *Acacia rostellifera* over Open Shrubland of *Rhagodia latifolia* var. *latifolia*, *Olearia axillaris*, *Scaevola crassifolia* over Very Open Hummock Grassland of *Spinifex longifolius*

6d High Shrubland of *Acacia rostellifera* over Shrubland *Olearia* sp. *indet.*, *Pimelea microcephala*, *Zygophyllum fruticosum* over Low Shrubland of *Acanthocarpus preissii*, *Pimelea sessilis*, *Solanum oldfieldii*

Melaleuca High Shrubland

7 High Shrubland of *Melaleuca cardiophylla* over Shrubland of *Diplolaena grandiflora*, *Rhagodia latifolia* var. *latifolia*, *Pimelea microcephala* over Very Open Herbs of *Brassica tournefortii*

Grevillea High Shrubland

8 High Shrubland of *Grevillea argyrophylla*, *Acacia rostellifera*, *Melaleuca cardiophylla* over Shrubland of *Pittosporum ligustrifolium*, *Rhagodia latifolia* var. *latifolia*, *Zygophyllum fruticosum* over Open Climbers of *Clematicissus angustissimus*, *Tetragona implexa*, *Dioscorea hastifolia*

Melaleuca Open Heath

9 Open Heath of *Melaleuca cardiophylla*, *Olearia* sp. *indet.* over Low Shrubland of *Comesperma scoparium*, *Scholtzia* sp. Kalbarri (N. Hoyle 623), *Acanthocarpus preissii* over Very Open Hermland of *Medicago truncata*, *Brassica tournefortii*, *Anagallis arvensis*

Olearia Open Heath

10 Open Heath of *Olearia* sp. *indet.* with High Open Shrubland of *Acacia rostellifera* over Low Open Shrubland of *Acanthocarpus preissii*, *Solanum oldfieldii*

Pimelea Shrubland

11 Shrubland of *Pimelea microcephala*, *Olearia* sp. *indet.*, *Quoya loxocarpa* over Low Shrubland of *Quoya loxocarpa*, *Zygophyllum fruticosum*, *Tricoryne elatior* over Open Annual Tussock Grassland of *Avena barbata*, *Bromus rubens*, *Ehrharta longiflora*

Rhagodia Shrubland

12 Shrubland of *Rhagodia latifolia* var. *latifolia*, *Pimelea microcephala*, *Olearia* sp. *indet.* with High Open Shrubland of *Grevillea argyrophylla*, *Acacia rostellifera*, *Santalum spicatum* over Low Open Shrubland of *Melaleuca cardiophylla*, *Scholtzia* sp. Kalbarri (N. Hoyle 623), *Diplopeltis petiolaris*

Melaleuca Low Closed Heath

13 Low Closed Heath of *Melaleuca cardiophylla*, *Melaleuca campanae*, *Cryptandra arbutiflora* over Very Open Herbs of *Brassica tournefortii*, *Anagallis arvensis*

Scholtzia Low Open Heath

14 Low Open Heath of *Scholtzia* sp. Kalbarri (N. Hoyle 623), *Comesperma scoparium*, *Acanthocarpus preissii* with Open Shrubland of *Olearia* sp. *indet.*, *Acacia rostellifera*, *Pimelea microcephala* over Scattered Tussock Grass of *Austrostipa crinita*

Sarcocornia Low Shrubland

15 Low Shrubland of *Sarcocornia blackiana*, *Frankenia pauciflora* with Scattered Low Trees of *Casuarina obesa*

***Avena Annual Tussock**

16 Annual Tussock Grassland of *Avena barbata*, *Bromus rubens* over Open Hermland of *Brassica tournefortii*, *Medicago truncata* with Scattered High Shrubs of *Acacia rostellifera*

Cleared

 Cleared Areas

3.8 Vegetation Condition

Vegetation condition within the study area ranged from excellent to completely degraded, with the largest proportion of the area having been historically cleared for agriculture and mapped as completely degraded (Figure 9). The larger area of remnant vegetation was rated as good, with smaller sectors rated as very good or degraded. Very small areas of vegetation situated along the western border of the study area were rated as excellent; these extended onto sand dunes further west and outside the study area. The major disturbances recorded within the study area were related to historical agriculture, specifically clearing of native vegetation, establishment of annual pasture and seasonal crops, grazing by domestic stock, and introduction of weeds and feral animals such as rabbits. There were established access tracks throughout a majority of the study area and remnant vegetation was typically long unburnt (> 10 years) with some of the stands in a senescent phase.

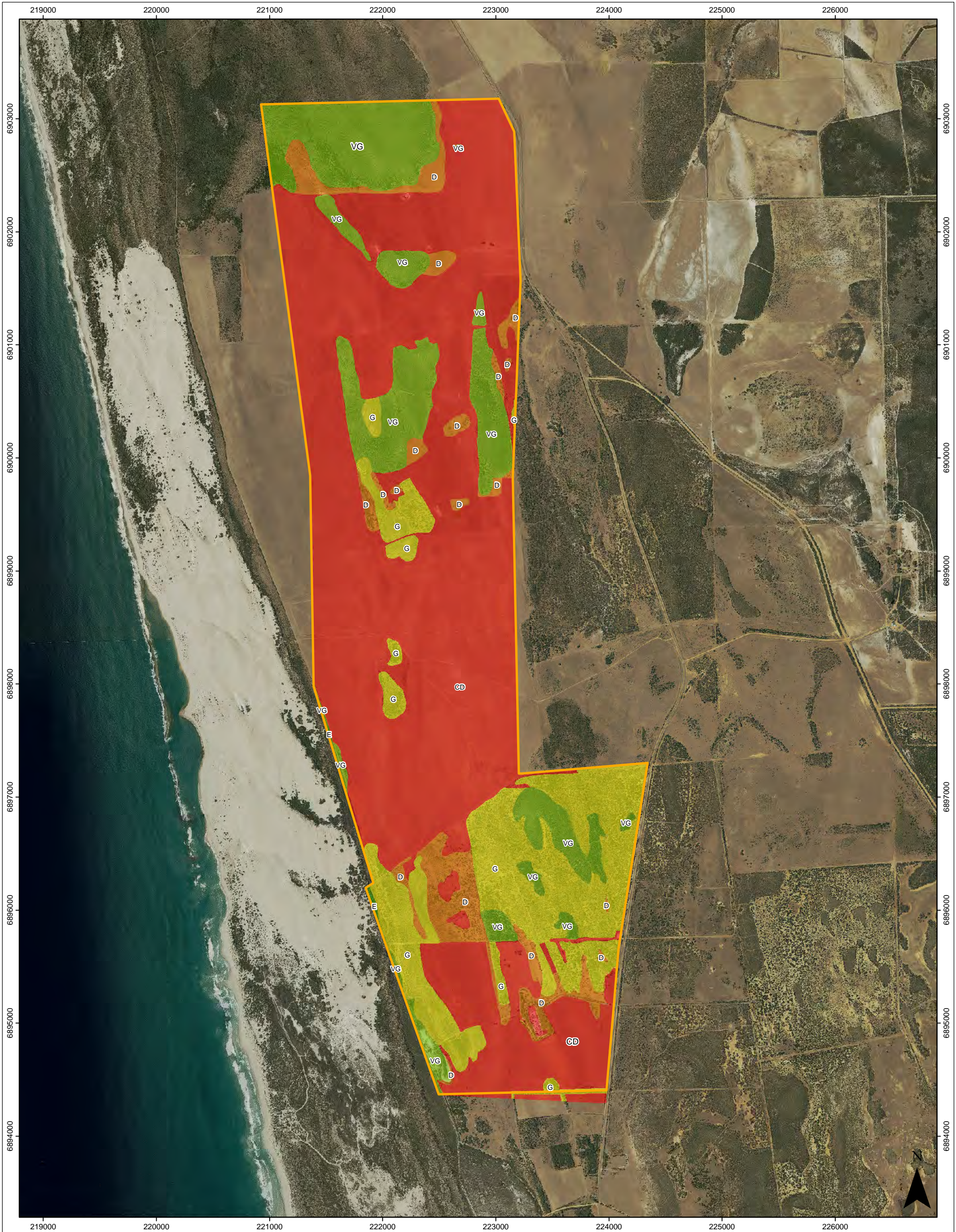
3.9 Groundwater Dependence of Vegetation

The majority of vegetation recorded within the study area occurs on undulating low hills and ridges comprising limestone and sand. Associated vegetation is dominated by xerophytic plant taxa that have no reliance of groundwater to survive.

There are four localised vegetation associations restricted to the south-western corner of the study area where seasonal interaction between groundwater and vegetation is likely to be occurring (Figure 8):

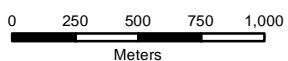
- Vegetation association 1 - Low Open Forest of *Casuarina obesa* over Low Shrubland of *Atriplex amnicola*, *Sarcocornia blackiana* and *Dissocarpos paradoxus* over Very Open Tussock Grass of *Sporobolus virginicus* on limestone clay loam flats in leeward side of white sand dunes;
- Vegetation association 2 - Low Woodland of *Eucalyptus camaldulensis*, *Eucalyptus sargentii* and *Casuarina obesa* over High Open Shrubland of *Acacia rostellifera*, *Melaleuca viminea* subsp. *viminea* and *Acacia saligna* subsp. *saligna* over Scattered Low Shrubs of *Atriplex amnicola* occurring as planted and partly rehabilitated vegetation adjacent to exposed limestone;
- Vegetation association 3 - Low Woodland of *Casuarina obesa* over Low Open Shrubland of *Sarcocornia blackiana*, *Frankenia pauciflora* and *Dissocarpos paradoxus* on limestone clay loam flats; and
- Vegetation association 15 - Low Shrubland of *Sarcocornia blackiana* and *Frankenia pauciflora* with Scattered Low Trees of *Casuarina obesa* on lower parts of limestone clay loam flats.

Vegetation associations 1, 2, 3 and 15 occur on exposed limestone clay loam flats situated at the lowest position in the landscape, close to the coastline in the south-west sector of the study area, and where depth to groundwater is at its shallowest. Data from site monitoring bores confirms groundwater depth approximates 4m to 7m in the south-west, increasing to 20m to 40m at central and northern sectors of the study area. Species composition of the four vegetation associations is characterised by halophytic plant taxa that are known to tolerate elevated soil salinity and interaction with brackish water at least seasonally. Given the salinity of groundwater from monitoring bores closest to coast and at the very top of the water table is in the range 4,000 - 7,000 mg/L TDS, it is likely that Vegetation associations 1, 2, 3 and 15 have interaction with this groundwater at least seasonally during the year.



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BALLINE
VEGETATION CONDITION



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Datum: GDA94
Projection: MGA Zone 50



ONSHORE ENVIRONMENTAL CONSULTANTS		Date: 09/12/2013
Sheet Size: A3	Status: Draft	
Drawn by: GSM	Requested by: DB	Internal Reference: Kalbarri_Vegcond20131114

Legend

Survey Area

Vegetation Mapping

- Completely Degraded
- Degraded
- Good
- Very Good
- Excellent

4.0 Summary

A total number of 151 plant taxa (including varieties and subspecies) from 54 families and 116 genera were recorded from the study area by Onshore Environmental during October 2013. Species representation was greatest among the Poaceae, Asteraceae, Fabaceae, Chenopodaceae and Myrtaceae families.

Following intensive quadrat sampling and extensive ground truthing of the study area none of the plant taxa recorded were gazetted as Threatened Flora (T) pursuant to subsection (2) of section 23F of the WC Act, or listed under the EPBC Act.

There were four Priority flora taxa (as defined by DPaW) recorded from the study area; *Melaleuca huttensis* (Priority 1), *Cryptandra glabriflora* (Priority 2), *Anthocercis intricata* (Priority 3) and *Beyeria cinerea* subsp. *cinerea* (Priority 3).

There were 24 introduced (weed) species recorded from the study area. None of the weeds are listed as Declared Pests under the BAM Act.

Vegetation within the study area was described and mapped as 19 vegetation associations. The vegetation associations were classified into sixteen Broad Floristic Formations on the basis of canopy structure.

None of the vegetation associations from the study area were affiliated with any Commonwealth listed TECs. However, Vegetation association 4 does show similarities to the State listed PEC 'Coastal sands dominated by *Acacia rostellifera*, *Eucalyptus oraria* and *Eucalyptus obtusiflora* (Priority 1)'.

A large proportion of the study area has been historically cleared for agriculture and vegetation condition was subsequently mapped as completely degraded. The larger area of remnant vegetation was rated as good, with smaller sections rated as very good or degraded. The major disturbances recorded within the study area were related to historical agriculture, specifically clearing of native vegetation, establishment of annual pasture and seasonal crops, grazing by domestic stock, and introduction of weeds and feral animals such as rabbits.

The majority of vegetation recorded within the study area occurs on undulating low hills and ridges comprising limestone and sand. Associated vegetation is dominated by xerophytic plant taxa that have no reliance of groundwater to survive. Vegetation associations 1, 2, 3 and 15 occur on exposed limestone clay loam flats situated at the lowest position in the landscape, close to the coastline in the south-west sector of the study area, and where depth to groundwater is at its shallowest. Given the salinity of groundwater from monitoring bores closest to coast and at the very top of the water table is in the range 4,000 - 7,000 mg/L TDS, it is likely that Vegetation associations 1, 2, 3 and 15 have interaction with this groundwater at least seasonally during the year.

Currently, flora and vegetation values of significance within the study area include the four Priority flora taxa; *Melaleuca huttensis* (Priority 1), *Cryptandra glabriflora* (Priority 2), *Anthocercis intricata* (Priority 3) and *Beyeria cinerea* subsp. *cinerea* (Priority 3), as well as Vegetation association 4 which is closely affiliated with a State listed PEC.

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APPENDIX 1

Vegetation Classifications for the study area based on
Specht (1970), as modified by Aplin (1979)

Height Class	Canopy Cover				
	100 - 70%	70 - 30%	30 - 10%	10 - 2%	< 2%
Trees > 30 m	High Closed Forest	High Open Forest	High Woodland	High Open Woodland	Scattered Tall Trees
Trees 10-30 m	Closed Forest	Open Forest	Woodland	Open Woodland	Scattered Trees
Trees < 10 m	Low Closed Forest	Low Open Forest	Low Woodland	Low Open Woodland	Scattered Low Trees
Mallee	Closed Mallee	Mallee	Open Mallee	Very Open Mallee	Scattered Mallees
Shrubs > 2 m	Closed Scrub	Open Scrub	High Shrubland	High Open Shrubland	Scattered Tall Shrubs
Shrubs 1-2 m	Closed Heath	Open Heath	Shrubland	Open Shrubland	Scattered Shrubs
Shrubs < 1 m	Low Closed Heath	Low Open Heath	Low Shrubland	Low Open Shrubland	Low Scattered Shrubs
Hummock Grass	Closed Hummock Grassland	Hummock Grassland	Open Hummock Grassland	Very Open Hummock Grassland	Scattered Hummock Grass
Tussock Grass	Closed Tussock Grassland	Tussock Grassland	Open Tussock Grassland	Very Open Tussock Grassland	Scattered Tussock Grass
Bunch Grass	Closed Bunch Grassland	Bunch Grassland	Open Bunch Grassland	Very Open Bunch Grassland	Scattered Bunch Grass
Sedges	Closed Sedges	Sedges	Open Sedges	Very Open Sedges	Scattered Sedges
Herbs	Closed Herbs	Herbs	Open Herbs	Very Open Herbs	Scattered Herbs

APPENDIX 2

Vegetation condition scale (as developed by Keighery 1994)

CONDITION	CODE	DESCRIPTION
Pristine	1	Pristine or nearly so, no obvious signs of disturbance.
Excellent	2	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species.
Very Good	3	Vegetation structure altered; obvious signs of disturbance.
Good	4	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate it.
Degraded	5	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching Very Good condition without intensive management.
Completely Degraded	6	The structure of the vegetation is no longer intact and the area is completely or almost completely without native species.

APPENDIX 3

Conservation categories for flora described
under the EPBC Act and Conservation Codes for Western Australian Flora

Conservation Categories under the EPBC Act

CATEGORY	DESCRIPTION
Extinct	A species is extinct if there is no reasonable doubt that the last member of the species has died.
Extinct in the Wild	A species is categorised as extinct in the wild if it is only known to survive in cultivations, in captivity, or as a naturalised population well outside its past range; or if it has not been recorded in its known/expected habitat, at appropriate seasons, anywhere in its past range, despite exhaustive surveys over a time frame appropriate to its life cycle and form.
Critically Endangered	The species is facing an extremely high risk of extinction in the wild and in the immediate future.
Endangered	The species is likely to become extinct unless the circumstances and factors threatening its abundance, survival, or evolutionary development cease to operate; or its numbers have been reduced to such a critical level, or its habitats have been so drastically reduced, that it is in immediate danger of extinction.
Vulnerable	Within the next 25 years, the species is likely to become endangered unless the circumstances and factors threatening its abundance, survival or evolutionary development cease to operate.
Conservation Dependent	The species is the focus of a specific conservation program, the cessation of which would result in the species becoming vulnerable, endangered or critically endangered within a period of 5 years.

Conservation Codes for Western Australian Flora Priority Flora list.

R: Declared Rare Flora - Extant Taxa

Taxa which have been adequately searched for, and are deemed to be in the wild either rare, in danger of extinction, or otherwise in need of special protection, and have been gazetted as such.

1: Priority One - Poorly Known Taxa

Taxa that are known from one or a few collections or sight records (generally less than five), all on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, Shire, Westrail and Main Roads WA road, gravel and soil reserves, and active mineral leases and under threat of habitat destruction or degradation. Taxa may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements and appear to be under immediate threat from known threatening processes.

2: Priority Two - Poorly Known Taxa

Taxa that are known from one or a few collections or sight records, some of which are on lands not under imminent threat of habitat destruction or degradation, e.g. national parks, conservation parks, nature reserves, State forest, vacant Crown land, water reserves, etc. Taxa may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements and appear to be under threat from known threatening processes.

3: Priority Three - Poorly Known Taxa

Taxa that are known from collections or sight records from several localities not under imminent threat, or from few but widespread localities with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat. Taxa may be included if they are comparatively well known from several localities but do not meet adequacy of survey requirements and known threatening processes exist that could affect them.

4: Priority Four - Rare, Near Threatened and other taxa in need of monitoring

(a) **Rare.** Taxa that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These taxa are usually represented on conservation lands.

(b) **Near Threatened.** Taxa that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable.

(c) Taxa that have been removed from the list of threatened species during the past five years for reasons other than taxonomy.

5: Priority Five - Conservation Dependent taxa

Taxa that are not threatened but are subject to a specific conservation program, the cessation of which would result in the taxa becoming threatened within five years.

APPENDIX 4

Department of Parks and Wildlife,
Western Australian Wildlife Conservation Act and Environment and Protection and Biodiversity
Conservation Act Categories of Conservation.

Categories used in the assessment of conservation status. IUCN categories (based on review by Mace and Stuart 1994) as used for the Environmental Protection and Biodiversity Conservation (EPBC) Act and the WA Wildlife Conservation Act 1950.

Category	Definition
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.

Category	Definition
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 Parks and Wildlife Priority species (species not listed under the Conservation Act, but for which there is some concern).

Category	Definition
Priority 1	Taxa with few, poorly known populations on threatened lands.
Priority 2	Taxa with few, poorly known populations on conservation lands; or taxa with several, poorly known populations not on conservation lands.
Priority 3	Taxa with several, poorly known populations, some on conservation lands.
Priority 4	Taxa in need of monitoring. Taxa which are considered to have been adequately surveyed, or for which sufficient knowledge is available, and which are considered not currently threatened or in need of special protection, but could be if present circumstances change.
Priority 5	Taxa in need of monitoring. Taxa which are not considered threatened but are subject to a specific conservation program, the cessation of which would result in the species becoming threatened within five years (IUCN Conservation Dependent).

APPENDIX 5

Total flora list from the study area

GENUS	SPECIES	SUBSP. /VAR.	CONS. CODE
<i>Carpobrotus</i>	<i>virescens</i>		
<i>Tetragonia</i>	<i>implexica</i>		
<i>Ptilotus</i>	<i>divaricatus</i>		
<i>Ptilotus</i>	<i>eriotrichus</i>		
<i>Ptilotus</i>	<i>gaudichaudii</i>	subsp. <i>eremita</i>	
<i>Ptilotus</i>	<i>humilis</i>		
<i>Aphanopetalum</i>	<i>clematideum</i>		
<i>Acanthocarpus</i>	<i>preissii</i>		
<i>Lomandra</i>	<i>maritima</i>		
<i>Thysanotus</i>	<i>manglesianus</i>		
* <i>Centaurea</i>	<i>melitensis</i>		
* <i>Hypochaeris</i>	<i>glabra</i>		
* <i>Sonchus</i>	<i>oleraceus</i>		
* <i>Urospermum</i>	<i>picroides</i>		
<i>Brachyscome</i>	<i>ciliocarpa</i>		
<i>Calocephalus</i>	<i>francisii</i>		
<i>Olearia</i>	<i>axillaris</i>		
<i>Olearia</i>	<i>sp. indet</i>		
<i>Podotheca</i>	<i>gnaphalioides</i>		
<i>Schoenia</i>	<i>cassiniana</i>		
<i>Senecio</i>	<i>pinnatifolius</i>	var. <i>latilobus</i>	
<i>Waitzia</i>	<i>suaveolens</i>		
* <i>Brassica</i>	<i>tournefortii</i>		
* <i>Silene</i>	<i>nocturna</i>		
<i>Casuarina</i>	<i>obesa</i>		
* <i>Chenopodium</i>	<i>murale</i>		
<i>Atriplex</i>	<i>amnicola</i>		
<i>Chenopodium</i>	<i>gaudichaudii</i>		
<i>Dysphania</i>	<i>melanocarpa</i>		
<i>Rhagodia</i>	<i>latifolia</i>	var. <i>latifolia</i>	
<i>Rhagodia</i>	sp. Watheroo (R.J. Cranfield & P.J. Spencer 8183)		
<i>Salsola</i>	<i>australis</i>		
<i>Sarcocornia</i>	<i>blackiana</i>		
<i>Tecticornia</i>	<i>halocnemoides</i>		
<i>Threlkeldia</i>	<i>diffusa</i>		
* <i>Cuscuta</i>	<i>planiflora</i>		
<i>Convolvulus</i>	<i>angustissimus</i>	subsp. <i>angustissimus</i>	
<i>Convolvulus</i>	<i>remotus</i>		
<i>Opercularia</i>	<i>spermacocea</i>		
<i>Gahnia</i>	<i>trifida</i>		
<i>Lepidosperma</i>	<i>costale</i>		
<i>Hibbertia</i>	<i>spicata</i>	subsp. <i>spicata</i>	
<i>Dioscorea</i>	<i>hastifolia</i>		
^ <i>Beyeria</i>	<i>cinerea</i>	subsp. <i>cinerea</i>	Priority 3
<i>Euphorbia</i>	<i>sharkoensis</i>		
<i>Euphorbia</i>	<i>tannensis</i>	subsp. <i>eremophila</i>	
<i>Monotaxis</i>	<i>bracteata</i>		
* <i>Medicago</i>	<i>truncatula</i>		
* <i>Melilotus</i>	<i>indicus</i>		

GENUS	SPECIES	SUBSP. /VAR.	CONS. CODE
<i>Acacia</i>	<i>idiomorpha</i>		
<i>Acacia</i>	<i>leptospermoides</i>		
<i>Acacia</i>	<i>rostellifera</i>		
<i>Acacia</i>	<i>saligna</i>	subsp. <i>saligna</i>	
<i>Acacia</i>	<i>spathulifolia</i>		
<i>Dillwynia</i>	<i>pungens</i>		
<i>Glycine</i>	<i>canescens</i>		
<i>Mirbelia</i>	sp. Bursarioides (T.R. Lally 760)		
<i>Senna</i>	<i>glutinosa</i>	subsp. <i>chatelainiana</i>	
<i>Templetonia</i>	<i>retusa</i>		
<i>Frankenia</i>	<i>pauciflora</i>		
* <i>Centaurium</i>	<i>tenuiflorum</i>		
<i>Erodium</i>	<i>cygnorum</i>		
<i>Goodenia</i>	<i>berardiana</i>		
<i>Lechenaultia</i>	<i>linarioides</i>		
<i>Scaevola</i>	<i>anchusifolia</i>		
<i>Scaevola</i>	<i>crassifolia</i>		
<i>Scaevola</i>	<i>tomentosa</i>		
<i>Gyrostemon</i>	<i>racemiger</i>		
<i>Gyrostemon</i>	<i>ramulosus</i>		
<i>Tricoryne</i>	<i>elatoir</i>		
<i>Juncus</i>	<i>kraussii</i>	subsp. <i>australiensis</i>	
<i>Triglochin</i>	<i>mucronata</i>		
<i>Quoya</i>	<i>loxocarpa</i>		
<i>Cassytha</i>	<i>aurea</i>	var. <i>hirta</i>	
<i>Cassytha</i>	<i>racemosa</i>	forma <i>racemosa</i>	
<i>Amyema</i>	<i>linophylla</i>		
<i>Amyema</i>	<i>miraculosa</i>	subsp. <i>boormanii</i>	
<i>Amyema</i>	<i>miraculosa</i>	subsp. <i>miraculosa</i>	
<i>Alyogyne</i>	<i>hakeifolia</i>		
<i>Androcalva</i>	<i>gaudichaudii</i>		
<i>Guichenotia</i>	<i>intermedia</i>		
<i>Guichenotia</i>	<i>ledifolia</i>		
<i>Hannafordia</i>	<i>quadrivalvis</i>		
<i>Lasiopetalum</i>	<i>angustifolium</i>		
^ <i>Melaleuca</i>	<i>huttensis</i>		Priority 1
<i>Eucalyptus</i>	<i>oraria</i>		
<i>Eucalyptus</i>	<i>fruticosa</i>		
<i>Eucalyptus</i>	<i>sargentii</i>		
<i>Melaleuca</i>	<i>campanae</i>		
<i>Melaleuca</i>	<i>cardiophylla</i>		
<i>Melaleuca</i>	<i>lanceolata</i>		
<i>Melaleuca</i>	<i>viminea</i>	subsp. <i>viminea</i>	
<i>Scholtzia</i>	sp. Kalbarri (N. Hoyle 623)		
<i>Nitraria</i>	<i>billardierei</i>		
<i>Commicarpus</i>	<i>australis</i>		
<i>Jasminum</i>	<i>calcareum</i>		
* <i>Orobanche</i>	<i>minor</i>		
<i>Phyllanthus</i>	<i>calycinus</i>		

GENUS	SPECIES	SUBSP. /VAR.	CONS. CODE
<i>Phyllanthus</i>	<i>scaber</i>		
<i>Pittosporum</i>	<i>ligustrifolium</i>		
* <i>Avena</i>	<i>barbata</i>		
* <i>Bromus</i>	<i>rubens</i>		
* <i>Ehrharta</i>	<i>brevifolia</i>	var. <i>cuspidata</i>	
* <i>Ehrharta</i>	<i>longiflora</i>		
* <i>Eragrostis</i>	<i>curvula</i>		
* <i>Hordeum</i>	<i>leporinum</i>		
* <i>Parapholis</i>	<i>incurva</i>		
* <i>Rostraria</i>	<i>pumila</i>		
* <i>Vulpia</i>	<i>myuros</i>		
<i>Austrostipa</i>	<i>crinita</i>		
<i>Austrostipa</i>	<i>elegantissima</i>		
<i>Austrostipa</i>	<i>nitida</i>		
<i>Bromus</i>	<i>arenarius</i>		
<i>Paspalidium</i>	<i>reflexum</i>		
<i>Rytidosperma</i>	<i>caespitosum</i>		
<i>Sporobolus</i>	<i>virginicus</i>		
<i>Comesperma</i>	<i>integerrimum</i>		
<i>Comesperma</i>	<i>scoparium</i>		
* <i>Emex</i>	<i>australis</i>		
<i>Muehlenbeckia</i>	<i>adpressa</i>		
<i>Calandrinia</i>	<i>liniflora</i>		
<i>Calandrinia</i>	<i>polyandra</i>		
* <i>Lysimachia</i>	<i>arvensis</i>		
<i>Samolus</i>	<i>repens</i>	var. <i>paucifolius</i>	
<i>Grevillea</i>	<i>argyrophylla</i>		
<i>Grevillea</i>	<i>commutata</i>		
<i>Clematis</i>	<i>linearifolia</i>		
<i>Desmocladius</i>	<i>asper</i>		
^ <i>Cryptandra</i>	<i>glabriflora</i>		Priority 2
<i>Cryptandra</i>	<i>arbutiflora</i>		
<i>Diplolaena</i>	<i>grandiflora</i>		
<i>Diplolaena</i>	<i>mollis</i>		
<i>Exocarpos</i>	<i>sparteus</i>		
<i>Santalum</i>	<i>spicatum</i>		
<i>Diplopeltis</i>	<i>petiolaris</i>		
<i>Dodonaea</i>	<i>aptera</i>		
<i>Eremophila</i>	<i>decipiens</i>	subsp. <i>decipiens</i>	
<i>Myoporum</i>	<i>insulare</i>		
^ <i>Anthocercis</i>	<i>intricata</i>		Priority 3
<i>Anthocercis</i>	<i>ilicifolia</i>	subsp. <i>caldariola</i>	
<i>Nicotiana</i>	<i>rotundifolia</i>		
<i>Solanum</i>	<i>oldfieldii</i>		
<i>Stylobasium</i>	<i>spathulatum</i>		
<i>Pimelea</i>	<i>microcephala</i>		
<i>Pimelea</i>	<i>sessilis</i>		
* <i>Urtica</i>	<i>urens</i>		
<i>Parietaria</i>	<i>cardiostegia</i>		

GENUS	SPECIES	SUBSP./VAR.	CONS. CODE
<i>Hybanthus</i>	<i>floribundus</i>	subsp. <i>floribundus</i>	
<i>Clematicissus</i>	<i>angustissima</i>		
<i>Zygophyllum</i>	<i>fruticulosum</i>		
<i>Zygophyllum</i>	<i>simile</i>		

APPENDIX 6

Records of conservation significant flora
from the study area

Easting (GDA94)	Northing (GDA94)	Genus	Species	subsp. / var.	Conservation Code
222019.0	6902626	<i>Anthocercis</i>	<i>intricata</i>		Priority 3
222176.5	6901662	<i>Anthocercis</i>	<i>intricata</i>		Priority 3
222281.7	6901727	<i>Anthocercis</i>	<i>intricata</i>		Priority 3
222089.4	6901738	<i>Anthocercis</i>	<i>intricata</i>		Priority 3
222130.4	6901666	<i>Anthocercis</i>	<i>intricata</i>		Priority 3
222078.6	6901567	<i>Anthocercis</i>	<i>intricata</i>		Priority 3
222843.6	6901054	<i>Anthocercis</i>	<i>intricata</i>		Priority 3
222892.0	6900948	<i>Anthocercis</i>	<i>intricata</i>		Priority 3
222838.1	6901010	<i>Anthocercis</i>	<i>intricata</i>		Priority 3
222315.3	6902756	<i>Anthocercis</i>	<i>intricata</i>		Priority 3
222000.1	6902760	<i>Anthocercis</i>	<i>intricata</i>		Priority 3
222056.2	6902818	<i>Anthocercis</i>	<i>intricata</i>		Priority 3
223317.0	6896858	<i>Beyeria</i>	<i>cinerea</i>	subsp. <i>cinerea</i>	Priority 3
225770.6	6792407	<i>Beyeria</i>	<i>cinerea</i>	subsp. <i>cinerea</i>	Priority 3
222019.0	6902625	<i>Cryptandra</i>	<i>glabriflora</i>		Priority 2
216226.6	6896440	<i>Melaleuca</i>	<i>huttensis</i>		Priority 1
223676.8	6896966	<i>Melaleuca</i>	<i>huttensis</i>		Priority 1

APPENDIX 7

Records for introduced weed species recorded
from the study area

Latitude/Easting (GDA94)	Longitude/Northing (GDA94)	Genus	Species	Subsp/Var
222509	6894616	* <i>Centaurium</i>	<i>tenuiflorum</i>	
222509	6894616	* <i>Parapholis</i>	<i>incurva</i>	
222367	6895061	* <i>Avena</i>	<i>barbata</i>	
222367	6895061	* <i>Brassica</i>	<i>tournefortii</i>	
222367	6895061	* <i>Bromus</i>	<i>rubens</i>	
222367	6895061	* <i>Ehrharta</i>	<i>longiflora</i>	
222367	6895061	* <i>Lysimachia</i>	<i>arvensis</i>	
222367	6895061	* <i>Medicago</i>	<i>truncatula</i>	
222367	6895061	* <i>Orobancha</i>	<i>minor</i>	
222367	6895061	* <i>Rostraria</i>	<i>pumila</i>	
222367	6895061	* <i>Sonchus</i>	<i>oleraceus</i>	
222367	6895061	* <i>Urospermum</i>	<i>picroides</i>	
223641	6895909	* <i>Brassica</i>	<i>tournefortii</i>	
223641	6895909	* <i>Ehrharta</i>	<i>longiflora</i>	
223641	6895909	* <i>Sonchus</i>	<i>oleraceus</i>	
223641	6895909	* <i>Urospermum</i>	<i>picroides</i>	
223148	6896178	* <i>Avena</i>	<i>barbata</i>	
223148	6896178	* <i>Brassica</i>	<i>tournefortii</i>	
223148	6896178	* <i>Bromus</i>	<i>rubens</i>	
223148	6896178	* <i>Bromus</i>	<i>rubens</i>	
223148	6896178	* <i>Ehrharta</i>	<i>longiflora</i>	
223148	6896178	* <i>Eragrostis</i>	<i>curvula</i>	
223148	6896178	* <i>Hypochaeris</i>	<i>glabra</i>	
223148	6896178	* <i>Lysimachia</i>	<i>arvensis</i>	
223148	6896178	* <i>Medicago</i>	<i>truncatula</i>	
223148	6896178	* <i>Silene</i>	<i>nocturna</i>	
223148	6896178	* <i>Sonchus</i>	<i>oleraceus</i>	
223148	6896178	* <i>Urospermum</i>	<i>picroides</i>	
223148	6896178	* <i>Urospermum</i>	<i>picroides</i>	
223705	6896406	* <i>Ehrharta</i>	<i>longiflora</i>	
223584	6896845	* <i>Lysimachia</i>	<i>arvensis</i>	
223584	6896845	* <i>Rostraria</i>	<i>pumila</i>	
223584	6896845	* <i>Sonchus</i>	<i>oleraceus</i>	
223584	6896845	* <i>Sonchus</i>	<i>oleraceus</i>	
223584	6896845	* <i>Vulpia</i>	<i>myuros</i>	
223317	6896858	* <i>Brassica</i>	<i>tournefortii</i>	
223317	6896858	* <i>Cuscuta</i>	<i>planiflora</i>	
223317	6896858	* <i>Ehrharta</i>	<i>brevifolia</i>	var. <i>cuspidata</i>
223317	6896858	* <i>Hypochaeris</i>	<i>glabra</i>	
223317	6896858	* <i>Lysimachia</i>	<i>arvensis</i>	
223317	6896858	* <i>Medicago</i>	<i>truncatula</i>	
223317	6896858	* <i>Rostraria</i>	<i>pumila</i>	
223317	6896858	* <i>Urospermum</i>	<i>picroides</i>	
223973	6897014	* <i>Avena</i>	<i>barbata</i>	
223973	6897014	* <i>Brassica</i>	<i>tournefortii</i>	
223973	6897014	* <i>Bromus</i>	<i>rubens</i>	
223973	6897014	* <i>Centaurea</i>	<i>melitensis</i>	
223973	6897014	* <i>Ehrharta</i>	<i>longiflora</i>	
223973	6897014	* <i>Hypochaeris</i>	<i>glabra</i>	

Latitude/Easting (GDA94)	Longitude/Northing (GDA94)	Genus	Species	Subsp/Var
223973	6897014	<i>*Lysimachia</i>	<i>arvensis</i>	
223973	6897014	<i>*Medicago</i>	<i>truncatula</i>	
223973	6897014	<i>*Sonchus</i>	<i>oleraceus</i>	
223973	6897014	<i>*Sonchus</i>	<i>oleraceus</i>	
223973	6897014	<i>*Urospermum</i>	<i>picroides</i>	
223973	6897014	<i>*Urospermum</i>	<i>picroides</i>	
222104	6897876	<i>*Avena</i>	<i>barbata</i>	
222104	6897876	<i>*Brassica</i>	<i>tournefortii</i>	
222104	6897876	<i>*Bromus</i>	<i>rubens</i>	
222104	6897876	<i>*Ehrharta</i>	<i>longiflora</i>	
222104	6897876	<i>*Lysimachia</i>	<i>arvensis</i>	
222104	6897876	<i>*Medicago</i>	<i>truncatula</i>	
222104	6897876	<i>*Rostraria</i>	<i>pumila</i>	
222104	6897876	<i>*Sonchus</i>	<i>oleraceus</i>	
222104	6897876	<i>*Urospermum</i>	<i>picroides</i>	
222104	6897876	<i>*Urospermum</i>	<i>picroides</i>	
222105	6899457	<i>*Brassica</i>	<i>tournefortii</i>	
222105	6899457	<i>*Ehrharta</i>	<i>longiflora</i>	
222105	6899457	<i>*Lysimachia</i>	<i>arvensis</i>	
222105	6899457	<i>*Medicago</i>	<i>truncatula</i>	
222105	6899457	<i>*Rostraria</i>	<i>pumila</i>	
222105	6899457	<i>*Urospermum</i>	<i>picroides</i>	
221864	6900129	<i>*Avena</i>	<i>barbata</i>	
221864	6900129	<i>*Ehrharta</i>	<i>longiflora</i>	
221864	6900129	<i>*Lysimachia</i>	<i>arvensis</i>	
221864	6900129	<i>*Medicago</i>	<i>truncatula</i>	
221864	6900129	<i>*Rostraria</i>	<i>pumila</i>	
221864	6900129	<i>*Sonchus</i>	<i>oleraceus</i>	
221864	6900129	<i>*Urospermum</i>	<i>picroides</i>	
221864	6900129	<i>*Urospermum</i>	<i>picroides</i>	
223019	6900189	<i>*Brassica</i>	<i>tournefortii</i>	
223019	6900189	<i>*Bromus</i>	<i>rubens</i>	
223019	6900189	<i>*Lysimachia</i>	<i>arvensis</i>	
223019	6900189	<i>*Sonchus</i>	<i>oleraceus</i>	
223019	6900189	<i>*Urospermum</i>	<i>picroides</i>	
222054	6900511	<i>*Avena</i>	<i>barbata</i>	
222054	6900511	<i>*Brassica</i>	<i>tournefortii</i>	
222054	6900511	<i>*Ehrharta</i>	<i>longiflora</i>	
222054	6900511	<i>*Lysimachia</i>	<i>arvensis</i>	
222054	6900511	<i>*Medicago</i>	<i>truncatula</i>	
222054	6900511	<i>*Rostraria</i>	<i>pumila</i>	
222054	6900511	<i>*Sonchus</i>	<i>oleraceus</i>	
222054	6900511	<i>*Sonchus</i>	<i>oleraceus</i>	
222428	6900903	<i>*Avena</i>	<i>barbata</i>	
222428	6900903	<i>*Brassica</i>	<i>tournefortii</i>	
222428	6900903	<i>*Bromus</i>	<i>rubens</i>	
222428	6900903	<i>*Hypochaeris</i>	<i>glabra</i>	
222428	6900903	<i>*Lysimachia</i>	<i>arvensis</i>	
222428	6900903	<i>*Medicago</i>	<i>truncatula</i>	

Latitude/Easting (GDA94)	Longitude/Northing (GDA94)	Genus	Species	Subsp/Var
222428	6900903	<i>*Sonchus</i>	<i>oleraceus</i>	
222428	6900903	<i>*Urospermum</i>	<i>picroides</i>	
222019	6902625	<i>*Brassica</i>	<i>tournefortii</i>	
222019	6902625	<i>*Ehrharta</i>	<i>longiflora</i>	
222019	6902625	<i>*Lysimachia</i>	<i>arvensis</i>	
222019	6902625	<i>*Medicago</i>	<i>truncatula</i>	
222019	6902625	<i>*Sonchus</i>	<i>oleraceus</i>	
222019	6902625	<i>*Sonchus</i>	<i>oleraceus</i>	
222123.7	6898276	<i>*Chenopodium</i>	<i>murale</i>	
222135.1	6900121	<i>*Chenopodium</i>	<i>murale</i>	
222420.1	6895042	<i>*Chenopodium</i>	<i>murale</i>	
222757.1	6895010	<i>*Chenopodium</i>	<i>murale</i>	
222757.1	6895010	<i>*Melilotus</i>	<i>indicus</i>	
222691.3	6902750	<i>*Urtica</i>	<i>urens</i>	
223140.4	6896874	<i>*Emex</i>	<i>australis</i>	
223140.4	6896874	<i>*Hordeum</i>	<i>leporinum</i>	

APPENDIX 8

Site sheets summarising raw data for quadrats
within the study area

Site	Balline- Site B01
Date	7/09/13
Recorder	JB
Photo	560
Shape/Size	50m x 50m
Datum	GDA 94
Zone	50K
Easting	223317
Northing	6896858
Habitat	Hillcrest (HCR)
Aspect	270°
Slope	Gently Inclined (GE) (1°46' to 5°45')
Soil	Sand
Rock Type	Limestone (outcrops, boulders, cobbles)
% Leaves:Logs	15:1
Vegetation Condition	Very Good
Disturbance Type	Limestone outcropping on hillcrest - upper slope
Fire Age	Fire - Old 5-10yrs
Vegetation	Low Closed Heath of <i>Melaleuca cardiophylla</i> , * <i>Lysimachia arvensis</i> , ^ <i>Beyeria cinerea</i> subsp. <i>cinerea</i> over Very Open Herbs of * <i>Brassica tournefortii</i> , * <i>Anagallis arvensis</i>

Species			% Cover	Height
* <i>Brassica</i>	<i>tournefortii</i>		2	0.2
* <i>Ehrharta</i>	<i>brevifolia</i>	var. <i>cuspidata</i>	<1	0.15
* <i>Hypochaeris</i>	<i>glabra</i>		<1	0.1
* <i>Lysimachia</i>	<i>arvensis</i>		0.5	0.1
* <i>Medicago</i>	<i>truncatula</i>		<1	0.1
* <i>Rostraria</i>	<i>pumila</i>		<1	0.1
* <i>Urospermum</i>	<i>picroides</i>		<1	0.2
^ <i>Beyeria</i>	<i>cinerea</i>	subsp. <i>cinerea</i>	1.5	0.3
<i>Acacia</i>	<i>idiomorpha</i>		1	0.4
<i>Acacia</i>	<i>leptospermoides</i>		1	1.2
<i>Alyogyne</i>	<i>hakeifolia</i>		-	-
<i>Aphanopetalum</i>	<i>clematideum</i>		-	1-1.5
<i>Austrostipa</i>	<i>elegantissima</i>		<1	1.2
<i>Calandrinia</i>	<i>liniflora</i>		<1	0.1
<i>Calandrinia</i>	<i>polyandra</i>		<1	0.2
<i>Calocephalus</i>	<i>francisii</i>		<1	0.03
<i>Carpobrotus</i>	<i>virescens</i>		<1	Cr
<i>Cassytha</i>	<i>aurea</i>	var. <i>hirta</i>	<1	Cl
<i>Casuarina</i>	<i>obesa</i>		-	-
<i>Comesperma</i>	<i>integerrimum</i>		<1	Cl
<i>Cryptandra</i>	<i>arbutiflora</i>		1	0.2
<i>Desmocladius</i>	<i>asper</i>		<1	0.2
<i>Dillwynia</i>	<i>pungens</i>		-	0.5-1
<i>Dioscorea</i>	<i>hastifolia</i>		0.5	Cl
<i>Dioscorea</i>	<i>hastifolia</i>		<1	Cl
<i>Diplolaena</i>	<i>grandiflora</i>		-	1-2
<i>Diplolaena</i>	<i>mollis</i>		1	0.5
<i>Diplopeltis</i>	<i>petiolaris</i>		-	0.5-1
<i>Dodonaea</i>	<i>aptera</i>		-	1-1.5

<i>Species</i>			% Cover	Height
<i>Eremophila</i>	<i>decepiens</i>	subsp. <i>decepiens</i>	-	-
<i>Goodenia</i>	<i>berardiana</i>		<1	0.1
<i>Goodenia</i>	<i>berardiana</i>		<1	0.15
<i>Guichenotia</i>	<i>intermedia</i>		<1	0.4
<i>Hibbertia</i>	<i>spicata</i>	subsp. <i>spicata</i>	1.5	0.4
<i>Lasiopetalum</i>	<i>angustifolium</i>		-	
<i>Lepidosperma</i>	<i>costale</i>		<1	0.3
<i>Melaleuca</i>	<i>campanae</i>		6	0.3-0.5
<i>Melaleuca</i>	<i>cardiophylla</i>		70	0.5-1.2
<i>Olearia</i>	sp. indet		1	0.5-1
<i>Opercularia</i>	<i>spermacocea</i>		<1	0.15
<i>Pimelea</i>	<i>microcephala</i>		1.5	0.5-1
<i>Ptilotus</i>	<i>gaudichaudii</i>	subsp. <i>eremita</i>	<1	0.4
<i>Rhagodia</i>	<i>latifolia</i>	var. <i>latifolia</i>	1.5	0.5-1.1
<i>Rhagodia</i>	<i>latifolia</i>	var. <i>latifolia</i>	<1	0.5-1
<i>Scholtzia</i>	sp. Kalbarri (N. Hoyle 623)		-	1-1.5
<i>Senna</i>	<i>glutinosa</i>	subsp. <i>chatelainiana</i>	-	1-1.5
<i>Tetragona</i>	<i>implexa</i>		<1	CI
<i>Waitzia</i>	<i>suaveleons</i>		<1	0.05
<i>Zygophyllum</i>	<i>fruticosum</i>		<1	0.5-1

Site	Balline- Site B02
Date	7/09/13
Recorder	JB
Photo	573
Shape/Size	50m x 50m
Datum	GDA 94
Zone	50K
Easting	223973
Northing	6897014
Habitat	Hillslope (HSL)
Aspect	290°
Slope	Gently Inclined (GE) (1°46' to 5°45')
Soil	Sand
Rock Type	Limestone (cobbles, pebbles)
% Leaves:Logs	20:10
Vegetation Condition	Good
Fire Age	Fire - Very Old >10yrs
Vegetation	High Shrubland of <i>Acacia rostellifera</i> over Annual Open Tussock Grassland of * <i>Avena barbata</i> , * <i>Ehrharta longiflora</i> , * <i>Bromus rubens</i> with Open Shrubland of <i>Rhagodia latifolia</i> var. <i>latifolia</i> , <i>Pimelea microcephala</i> , <i>Stylobasium spathulatum</i> §

Species			% Cover	Height
* <i>Avena</i>	<i>barbata</i>		6	0.3-0.5
* <i>Brassica</i>	<i>tournefortii</i>		6	0.35
* <i>Bromus</i>	<i>rubens</i>		3	0.15
* <i>Ehrharta</i>	<i>longiflora</i>		5	0.25
* <i>Hypochaeris</i>	<i>glabra</i>		<1	0.15
* <i>Lysimachia</i>	<i>arvensis</i>		1	0.1
* <i>Medicago</i>	<i>truncatula</i>		2	0.1
* <i>Sonchus</i>	<i>oleraceus</i>		1	0.4
* <i>Sonchus</i>	<i>oleraceus</i>		0.5	0.15
* <i>Urospermum</i>	<i>picroides</i>		1	0.15
<i>Acacia</i>	<i>rostellifera</i>		20	2-4
<i>Acanthocarpus</i>	<i>preissii</i>		-	-
<i>Austrostipa</i>	<i>elegantissima</i>		1	1-2
<i>Calandrinia</i>	<i>liniflora</i>		<1	0.05
<i>Clematicissus</i>	<i>angustissima</i>		<1	Cr
<i>Dioscorea</i>	<i>hastifolia</i>		<1	Cl
<i>Erodium</i>	<i>cygnorum</i>		<1	0.3
<i>Euphorbia</i>	<i>sharkoensis</i>		1	Prostrate
<i>Goodenia</i>	<i>berardiana</i>		<1	0.1
<i>Guichenotia</i>	<i>intermedia</i>		<1	0.2
<i>Guichenotia</i>	<i>intermedia</i>		<1	1-1.5
<i>Olearia</i>	sp. indet		<1	1-1.5
<i>Pimelea</i>	<i>microcephala</i>		5	1.5-2.5
<i>Podotheca</i>	<i>gnaphalioides</i>		<1	0.15
<i>Rhagodia</i>	<i>latifolia</i>	var. <i>latifolia</i>	4.5	1.5-2.5
<i>Solanum</i>	<i>oldfieldii</i>		<1	0.35
<i>Stylobasium</i>	<i>spathulatum</i>		3	0.5-1.7
<i>Thysanotus</i>	<i>manglesianus</i>		<1	Cl

Site	Balline- Site B03
Date	8/09/13
Recorder	JB
Photo	578
Shape/Size	50m x 50m
Datum	GDA 94
Zone	50K
Easting	223641
Northing	6895909
Habitat	Hillslope (HSL)
Aspect	270°
Slope	Gently Inclined (GE) (1°46' to 5°45')
Soil	Sand
Rock Type	Limestone (scattered pebbles)
% Leaves:Logs	95:25
Vegetation Condition	Very Good
Disturbance Type	
Fire Age	Fire - Very Old >10yrs
Vegetation	Closed Scrub of <i>Acacia rostellifera</i> over Very Open Annual Tussock Grass of <i>*Ehrharta longiflora</i> over Scattered Herbs of <i>*Sonchus oleraceus</i> , <i>*Brassica tournefortii</i>

Species			% Cover	Height
<i>*Brassica</i>	<i>tournefortii</i>		<1	0.4
<i>*Ehrharta</i>	<i>longiflora</i>		6	0.4
<i>*Sonchus</i>	<i>oleraceus</i>		0.5	0.3-0.6
<i>*Urospermum</i>	<i>picroides</i>		<1	0.3
<i>Acacia</i>	<i>rostellifera</i>		90	4-8
<i>Alyogyne</i>	<i>hakeifolia</i>		<1	CI
<i>Calandrinia</i>	<i>liniflora</i>		<1	0.05
<i>Dioscorea</i>	<i>hastifolia</i>		<1	CI
<i>Guichenotia</i>	<i>intermedia</i>		<1	2
<i>Olearia</i>	sp. indet		<1	1-2
<i>Parietaria</i>	<i>cardiostegia</i>		<1	0.25
<i>Pimelea</i>	<i>microcephala</i>		<1	1

Site	Balline- Site B04
Date	8/09/13
Recorder	JB
Photo	584
Shape/Size	50m x 50m
Datum	GDA 94
Zone	50K
Easting	223148
Northing	6896178
Habitat	Hillslope (HSL)
Aspect	270°
Slope	Moderately Inclined (MO) (5°46' to 18°)
Soil	Sand
Rock Type	Limestone (scattered pebbles)
% Leaves:Logs	12:8
Vegetation Condition	Good
Disturbance Type	
Fire Age	Fire - Moderate 2-5yrs
Vegetation	Shrubland of <i>Acacia rostellifera</i> , <i>Olearia</i> sp. indet., <i>Pimelea macrocephala</i> over Open Annual Tussock Grassland of <i>*Avena barbata</i> , <i>*Bromus rubens</i> , <i>Bromus arenarius</i> with Low Open Shrubland of <i>Olearia</i> sp. indet., <i>Acacia rostellifera</i> , <i>Pimelea macrocephala</i>

Species		% Cover	Height
<i>*Avena</i>	<i>barbata</i>	20	0.4
<i>*Brassica</i>	<i>tournefortii</i>	4	0.35
<i>*Bromus</i>	<i>rubens</i>	1.5	0.2
<i>*Bromus</i>	<i>rubens</i>	<1	0.3
<i>*Ehrharta</i>	<i>longiflora</i>	2	0.2
<i>*Eragrostis</i>	<i>curvula</i>	<1	0.15
<i>*Hypochaeris</i>	<i>glabra</i>	1	0.25
<i>*Lysimachia</i>	<i>arvensis</i>	2	0.1
<i>*Medicago</i>	<i>truncatula</i>	2	0.1
<i>*Sonchus</i>	<i>oleraceus</i>	<1	0.4
<i>*Urospermum</i>	<i>picroides</i>	<1	0.3
<i>*Urospermum</i>	<i>picroides</i>	<1	0.15
<i>Acacia</i>	<i>rostellifera</i>	8	1-2.5
<i>Acanthocarpus</i>	<i>preissii</i>	0.5	0.3
<i>Alyogyne</i>	<i>hakeifolia</i>	<1	CI
<i>Austrostipa</i>	<i>crinita</i>	0.5	0.6
<i>Austrostipa</i>	<i>elegantissima</i>	0.5	0.5-1
<i>Bromus</i>	<i>arenarius</i>	1	0.1
<i>Clematicissus</i>	<i>angustissima</i>	<1	Cr
<i>Dioscorea</i>	<i>hastifolia</i>	<1	CI
<i>Dioscorea</i>	<i>hastifolia</i>	2	0.3
<i>Euphorbia</i>	<i>sharkoensis</i>	1	CI
<i>Goodenia</i>	<i>berardiana</i>	3	0.2
<i>Olearia</i>	sp. indet	7	0.5-1.5
<i>Operculina</i>	<i>spermacocea</i>	<1	0.2
<i>Pimelea</i>	<i>microcephala</i>	4.5	1-2
<i>Ptilotus</i>	<i>divaricatus</i>	<1	1.3

<i>Species</i>			% Cover	Height
<i>Ptilotus</i>	<i>gaudichaudii</i>	subsp. <i>eremita</i>	0.5	1-1.5
<i>Rhagodia</i>	<i>latifolia</i>	var. <i>latifolia</i>	0.5	Prostrate
<i>Scaevola</i>	<i>crassifolia</i>		<1	1-2
<i>Solanum</i>	<i>oldfieldii</i>		0.5	0.3
<i>Thysanotus</i>	<i>manglesianus</i>		-	-
<i>Waitzia</i>	<i>suaveleons</i>		<1	0.1

Site	Balline- Site B05
Date	8/09/13
Recorder	JB
Photo	613
Shape/Size	50m x 50m
Datum	GDA 94
Zone	50K
Easting	222367
Northing	6895061
Habitat	Hillslope (HSL)
Aspect	270°
Slope	Gently Inclined (GE) (1°46' to 5°45')
Soil	Sand
Rock Type	None evident
% Leaves:Logs	20:20
Vegetation Condition	Good
Disturbance Type	
Fire Age	Fire - Very old >10yrs
Vegetation	Shrubland of <i>Pimelea microcephala</i> , <i>Olearia</i> sp. indet., <i>Quoya loxocarpa</i> over Low Shrubland of <i>Pimelea microcephala</i> , <i>Olearia</i> sp. indet., <i>Quoya loxocarpa</i> over Open Annual Tussock Grassland of * <i>Avena barbata</i> , * <i>Ehrharta longiflora</i> with High Open Shrubland of <i>Acacia rostellifera</i>

Species			% Cover	Height
* <i>Avena</i>	<i>barbata</i>		20	0.3-0.5
* <i>Brassica</i>	<i>tournefortii</i>		3	0.2-0.4
* <i>Bromus</i>	<i>rubens</i>		1	0.1
* <i>Ehrharta</i>	<i>longiflora</i>		7	0.2
* <i>Lysimachia</i>	<i>arvensis</i>		2	0.05
* <i>Medicago</i>	<i>truncatula</i>		<1	0.05
* <i>Orobanche</i>	<i>minor</i>		<1	0.15
* <i>Rostraria</i>	<i>pumila</i>		2	0.1
* <i>Sonchus</i>	<i>oleraceus</i>		<1	-
* <i>Urospermum</i>	<i>picroides</i>		<1	0.2
<i>Acacia</i>	<i>rostellifera</i>		3	1-2.5
<i>Austrostipa</i>	<i>elegantissima</i>		<1	1
<i>Cassytha</i>	<i>racemosa</i>	forma <i>racemosa</i>	<1	CI
<i>Commicarpus</i>	<i>australis</i>		<1	CI
<i>Erodium</i>	<i>cygnorum</i>		2	0.2
<i>Euphorbia</i>	<i>sharkoensis</i>		1.5	Prostrate
<i>Euphorbia</i>	<i>tannensis</i>	subsp. <i>eremophila</i>	1	0.2
<i>Goodenia</i>	<i>berardiana</i>		2	0.1
<i>Lechenaultia</i>	<i>linarioides</i>		<1	1
<i>Olearia</i>	sp. indet		8	1-1.5
<i>Pimelea</i>	<i>microcephala</i>		13	1-1.5
<i>Quoya</i>	<i>loxocarpa</i>		10	1-1.8
<i>Rhagodia</i>	<i>latifolia</i>	var. <i>latifolia</i>	1.5	0.5-1
<i>Rhagodia</i>	<i>latifolia</i>	var. <i>latifolia</i>	<1	CI
<i>Solanum</i>	<i>oldfieldii</i>		0.5	0.35
<i>Stylobasium</i>	<i>spathulatum</i>		1	1-2
<i>Tetragona</i>	<i>implexa</i>		<1	CI

<i>Species</i>			% Cover	Height
<i>Threlkeldia</i>	<i>diffusa</i>		<1	0.3
<i>Thysanotus</i>	<i>manglesianus</i>		<1	Cl
<i>Tricoryne</i>	<i>elatoir</i>		0.5	0.5
<i>Waitzia</i>	<i>suaveleons</i>		2	0.1
<i>Zygophyllum</i>	<i>fruticulosum</i>		1	0.5
<i>Zygophyllum</i>	<i>fruticulosum</i>		<1	0.5
<i>Zygophyllum</i>	<i>simile</i>		<1	0.05

Site	Balline- Site B06
Date	9/09/13
Recorder	JB
Photo	659
Shape/Size	50m x 50m
Datum	GDA 94
Zone	50K
Easting	223019
Northing	6900189
Habitat	Hillslope (HSL)
Aspect	90°
Slope	Moderately Inclined (MO) (5°46' to 18°)
Soil	Sand
Rock Type	Limestone
% Leaves:Logs	10:20
Vegetation Condition	Very Good
Disturbance Type	
Fire Age	Fire - Very Old >10yrs
Vegetation	Open Heath of <i>Olearia</i> sp. indet., <i>Acacia</i> <i>rostellifera</i> , <i>Pimelea</i> <i>microcephala</i> over Low Open Shrubland of <i>Acanthocarpus</i> <i>preissii</i> over Very Open Herbs of <i>Goodenia</i> <i>berardiana</i> , * <i>Brassica</i> <i>tournefortii</i> , * <i>Lysimachia</i> <i>arvensis</i> with Scattered Tall Shrubs of <i>Acacia</i> <i>rostellifera</i>

Species			% Cover	Height
* <i>Brassica</i>	<i>tournefortii</i>		2	0.4
* <i>Bromus</i>	<i>rubens</i>		<1	0.2
* <i>Lysimachia</i>	<i>arvensis</i>		2	0.05
* <i>Sonchus</i>	<i>oleraceus</i>		<1	0.2
* <i>Urospermum</i>	<i>picroides</i>		<1	0.1
<i>Acacia</i>	<i>rostellifera</i>		3	2-3
<i>Acanthocarpus</i>	<i>preissii</i>		5	0.4
<i>Austrostipa</i>	<i>nitida</i>		1	1.2
<i>Calandrinia</i>	<i>liniflora</i>		<1	0.05
<i>Clematicissus</i>	<i>angustissima</i>		<1	CI
<i>Comesperma</i>	<i>integerrimum</i>		-	-
<i>Comesperma</i>	<i>scoparium</i>		-	-
<i>Dioscorea</i>	<i>hastifolia</i>		1	CI
<i>Dioscorea</i>	<i>hastifolia</i>		<1	CI
<i>Glycine</i>	<i>canescens</i>		<1	CI
<i>Goodenia</i>	<i>berardiana</i>		5	0.3
<i>Melaleuca</i>	<i>cardiophylla</i>		-	-
<i>Olearia</i>	sp. indet		50	1-2
<i>Operculina</i>	<i>spermacocea</i>		<1	0.25
<i>Phyllanthus</i>	<i>calycinus</i>		<1	0.35
<i>Pilotus</i>	<i>gaudichaudii</i>	subsp. <i>eremita</i>	<1	0.25
<i>Pimelea</i>	<i>microcephala</i>		3	1-1.5
<i>Rhagodia</i>	<i>latifolia</i>	var. <i>latifolia</i>	<1	0.5-1
<i>Rhagodia</i>	<i>latifolia</i>	var. <i>latifolia</i>	2	1-1.5
<i>Schoenia</i>	<i>cassiniana</i>		<1	0.3
<i>Scholtzia</i>	sp. Kalbarri (N. Hoyle 623)		-	-

<i>Species</i>			% Cover	Height
<i>Solanum</i>	<i>oldfieldii</i>		0.5	0.35
<i>Waitzia</i>	<i>suaveleons</i>		0.5	0.1

Site	Balline- Site B07
Date	9/09/13
Recorder	JB
Photo	697
Shape/Size	50m x 50m
Datum	GDA 94
Zone	50K
Easting	222104
Northing	6897876
Habitat	Hillslope (HSL)
Aspect	160°
Slope	Gently Inclined (GE) (1°46' to 5°45')
Soil	Sand
Rock Type	None evident
% Leaves:Logs	25:25
Vegetation Condition	Degraded
Disturbance Type	
Fire Age	Fire - Very Old >10yrs
Vegetation	Open Scrub of <i>Acacia rostellifera</i> over Open Annual Tussock Grassland of * <i>Avena barbata</i> , * <i>Bromus rubens</i> , * <i>Ehrharta longiflora</i> over Open Herbs of * <i>Brassica tournefortii</i> , * <i>Urospermum picroides</i>

Species			% Cover	Height
* <i>Avena</i>	<i>barbata</i>		8	0.35
* <i>Brassica</i>	<i>tournefortii</i>		20	0.3
* <i>Bromus</i>	<i>rubens</i>		6	0.2
* <i>Ehrharta</i>	<i>longiflora</i>		5	0.15
* <i>Lysimachia</i>	<i>arvensis</i>		<1	0.05
* <i>Medicago</i>	<i>truncatula</i>		2	0.1
* <i>Rostraria</i>	<i>pumila</i>		0.5	0.1
* <i>Sonchus</i>	<i>oleraceus</i>		1	0.1
* <i>Urospermum</i>	<i>picroides</i>		<1	0.1
* <i>Urospermum</i>	<i>picroides</i>		1	0.15
<i>Acacia</i>	<i>rostellifera</i>		58	4-6
<i>Acanthocarpus</i>	<i>preissii</i>		<1	0.4
<i>Austrostipa</i>	<i>nitida</i>		<1	0.5
<i>Calandrinia</i>	<i>liniflora</i>		<1	0.05
<i>Convolvulus</i>	<i>remotus</i>		<1	CI
<i>Euphorbia</i>	<i>sharkoensis</i>		<1	Prostrate
<i>Pimelea</i>	<i>microcephala</i>		2	1-2
<i>Rhagodia</i>	<i>latifolia</i>	var. <i>latifolia</i>	1	1
<i>Rhagodia</i>	<i>latifolia</i>	var. <i>latifolia</i>	1	1-2

Site	Balline- Site B08
Date	9/09/13
Recorder	JB
Photo	723
Shape/Size	50m x 50m
Datum	GDA 94
Zone	50K
Easting	222105
Northing	6899457
Habitat	Hillcrest (HCR)
Aspect	270°
Slope	Moderately Inclined (MO) (5°46' to 18°)
Soil	Sand
Rock Type	Limestone (outcrops, cobbles)
% Leaves:Logs	14:18
Vegetation Condition	Good
Disturbance Type	
Fire Age	Fire - Very Old >10yrs
Vegetation	High Shrubland of <i>Melaleuca cardiophylla</i> over Shrubland of <i>Pimelea microcephala</i> , <i>Rhagodia</i> sp. Watheroo (R.J. Cranfield & P.J. Spencer 8183), <i>Diplolaena grandiflora</i> over Very Open Herbs of <i>*Brassica tournefortii</i>

Species			% Cover	Height
<i>*Brassica</i>	<i>tournefortii</i>		5	0.25
<i>*Ehrharta</i>	<i>longiflora</i>		<1	0.15
<i>*Lysimachia</i>	<i>arvensis</i>		<1	0.05
<i>*Medicago</i>	<i>truncatula</i>		<1	0.05
<i>*Rostraria</i>	<i>pumila</i>		1	0.1
<i>*Urospermum</i>	<i>picroides</i>		<1	0.15
<i>Acacia</i>	<i>rostellifera</i>		2	2-3
<i>Austrostipa</i>	<i>nitida</i>		<1	0.4
<i>Calandrinia</i>	<i>liniflora</i>		1	0.05
<i>Clematicissus</i>	<i>angustissima</i>		<1	Cr
<i>Diplolaena</i>	<i>grandiflora</i>		1.5	1-2
<i>Goodenia</i>	<i>berardiana</i>		<1	0.15
<i>Melaleuca</i>	<i>cardiophylla</i>		25	2-4
<i>Nicotiana</i>	<i>rotundifolia</i>		<1	0.3
<i>Olearia</i>	sp. indet		<1	0.5-1
<i>Phyllanthus</i>	<i>calycinus</i>		<1	0.4
<i>Pimelea</i>	<i>microcephala</i>		4	1-1.5
<i>Ptilotus</i>	<i>gaudichaudii</i>	subsp. <i>eremita</i>	1	0.15-0.4
<i>Rhagodia</i>	<i>latifolia</i>	var. <i>latifolia</i>	3	1-2
<i>Rhagodia</i>	<i>latifolia</i>	var. <i>latifolia</i>	1	0.5-1
<i>Zygophyllum</i>	<i>simile</i>		<1	0.05

Site	Balline- Site B09
Date	10/09/13
Recorder	JB
Photo	742
Shape/Size	50m x 50m
Datum	GDA 94
Zone	50K
Easting	222019
Northing	6902625
Habitat	Hillcrest (HCR)
Aspect	320°
Slope	Gently Inclined (GE) (1°46' to 5°45')
Soil	Sand
Rock Type	Limestone (pebbles)
% Leaves:Logs	5:5
Vegetation Condition	Very Good
Disturbance Type	
Fire Age	Fire - Old 5-10yrs
Vegetation	Low Open Heath of Scholtzia sp. Kalbarri (N. Hoyle 623) , Olearia sp. indet., Acanthocarpus preissii over Open Shrubland of Olearia sp. indet., Pimelea microcephala, ^Anthocercis intricata over Scattered Tussock Grassland of Austrostipa elegantissima, Austrostipa crinita

Species			% Cover	Height
* <i>Brassica</i>	<i>tournefortii</i>		1	0.25
* <i>Ehrharta</i>	<i>longiflora</i>		<1	0.2
* <i>Lysimachia</i>	<i>arvensis</i>		<1	0.05
* <i>Medicago</i>	<i>truncatula</i>		<1	0.05
* <i>Sonchus</i>	<i>oleraceus</i>		<1	0.1
* <i>Sonchus</i>	<i>oleraceus</i>		<1	0.2
^ <i>Anthocercis</i>	<i>intricata</i>		<1	1-2
^ <i>Cryptandra</i>	<i>glabriflora</i>		-	-
<i>Acacia</i>	<i>rostellifera</i>		1	0.5-1.5
<i>Acanthocarpus</i>	<i>preissii</i>		6	0.5
<i>Austrostipa</i>	<i>crinita</i>		1	0.5-1
<i>Austrostipa</i>	<i>elegantissima</i>		1	1
<i>Brachyscome</i>	<i>ciliocarpa</i>		<1	0.05
<i>Comesperma</i>	<i>scoparium</i>		3	0.5-1
<i>Desmocladius</i>	<i>asper</i>		-	-
<i>Dioscorea</i>	<i>hastifolia</i>		1	Cl
<i>Dioscorea</i>	<i>hastifolia</i>		3	Cl
<i>Goodenia</i>	<i>berardiana</i>		0.5	0.15
<i>Lomandra</i>	<i>maritima</i>		0.5	0.4
<i>Olearia</i>	sp. indet		8	0.5-1.4
<i>Operculina</i>	<i>spermacocea</i>		1.5	0.15
<i>Phyllanthus</i>	<i>calycinus</i>		0.5	0.4
<i>Phyllanthus</i>	<i>scaber</i>		1	0.4
<i>Pilotus</i>	<i>gaudichaudii</i>	subsp. <i>eremita</i>	<1	0.2
<i>Pimelea</i>	<i>microcephala</i>		2	1
<i>Pimelea</i>	<i>sessilis</i>		3	0.4
<i>Ptilotus</i>	<i>divaricatus</i>		3	0.6

<i>Species</i>			% Cover	Height
<i>Rhagodia</i>	<i>latifolia</i>	var. <i>latifolia</i>	0.5	0.5-1
<i>Rhagodia</i>	<i>latifolia</i>	var. <i>latifolia</i>	3	0.5-1
<i>Rytidosperma</i>	<i>caespitosum</i>		<1	0.15
<i>Salsola</i>	<i>australis</i>		<1	0.35
<i>Scaevola</i>	<i>crassifolia</i>		-	-
<i>Scaevola</i>	<i>tomentosa</i>		1	0.6
<i>Scholtzia</i>	sp. Kalbarri (N. Hoyle 623)		12	0.65
<i>Solanum</i>	<i>oldfieldii</i>		<1	0.2
<i>Stylobasium</i>	<i>spathulatum</i>		1	0.5-2
<i>Tetragona</i>	<i>implexa</i>		1	CI
<i>Waitzia</i>	<i>suaveleons</i>		<1	0.1
<i>Zygophyllum</i>	<i>fruticulosum</i>		2.5	0.5

Site	Balline- Site B10
Date	10/09/13
Recorder	JB
Photo	760
Shape/Size	50m x 50m
Datum	GDA 94
Zone	50K
Easting	222054
Northing	6900511
Habitat	Hillslope (HSL)
Aspect	310°
Slope	Gently Inclined (GE) (1°46' to 5°45')
Soil	Sand
Rock Type	Limestone (scattered pebbles)
% Leaves:Logs	20:25
Vegetation Condition	Good
Disturbance Type	Fire _ Old 5-10yrs
Fire Age	
Vegetation	Shrubland of <i>Acacia rostellifera</i> , <i>Rhagodia latifolia</i> var. <i>latifolia</i> , <i>Pimelea microcephala</i> over Very Open Annual Tussock Grassland of * <i>Avena barbata</i> over Very Open Herbs of * <i>Brassica tournefortii</i> , * <i>Medicago truncata</i> with Scattered Tall Shrubs of <i>Acacia rostellifera</i>

Species			% Cover	Height
* <i>Avena</i>	<i>barbata</i>		6	0.35
* <i>Brassica</i>	<i>tournefortii</i>		6	0.25
* <i>Ehrharta</i>	<i>longiflora</i>		<1	0.2
* <i>Lysimachia</i>	<i>arvensis</i>		1	0.05
* <i>Medicago</i>	<i>truncatula</i>		1	0.05
* <i>Rostraria</i>	<i>pumila</i>		0.5	0.1
* <i>Sonchus</i>	<i>oleraceus</i>		1	0.2
* <i>Sonchus</i>	<i>oleraceus</i>		0.5	0.15
<i>Acacia</i>	<i>rostellifera</i>		24	1-4
<i>Austrostipa</i>	<i>crinita</i>		<1	0.7
<i>Euphorbia</i>	<i>sharkoensis</i>		0.5	Prostrate
<i>Jasminum</i>	<i>calcareum</i>		<1	Cl
<i>Phyllanthus</i>	<i>calycinus</i>		0.5	0.3
<i>Pilotus</i>	<i>gaudichaudii</i>	subsp. <i>eremita</i>	<1	0.15
<i>Pimelea</i>	<i>microcephala</i>		1	1-1.5
<i>Ptilotus</i>	<i>divaricatus</i>		<1	0.6
<i>Rhagodia</i>	<i>latifolia</i>	var. <i>latifolia</i>	1	1-2
<i>Rhagodia</i>	<i>latifolia</i>	var. <i>latifolia</i>	8	1-1.5

Site	Balline- Site B11
Date	10/09/13
Recorder	JB
Photo	765
Shape/Size	50m x 50m
Datum	GDA 94
Zone	50K
Easting	222428
Northing	6900903
Habitat	Hillslope (HSL)
Aspect	120°
Slope	Gently Inclined (GE) (1°46' to 5°45')
Soil	Sand
Rock Type	Limestone (scattered pebbles)
% Leaves:Logs	10:7
Vegetation Condition	Very Good
Disturbance Type	
Fire Age	Fire - Very Old >10yrs
Vegetation	Low Open Heath of <i>Melaleuca cardiophylla</i> , <i>Comesperma scoparium</i> , <i>Scholtzia</i> sp. <i>Kalbarri</i> (N. Hoyle 623) over Open Shrubland of <i>Melaleuca cardiophylla</i> over Very Open Herbs of * <i>Medicago truncata</i> , * <i>Brassica tournefortii</i>

Species			% Cover	Height
* <i>Avena</i>	<i> barbata</i>		<1	0.2
* <i>Brassica</i>	<i> tournefortii</i>		B01.05	0.2
* <i>Bromus</i>	<i> rubens</i>		<1	0.2
* <i>Hypochaeris</i>	<i> glabra</i>		<1	0.1
* <i>Lysimachia</i>	<i> arvensis</i>		1	0.05
* <i>Medicago</i>	<i> truncatula</i>		2	0.05
* <i>Sonchus</i>	<i> oleraceus</i>		<1	0.1
* <i>Urospermum</i>	<i> picroides</i>		<1	0.1
<i>Acacia</i>	<i> idiomorpha</i>		<1	0.2
<i>Acacia</i>	<i> rostellifera</i>		<1	1
<i>Acanthocarpus</i>	<i> preissii</i>		4	0.5
<i>Androcalva</i>	<i> gaudichaudii</i>		<1	0.2
<i>Austrostipa</i>	<i> crinita</i>		2	0.4
<i>Clematicissus</i>	<i> angustissima</i>		<1	Cr
<i>Comesperma</i>	<i> scoparium</i>		6	0.5
<i>Cryptandra</i>	<i> arbutiflora</i>		<1	0.2
<i>Desmocladius</i>	<i> asper</i>		<1	0.2
<i>Dioscorea</i>	<i> hastifolia</i>		<1	CI
<i>Erodium</i>	<i> cygnorum</i>		<1	0.1
<i>Euphorbia</i>	<i> sharkoensis</i>		<1	Prostrate
<i>Euphorbia</i>	<i> tannensis</i>	subsp. <i>eremophila</i>	<1	0.4
<i>Goodenia</i>	<i> berardiana</i>		<1	0.2
<i>Hibbertia</i>	<i> spicata</i>	subsp. <i>spicata</i>	<1	0.25
<i>Lomandra</i>	<i> maritima</i>		<1	0.3
<i>Melaleuca</i>	<i> cardiophylla</i>		25	0.5-2
<i>Olearia</i>	sp. indet		1.5	0.5-1
<i>Phyllanthus</i>	<i> calycinus</i>		<1	0.3
<i>Pilotus</i>	<i> gaudichaudii</i>	subsp. <i>eremita</i>	<1	0.2

<i>Species</i>			% Cover	Height
<i>Pimelea</i>	<i>microcephala</i>		1	1-1.5
<i>Pimelea</i>	<i>sessilis</i>		5	0.35
<i>Ptilotus</i>	<i>divaricatus</i>		1	0.4
<i>Ptilotus</i>	<i>eriotrichus</i>		<1	0.3
<i>Rhagodia</i>	<i>latifolia</i>	var. <i>latifolia</i>	2.5	1
<i>Scholtzia</i>	sp. Kalbarri (N. Hoyle 623)		5	0.3
<i>Solanum</i>	<i>oldfieldii</i>		<1	0.3
<i>Zygophyllum</i>	<i>fruticosum</i>		<1	0.3

Site	Balline- Site B12
Date	10/09/13
Recorder	JB
Photo	779
Shape/Size	50m x 50m
Datum	GDA 94
Zone	50K
Easting	221864
Northing	6900129
Habitat	Hillcrest (HCR)
Aspect	250°
Slope	Very Gently Inclined (VG) (0°36' to 1°45')
Soil	Sand
Rock Type	Limestone (pebbles)
% Leaves:Logs	15:20
Vegetation Condition	Good
Disturbance Type	
Fire Age	Fire - Very Old >10yrs
Vegetation	High Shrubland of <i>Acacia rostellifera</i> over Shrubland of <i>Olearia</i> sp. indet., <i>Rhagodia latifolia</i> var. <i>latifolia</i> , <i>Pimelea microcephala</i> over Open Herbland of * <i>Brassica tournefortii</i> , * <i>Sonchus oleracea</i> , <i>Ptilotus gaudichaudii</i> subsp. <i>eremita</i>

Species			% Cover	Height
* <i>Avena</i>	<i> barbata</i>		3	0.4
* <i>Ehrharta</i>	<i> longiflora</i>		2	0.15
* <i>Lysimachia</i>	<i> arvensis</i>		1	0.05
* <i>Medicago</i>	<i> truncatula</i>		1	0.1
* <i>Rostraria</i>	<i> pumila</i>		<1	0.2
* <i>Sonchus</i>	<i> oleraceus</i>		2	0.1
* <i>Urospermum</i>	<i> picroides</i>		1	0.1
* <i>Urospermum</i>	<i> picroides</i>		<1	0.1
<i>Acacia</i>	<i> rostellifera</i>		28	3-5
<i>Alyogyne</i>	<i> hakeifolia</i>		0.5	2-3
<i>Austrostipa</i>	<i> nitida</i>		0.5	1
<i>Convolvulus</i>	<i> angustissimus</i>	subsp. <i> angustissimus</i>	10	0.25
<i>Euphorbia</i>	<i> sharkoensis</i>		<1	Prostrate
<i>Olearia</i>	sp. indet		4	1-2
<i>Paspalidium</i>	<i> reflexum</i>		<1	0.1
<i>Pimelea</i>	<i> microcephala</i>		1.5	1-2
<i>Ptilotus</i>	<i> divaricatus</i>		1	0.6-1.5
<i>Ptilotus</i>	<i> gaudichaudii</i>	subsp. <i> eremita</i>	1	0.2
<i>Rhagodia</i>	<i> latifolia</i>	var. <i> latifolia</i>	1	1.5
<i>Rhagodia</i>	<i> latifolia</i>	var. <i> latifolia</i>	5	1-2
<i>Thysanotus</i>	<i> manglesianus</i>		<1	CI

Site	Balline- Site B13
Date	11/09/13
Recorder	JB
Photo	807/808
Shape/Size	50m x 50m
Datum	GDA 94
Zone	50K
Easting	223705
Northing	6896406
Habitat	Hillslope (HSL)
Aspect	100°
Slope	Gently Inclined (GE) (1°46' to 5°45')
Soil	Sand
Rock Type	Limestone (outcrops, cobbles, boulders)
% Leaves:Logs	30:5
Vegetation Condition	Excellent
Disturbance Type	
Fire Age	Fire - Very Old >10yrs
Vegetation	Low Mallee of Eucalyptus fruticosa, Eucalyptus oraria over Scattered Tall Shrubs of Acacia rostellifera, Pittosporum ligustrifolium over Scattered Low Shrubs of Rhagodia latifolia var. latifolia

Species			% Cover	Height
<i>*Ehrharta</i>	<i>longiflora</i>		<1	0.15
<i>Acacia</i>	<i>rostellifera</i>		<1	0.5-2.5
<i>Austrostipa</i>	<i>elegantissima</i>		<1	1
<i>Calandrinia</i>	<i>liniflora</i>		<1	0.05
<i>Convolvulus</i>	<i>angustissimus</i>	subsp. <i>angustissimus</i>	<1	0.3
<i>Eucalyptus</i>	<i>oraria</i>		10	2.5-4
<i>Eucalyptus</i>	<i>fruticosa</i>		40	2-3
<i>Melaleuca</i>	<i>campanae</i>		<1	1
<i>Monotaxis</i>	<i>bracteata</i>		<1	0.3
<i>Pimelea</i>	<i>microcephala</i>		1	0.5-1
<i>Pittosporum</i>	<i>ligustrifolium</i>		0.5	1-2.5
<i>Ptilotus</i>	<i>divaricatus</i>		<1	0.4
<i>Rhagodia</i>	<i>latifolia</i>	var. <i>latifolia</i>	<1	1
<i>Rhagodia</i>	<i>latifolia</i>	var. <i>latifolia</i>	1	0.5
<i>Zygophyllum</i>	<i>fruticosum</i>		<1	0.5
<i>Zygophyllum</i>	<i>simile</i>		<1	0.05

Site	Balline- Site B14
Date	11/09/13
Recorder	JB
Photo	822
Shape/Size	50m x 50m
Datum	GDA 94
Zone	50K
Easting	223584
Northing	6896845
Habitat	Hillslope (HSL)
Aspect	90°
Slope	Moderately Inclined (MO) (5° 46' to 18°)
Soil	Sand
Rock Type	Limestone (cobbles, pebbles)
% Leaves:Logs	20:12
Vegetation Condition	Very Good
Disturbance Type	
Fire Age	Fire - Very Old >10yrs
Vegetation	Shrubland of <i>Pimelea microcephala</i> , <i>Olearia</i> sp. indet., <i>Rhagodia latifolia</i> var. <i>latifolia</i> with High Open Shrubland of <i>Grevillea commutata</i> , <i>Acacia rostellifera</i> over Very Open Annual Tussock Grassland of <i>Austrostipa elegantissima</i> , <i>Austrostipa crinita</i>

<i>Species</i>			% Cover	Height
<i>*Lysimachia</i>	<i>arvensis</i>		<1	0.05
<i>*Rostraria</i>	<i>pumila</i>		<1	0.15
<i>*Sonchus</i>	<i>oleraceus</i>		<1	0.3
<i>*Sonchus</i>	<i>oleraceus</i>		<1	0.3
<i>*Vulpia</i>	<i>myuros</i>		<1	0.3
<i>Acacia</i>	<i>rostellifera</i>		1	2-4
<i>Acacia</i>	<i>spathulifolia</i>		<1	1-2
<i>Austrostipa</i>	<i>crinita</i>		1	5
<i>Austrostipa</i>	<i>elegantissima</i>		2	1-2
<i>Calandrinia</i>	<i>polyandra</i>		<1	0.15
<i>Clematicissus</i>	<i>angustissima</i>		<1	Cr
<i>Clematicissus</i>	<i>angustissima</i>		0.5	Cl
<i>Convolvulus</i>	<i>angustissimus</i>	subsp. <i>angustissimus</i>	2	0.25
<i>Dioscorea</i>	<i>hastifolia</i>		1	Cl
<i>Diplolaena</i>	<i>mollis</i>		-	-
<i>Diplopeltis</i>	<i>petiolaris</i>		2.5	0.3-1.4
<i>Eremophila</i>	<i>decipiens</i>		<1	1
<i>Goodenia</i>	<i>berardiana</i>		<1	0.2
<i>Grevillea</i>	<i>commutata</i>		1.5	2-2.5
<i>Guichenotia</i>	<i>ledifolia</i>		<1	1-2
<i>Hibbertia</i>	<i>spicata</i>	subsp. <i>spicata</i>	<1	0.4
<i>Hybanthus</i>	<i>floribundus</i>	subsp. <i>floribundus</i>	1	0.5
<i>Melaleuca</i>	<i>cardiophylla</i>		0.5	1-2
<i>Monotaxis</i>	<i>bracteata</i>		1.5	0.35
<i>Myoporum</i>	<i>insulare</i>		1	1.5
<i>Olearia</i>	sp. indet		5	1-2
<i>Operculina</i>	<i>spermacocea</i>		<1	0.2

<i>Species</i>			% Cover	Height
<i>Pimelea</i>	<i>microcephala</i>		8.5	1-2
<i>Ptilotus</i>	<i>divaricatus</i>		2.5	0.4-1
<i>Rhagodia</i>	<i>latifolia</i>	var. <i>latifolia</i>	2	1-2
<i>Rhagodia</i>	<i>latifolia</i>	var. <i>latifolia</i>	1	0.5-1
<i>Scholtzia</i>	sp. Kalbarri (N. Hoyle 623)		1	1-2
<i>Stylobasium</i>	<i>spathulatum</i>		4	1-2.5
<i>Zygophyllum</i>	<i>fruticulosum</i>		3	0.5-1.5

Site	Balline- Site B15
Date	11/09/13
Recorder	JB
Photo	853
Shape/Size	50m x 50m
Datum	GDA 94
Zone	50K
Easting	222509
Northing	6894616
Habitat	Plain (PLA)
Aspect	270°
Slope	Very Gently Inclined (VG) (0°36' to 1°45')
Soil	Medium clay
Rock Type	None evident
% Leaves:Logs	20:2
Vegetation Condition	Very Good
Disturbance Type	
Fire Age	Fire - Very Old >10yrs
Vegetation	Low Woodland of <i>Casuarina obesa</i> over Low Open Shrubland of <i>Sarcocornia blackiana</i> , <i>Frankenia pauciflora</i> , <i>Threlkeldia diffusa</i> over Scattered Annual Tussock Grass of <i>Parapholis incurva</i>

Species			% Cover	Height
<i>*Centaurium</i>	<i>tenuiflorum</i>		<1	0.05
<i>*Parapholis</i>	<i>incurva</i>		1	0.05
<i>Amyema</i>	<i>linophylla</i>		<1	Parasite
<i>Casuarina</i>	<i>obesa</i>		30	2-5
<i>Frankenia</i>	<i>pauciflora</i>		4.5	0.2
<i>Melaleuca</i>	<i>cardiophylla</i>		3	2-3
<i>Melaleuca</i>	<i>viminea</i>	subsp. <i>viminea</i>	-	-
<i>Rhagodia</i>	<i>latifolia</i>	var. <i>latifolia</i>	<1	0.4
<i>Sarcocornia</i>	<i>blackiana</i>		3	0.4
<i>Threlkeldia</i>	<i>diffusa</i>		2	0.1-0.3
<i>Triglochin</i>	<i>mucronata</i>		<1	0.05
<i>Zygophyllum</i>	<i>simile</i>		<1	0.05

**ATTACHMENT 3: GOATER, S AND KNOTT, B (2009).
SUBTERRANEAN FAUNA PILOT SURVEY, DECEMBER 2009.
HADDINGTON RESOURCES LIMITED.**

**Balline Garnet Project, Kalbarri, Western Australia:
Subterranean Fauna Pilot Survey**



December, 2009

2.0 μ m

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INTRODUCTION

Altura Mining Ltd, (Altura) through its wholly owned subsidiary, Australian Garnet Pty Ltd (Australian Garnet) is planning to recover garnet from heavy mineral sands at the Balline Garnet Project, located in a coastal dunal geomorphic system within the Gascoyne region of Western Australia and approximately 40 km south of Kalbarri.

URS (2010) describe the geology, aquifers and general background to the project. The broad details of climate and regional and local surface hydrology have been described by URS (2010). Significantly:

1. Mean summer temperature in the 'low 30s'; mean winter temperature in the low 20s'.
2. Rainfall, essentially winter (but likely to be shifting now to significant summer input?) of 355+ mm pa.
3. The majority of rainfall can be expected to soak into the substrate and only rarely will overland flow be established - and then within sub-catchments no greater than 0.5 km². Flow generally will be from east to west.
4. Land surface has been cleared extensively for pastoral uses but there is a N-S trending limestone ridge with some remnant vegetation within the area.

Aquifers

Within the project area, ground water occurs within the Superficial Formations aquifer which grades conformably into the Tumblagooda Sandstone (URS 2010): URS (2010) describe a single aquifer, with westward discharge. Salinity of the ground water lies within the range 1323 - 6336 mg L⁻¹, i.e. it is brackish, although there is, not surprisingly, evidence of local variation (URS 2010). The salient message at this stage is that an aquifer is present, although its (their?) structure and functioning are unknown. It must be assumed, until there is substantive evidence to the contrary, that a stygofauna will occur, but probably of limited diversity and abundance.

Given these conditions, it was recommended (B. Knott to P. Hughes, 05 October, 2009) that bores within and outside the planned area of mining impact be surveyed for stygofauna, using both sieving method and visual assessment. The area subsequently was sampled Wednesday 16 - Friday 18 December, 2009.

SAMPLING PROGRAM - DECEMBER, 2009:

Fifteen bores were sampled, 11 within the proposed lease area (constructed 6 months prior by Altura Mining Ltd) and 4 external to its boundaries (Figure 1). The bores varied in structure and depth of intersecting the aquifer, including: 3 Production Bores (PB), internal diameter 200 mm with 2 mm slotting; 8 Monitoring Bores (MB), internal diameter 50 mm with 2 mm slotting; 3 private wells on adjacent properties (SIM1, HUT4; HUT3), internal diameter 145 mm with unknown slotting dimensions, and; 1 Main Roads bore (MRB), internal diameter 145 mm with unknown slotting dimensions. Bore characteristics are presented in Table 1.

Water Quality Data Collection:

Physico-chemical water properties: salinity (g/L), pH; temperature (°C), dissolved oxygen concentration (mg/L), and ORP (mV)) were recorded *in-situ* using a YSI 650XL multi-parameter probe lowered the length of the water column. The probe was immersed just below the surface of the groundwater table and rested until readings stabilised before being lowered through the water column, set to record data every 2 seconds with the

integrated depth logging providing depth profiles. Data were downloaded in the field and exported to MS Excel for further analyses. Accounting for bore design, complete water

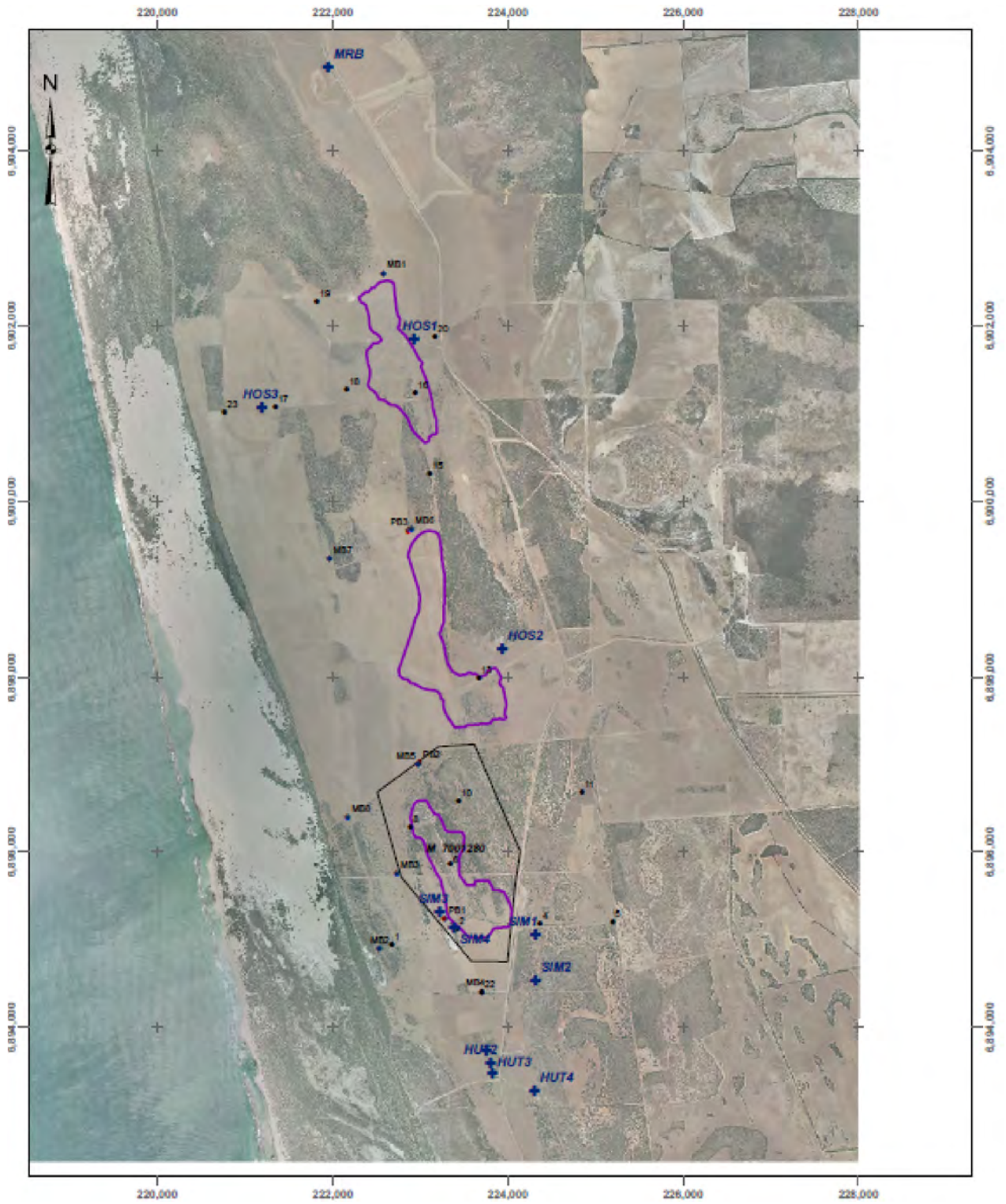


Figure 1: Altura and existing bores.

column data profiles were plotted (Appendix 1) but data presented in Table 2 were extracted from the slotted interface only to remove 'dead' water and best represent surrounding aquifer conditions.

Fauna Data Collection:

Digital Imaging

Prior to net sampling, image sequences were captured from 6 (PB1, PB2, PB3, MRB, SIM1, HUT4) of the 15 bores, as part of on-going equipment trials of a new digital camera developed by UWA - in collaboration with a technical support team from Underwater Video Systems (UVS) and the Water Corporation of WA. The overarching objective is to create an imaging device that can capture stygofauna presence and species assemblage data *in-situ* within a bore hole. The long-term objective is to develop imaging as an alternative, non-lethal, non-destructive sampling technique to netting and pumping currently employed to collect surveillance data. The 6 bores were selected based on having sufficiently large internal diameter (>80 mm) to fit the external dimensions of the camera housing without risk of getting stuck.

The image sequences from the new camera comprise strings of 8 digital frames captured per second (viewed as continuous footage) - but these images can be segregated into individual files. The camera lens is water-corrected so objects in view are real-size although depth of field varies with the size of target object in focus. The camera is equipped with LED lights (no heat source), remotely-operated focus and iris control, a depth sensor to record distance below the water table and 2x strobe capacitors (i.e. flash to take image stills) - all contained within a pressure-proof/water-proof housing. The camera housing connects to a cable which is lowered on a winch system to a maximum depth of 100 m. The digital image sequences are sent real-time to the surface and recorded to an external hard drive *via* a laptop interface. Select image stills were extracted for presentation in this report - full images sequences will be compressed and filed.

Net Sampling

Fauna sampling involved three net hauls of the accessible water column using modified plankton nets (150 μ m mesh) with removable sampling vials designed to fit each bore leaving an annulus of <5 mm and following the protocol as established by the Environmental Protection Authority (2003). Each haul involved lowering the net on a rope to the bottom of the water column, raised then lowered ~1 m to stir benthic organisms from the sediment into the water column, with a resting period of approximately one minute to allow suspended sediment to settle into the net. The net was then drawn gently upwards through the water column to avoid producing a bow wave and to maximise entrainment of animals within the net.

Processing at the bore-site involved decanting water back through the net before specimens were washed into the attached vial using 100% ethanol. This protocol reduced loss of animals that may occur in transfer between vials. The vial was then removed, labelled, sealed and stored in a temperature-controlled container for transport to the laboratory for sorting using a dissecting microscope at 40 x magnifications.

Table 1: Bore identifiers, locations and summary of sampling details. C: camera; WQ: water quality.

DATE	BORE	Within Impact area (Y/N)	EASTING	NORTHING	ID (mm)	Water TABLE	Water COLUMN	YSI SITE NO.	WQ LOG (Y/N)	C. LOG (Y/N)	3 NETS (Y/N)
17/12/09	HUT4	N	0224304.0	6893282.0	145 (?)	15.475	28.36	212	Y	Y	Y
17/12/09	HUT3	N	0223818.0	6893472.1	well	2.5	~1 m pool	213	Y	Y	Y
16/12/09	MB1	Y	0222577.0	6902598.4	50	23.88	31.86	209	Y	N	Y
16/12/09	MB2	N	0222529.9	6894893.4	50	8.05	23.063	205	Y	N	Y
16/12/09	MB3	Y	0222727.3	6895749.2	50	9.69	4.24	204	Y	N	Y
16/12/09	MB4	N	0223697.3	6894405.4	50	9.75 (?)	9.78	206	Y	N	Y
16/12/09	MB5	Y	0222968.0	6897004.4	50	39.91	6.72	202	Y	N	Y
16/12/09	MB6	Y	0222896.3	6899677.4	50	39.7	20	208	Y	N	Y
16/12/09	MB7	N	0221962.1	6899345.2	50	28.44	35.31	207	Y	N	Y
16/12/09	MB8	N	0222171.9	6896394.1	50	18.1	16.31	203	Y	N	Y
17/12/09	MRB	N	0221948.1	6904952.7	145	20.38	83.3	210	Y	Y	Y
16/12/09	PB1	Y	0223274.3	6895235.0	200	4.82	18.815	200	Y	Y	Y
16/12/09	PB2	Y	0222984.2	6897023.8	200	41.17	18.065	201	Y	Y	Y
16/12/09	PB3	Y	0222864.0	6899659.6	200	39.35	29.59	208	Y	Y	Y
17/12/09	SIM1	N	0224314.4	6895068.3	145 (?)	35.06	6.436	211	Y	Y	Y

RESULTS

Water Quality (Table 2)

Depth of the water table varied from 2.5 to 41.2 m with an average across the 15 bores of 22.4 m. Salinity throughout was predominantly in the fresh water range (<3 g/L) but in the two production bores PB 1 and 3, fresh water overlay brackish water at depth (10.34 and 10.12 g/L, respectively (Table 2). Temperatures (ranging from 24.3 - 26.7 °C), pH (ranging from 6.9 - 8.0), and minimum DO concentrations (ranging from 0.2 - 6.0 mg/L) are unlikely to preclude the presence of stygofauna (Table 2).

Water column profiles (Appendix 1)

There is a step within the salinity profile, within the slotting water interface, of bores PB1 (~17 m), PB3 (~18 m), MB1 (~18 m) and MB2 (~15 m), indicating these bores have intersected underlying more saline waters. The salinity profiles of 3 (PB3, MB7, and MB8) out of the 15 bores profiled are erratic and unstable, indicating the water column within these bores are not yet settled since the time of drilling.

Dissolved Oxygen concentration profiles exhibit step in the water column of bores PB3 (~5 m), MB1 (~15 m & ~20 m), MB2 (~10 m & 15 m), MB4 (~5 m), MB5 (~6 m), MB6 (~5 & 15 m), MB7 (~10 & ~20) and MB8 (~5 m & ~15 m). These steps do not always correlate with salinity profile data (where DO changes may be explained by mixing of water layers), and may alternatively indicate water movement or flows at these depths.

MRB has a step in the temperature profile (~20 m) before showing little variation to >100 m depth. This is likely explained by the digital images (appendix 2) where a thick flocculent layer can be observed at the beginning of the image profile sequence.

Fauna - observed and collected

Digital Imaging (Appendix 2)

The image sequences illustrate that the water column of PB1, PB2, PB3 and SIM1 were cloudy and not quite settled yet (when you compare to HUT3 and the bottom of MRB). Not altogether surprising considering the water quality profile data presented above but does not make for ideal conditions for viewing of fauna. Irrespective, active movement of larger fauna would have been distinguishable from sediment movement in PB2, PB3, MRB (the lower part) and HUT3.

Table 2: Water quality data

Date	Row Labels	Slotting (m)	Depth (m)	Salinity (min) (g/L)	Salinity (max) (g/L)	Temp (min) (°C)	Temp (max) (°C)	pH (min)	pH (max)	DO (min) (mg/L)	DO (max) (mg/L)
17/12/09	HUT4	?	15.48	0.46	0.51	25.54	25.7	7.38	7.7	0.47	146
17/12/09	HUT3	open well	0.30	1.62	1.62	24.33	24.34	7.65	7.69	6.85	3
16/12/09	MB1	26.0 - 62.0	31.86	0.05	3.16	24.89	25.42	6.9	7.89	2.3	96
16/12/09	MB2	9.0 - 33.0	23.09	4.72	8.45	25.18	25.54	7.01	7.25	0.32	118
16/12/09	MB3	5.0 - 29.0	4.24	2.94	2.94	25.56	25.7	7.24	7.28	2.51	20
16/12/09	MB4	5.6 - 23.6	9.78	0.78	1.82	25.54	25.8	7.23	7.52	5.52	79
16/12/09	MB5	38.6 - 50.6	6.28	2.54	2.89	26.57	26.66	7.29	7.32	6.03	30
16/12/09	MB6	35.0 - 65.0	20.00	2.83	2.99	25.16	25.43	7.13	7.46	0.96	73
16/12/09	MB7	32.0 - 68.0	35.39	3.33	6.64	25.94	26.16	6.85	6.93	2.17	193
16/12/09	MB8	15.5 - 33.5	16.31	4.2	5.35	25.55	25.81	7.08	7.18	5.03	58
17/12/09	MRB	>100 m	83.34	0.61	0.68	25.76	27.67	6.97	7.25	0.2	337
16/12/09	PB1	5.5-23.5	18.82	2.44	10.34	23.97	24.88	6.77	7.37	0.21	288
16/12/09	PB2	41.0 - 59.0	18.07	3.94	4.63	26.52	26.78	6.86	6.94	0.3	146
16/12/09	PB3	40.6 - 70.6	30.07	2.36	10.12	25.2	25.55	6.59	7.35	0.48	132
17/12/09	SIM1	<5.0 - 6.5	6.44	1.27	1.32	25.78	25.85	7.24	7.53	0.58	47

Net sampling:

Sampling in December 2009 yielded fauna of two broad categories (Table 2): stygofauna, and accidentals of terrestrial origins.

Table 3. Fauna recovered from the 12 bores and three wells sampled at Balline, 40 km south of Kalbarri, Western Australia, 17 December 2009.

<i>SITE</i>	<i>STRUCTURE</i>	<i>FAUNA</i>
MR1	Bore	No fauna
MB1	Bore	No fauna
MB2	Bore	No fauna
MB3	Bore	84 Copepoda; 2 Collembola
MB4	Bore	No fauna
MB5	Bore	No fauna
MB6	Bore	No fauna
MB7	Bore	No fauna
MB8	Bore	16 Collembola sp. 1.
PB1	Bore	1 Spider
PB2	Bore	30 Collembola, 1 Thysanura
PB3	Bore	1 Collembola, sp. 1; 2 spiders (lycosid); spider; 1 Thysanura
HUT3	Well	>200 Ostracoda; 32 Copepoda; 1 oniscoid; mosquito and ceratopogonid larvae
HUT4	Well	Spiders, 2 species including lycosid; 3 Collembola sp. 2
SIM1	Well	Considerable fragments of surface beetles, hemipterans, orthopterans; 1 surface rodent.

Stygofauna

Stygofauna were collected from two sites:

1. Calanoid Copepoda - from MB3 and HUT 3
2. Ostracoda - from HUT3

HUT3 and HUT4 wells are in excess of 1400 m south of the southern edge of the Menari lease, in areas cleared for pastoral activities, and it is highly unlikely that the mining proposed by Altura would have any negative impact on the fauna of these wells.

The pertinent question at this stage is: What is the likelihood for the calanoid copepod from MB3, a *Mesocyclops* sp. to occur within the limited areas to be impacted by mining? Given that no bores have been installed within the immediate areas of impact, but further sampling in winter - with the benefit of sampling under a wetter climate and with the

current bores having the benefit of aging by another 6-9 months, there is no reason to predict that the copepod will not be found elsewhere in the area.

Accidentals

The spiders from bores PB1 and PB3 and the well HUT4 have been identified by Prof B Y Main as follows:

- 2 spiders ex Bore PB3: Clubionidae, Adult ♀ possibly a *Clubiona* species; Gnaphosidae, juvenile. Unable to identify.
- Bore PB2: Gnaphosidae, juvenile, not able to identify. Not the same species as above.
- 6 specimens ex. well HUT 4: 1 Amaurobiidae (family placement varies amongst taxonomists!) ♀, ♀ *Badumna insignis* (Koch). A widespread species, southern Australia.
- 5 very small juveniles (2 sizes), probably of above species.

BYM comments that “None of the species appear to be cavernicolous, probably surface (litter) dwellers.” And, in verbal comment, she thought that all were probably widespread and of little conservation interest.

One species of Collembola was recovered from four bores, namely MB3, MB8, PB2 and PB3, a species with surface affinities (lightly pigmented, eyed).

No bores or wells are situated within the areas of mineralisation and certainly not within the zones predicted for aquifer draw-down. Consequently, it is not possible to state unequivocally there will be no adverse impact of mining on either Stygofauna or deep soil fauna.

However, the evidence from the December 2009 round of sampling is strongly suggestive that any species of either category will be limited in numbers.

DISCUSSION

Notwithstanding the above, only a limited fauna was found about the areas proposed for mining, and there is no biological reason to suspect there will be a fauna localised in the small areas where there will be an impact. It is understood that the mining will reach down below the water table across only a very small portion of the total area being considered for mining. (Figure 2)

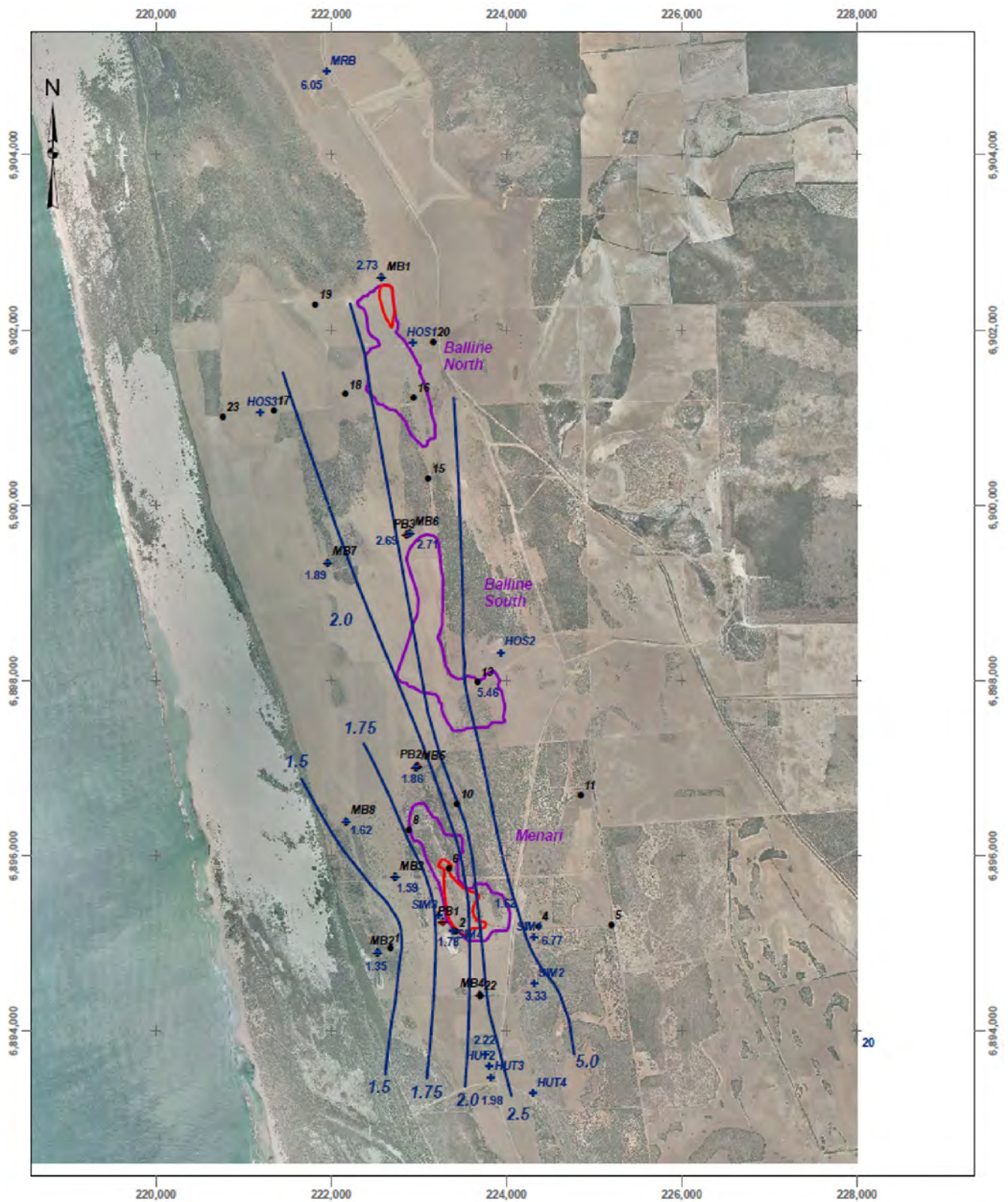


Figure 2: Water Table - October 2009

URS (2010) predict very little impact on the water table caused through the activities of Altura, increasing from a potential head drawdown of <0.1 m near the coast to a drawdown generally <0.3 m. This suggests, at this stage, there will be little deleterious impact on stygofauna directly from mining. Mining activities may cause some compaction of the living space of the stygofauna but this is likely to be confined to the area where the water table is intersected and where there is limited sediment profile above the watertable (but goodness knows how thick this sediment layer needs to be). However, the area of impact from the production bores will need to be considered, when such information becomes available.

A very limited subterranean fauna was recovered from the December 2009 sampling study. Stygofauna, aquatic animals adapted to living permanently underground, were found in just two locations, the well HUT3 and the monitoring bore MB3. Although no short range endemics were collected in litter sampling, there were 3 species of ground-dwelling spiders collected in the stygofaunal sampling programme (PB1, PB3, HUT4) that may be territorial in their behaviour. Several Collembola, lightly pigmented, though eyed occurred in MB3, MB8 and PB2. The taxonomic status of all these stygofaunal and terrestrial forms needs to be established as a matter of priority, given the geographic location of the area to be mined. Then the conservation status of the local stygofauna and terrestrial fauna can be evaluated.

Given the above considerations, the following actions are recommended:

RECOMMENDATION 1

That the bores be resurveyed in winter, i.e. under wetter conditions and with at least a further six months for colonisation to confirm the initial findings from the stage one programme.

These forms may have locally restricted distributions. Hence, the following recommendation is made:

RECOMMENDATION 2

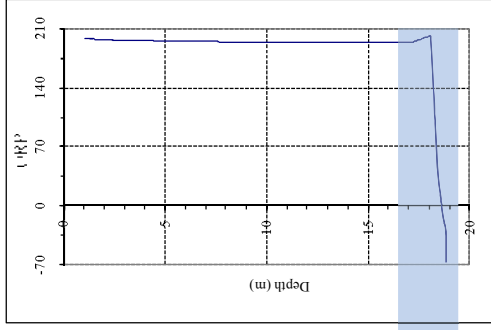
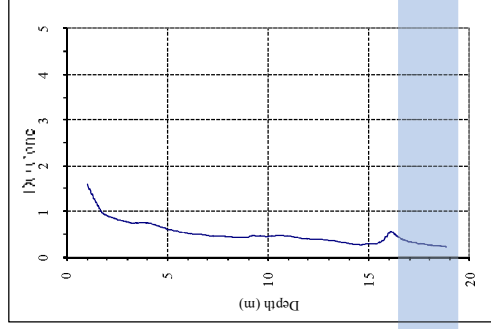
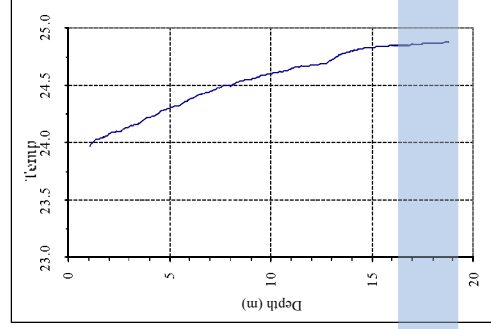
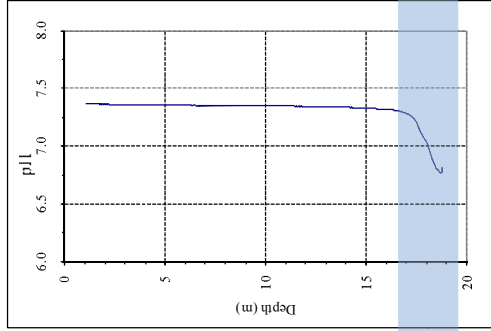
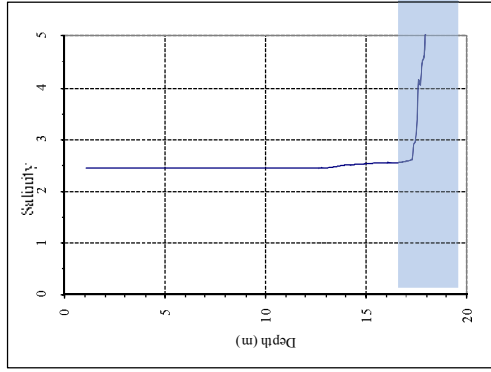
The distribution of the ground-dwelling spiders and the Collembola through the area of impact be assessed simultaneously with a winter sampling of the stygofauna to confirm stage 1 findings.

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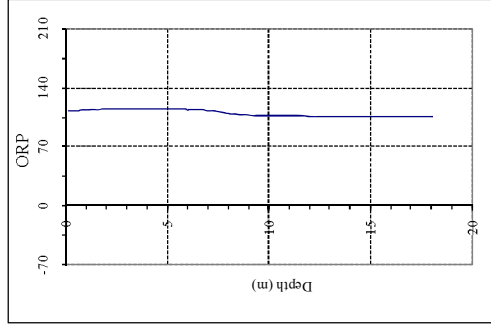
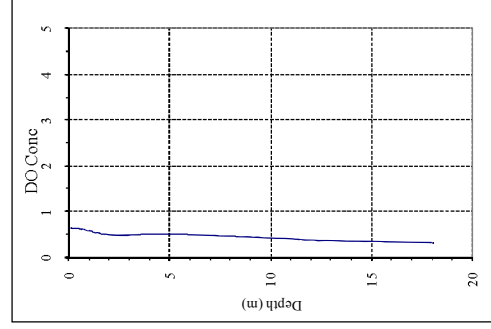
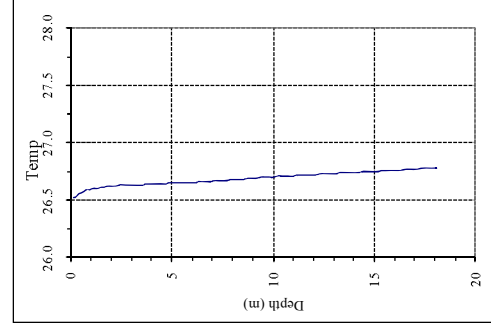
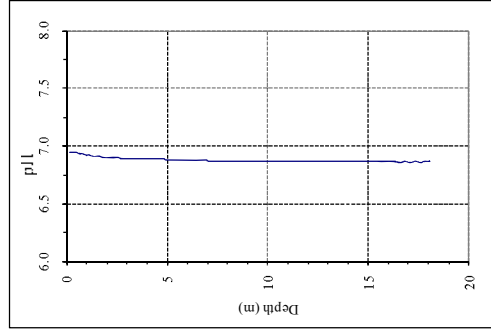
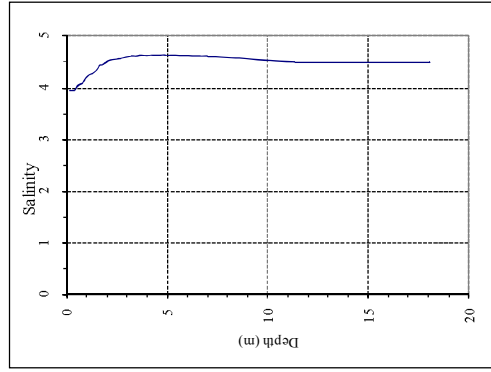
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APPENDIX 1_ WATER COLUMN PROFILES OF PHYSICO-CHEMICAL DATA

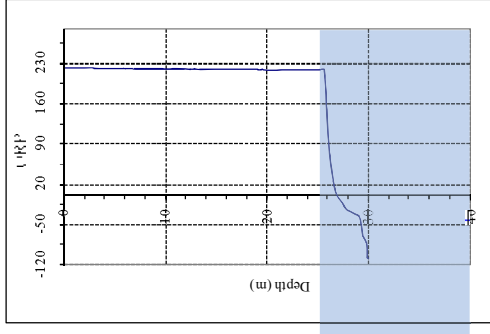
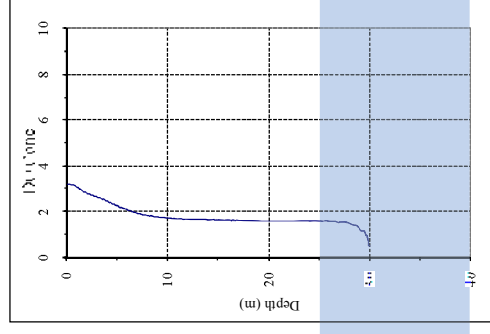
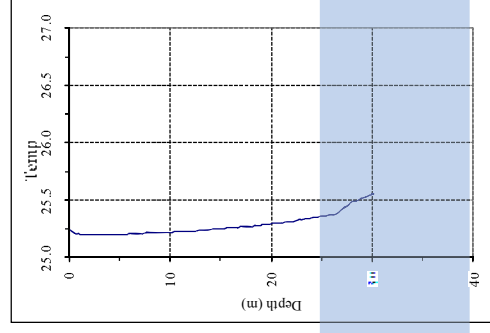
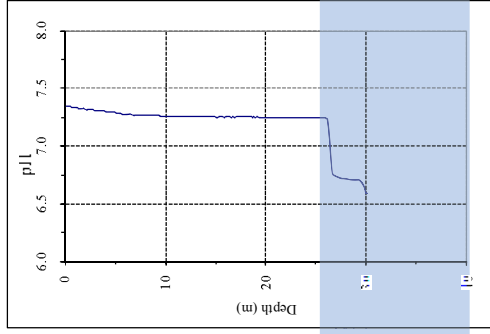
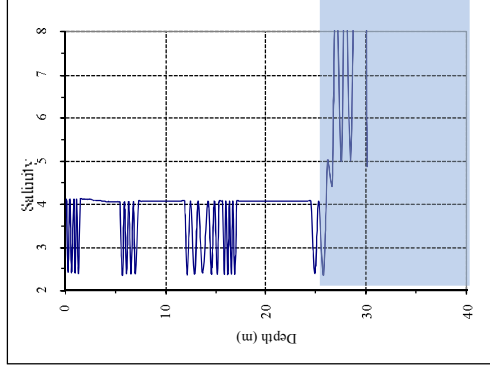


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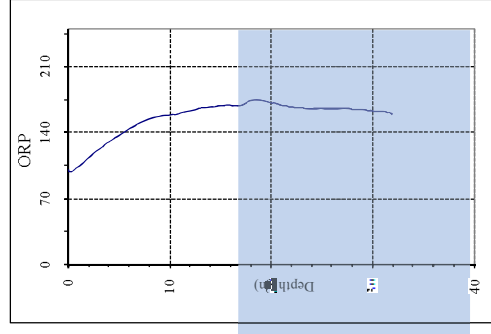
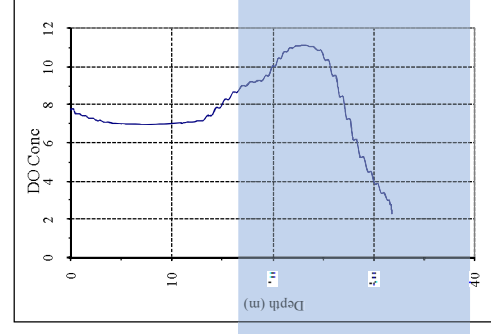
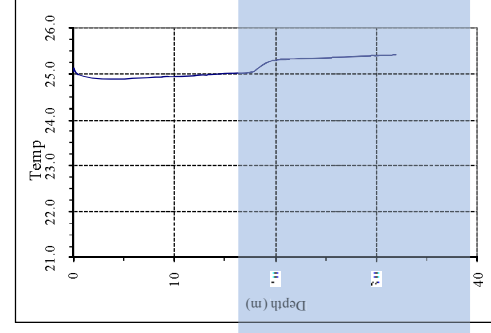
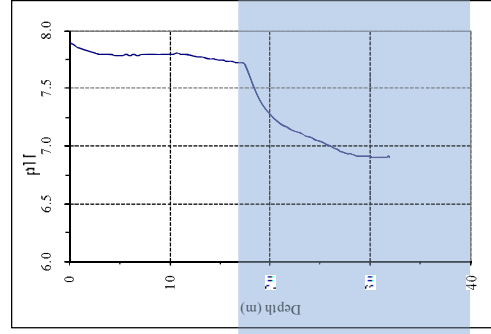
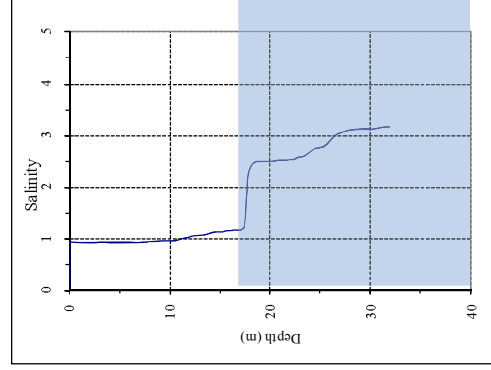


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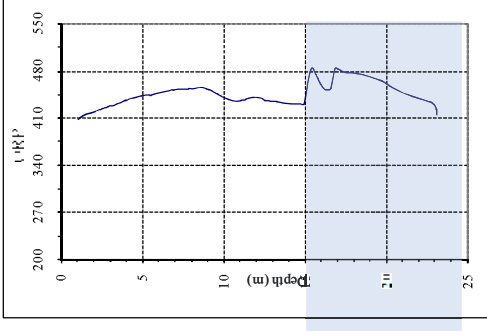
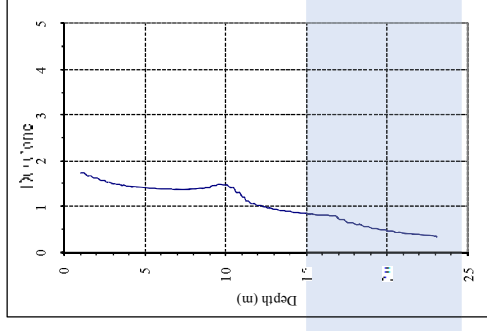
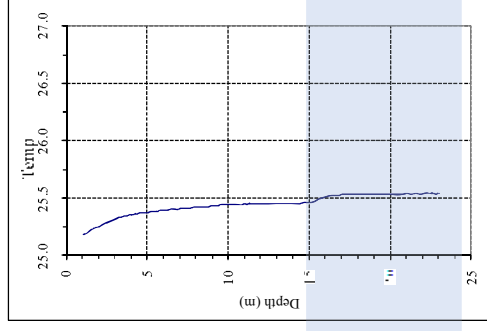
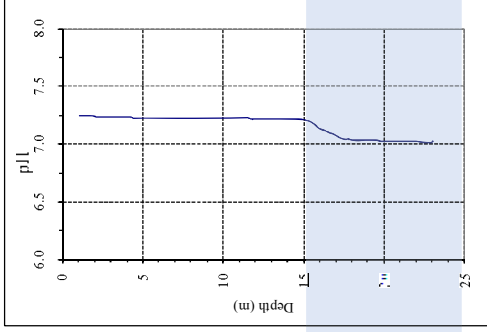
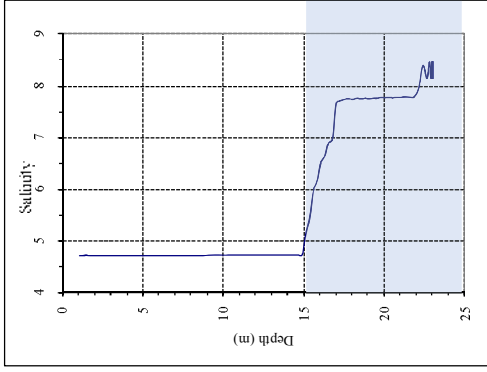


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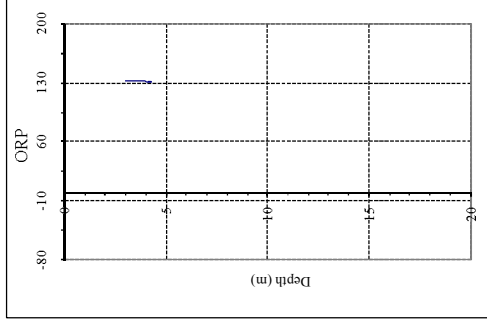
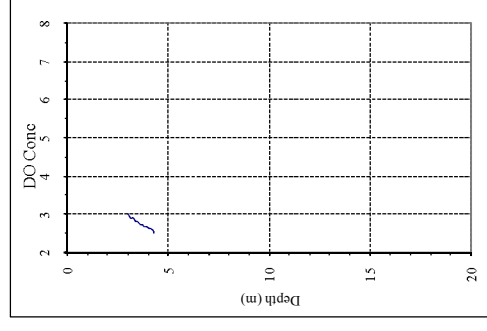
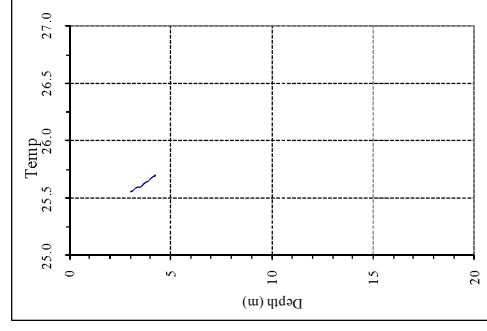
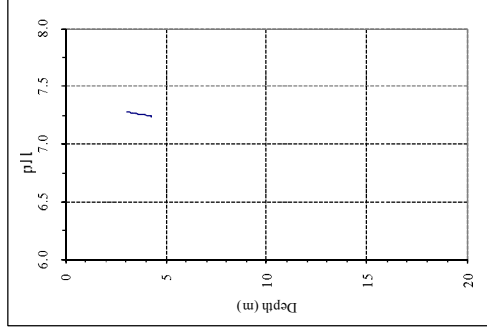
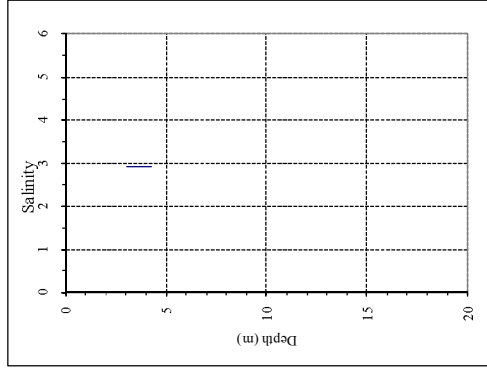


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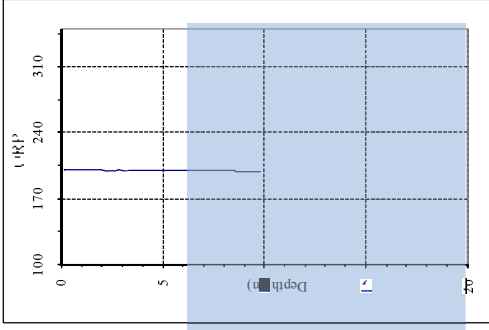
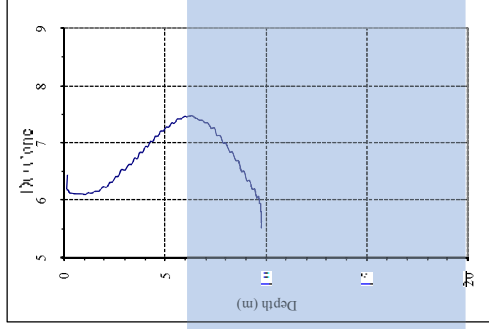
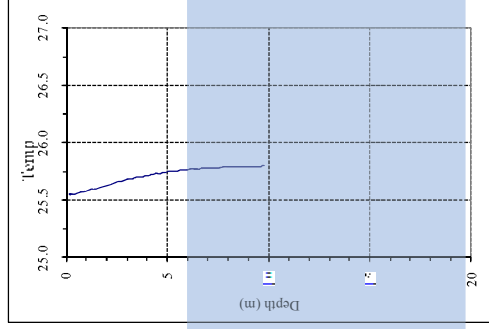
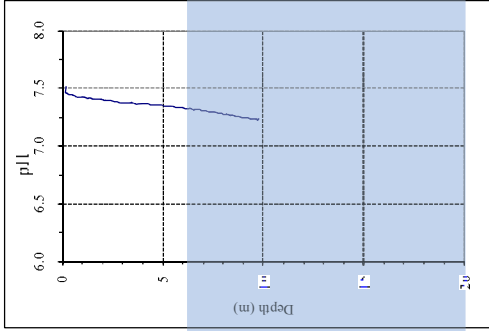
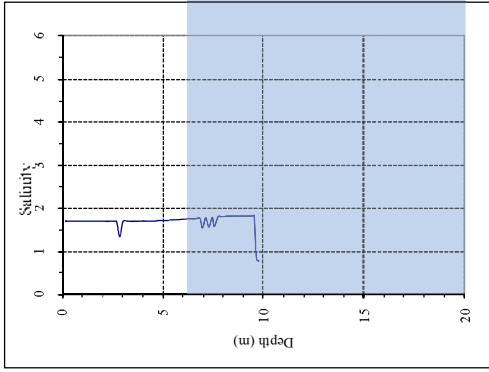


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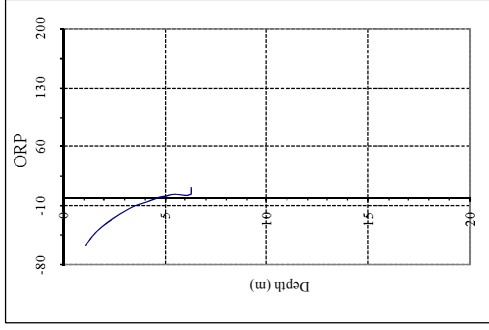
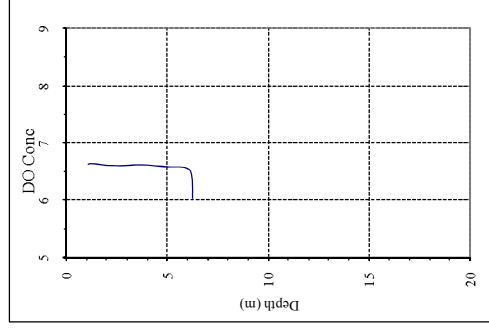
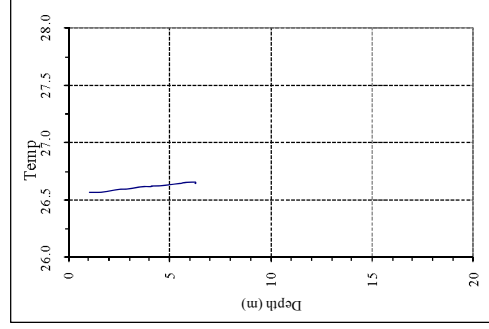
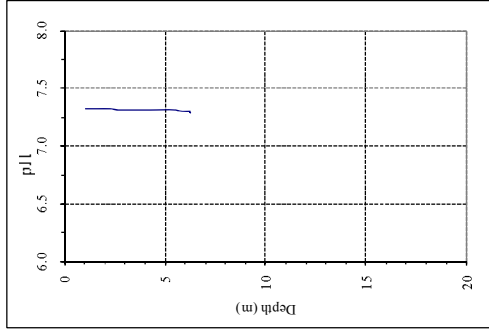
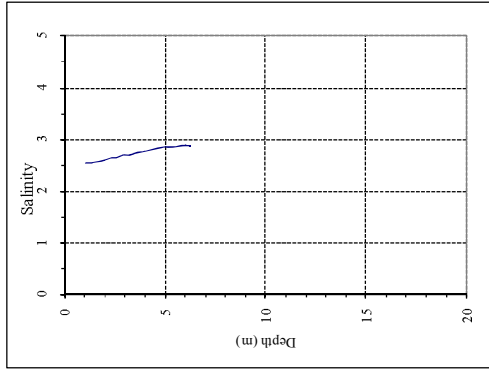


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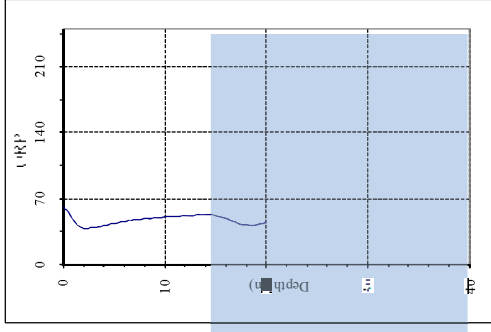
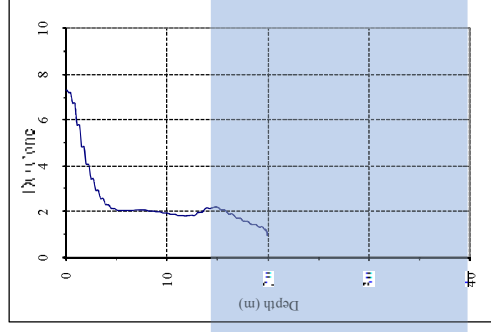
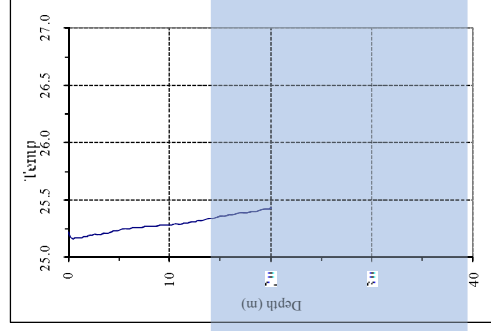
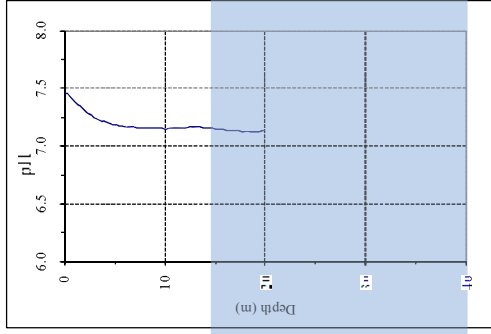
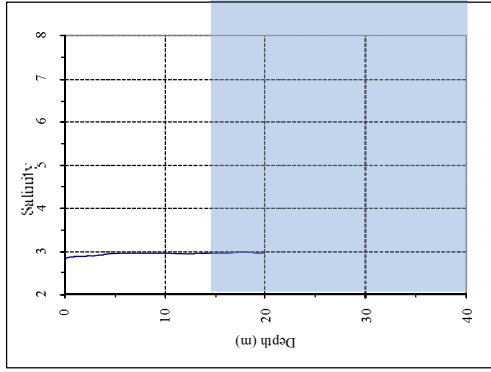


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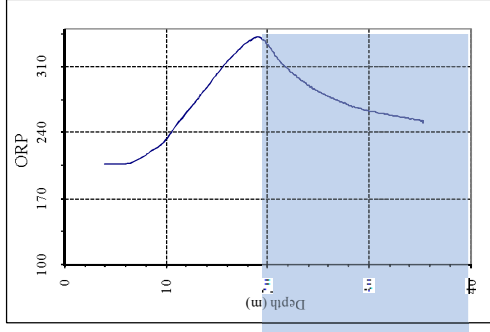
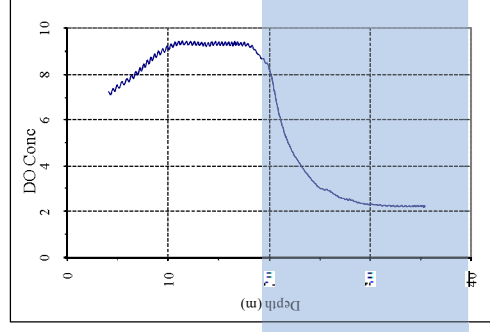
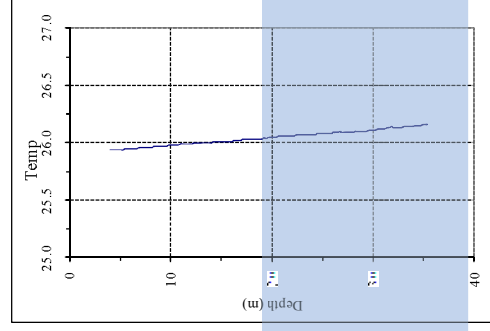
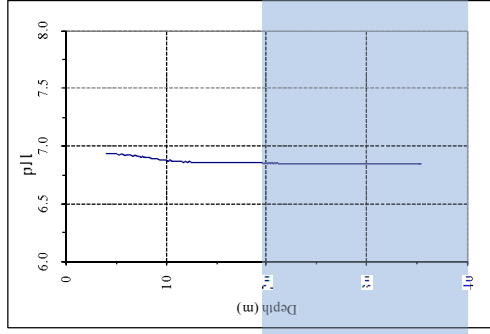
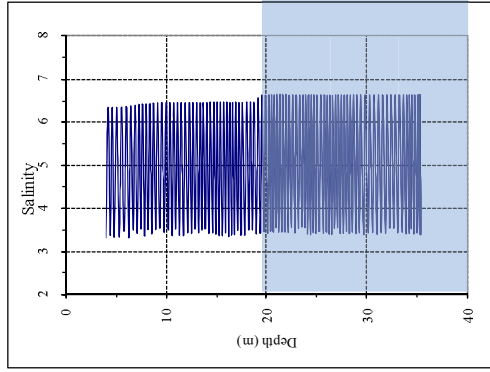


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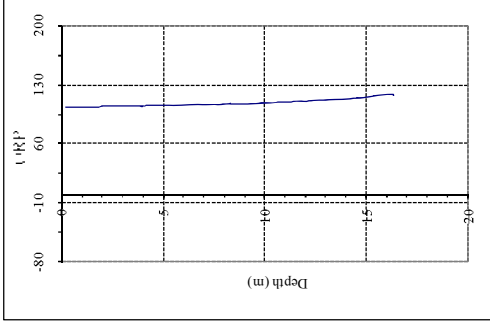
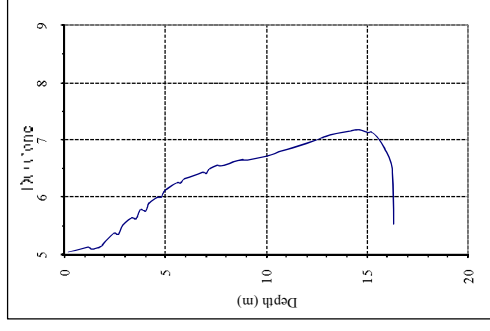
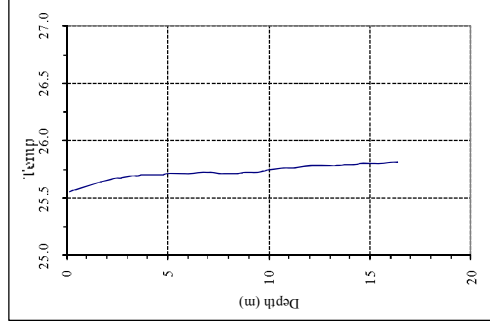
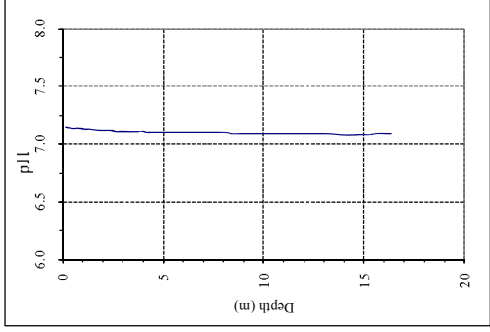
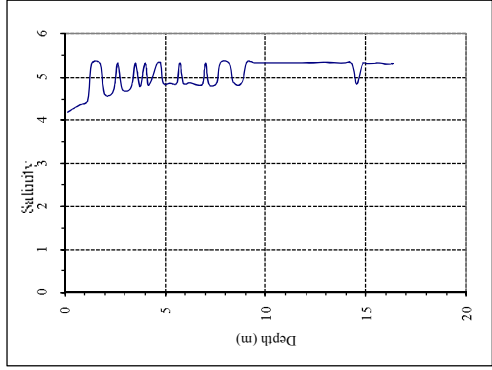


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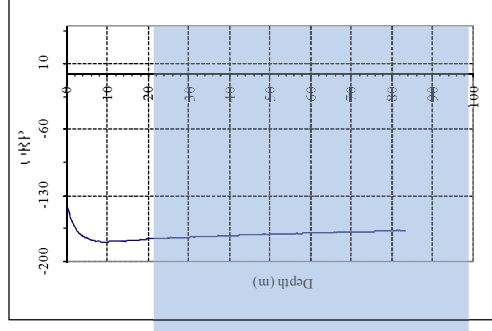
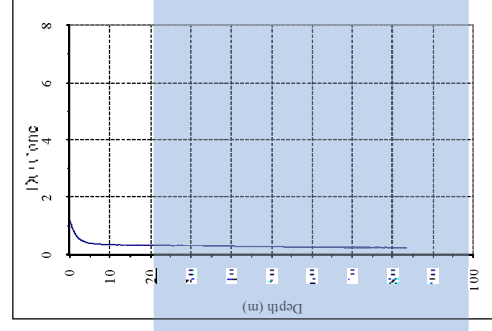
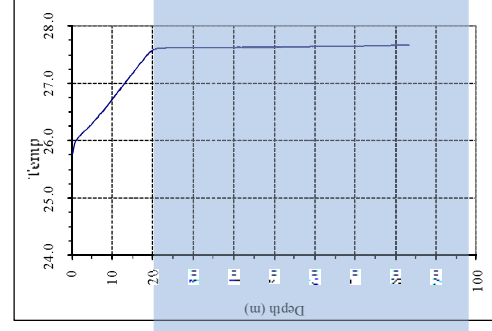
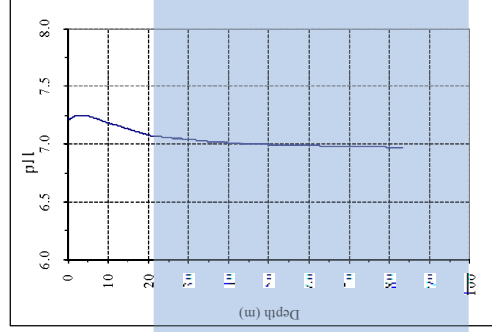
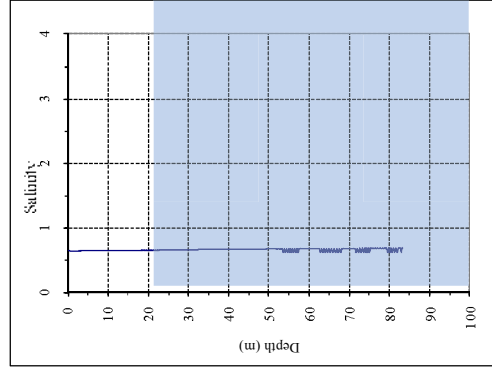


APPENDIX 1_ WATER COLUMN PROFILES OF PHYSICO-CHEMICAL DATA

MB7

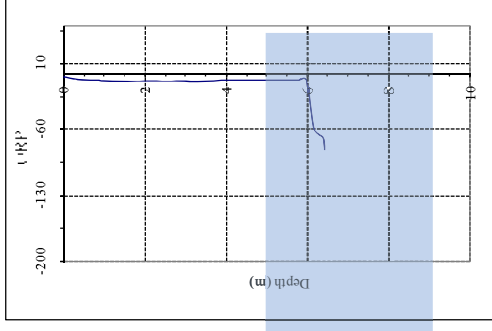
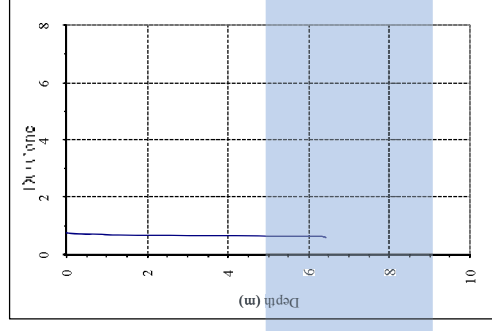
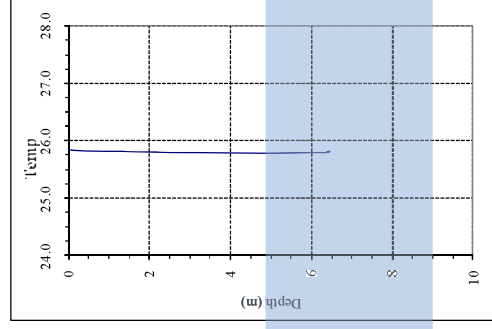
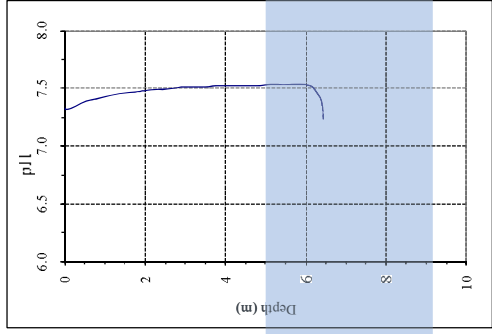
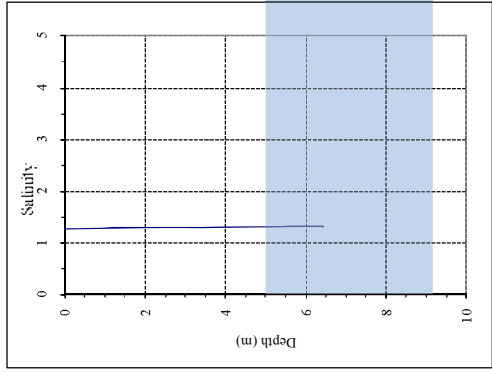


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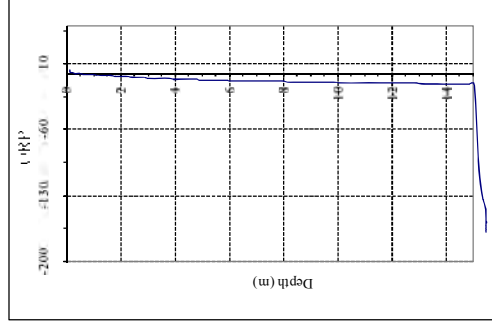
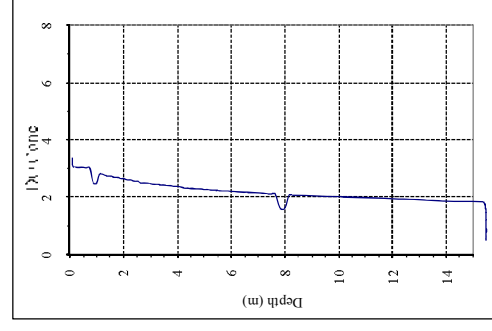
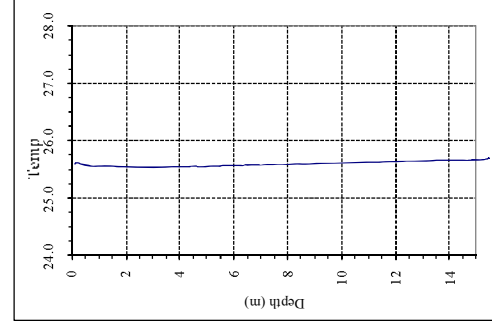
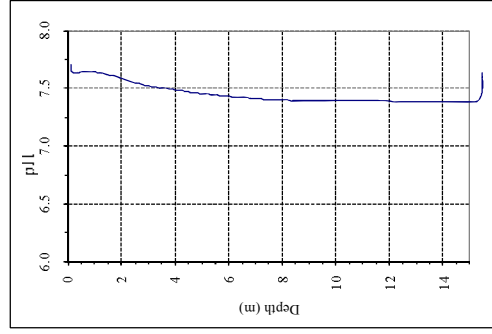
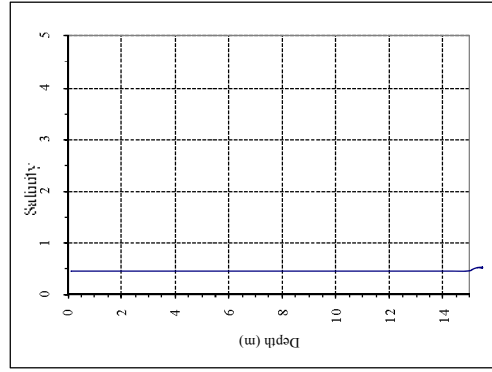


APPENDIX 1_ WATER COLUMN PROFILES OF PHYSICO-CHEMICAL DATA

MRB



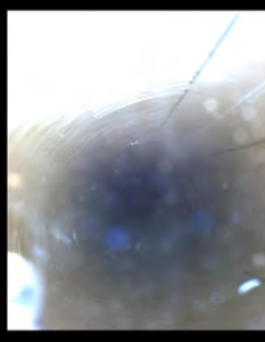
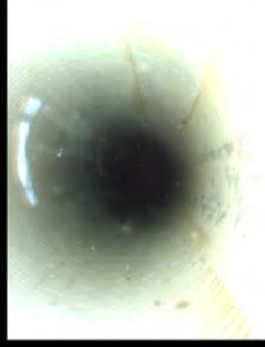
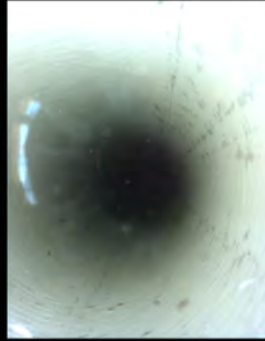
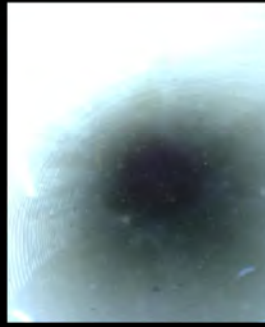
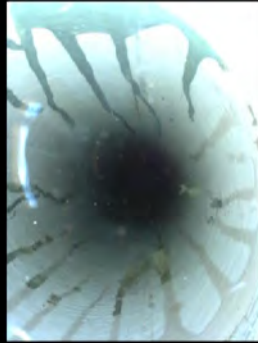
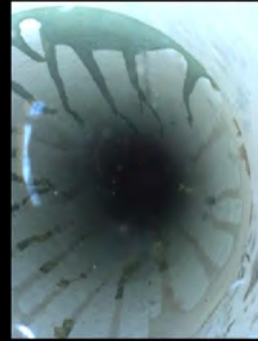
SIM1



**APPENDIX 2_ DIGITAL IMAGING STILLS, COLLECTED WITH INCREASING DEPTH WITHIN THE WATER COLUMN OF
SELECT BORES**

The following pages contain digital images taken from the bores in December 2009.

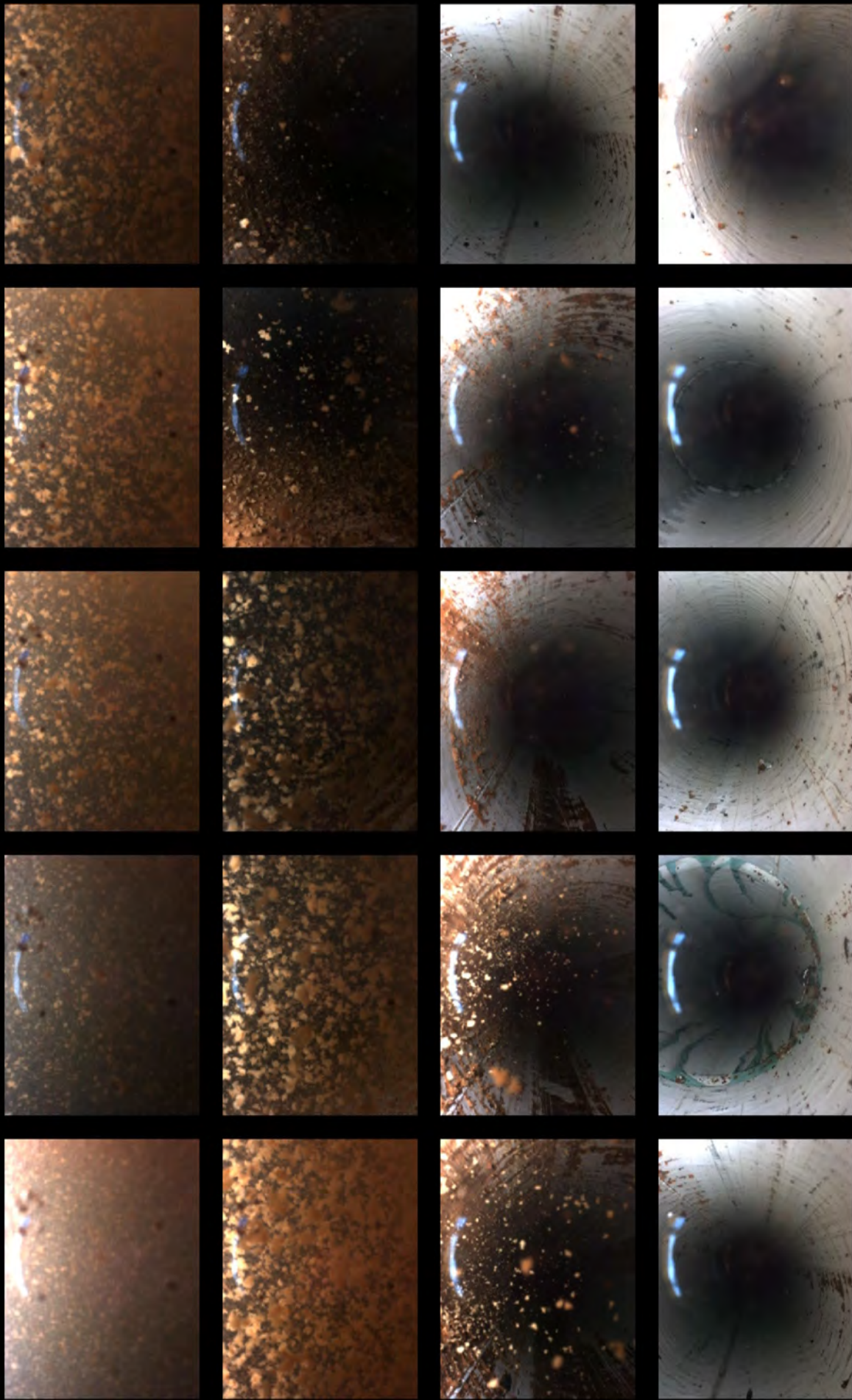
PB2 WATER COLUMN



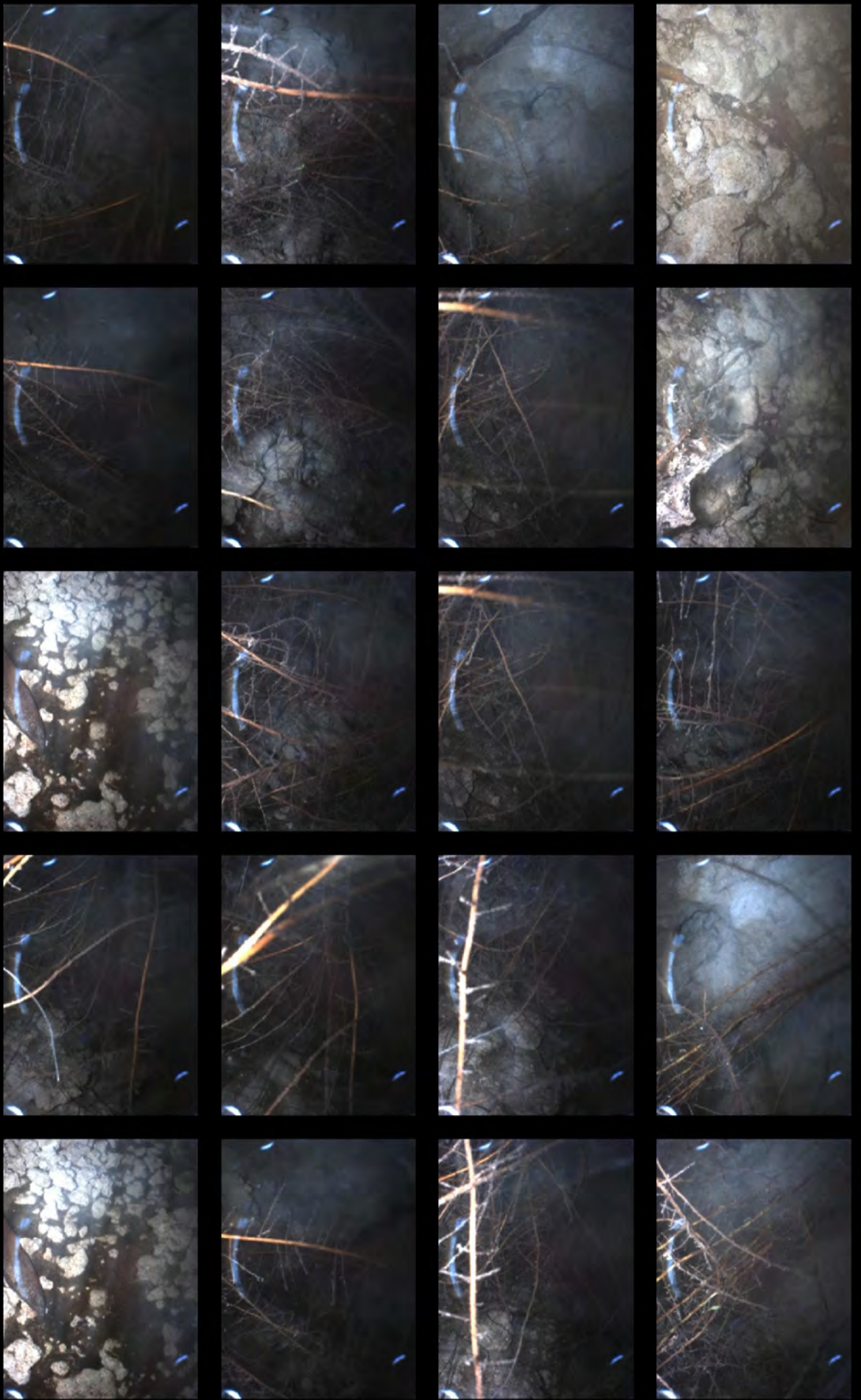
PB2 BOTTOM



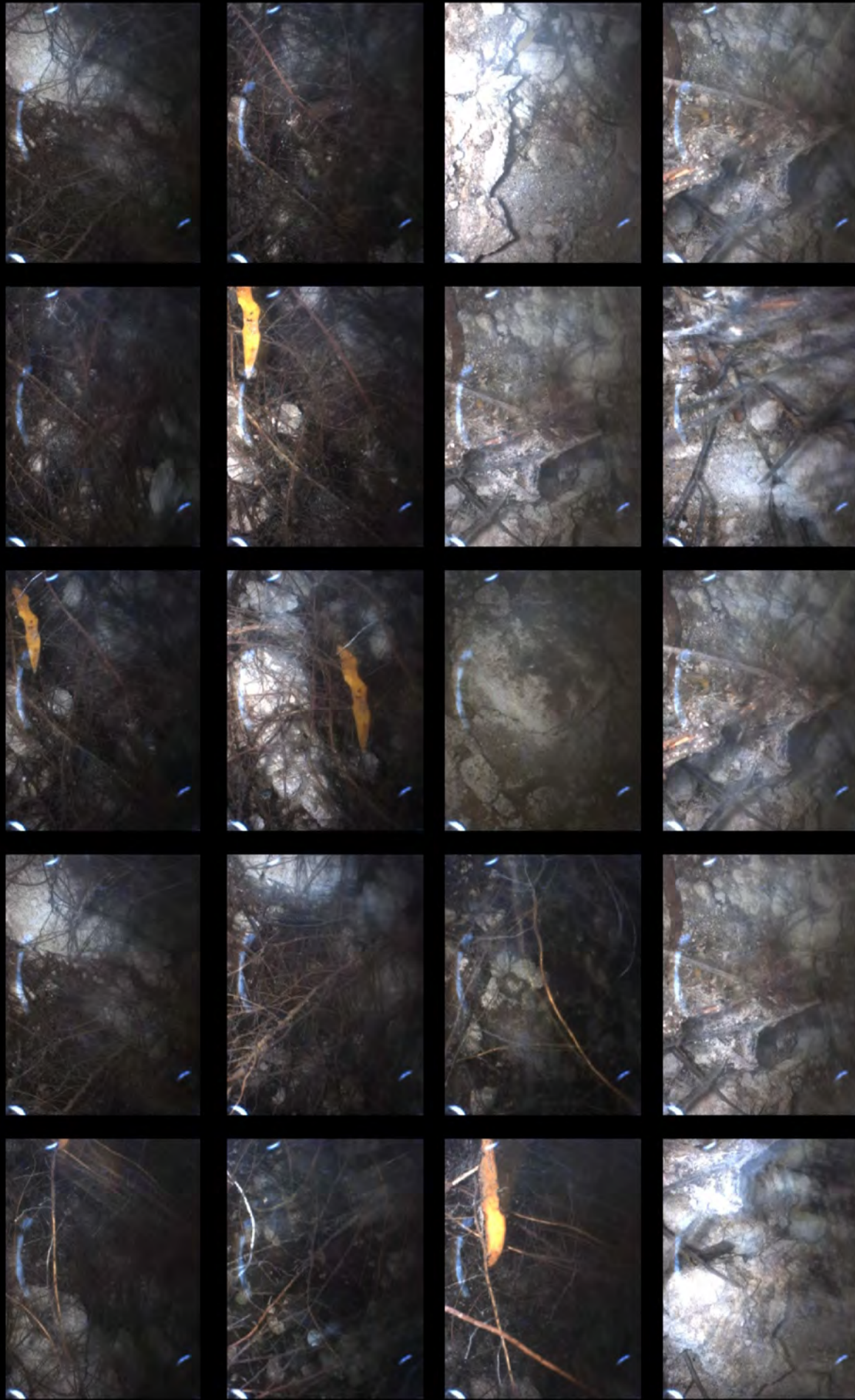
MR1 (MRB NORTH) WATER COLUMN



HUT3 (HOP2)



HUT3 (HOP2)



SIM1

