NORTHERN STAR RESOURCES LIMITED

CLEARING PERMIT SUPPORTING DOCUMENT Crossroads Gold Mine

Prepared By:
Northern Star Resources Limited
Kalgoorlie Operations - Environment Department
May 2023

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF APPENDICES

Appendix A. 1552-Phoenix-CrossroadsProject-Flora-ReportFinal.

Appendix B. 1551-CP-NSR-FAU_Basic-Fauna-Report_final.

Appendix C. 1551_CampoABAB-IHB-survey_Memo_final.

1. INTRODUCTION

1.1 Purpose

This document and accompanying Appendices have been prepared to support the application for a clearing permit (purpose permit), as required by Part V of the *Environmental Protection Act 1986.*

Northern Star Resources Limited (Northern Star) seeks to apply for a **Purpose Permit** to clear up to **350 hectares** of native vegetation on tenements: **M24/462, M24/640, M27/202, G24/40, M27/493** and **M27/497**.

The clearing permit application relates to the proposed Crossroads Gold Mine (the Project) which involves the development of new open cut pits, new Waste Rock Landform (WRL), topsoil stockpiles and associated mining related infrastructure to support the development and ongoing operation of the Project.

A Mining Proposal and Works Approval for this Project are being prepared and will be submitted to the relevant regulators in due course.

1.2 Location and ownership

The Project is located approximately 18km North of the City of Kalgoorlie-Boulder in Western Australia (**Figure 1**).

The following registered tenement holders associated with this Project (**Table 1**) are wholly owned subsidiaries of Northern Star: Northern Star (KLV) Pty Ltd, Northern Star (Saracen Kalgoorlie) Pty Ltd and Northern Star (Kanowna) Pty Limited. ASIC extracts demonstrating this, as well as the corporate structure by entity, can be found in attachment 'ASIC extracts'.

The tenement relating to Cove Mining Pty Ltd and Perilya Ltd (M27/493) is beneficially held by Northern Star (100%). Evidence that NSR is the 100% beneficiary of the Cove Mining Pty Ltd & Perilya Ltd tenement M27/493 can be found in attachment 'Cove and Perilya M27-493'. At the time of submitting this application, the tenement is undergoing a Transfer Duty Assessment with the Office of State Revenue. Once complete a Tenement Transfer will be lodged with DMIRS to update Northern Star as the sole registered holder.

With respect to tenement M27/497, Northern Star and Zebina Minerals Pty Ltd have a Joint Venture agreement in place, the 'Gidji JV'. Under the agreement Northern Star is 80% holder and responsible for management of the JV, with Zebina holding the remaining 20%.

Table 1. Tenement Holders of the Project Area

Tenement	Holder	Expiry Date	Area (ha)
M24/462	NORTHERN STAR (KLV) PTY LTD NORTHERN STAR (SARACEN KALGOORLIE) PTY LTD	23/11/2024	265.70
M24/640	NORTHERN STAR (KANOWNA) PTY LIMITED	20/01/2030	796.09
M27/202	NORTHERN STAR (KANOWNA) PTY LIMITED	05/12/2036	772.35
G24/40	NORTHERN STAR (KLV) PTY LTD NORTHERN STAR (SARACEN KALGOORLIE) PTY LTD	15/04/2040	325.00
M27/493	COVE MINING PTY LTD PERILYA LTD	24/01/2038	686.55
M27/497	NORTHERN STAR (KANOWNA) PTY LIMITED ZEBINA MINERALS PTY LTD	19/092040	600.00

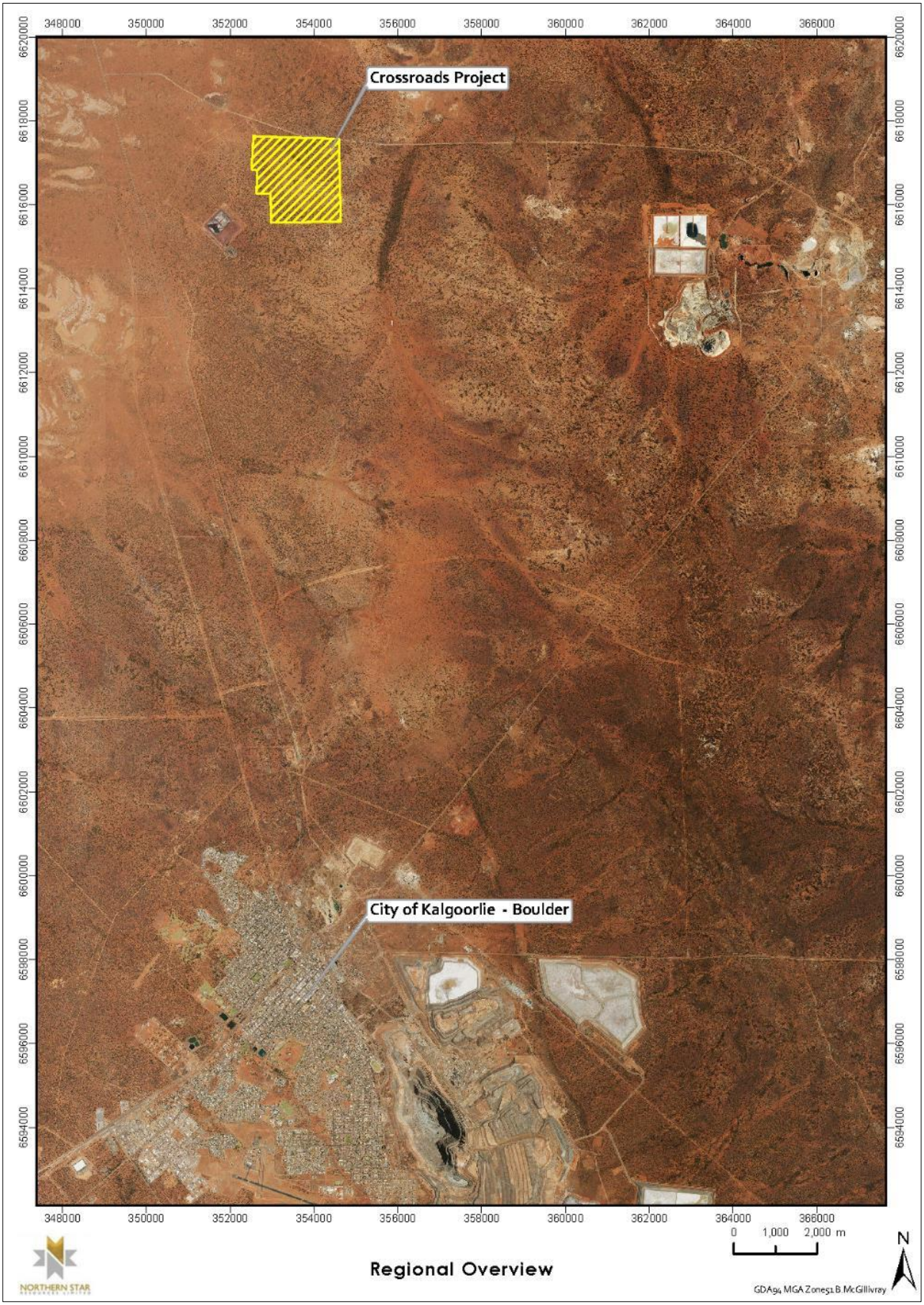


Figure 1. Regional Location Map

1.3 Project Description

The Crossroads Gold Mine is a greenfield project located approximately 18km North of the City of Kalgoorlie-Boulder in the Eastern Goldfields region of Western Australia.

The Project will involve the construction of two to three open cut pits with excavated mine waste rock be disposed of within a new Waste Rock Landform (WRL) to the south-west of the open cut pits. Ore produced will be transported via road trains to Northern Star's Kanowna Belle Processing Plant or KCGM Fimiston Processing Plant.

Vegetation clearing is required for the proposed open cut pits, WRL and other mining related infrastructure to support the development and ongoing operation of the Project. This includes, but is not limited to:

- Run of Mine (ROM) Pad;
- Maintenance workshop, washdown and fuel facilities;
- Administration building, ablution blocks and parking areas;
- Haul roads, access tracks and service corridors;
- Pipelines, powerlines and dewatering infrastructure;
- Magazine storage compound;
- Topsoil and vegetation stockpile areas;
- Safety / abandonment bunds; and
- Water storage facilities (e.g. turkeys nest).

Spatial data (ESRI shapefile format) of the proposed clearing permit boundary area, as depicted in **Figure 2**, have been provided with this application.

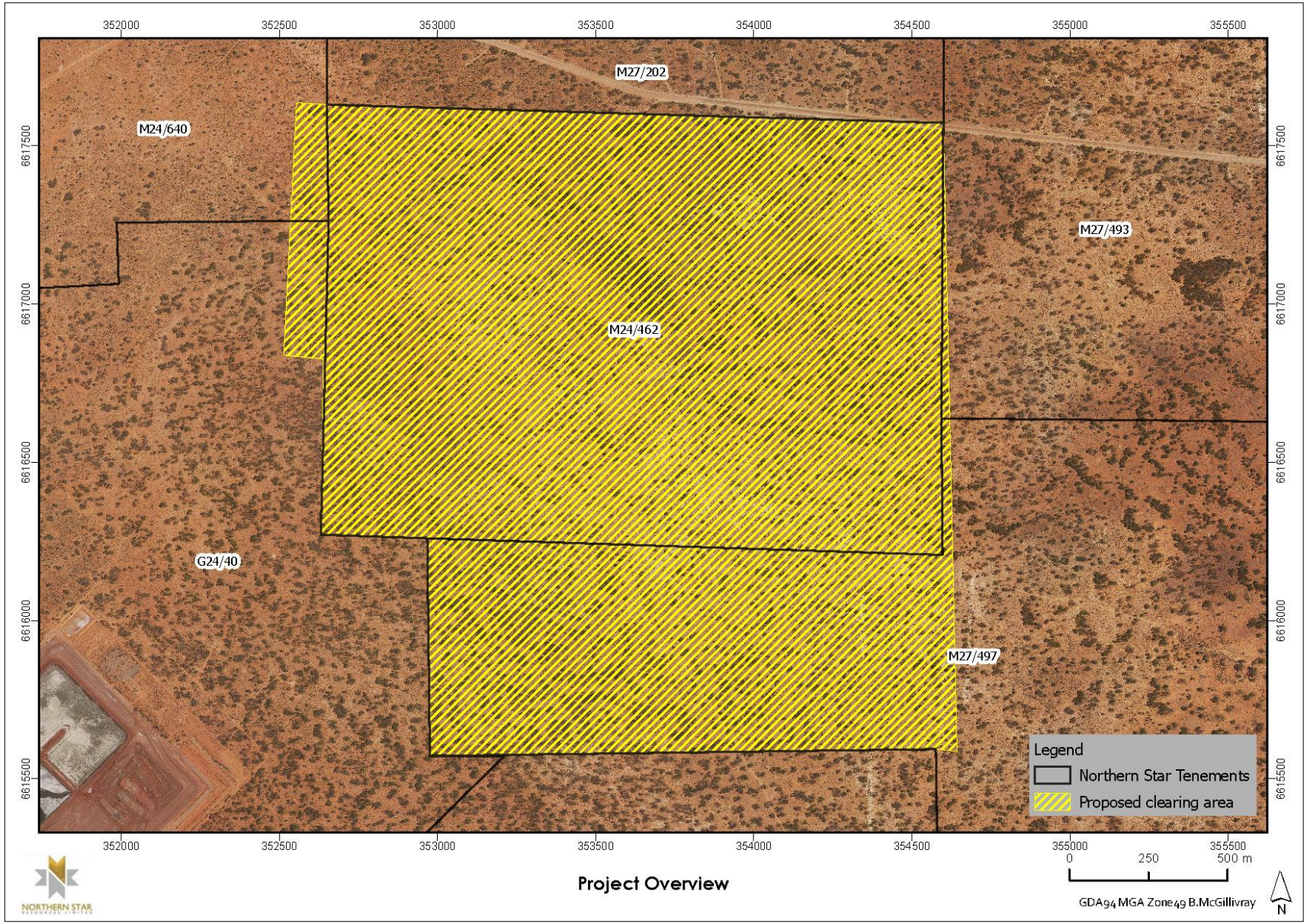


Figure 2. Map of clearing permit application area.

1.4 Flora

A detailed flora survey of the Crossroads Project area was conducted by Phoenix Environmental Sciences in November 2022 (IBSA-2023-0239). A copy of the final report can be found in **Appendix A**.

A total of 86 flora taxa representing 21 families and 45 genera identified to species level were recorded in the study area, 2 specimens could not be identified to species level. The assemblage included 80 native species and 6 introduced species, with 70 perennial species, and 16 annual or short lived species.

Six introduced flora were identified within the survey area, none of which are listed as a Declared Plant under the *Biosecurity and Agriculture Management Act 2007* or a Weed of National Significance (Australian Weeds Committee 2021):

1. *Centaurea melitensis* (Maltese star-thistle);
2. *Monoculus monstrosus* (One-eye monster);
3. *Sonchus oleraceus* (Common sowthistle);
4. *Carrichtera annua* (Wards Weed);
5. *Medicago laciniata* (Cutleaf medic); and
6. *Salvia verbenaca* (Wild Sage).

The condition of remnant vegetation in the study area was recorded from Degraded to Excellent with the majority (80.02%) as Very Good/Excellent condition. Areas in Excellent condition showed no evidence of disturbance. Areas in Very Good condition contained vehicle tracks, litter and the presence of some weeds in low numbers. Good areas showed evidence of historic large scale clearing, litter, the presence of weeds and evidence of feral animals. Degraded areas were more recently large scale cleared, contained litter, weeds and evidence of feral animals.

No Threatened Flora taxa listed under Commonwealth or State legislation were identified within the Assessment Area. The Assessment Area is not located within the boundary of any Threatened or Priority Ecological Communities (PEC). Vegetation types identified are well represented outside of the Assessment Area and are not considered endemic/ restricted to the Assessment Area.

Of the 29 significant flora identified from the desktop assessment to possibly occur in the study area, only one, Eremophila praecox (P2) was recorded during the field survey. This species was previously recorded in close proximity to the study area (Phoenix 2019a, b, 2020b).

A recent survey for Eremophila praecox (Phoenix 2020b) established that the species has a greater distribution than that currently recorded on FloraBase or NatureMap. The species is most frequently recorded in clay loam soils in Eucalyptus and/ or Allocasuarina woodland with a variable understorey, frequently with Acacia and Eremophila species. Phoenix (2020b) recorded a total of 340 Eremophila praecox plants, noting that some records of the species were not visited during the survey as they were not accessible and subsequently the total population size of the species would exceed this figure. Further flora surveys and targeted searches for the species have been conducted (Phoenix 2020a, 2021b, 2022b, c, 2023) and the known population of the species exceeded 481 individuals (Phoenix 2022b) of which 125 plants (ca26%) have been recorded in nature reserves.

The 13 individuals recorded in the current survey increases the known population to in excess of 494 individuals, with the 11 recorded in the study area representing 2.2% of the known population. Priority 2 species are "Species that are known from one or a few locations (generally five or less), some of which are on lands managed primarily for nature conservation, for example, national parks, conservation parks, nature reserves and other lands with secure tenure being managed for conservation" (DBCA 2020). As recent surveys (Phoenix 2020a, 2021b, 2022b, c, 2023) have identified that Eremophila praecox is known from a far greater number of populations than 5 with over a quarter of known plants in conservation reserves the species may be considered more likely to have a status of Priority 3 or lower. Priority 3 species are "Species that are known from several locations and the species does not appear to be under imminent threat or from few but widespread locations with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat" (DBCA 2020).

Due to the small size, it is considered that the Project does not represent any significant threat to the status of any of the significant flora or vegetation identified in the survey.

1.5 Fauna

A basic fauna survey of the Crossroad Project area was conducted by Phoenix Environmental Sciences in November 2022 (IBSA-2023-0196). Targeted surveys for habitat and presence of two significant species, the Arid Bronze Azure Butterfly (C. sp. nr. *Terebrans*) and the Inland Hairstreak Butterfly (*Jalmenus aridus*), were conducted concurrently (IBSA-2023-0203). Copies of these reports can be found in **Appendix B** and **Appendix C**.

During the field fauna survey, 48 vertebrate species were recorded within or just outside the study area, comprising 13 reptiles, 28 birds, and seven mammals, of which three were introduced species. This assemblage represents approximately 14% of those potentially occurring in the region. No conservation significant vertebrate species were recorded.

The study area is considered to have relatively low value as habitat for significant fauna species potentially occurring in the vicinity, including Threatened, Migratory, Specially Protected and Priority vertebrates and SRE invertebrates. No Environmentally Sensitive Areas, Threatened Ecological Communities or Priority Ecological Communities occur within the study area.

The study area was adequately searched for both C. sp. nr. *terebrans* and *Jalmenus aridus*. It is concluded that C. sp. nr. *terebrans* are absent, and consequently no part of the study area represents habitat for the ABAB. 16.2 ha of the study represents potentially suitable habitat for *Jalmenus aridus*; However, this species was not recorded therefore unlikely to be present at the site.

There was no sign of current or former use of the study area by Malleefowl (Leipoa ocellata, VU), and the study area is assessed as Medium to Low suitability for this species. Compared to occupied nesting/ foraging habitat in other regional surveys, the woodland canopy is relatively sparse (limiting shade, and shelter from aerial predators), soil has poor moisture retention and low biomass, and leaf litter is generally disturbed by surface runoff during storms. Malleefowl may use the study area occasionally for foraging/dispersal, but is unlikely to breed there.

2. ENVIRONMENTAL MANAGEMENT & REHABILITATION

The following management recommendations will be incorporated into the planning and development of the Project where appropriate:

- The movement of machines and other vehicles shall be restricted to the limits of the areas to be cleared;
- During site works, areas requiring clearing should be clearly marked and access to other areas restricted to prevent accidental clearing of areas to be retained;
- Topsoil / growth medium vegetation will be stripped and stockpiled separately for later re-use during rehabilitation activities.
- Earth-moving equipment will be free from soil and vegetation prior to and leaving the area to be cleared (wash down facilities are available at the site); and
- Dust suppression activities will be controlled to ensure that surrounding vegetation is not sprayed with saline water.

A Mine Closure Plan (MCP) for the Project will be prepared and submitted to the Department of Mines, Industry Regulation and Safety (DMIRS) in due course. Future revisions of this Mine Closure Plan and proposed rehabilitation strategies will include updated closure information as a result of activities described by this Project.

3. ASSESSMENT AGAINST TEN CLEARING PRINCIPALS

Clearing of vegetation is required for the purpose of developing the Crossroads Gold Mining Project. The total area proposed to clear will not exceed 350 hectares on tenements: M24/462, M24/640, M27/202, G24/40, M27/493 and M27/497. Clearing will be undertaken by mechanical means and kept to the minimum extent necessary to minimise any potential environmental impacts of the project.

Statements against the ten 'clearing principles' as defined in Schedule 5 of the *Environmental Protection Act 1986* have been provided below.

Principle (a) – Native vegetation should not be cleared if it comprises a high level of biological diversity.

Vegetation identified within the Assessment Area is not considered to be of high biological diversity and is well represented outside of the Assessment Area. There are no Threatened or Priority Ecological Communities within the Assessment Area.

Clearing and development within the survey area is unlikely to be at variance to this principle.

Principle (b) – Native vegetation should not be cleared if it comprises a whole or part of, or is necessary for the maintenance of, a significant habitat for fauna indigenous to Western Australia.

The field survey did not record any evidence of the presence of significant fauna within the Assessment Area. The habitat types within the Assessment Area are well represented in the local and broader area and there is direct connectivity from the habitat in the Assessment Area through to the surrounding habitat.

Clearing and development within the survey area is unlikely to be at variance to this principle.

Principle (c) – Native vegetation should not be cleared if it includes, or is necessary for the continued existence of, rare flora.

Eremophila praecox (P2) specimens were recorded in the proposed area of clearing. Eremophila praecox has been found to have a broad distribution and is typically found in low densities in Eucalyptus and/or Casuarina woodlands that are widespread in the surrounding landscape. It is therefore unlikely that disturbance in the study area would impose any significant impact on the habitat of Eremophila praecox.

Clearing and development within the survey area may be at variance to this principle.

Principle (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.

No TEC or PEC listed under the EPBC Act or by the BC Act occur within the Assessment Area.

Clearing and development within the survey area is unlikely to be at variance to this principle.

Principle (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.

The Eucalyptus woodlands recorded in the study area are representative of vegetation association 468 that has more than 98% of pre-European extent remaining and covers large areas (>500,000 ha).

Clearing and development within the survey area is unlikely to be at variance to this principle.

Principle (f) – Native vegetation should not be cleared if it is growing in, or in association with, an environment associated with a watercourse or wetland

No inland waters or drainage lines (perennial or ephemeral) occur within the Assessment Area. No vegetation associated with a watercourse or wetland occur within the Assessment Area.

Clearing and development within the survey area is unlikely to be at variance to this principle.

Principle (g) – Native vegetation should not be cleared if the clearing of the vegetation is likely to cause appreciable land degradation.

The Assessment Area and surrounding region has not been extensively cleared. Clearing within the Assessment Area is not considered likely to lead to land degradation issues such as salinity, water logging or acidic soils.

Clearing and development within the survey area is unlikely to be at variance to this principle.

Principle (h) – Native vegetation should not be cleared if the clearing of vegetation is likely to have an impact on the environmental values of any adjacent or nearby conservation areas.

The Assessment Area is not located within or adjacent to any conservation areas, Environmentally Sensitive Areas or Nationally Important Wetlands.

Clearing and development within the survey area is unlikely to be at variance to this principle.

Principle (i) – Native vegetation should not be cleared if the clearing of the vegetation is likely to cause deterioration in the quality of surface and groundwater.

No inland waters or drainage lines (perennial or ephemeral) occur within the Assessment Area. No vegetation associated with a watercourse or wetland occur within the Assessment Area. According to the DWER groundwater salinity database, groundwater salinities in the Assessment Area range from 30,000 mg/L to 150,000 mg/L. Clearing within the Assessment Area is not expected to significantly affect water quality.

Clearing and development within the survey area is unlikely to be at variance to this principle.

Principle (j) – Native vegetation should not be cleared if clearing the vegetation is likely to cause, or exacerbate, the incidence of flooding.

Rainfall in the Eastern Goldfields subregion has an average rainfall of 200-300mm and an evaporation rate of 2400 mm. Rainfall data for Kalgoorlie-Boulder indicates that rainfall is spread throughout the year and rainfall events are unlikely to result in localised flooding. Clearing within the Assessment Area is not likely to increase the incidence or intensity of flooding within the Assessment Area or surrounds.

Clearing and development within the survey area is unlikely to be at variance to this principle.

4. APPENDICES

Appendix A. 1552-Phoenix-CrossroadsProject-Flora-ReportFinal.

Appendix B. 1551-CP-NSR-FAU_Basic-Fauna-Report_final.

Appendix C. 1551_CampoABAB-IHB-survey_Memo_final.

5. REFERENCES

DBCA. 2020. *Conservation codes for Western Australian flora and fauna*. Department of Biodiversity, Conservation and Attractions, Kensington, WA.

Phoenix. 2019a. Regional flora, vegetation and terrestrial fauna survey for the Gidji Operations. Phoenix Environmental Sciences, Balcatta, WA. Unpublished report prepared for KCGM Operations.

Phoenix. 2019b. Regional survey for Eremophila praecox for the FIM IIE Project. Phoenix Environmental Sciences, Balcatta, WA. Unpublished report prepared for KCGM Pty Ltd.

Phoenix. 2020a. Kambalda West regional flora and fauna survey for the St Ives Gold Mine. Phoenix Environmental Sciences Pty Ltd, Osborne Park, WA. Unpublished report prepared for St Ives Gold Mining Company Pty Ltd.

Phoenix. 2020b. Regional survey for Eremophila praecox for the FIM IIE Project. Phoenix Environmental Sciences Pty Ltd, Osborne Park, W.A. Unpublished report prepared for Kalgoorlie Consolidated Mines Pty Ltd.

Phoenix. 2021a. Baseline flora, vegetation and fauna surveys for the Parker Range Haul Road project - northern extension. Phoenix Environmental Sciences Pty Ltd. Unpublished report prepared for Mineral Resources Ltd.

Phoenix. 2021b. Detailed flora and vegetation and basic/detailed fauna surveys for the Larkinville and Eagles Nest Projects. Phoenix Environmental Sciences Pty Ltd, Osborne Park, WA. Unpublished report prepared for Maximus Resources Ltd.

Phoenix. 2021c. Targeted searches at Hunt Range. Phoenix Environmental Sciences Pty Ltd, Osborne Park, WA. Unpublished report prepared for Mineral Resources Ltd.

Phoenix. 2022a. Desktop assessment and targeted significant flora and vegetation surveys for the Marda Gold Project. Phoenix Environmental Sciences Pty ltd, Osborne Park, Western Australia. Unpublished report prepared for Ramelius Resources Limited.

Phoenix. 2022b. Flora and vegetation assessments for the Fimiston Gold Mine Operations. Phoenix Environmental Sciences Pty Ltd, Osborne Park, WA.

Phoenix. 2022c. Reconnaissance flora and vegetation survey for the Kalgoorlie Operations Project. Phoenix Environmental Sciences Pty Ltd, Osborne Park, Western Australia. Unpublished report prepared for Northern Star Resources Limited.

Phoenix. 2023. Reconnaissance flora and vegetation survey for the regional core yard project. Phoenix environmental Sciences Pty Ltd, Osborne Park, Western Australia. Unpublished report prepared for Northern Star Resources Limited.

Appendix A. 1552-Phoenix-CrossroadsProject-Flora-ReportFinal

PHOENIX
ENVIRONMENTAL SCIENCES

Detailed flora and vegetation survey for the Crossroads Project

Prepared for Northern Star Resources Ltd

May 2023

Final

Detailed flora and vegetation survey for the Crossroads Project

Prepared for Northern Star Resources Ltd

Version history

Author/s	Reviewer/s	Version	Version number	Date submitted	Submitted to
G. Wells	G.G. Wells	Draft for client comments	0.1	16-Mar-23	Y. Hynes
G. Wells	Y. Hynes	Final, client comments addressed	1.0	10-May-23	Y. Hynes

Phoenix Environmental Sciences Pty Ltd

2/3 King Edward Road OSBORNE PARK WA 6017

P: 08 6323 5410

E: admin@phoenixenv.com.au

Project code: 1552-CP-NSR-BOT

EXECUTIVE SUMMARY

Northern Star Resources Ltd (NSR) is conducting studies for the Crossroads Project (the Project), located approximately 20 km north of Kalgoorlie-Boulder in the Eastern Murchison subregion. Phoenix Environmental Sciences (Phoenix) was commissioned by NSR in October 2022 to undertake a detailed flora and vegetation survey for the Project with a study area of approximately 386 hectares. A large section of the current study area had been previously surveyed.

The scope of work for the survey was to conduct a desktop study to gather contextual information, undertake a single season field survey involving revisiting previous survey sites and installation of additional quadrats in unsurveyed areas to map vegetation type and condition, and to undertake targeted searches for significant flora and vegetation. The field survey was conducted between 29-30 November 2022.

A total of 86 flora taxa representing 21 families and 45 genera identified to species level were recorded in the study area, 2 specimens could not be identified to species level. The assemblage included 80 native species and 6 introduced species, with 70 perennial species, and 16 annual or short-lived species. The most prominent families were the Chenopodiaceae (22 spp.), Asteraceae (9 spp.), Poaceae (9 spp.), Scrophulariaceae (9 spp.) and Myrtaceae (7 spp.).

No Threatened flora and one Priority flora were recorded during the field survey, *Eremophila praecox* (P2) with a total of 13 individual plants, 11 in the study area and 2 just outside the perimeter of the study area. None of the recorded 6 introduced flora were a Declared Pest or Weed of National Significance.

There were 6 vegetation types in the study area dominated by 5 *Eucalyptus* woodlands (98.9% of the vegetation) and a *Eremophila*/chenopod shrubland which accounted for the remaining 1.1%. The *Eucalyptus* woodlands recorded in the study area are representative of vegetation association 468 that has more than 98% of pre-European extent remaining and covers large areas (>500,000 ha). The shrubland community was dominated by common species with broad distributions that were also prominent in the understorey of the adjacent woodlands. No vegetation in the study area is representative of a TEC or PEC.

Eremophila praecox (P2) was recorded in 4 of the *Eucalyptus* woodlands present in the study area and these may therefore be considered locally significant providing a refuge for the significant species. The fifth woodland also represents suitable habitat for this significant species.

Eremophila praecox has been found to have a broad distribution and is typically found in low densities in *Eucalyptus* and/or *Casuarina* woodlands that are widespread in the surrounding landscape. It is therefore unlikely that disturbance in the study area would impose any significant impact on the habitat of *Eremophila praecox*.

The key botanical value of the study area is the presence of *Eremophila praecox* and possible presence of other significant flora. Due to the small size, it is considered that the Project does not represent any significant threat to the status of any of the significant flora or vegetation identified in the survey.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

ACRONYMS AND ABBREVIATIONS

AHD	Australian Height Datum
BoM	Bureau of Meteorology
CALM	Conservation and Land Management
CD	Conservation Dependent
DBCA	Department of Biodiversity, Conservation and Attractions
DCCEEW	Department of Climate Change, Energy, the Environment and Water
DPIRD	Department of Primary Industries and Regional Development
EP	Environmental Protection
EPA	Environmental Protection Authority
EPBC	Environment Protection and Biodiversity Conservation
ESE	East southeast
IBRA	Interim Biogeographic Regionalisation of Australia
KCGM	Kalgoorlie Consolidated Gold Mines
NES	National Environmental Significance
NNW	North northwest
NSR	Northern Star Resources
NVIS	National Vegetation Information System
NW	Northwest
PEC	Priority Ecological Communities
SP	Specially protected
SSE	South southeast
SSW	South southwest
SW	Southwest
T&P	Threatened and Priority
TEC	Threatened Ecological Communities
UPGMA	Unweighted pair group method with arithmetic mean
WA	Western Australia
WoNS	Weed of National Significance
WSW	West southwest

1 INTRODUCTION

As part of the Kalgoorlie Operations, Northern Star Resources Ltd (NSR) is seeking to develop the Crossroads Project (the Project), located approximately 20 km north of Kalgoorlie, Western Australia (Figure 1-1), in the Eremaean Botanical Province defined by EPA (2016b).

In October 2022, Phoenix Environmental Sciences Pty Ltd (Phoenix) was commissioned by NSR to undertake a detailed flora and vegetation survey for the Project. The purpose of the survey was to provide supporting information for a mining proposal.

Phoenix Environmental Sciences Pty Ltd (Phoenix) have previously undertaken a detailed flora and vegetation surveys (Phoenix 2018a, 2019a) for the Project. The areas surveyed and mapped intercept a substantial proportion of the current survey area (Figure 1-2).

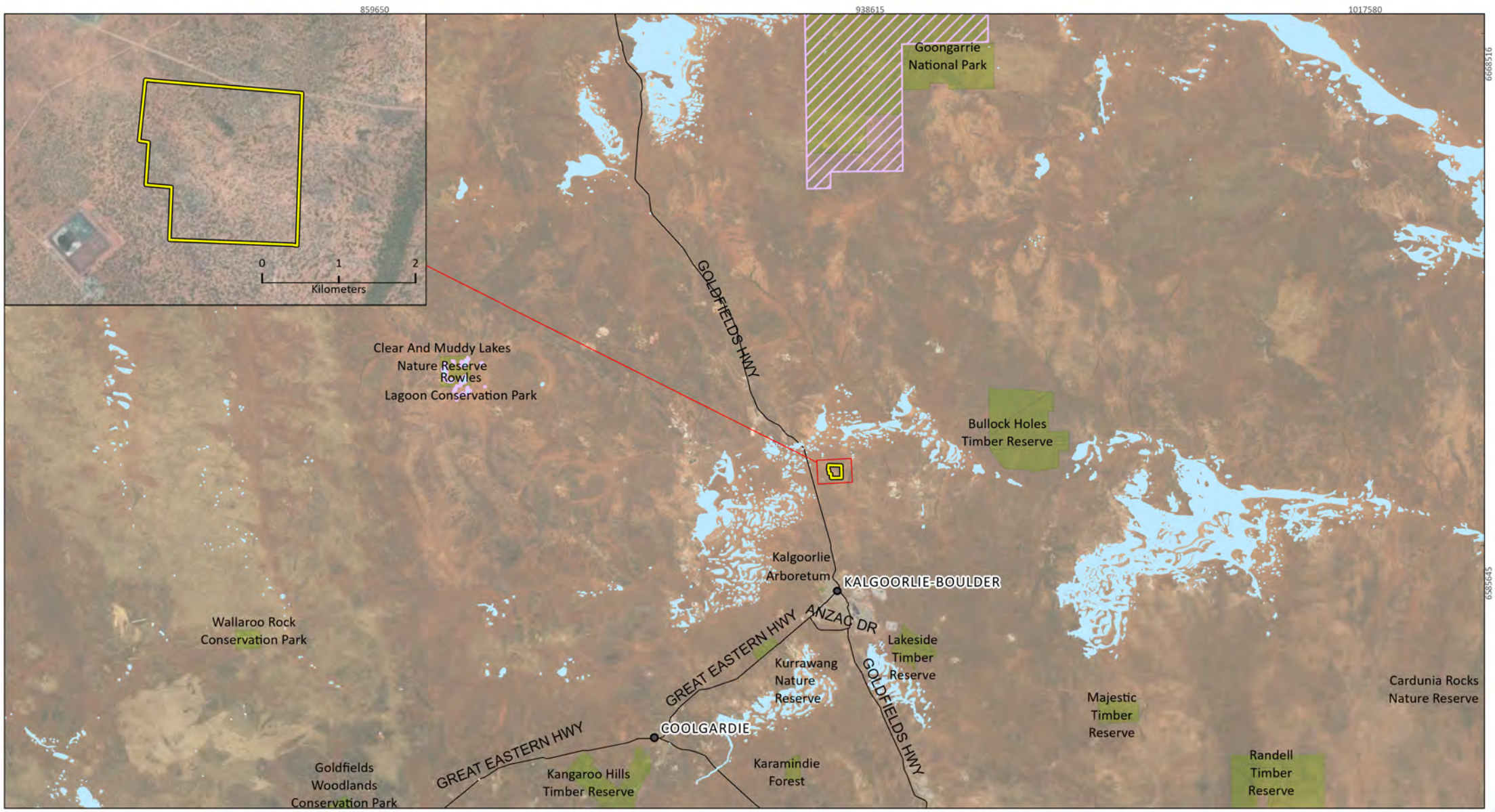
1.1 SCOPE OF WORK

The scope of work for the detailed flora and vegetation survey was as follows:

- Desktop study– to gather contextual information on the study area
- Single season field survey including revisit of the 9 Phoenix (2018a) quadrats and installation of additional quadrats in unsurveyed areas to map vegetation type and condition
- Undertake targeted searches for significant flora and vegetation that may occur in the study area

1.2 STUDY AREA

The study area (385. ha) is located adjacent to the Gidji tailings facility, approximately 19 km north of Kalgoorlie (Figure 1-1).



Northern Star Resources Ltd
Crossroads Project

Project No	1552
Date	8/03/2023
Drawn by	BK
Map author	GW

0 12.5 25
Kilometers

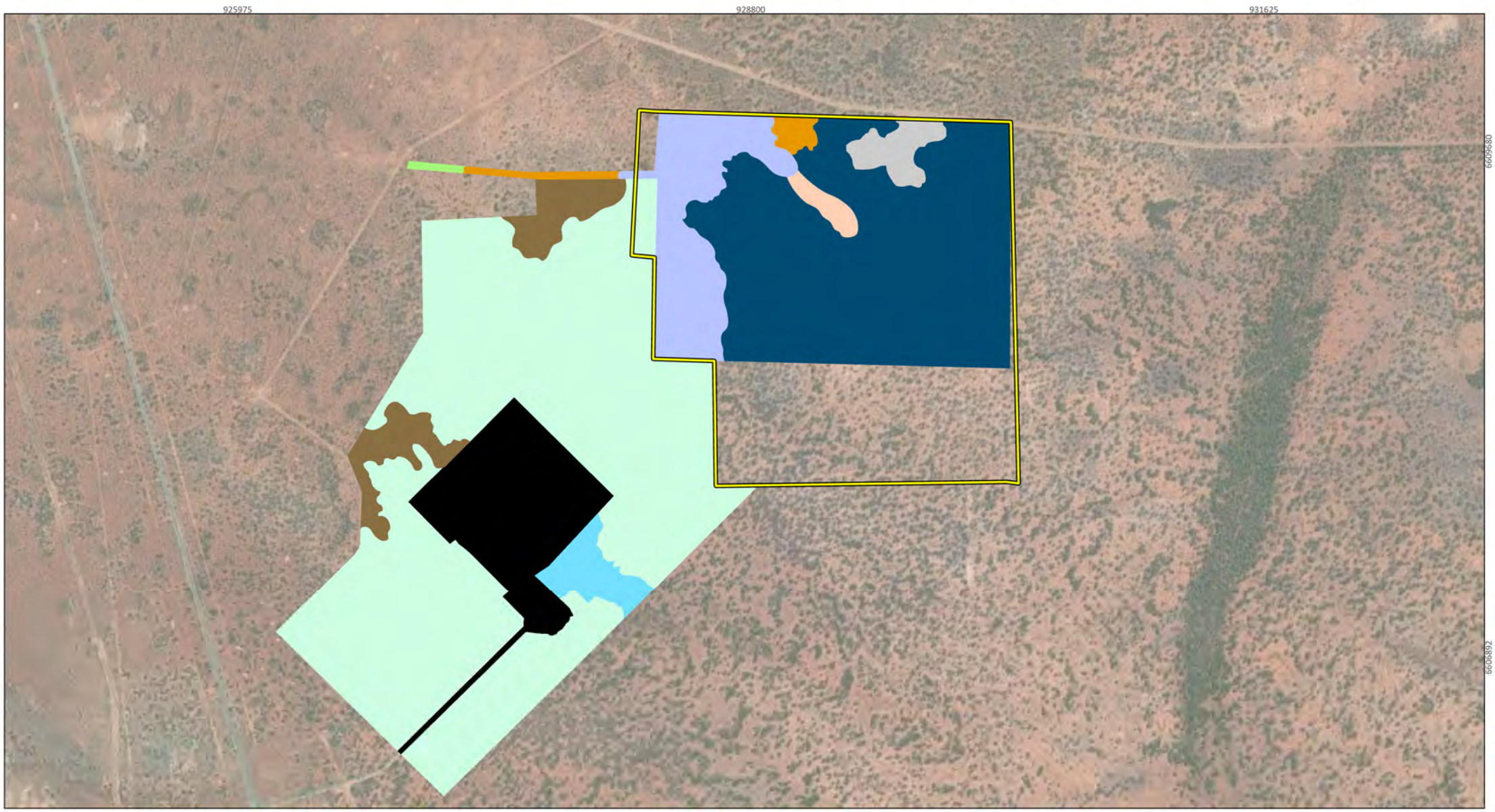
1:816,500 (at A4) GDA 1994 MGA Zone 51

- Study area
- DBCA managed land
- Lakes
- Environmentally sensitive areas
- Roads

Figure 1-1

Project location and study area

PHOENIX
ENVIRONMENTAL SCIENCES



Northern Star Resources Ltd
Crossroads Project

Project No	1552
Date	8/03/2023
Drawn by	BK
Map author	GW

0 0.5 1
Kilometer

1:28,200 (at A4) GDA 1994 MGA Zone 51

Study area

Vegetation type

- Cleared
- CpAcOm
- CpEsMs
- ElEaMs
- ElEcMs
- ElEsA
- ElEsAv
- ElEsAv Gidji
- ElMsAs
- EsMsAu

Figure 1-2

Mapping from previous surveys (Phoenix 2018b, 2019a) that intercept the current study area

PHOENIX ENVIRONMENTAL SCIENCES

2 LEGISLATIVE CONTEXT

The protection of flora in WA is principally governed by three acts:

- Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)
- State *Biodiversity Conservation Act 2016* (BC Act)
- State *Environmental Protection Act 1986* (EP Act).

The BC Act came into full effect on 1 January 2019 and replaced the functions of the *Wildlife Conservation Act 1950* (WC Act).

2.1 COMMONWEALTH

The EPBC Act is administered by the Federal Department of Climate Change, Energy, the Environment and Water (DCCEEW). The EPBC Act provides for the listing of Threatened flora and Threatened Ecological Communities (TECs) as matters of National Environmental Significance (NES). Under the EPBC Act, actions that have, or are likely to have, a significant impact on a matter of NES, require approval from the Australian Government Minister for the Environment through a formal referral process.

Conservation categories applicable to Threatened flora species under the EPBC Act are as follows:

- Extinct (EX)[1] – there is no reasonable doubt that the last individual has died
- Extinct in the Wild (EW) – taxa known to survive only in captivity
- Critically Endangered (CR) – taxa facing an extremely high risk of extinction in the wild in the immediate future
- Endangered (EN) – taxa facing a very high risk of extinction in the wild in the near future
- Vulnerable (VU) – taxa facing a high risk of extinction in the wild in the medium term
- Conservation Dependent (CD)[1] – taxa whose survival depends upon ongoing conservation measures; without these measures, a conservation dependent taxon would be classified as Vulnerable, Endangered or Critically Endangered.

Ecological communities are defined as 'naturally occurring biological assemblages that occur in a particular type of habitat' (English & Blyth 1997). There are three categories under which ecological communities can be listed as TECs under the EPBC Act: Critically Endangered, Endangered and Vulnerable.

2.2 STATE

2.2.1 Threatened and Priority species

In WA, the BC Act provides for the listing of Threatened flora species (Government of Western Australia 2018a, b)[2] in the following categories:

[1] Species listed as Extinct and Conservation Dependent are not matters of NES and therefore do not trigger the EPBC Act.

[2] The *Wildlife Conservation (Specially Protected Fauna) Notice 2018* and the *Wildlife Conservation (Rare Flora) Notice 2018* have been transitioned under regulations 170, 171 and 172 of the *Biodiversity Conservation Regulations 2018* to be the lists of Threatened, Extinct and Specially Protected species under Part 2 of the BC Act.

- Critically Endangered (CR) – species facing an extremely high risk of extinction in the wild in the immediate future[3]
- Endangered (EN) – species facing a very high risk of extinction in the wild in the near future[3]
- Vulnerable (VU) – species facing a high risk of extinction in the wild in the medium term future[3].

Species may also be listed as specially protected (SP) under the BC Act in one or more of the following categories:

- species of special conservation interest (conservation dependent fauna, CD) – species with a naturally low population, restricted natural range, of special interest to science, or subject to or recovering from a significant population decline or reduction in natural range
- species otherwise in need of special protection (OS).

The Department of Biodiversity, Conservation and Attractions (DBCA) administers the BC Act and also maintains a non-statutory list of Priority flora. Priority species are still considered to be of conservation significance – that is they may be Threatened – but cannot be considered for listing under the BC Act until there is adequate understanding of threat levels imposed on them. Species on the Priority flora list are assigned to one of four Priority (P) categories, P1 (highest) – P4 (lowest), based on level of knowledge/concern.

2.2.2 Critical habitat

Under the BC Act, habitat is eligible for listing as critical habitat if it is critical to the survival of a Threatened species or a TEC and its listing is otherwise in accordance with the ministerial guidelines.

2.2.3 Threatened and Priority Ecological Communities

The BC Act provides for the listing of TECs in the following categories:

- Critically Endangered – facing an extremely high risk of becoming eligible for listing as a collapsed ecological community in the immediate future[3]
- Endangered – facing a very high risk of becoming eligible for listing as a collapsed ecological community in the near future[3]
- Vulnerable – facing a high risk of becoming eligible for listing as a collapsed ecological community in the medium term future[3].

An ecological community may be listed as a collapsed ecological community under the BC Act if there is no reasonable doubt that the last occurrence of the ecological community has collapsed or the ecological community has been so extensively modified throughout its range that no occurrence of it is likely to recover its species composition and/or structure.

The DBCA also maintains a non-statutory list of Priority Ecological Communities (PECs), which may become TECs in the future; however, do not currently meet survey criteria or that are not adequately defined. PECs are assigned to one of five categories depending on their priority for survey or definition, with Priority 1 of highest concern and Priority 5 of lowest concern.

2.2.4 Other significant flora and vegetation

Under the EPA's environmental factor guidelines, flora and vegetation may be considered significant for a range of reasons other than listing as a Threatened or Priority species or Ecological Community.

In addition to listing as Threatened or Priority, EPA (2016a) identifies the following:

[3] As determined in accordance with criteria set out in the ministerial guidelines.

- flora may be significant for
    - local endemism or association with a restricted habitat type (e.g. surface water or groundwater dependent ecosystems)
    - new species or anomalous features that indicate a potential new species
    - representing the range of a species (particularly at the extremes of range, recently discovered range extensions, or isolated outliers of the main range)
    - being unusual species, including restricted subspecies, varieties or naturally occurring hybrids
    - having relictual status, being representative of taxonomic groups that no longer occur widely in the broader landscape
- vegetation may be significant for:
    - having restricted distribution
    - subject to a degree of historical impact from threatening processes
    - having a role as a refuge
    - providing an important function required to maintain ecological integrity of a significant ecosystem.

Provided in the guide for assessment of applications to clear native vegetation (DER 2014) is a scale for assessing the bioregional conservation status of ecological vegetation classes (Table 2-1).

Table 2-1 Bioregional conservation status of ecological vegetation classes

Conservation status	Description
Presumed extinct	Probably no longer present in the bioregion
Endangered*	Less than 10% of pre-European extent remains
Vulnerable*	10-30% of pre-European extent exists
Depleted*	More than 30% and up to 50% pre-European extent exists
Least concern	More than 50% of pre-European extent exists and subject to little or no degradation over a majority of this area

*or a combination of depletion, loss of quality, current threats and rarity gives a comparable status.

2.2.5 Environmentally Sensitive Areas

Under section 51B of the EP Act the Minister for Environment may declare by notice either a specified area of the State or a class of areas of the State to be Environmentally Sensitive Areas (ESAs). ESAs are declared in the *Environmental Protection (Environmentally Sensitive Areas) Notice 2005*, which was gazetted on 8 April 2005 (Government of Western Australia 2005).

ESAs are areas where the vegetation has high conservation value. Several types of areas are declared ESAs including:

- the area covered by vegetation within 50 metres (m) of Threatened flora, to the extent to which the vegetation is continuous with the vegetation in which the Threatened flora is located
- the area covered by a TEC
- a defined wetland (Ramsar wetlands, conservation category wetlands and nationally important wetlands) and the area within 50 m of the wetland
- Bush Forever sites.

2.2.6 Introduced flora

Introduced flora (weeds) pose threats to biodiversity and natural values by successfully out-competing native species for available nutrients, water, space and sunlight; reducing the natural structural and biological diversity by smothering native plants or preventing them from growing back after clearing, fire or other disturbance; replacing the native plants that animals use for shelter, food and nesting; and altering fire regimes, often making fires hotter and more destructive (Australian Weeds Committee 2007).

Management of some weed species is required under Commonwealth or State frameworks. Key classifications for significant introduced flora that are relevant to this report are:

- Declared Pest – the Biosecurity and Agriculture Management Act 2007, Section 22 makes provision for a plant taxon to be listed as a Declared Pest organism in parts of, or the entire State. Under the Biosecurity and Agriculture Management Regulations 2013 Declared Pests are assigned to one of three control categories that dictate the level of management required (DPIRD 2019).
- Weed of National Significance (WoNS) – high impact, established introduced flora causing major economic, environmental, social and/or cultural impacts in a number of states/territories, and which have strong potential for further spread (Australian Weeds Committee 2012). Management is required in accordance with Department of Primary Industries and Regional Development (DPIRD) guidelines for particular WoNS.

Throughout this report, introduced flora species are indicated with an asterisk (*).

3 EXISTING ENVIRONMENT

3.1 INTERIM BIOGEOGRAPHIC REGIONALISATION OF AUSTRALIA

The Interim Biogeographic Regionalisation of Australia (IBRA) classifies Australia's landscapes into large 'bioregions' and 'subregions' based on climate, geology, landform, native vegetation and species information (DoEE 2016).

The study area is located on the southern margin of the Eastern Murchison subregion (MUR1) of the Murchison bioregion (Figure 3-1), which is characterised by its internal drainage, and extensive areas of elevated red desert sandplains with minimal dune development; salt lake systems associated with the occluded Paleodrainage system; broad plains of red-brown soils and breakaway complexes as well as red sandplains. Vegetation is dominated by Mulga Woodlands often rich in ephemerals; hummock grasslands, saltbush shrublands and samphire (*Tecticornia*, formerly *Halosarcia*) shrublands; arid climate, with mainly winter rainfall (200 mm) (Cowan 2001b).

The study area lies immediately north of the Eastern Goldfield subregion (COO3) of the Coolgardie bioregion, characterised as: subdued relief, comprising gently undulating plains interrupted in the west with low hills and ridges of Archaean greenstones and in the east by a horst of Proterozoic basic granulite. The underlying geology is of gneisses and granites eroded into a flat plane covered with tertiary soils and with scattered exposures of bedrock. Calcareous earths are the dominant soil group and cover much of the plains and greenstone areas. A series of large playa lakes in the western half are the remnants of an ancient major drainage line. The vegetation is of mallees, Acacia thickets and shrubheaths on sandplains. Diverse Eucalyptus woodlands occur around salt lakes, on ranges, and in valleys. Salt lakes support dwarf shrublands of samphire. Woodlands and Dodonaea shrubland occur on basic graninulites of the Fraser Range. The area is rich in endemic Acacias. The climate is arid to semi-arid with 200-300 mm of rainfall, sometimes in summer but usually in winter (Cowan 2001a).

3.2 LAND SYSTEMS AND SURFACE GEOLOGY

DPIRD undertakes land system mapping for WA using a nesting soil-landscape mapping hierarchy (Schoknecht & Payne 2011). While the primary purpose of the mapping is to inform pastoral and agricultural land capability, it is also useful for informing biological assessments. Under this hierarchy, land systems are defined as areas with recurring patterns of landforms, soils, vegetation and drainage (Payne & Leighton 2004).

The study area lies entirely within the Gumland System, characterised as: Extensive pedeplains supporting eucalypt woodlands with halophytic and non-halophytic shrub understoreys. To the north and northwest is the Carnegie System (Salt lakes with fringing saline alluvial plains, kopi dunes and sandy banks, supporting halophytic shrublands and Acacia tall shrublands) extending to within 350 m of the study area.

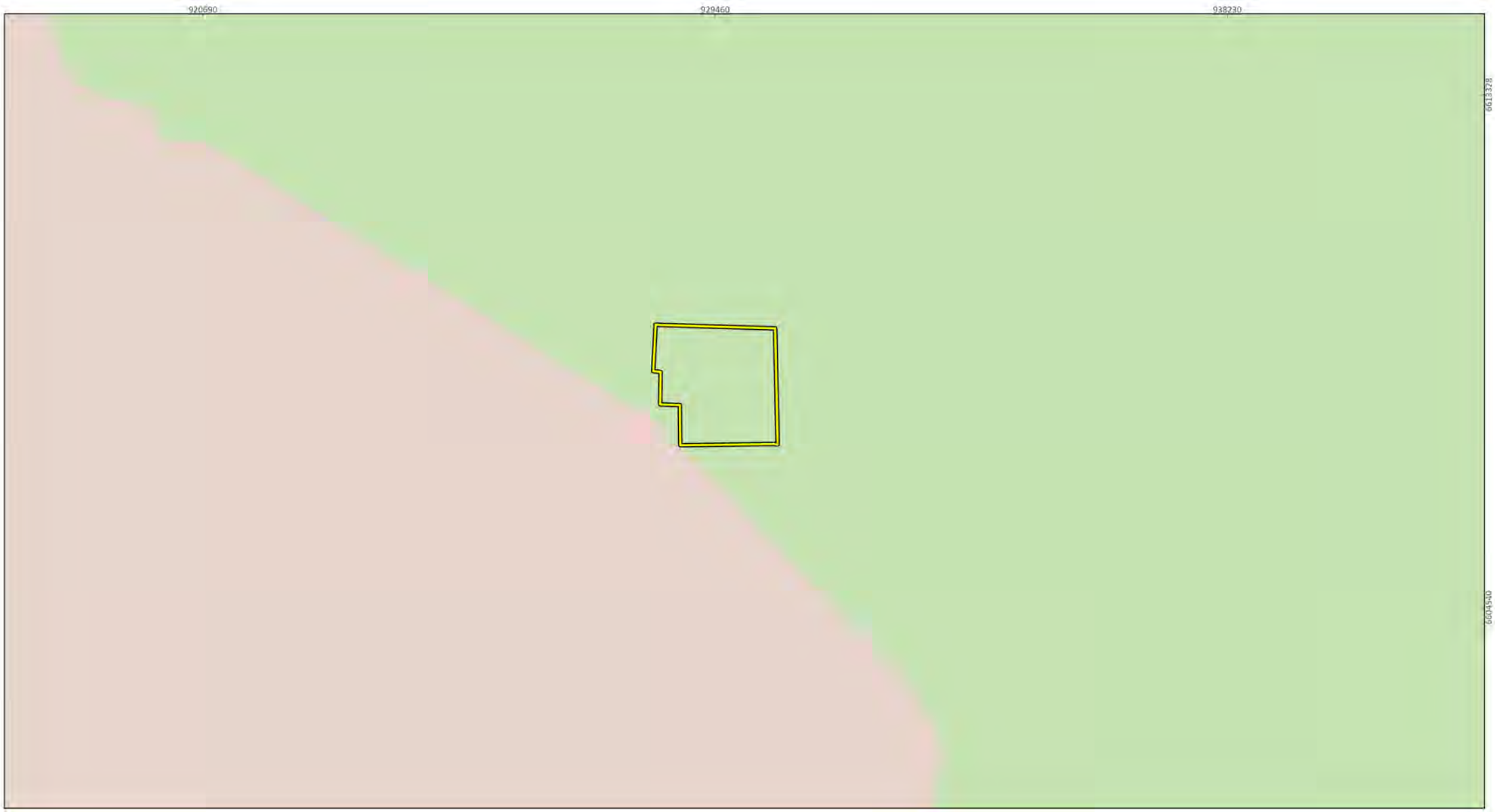
According to the Surface Geology of Australia 1:1,000,000 scale, Western Australia database (Stewart *et al.* 2008), the study area intersects four geological formations (Table 3-1;Figure 3-2).

The Geoscience Australia surface hydrology dataset (Crossman & Li 2015) shows no surface water features in the study area, but it is partly encircled by ephemeral playa lakes in a paleodrainage channel to the north and west, the nearest small lake occurring 1.6 km northwest of the study area (Figure 1-1).

Topographic relief across the study area is minor and gradual (347 – 365 m AHD; Geoscience Australia 2021), highest in the southeast and lowest in the northwest.

Table 3-1 Surface geology of the study area, extent by deposit type

Surface geology	Abbreviation	Description	Area (ha)	% of study area
mafic extrusive rocks 74248	Abe	Basalt, high-Mg basalt, minor mafic intrusive rocks; some andesite; agglomerate; mafic schist; amphibolite; dolerite; komatiitic basalt; carbonated basalt; basaltic andesite; mafic rock interleaved with minor granitic rock	79.32	20.56
felsic volcanic and volcaniclastic rocks 74288	Afe	Quartz-feldspar (meta-) porphyry, porphyritic microgranite; rhyolite, dacite, rhyodacite, andesite; agglomerate, breccia tuff; felsic schist; felsic volcanic and volcaniclastic rocks; dacite and rhyodacite tuff; dacite porphyry	162.16	42.03
lunette dunes 72955	Qdlu	Quartz and gypsum dunes and mounds (kopi); may include minor silt, sand, gravel, and clay flats adjacent to playas; locally includes some playa sediments	0.08	0.02
colluvium 38491	Qrc	Colluvium, sheetwash, talus; gravel piedmonts and aprons over and around bedrock; clay-silt-sand with sheet and nodular kankar; alluvial and aeolian sand-silt-gravel in depressions and broad valleys in Canning Basin; local calcrete, reworked laterite	144.23	37.39
Total			**385.79**	**100.00**



Northern Star Resources Ltd
Crossroads Project

Project No	1552
Date	8/03/2023
Drawn by	BK
Map author	GW

0 1.5 3
Kilometers

1:87,700 (at A4) GDA 1994 MGA Zone 51

Study area

Region, subregion

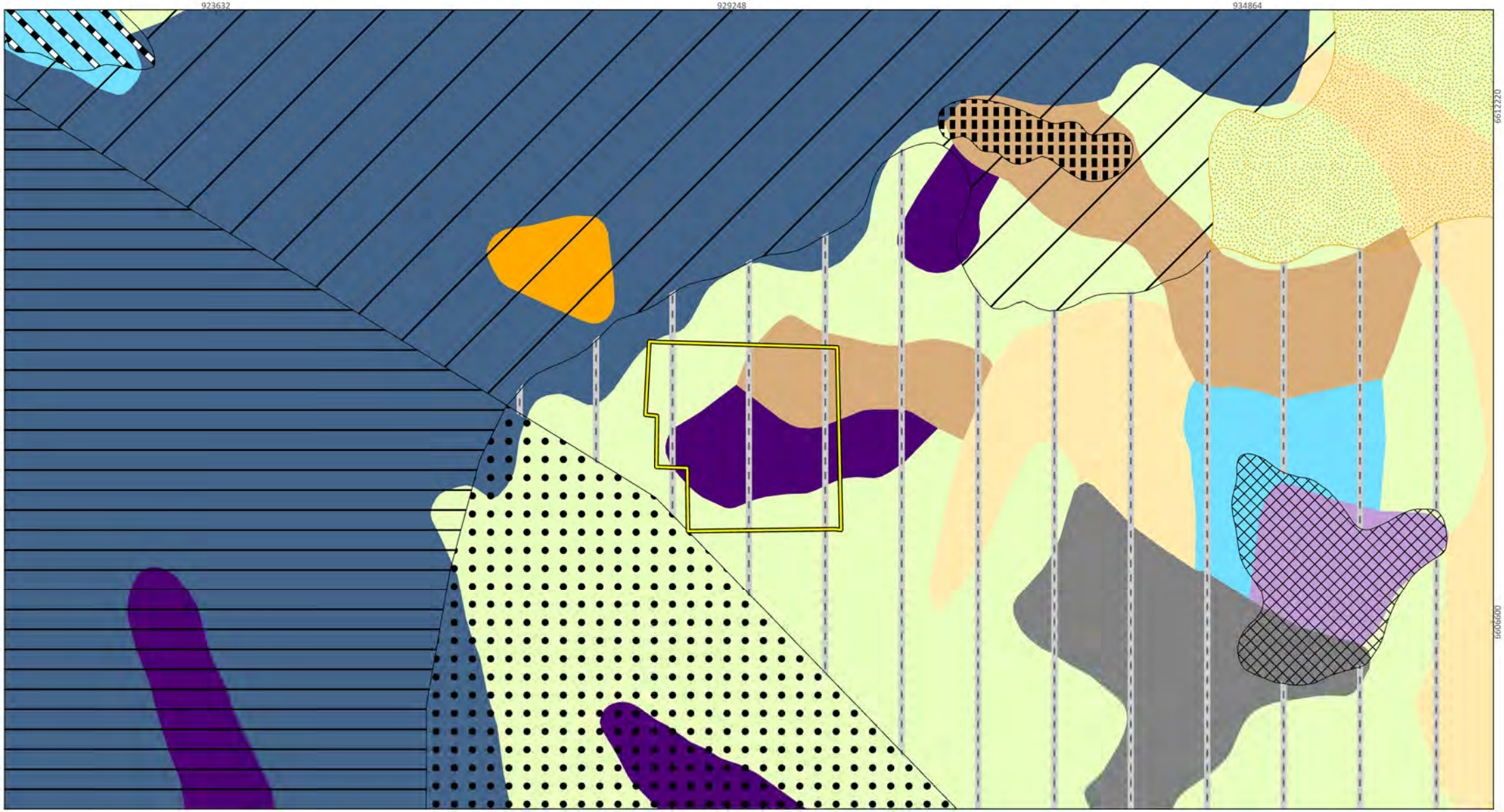
Coolgardie,Eastern Goldfield

Murchison,Eastern Murchison

Figure 3-1

Study area in relation to IBRA bioregions and subregions

PHOENIX
ENVIRONMENTAL SCIENCES



Northern Star Resources Ltd
Crossroads Project

Project No	1552
Date	8/03/2023
Drawn by	BK
Map author	GW

0 1 2
Kilometers

1:56,100 (at A4) GDA 1994 MGA Zone 51

Study area

Land systems
- Carnegie System
- Doney System
- Gumland System
- Illaara System
- Lawrence System
- Moriarty System

Surface geology
- Abe
- Afe
- Ase
- Aue
- Ave
- Mx43
- SV15
- Czl
- Qa
- Qdlu
- Qrc

Figure 3-2
Land systems and surface geology in the study area

PHOENIX ENVIRONMENTAL SCIENCES

3.3 CLIMATE AND WEATHER

The climate of the Eastern Murchison subregion is described as arid, with mainly winter rainfall (~200 mm) (Cowan 2001b). The climate of the Eastern Goldfields subregion is characterised by arid to semi-arid with 200-300 mm of rainfall annually, sometimes falling in summer but usually winter (Cowan 2001a).

The nearest Bureau of Meteorology (BoM) weather station with comprehensive data collection and recent historic climate data is Kalgoorlie-Boulder Airport (no. 012038; Latitude: 30.78°S Longitude 121.45°E), located 22 km south of the study area.

Kalgoorlie-Boulder Airport records the highest mean maximum monthly temperature (33.7°C) in January (lowest in July, 16.9°C) and the lowest minimum mean monthly temperature (5.1°C) in July (highest in January, 18.3°C) (BoM 2022) (Figure 3-3). Median annual rainfall is 254 mm with July, June and May recording the highest monthly median (20.0, 18.6 and 18.6 mm respectively; Figure 3-3).

Daily mean temperatures at Kalgoorlie-Boulder Airport preceding the surveys were up to several degrees higher than long-term average in December 2021-January 2022, lower than average in March-June, then 2-3 degrees above average in September-November up to and including the survey (Figure 3-3).

Records from Kalgoorlie-Boulder Airport show rainfall was below long-term average in December 2021-March 2022 and May-June, but well above average in August and the first half of September; October was again relatively dry except for 8.4 mm recorded in the last two days. During the month of survey, there were falls of 4.0 and 4.6 mm on Nov 8 and 9, and 7.0 mm overnight (associated with extensive thunderstorm activity) preceding the last day of survey Nov 17 (Figure 3-3).

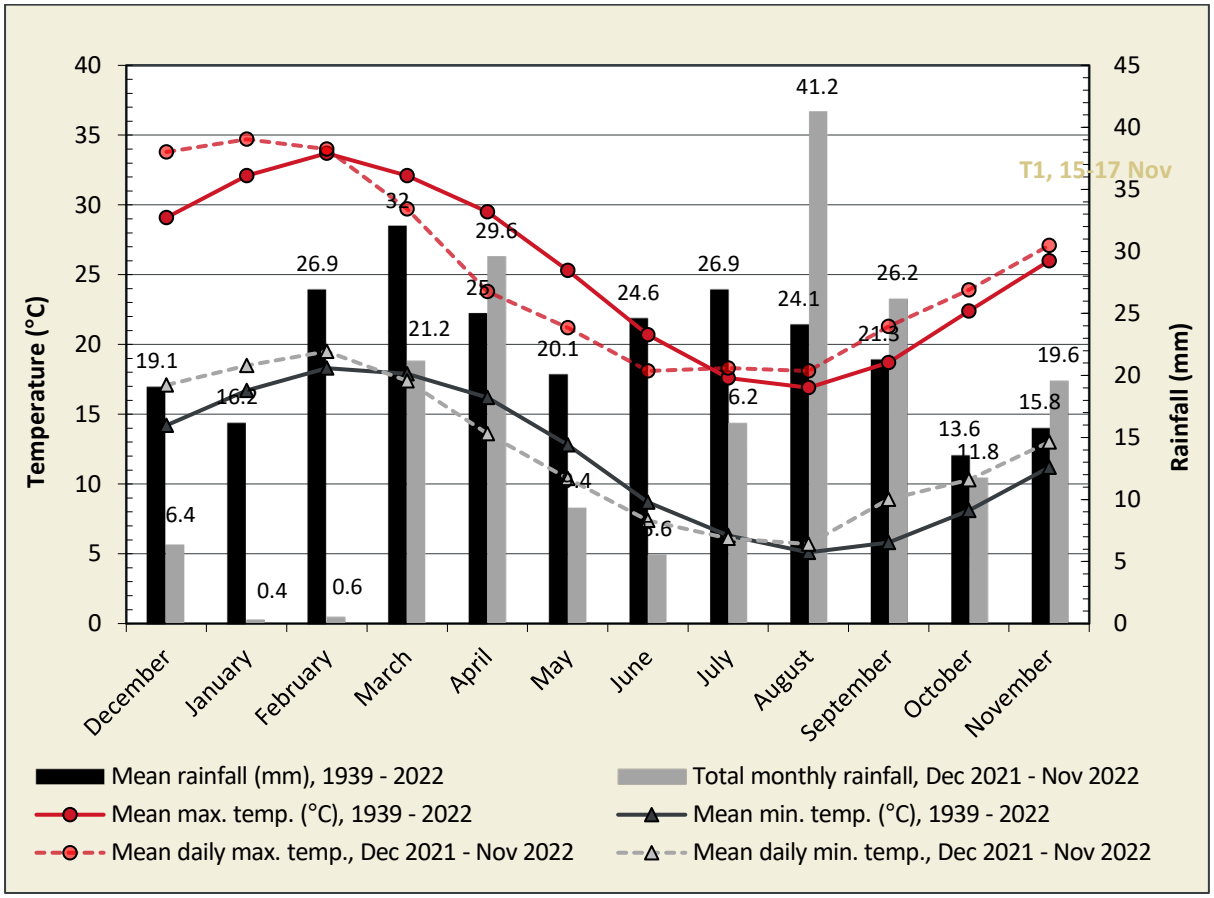


Figure 3-3 **Annual climate and weather data for Kalgoorlie-Boulder Airport (no. 012038) and mean monthly data for the 12 months preceding the survey (BoM 2022)**

3.4 LAND USE

Grazing on native pastures is described as the dominant land use within the Eastern Murchison subregion, occupying 85.47% of the area. Unallocated Crown Lands and Crown Reserves constitute a further 11.34% of the subregion. Conservation land use, most of which falls outside of the IUCN I-IV categories, accounts for 1.4% of the subregion. There is also a substantial amount of interest in nickel and gold mining in the area, however, most mining leases remain subject to the pastoral lands act and are therefore still required to be stocked (Cowan 2001b).

Land use within the study area (DoE 2016) consists of grazing native vegetation (99.52%) as part of a pastoral lease. A corridor extending west-northwest into the study area from the centre of its eastern edge is designated as other minimal use/Conservation and natural environments (20 x 900 m, 0.47%), and a small area classified as intensive uses consists of a section of road within the north-eastern corner of the study site (0.007%).

3.5 CONSERVATION RESERVES AND ESAS

Other than the corridor within the study site allocated to conservation and natural environments, as mentioned above, no conservation reserves intersect the study area. The closest conservation reserves under the CALM Act 1984 include the Bullock Holes timber reserve (approximately 27 km east of study area), the Lakeside Timber Reserve (approximately 25 km southeast), Kurrawang Nature reserve (approximately 27 km southwest), Kalgoorlie arboretum (approximately 17.5 km south), and Goongarrie National park (approximately 50 km north of the study area) (Figure 1-1).

4 METHODS

The survey was conducted in accordance with relevant survey guidelines and guidance, including:

- *EPA Environmental Factor Guideline: Flora and vegetation* (EPA 2016a)
- *EPA Technical Guidance: Flora and vegetation surveys for Environmental Impact Assessment* (EPA 2016b)

4.1 DESKTOP REVIEW

Searches of several biological databases were undertaken to identify and prepare lists of significant flora and vegetation that may occur within the study area (Table 4-1). A literature search was conducted for accessible reports for biological surveys conducted within 50 km of the study area to build on the lists developed from the database searches (Table 4-2).

Table 4-1 Database searches conducted for the desktop review

Database	Target group/s	Search coordinates and extent
Protected Matters Search Tool (DCCEEW 2022)	EPBC Act Threatened flora and ecological communities	Study area polygon as shapefile (buffers are included in modelled distribution of Protected Matters)
DBCA Threatened and Priority Flora Database (DBCA 2022c)	Threatened and Priority flora	Study area plus a 50 km buffer
DBCA Threatened and Priority Ecological Communities Database (DBCA 2022b)	TECs and PECs	Study area plus a 50 km buffer
DBCA NatureMap Database (DBCA 2022a)	Flora records	Study area plus a 50 km buffer

Table 4-2 Survey reports included in the desktop review

Report author	Survey description	Project
Botanica (2008)	Flora and vegetation survey	Crossroads area (Barrick Kanowna Ltd)
Phoenix (2018a)	Detailed flora and vegetation survey	Crossroads area
Phoenix (2018b)	Detailed flora and vegetation survey	Gidji operations
Phoenix (2019a)	Detailed flora and vegetation survey	Gidji operations

4.2 FIELD SURVEY

4.2.1 Survey timing

The field survey was conducted 29-30 November 2022.

4.2.2 Field methods

Field methods for the flora and vegetation survey of the study area included:

- surveying of quadrats (see 4.2.2.1)
- targeted flora searches (4.2.2.2)
- vegetation type and condition mapping (4.2.2.3, 4.2.2.4)

Prior to the commencement of the field survey, data including satellite imagery, survey boundary, and pre-selected vegetation quadrats were loaded onto electronic field devices. The field survey involved assessing and mapping vegetation boundaries, conducting quadrat sampling and collecting opportunistic flora specimens. GPS locations of vegetation and condition boundaries, survey sites and flora specimen data were recorded digitally.

4.2.2.1 Quadrats, relevés and transects

The 9 quadrats previously recorded in the study area were revisited. A field guide comprised of the vegetation description, vegetation condition and list of species with foliage cover and heights data was used to facilitate the field staff identifying any new species and any changes to vegetation condition or abundance of the previously recorded species.

A further 8 quadrats were installed in the section of the study area that had not previously been surveyed. Quadrat locations in the unsurveyed areas were selected to ensure that an accurate representation of the major vegetation types were sampled. Two methods were used for the selection of quadrat placement. Preliminary quadrat locations were pre-selected using aerial photography, with selection based on apparent changes in the vegetation visible in the aerial imagery. Final quadrat placement was determined in the field while ground-truthing the study area on foot. Some preliminary quadrats were moved to locations which better represented vegetation types. In total, 17 quadrats were surveyed across the study area (Figure 4-1; Appendix 1).

Quadrat sampling dimensions were 20 m x 20 m in accordance with EPA guidance for the Eremaean Botanical Province. The following information was recorded for each quadrat (Appendix 2):

- location – the geographic coordinates of all four corners of the quadrat in WGS84 projection
- description of vegetation – a broad description utilising the structural formation and height classes based on National Vegetation Information System (ESCAVI 2003) and in accordance with EPA (2016b) (Appendix 3)
- habitat – a brief description of landform and habitat
- geology – a broad description of surface soil type and rock type
- disturbance history – a description of any observed disturbance including an estimate of time since last fire, weed invasions, soil disturbance, human activity and fauna activity
- vegetation condition – using the condition scale in EPA (2016b) for the Eremaean Botanical Province
- height and percentage foliage cover (PFC) – a visual estimate of cover of total vegetation cover, cover of shrubs and trees >2 m tall, cover of shrubs <2 m, total grass cover and total herb cover
- photograph – a colour photograph of the vegetation within each quadrat in a south-easterly direction from the north-west corner of the quadrat
- flora species list – comprehensive list of all flora species recorded within the quadrat.

To ensure accurate taxonomic identification of flora species present within the study area, collections were made of each specimen at least once and each collection was pressed and documented for identification using the WA Herbarium resources.

For each species identified, records on FloraBase and the Australasian Virtual Herbarium were consulted to provide information on known ranges to determine whether the study area represented a range extension for the species.

4.2.2.2 Targeted flora searches

Targeted searches were undertaken for significant flora (Threatened and Priority), Declared Pests and WoNS. Sections of the study area were traversed by foot in meandering transects. The searches focused on habitats considered likely to support significant flora.

If a flora species was considered to potentially be a significant species (i.e. similar floristic characteristics and occurring within suitable habitat) the following information was collected:

- GPS coordinates, including population boundary where applicable
- description of the habitat and floristic community in which the potential significant species was located
- population size estimate (i.e. estimated number of individual plants) where applicable
- specimen collection for taxonomic identification and lodgement at the WA Herbarium
- photograph of live plant in situ and description of important details, such as flower colour, height of individual or average height of population.

Following the field survey, the likelihood of occurrence for each significant flora species identified in the desktop review was assessed and assigned to one of three ratings:

- recorded – species recorded within the study area by previous or current survey
- possible – study area within known range of species; potential habitat within the study area, may not have been detectible during survey (e.g. survey conducted outside flowering period, annual plant survey conducted outside likely period of occurrence, small herbaceous plant in dense vegetation), or entire area of habitat not thoroughly searched
- unlikely – study area outside known range of species and/or no suitable habitat present in study area and/or suitable/potential habitat present but study area considered adequately searched for the species.

4.2.2.3 Vegetation type mapping

Vegetation mapping was undertaken at a scale of 1:10,000 using the National Vegetation Information System (NVIS) sub-association level (L5) for structural descriptions (ESCAVI 2003). The vegetation descriptions from quadrats and relevés from the survey were grouped according to similarity of community structure (i.e. canopy levels), species composition and combination of species, and the prevalent community structure (i.e. woodland, shrubland, etc.). The vegetation boundaries were mapped utilising ArcGIS ESRI imagery and from vegetation boundaries recorded on GPS during the field survey.

To support delineation of vegetation types, a cluster analysis was conducted based on species presence in each quadrat. Quadrat data from previous surveys conducted in close proximity to the current study area was included in the analysis (termed the regional data) to define the vegetation types in the current study area in context with the surrounding vegetation. Data from 30 quadrats were used in the analysis.

The fusion strategy for the site classification was flexible UPGMA with a beta value of -0.1 and Bray Curtis association measure in the software package PATN (Belbin 2003). A dendrogram was produced to illustrate the similarities between the vegetation units identified. Statistically distinct vegetation units (the floristic group) classified the vegetation at a local scale. Local scale vegetation units were described at NVIS Level V – Association (ESCAVI 2003). The term ‘vegetation type’ was used for local scale vegetation units in accordance with EPA technical guidance (EPA 2016b).

4.2.2.4 Vegetation condition mapping

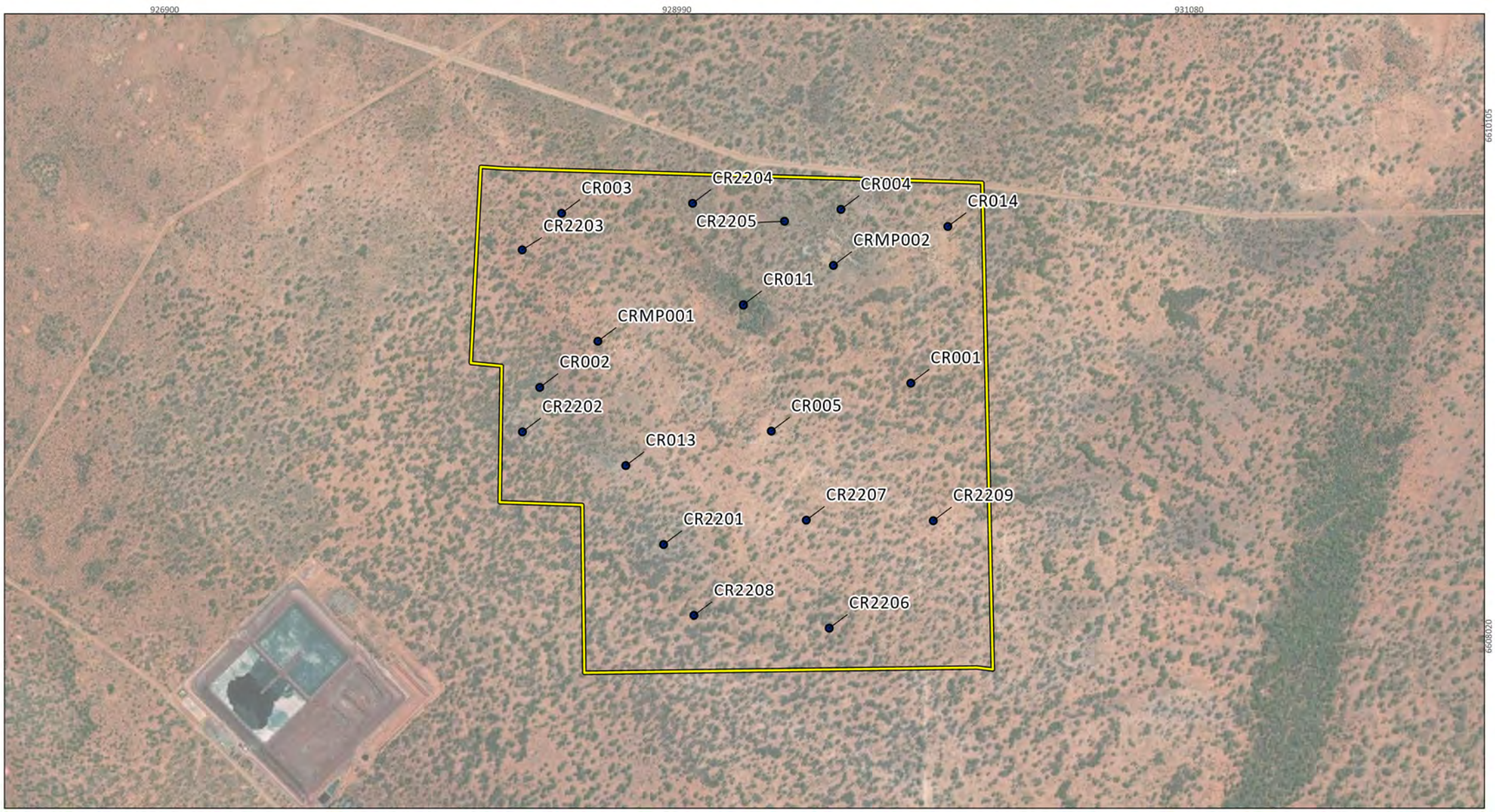
The condition of vegetation was mapped across the study area based on the appropriate condition scale for the Eremaean Botanical Province (Trudgen 1988 in EPA 2016b) (Table 4-3). The vegetation condition ratings relate to vegetation structure, the level of disturbance and weed cover at each structural layer, and the ability of the vegetation unit to regenerate. Vegetation condition ranges from Excellent being the highest rating to Completely Degraded as the lowest.

Table 4-3 Vegetation condition rating scale (EPA 2016b)

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

4.2.2.5 Analysis of survey completeness

A species accumulation curve based on accumulated species versus number of sites surveyed was used to evaluate the level of adequacy of the survey effort. The species accumulation curve was generated by inputting the site-species matrix into Phoenix's proprietary spreadsheet.



Northern Star Resources Ltd
Crossroads Project

Project No	1552
Date	9/03/2023
Drawn by	BK
Map author	GW

0 0.5 1
Kilometer

1:20,900 (at A4) GDA 1994 MGA Zone 51

Study area
Sites

Figure 4-1

Flora and vegetation survey sites

PHOENIX ENVIRONMENTAL SCIENCES

5 RESULTS

5.1 DESKTOP REVIEW

5.1.1 Flora assemblage

Botanica (2008) recorded 40 flora taxa representing 14 families and 20 genera all were perennial species. The most prominent families were Chenopodiaceae (11), Fabaceae (6), Scrophulariaceae (6) and Myrtaceae (5).

Phoenix (2018a) recorded 90 flora taxa representing 24 families and 47 genera with 72 perennial species, 17 annual or short-lived species and one species for which the life cycle could not be determined. The most prominent families were Chenopodiaceae (20 species), Asteraceae (12), Scrophulariaceae (11), Fabaceae (8) and Poaceae (7).

Phoenix (2019a) recorded 62 flora taxa representing 15 families and 30 genera with 56 perennials and 6 annual or short-lived species. The most prominent families recorded were Chenopodiaceae (16 species), Scrophulariaceae (9), Fabaceae (7), Asteraceae (6), Poaceae (6) and Myrtaceae (5).

5.1.2 Significant flora

Records of 29 significant flora species were identified within the desktop search extent, comprising no Threatened flora listed under the EPBC Act and/or BC Act, 28 Priority flora and one locally significant flora (Table 5-1).

Phoenix (2019a) recorded a single plant of *Eremophila praecox* (P2) near the current study area. Regional surveys for *Eremophila praecox* (Phoenix 2019b, 2020b) located a further 7 plants within 2 km of the study area. No records of significant flora occurred in the study area (Figure 5-1):

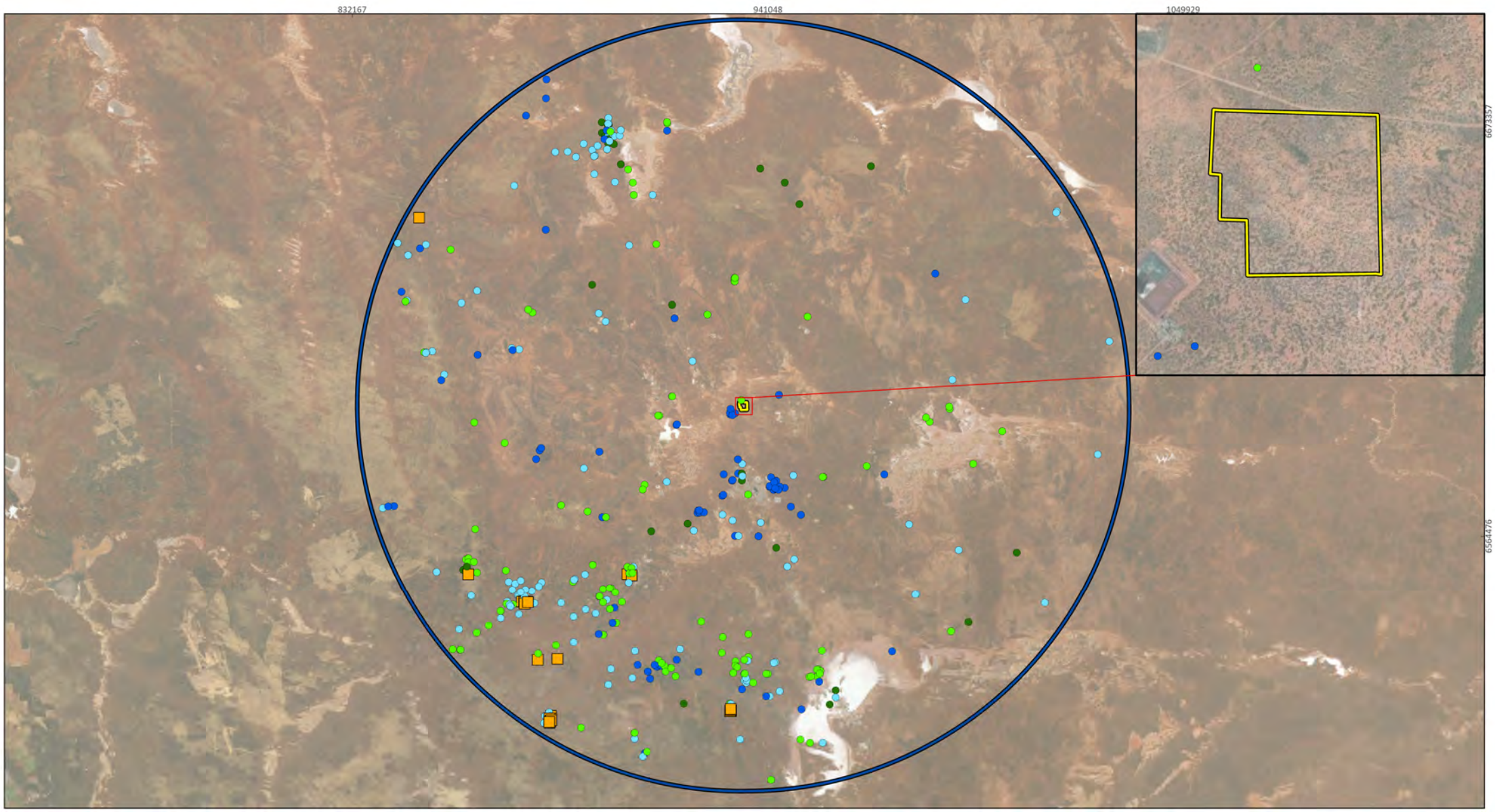
Table 5-1 Significant flora identified in the desktop review

Species	Status	Proximity to study area	Habitat
Acacia epedunculata	P1 (DBCA list)	24.4 km NNW of study area	*Eucalyptus* mallee woodland, *Callitris*, *Banksia* and shrubland over *Triodia* grasses on yellow sand plain. Flowers July to August (WA Herbarium 1998).
Calandrinia lefroyensis	P1 (DBCA list)	21.1 km W of study area	Occurs on salt lake flats among samphire communities, soils are brown silty loams or brown-grey sandy clays, favour the outer edges of samphire communities including within the ecotone of adjacent communities where there are open assemblages of taller species such as *Casuarina obesa* and *Eucalyptus* spp. Flowers October to November (Obbens 2018).
Eremophila xantholaemus	P1 (DBCA list)	26.4 km SE of study area	Growing in stony, brown loam soils in *Eucalyptus-Casuarina* woodland on the upper slopes of low rocky hills. Associated species include *Casuarina pauper*, *Eremophila glabra* subsp. *glabra*, *E. parvifolia* subsp. *auricampa*, *E. pustulata*, *Senna artemisioides* subsp. *filifolia* and *Westringia rigida*. Flowers from September to October (Brown & Davis 2019).
Phebalium appressum	P1 (DBCA list)	45.1 km WSW of study area	Open mallee woodlands over mixed shrublands and *Triodia* grassland in yellow sand, Mixed shrublands with *Triodia* grassland in yellow sand on plains.

Species	Status	Proximity to study area	Habitat
			Recorded flowering in July and September (WA Herbarium 1998).
Ptilotus procumbens	P1 (DBCA list)	22.2 km S of study area	Open *Acacia* shrubland over mixed forbland in red clay, in deep red clay and in mulga scrub on plain with lateritic gravel. Recorded flowering September to November (WA Herbarium 1998).
Ptilotus rigidus	P1 (DBCA list)	21.4 km W of study area	Associated with salt lakes, occurs in red loam/clay, orange sand on salt lake edges, quartz rises, rocky outcrops in *Tecticornia* shrublands, kopi dune vegetation and *Melaleuca* shrublands> Flowers September to November (Lally 2009; WA Herbarium 1998).
Ptilotus sp. Kalgoorlie (J. Jackson & B. Moyle 260)	P1 (DBCA list)	17.6 km W of study area	Quartz hills and outcrop in *Tecticornia* dominated shrublands. Recorded in flower bud in September (WA Herbarium 1998).
Ricinocarpos digynus	P1 (DBCA list)	31.5 km N of study area	Grows in sandy loam on rocky hillsides in association with *Casuarina pauper*, *Acacia kalgoorliensis*, *Ptilotus obovatus* and *Triodia scariosa*. Flowering November to March (Hislop & Wege 2020).
Tecticornia flabelliformis	P1 (DBCA list)	40.5 km ESE of study area	Low samphire shrubland in red-brown clayey sand on saline flats (WA Herbarium 1998).
Elachanthus pusillus	P2 (DBCA list)	16.6 km S of study area	Sparse *Eucalyptus* spp. woodland over open mixed shrubland over open mixed herbs or Chenopod shrubland in bare lateritic gravel – red loamy clay soils or red loam over limestone on low plain. Flowers August to October (WA Herbarium 1998).
Eremophila praecox	P2 (DBCA list)	1.1 km SW of study area	Red/brown sandy loam. Undulating plains. Hill slope. Red-brown clay loam over ferrous ironstone. Low *Eucalyptus* woodland over dwarf scrubland in red-brown sandy loam on undulating plains. Flowers October to December (WA Herbarium 1998).
Goodenia salina	P2 (DBCA list)	33.0 km S of study area	Found in low gypseous dunes near salt pans in well-drained, saline, grey or brown loamy clay with scattered *Callitris preissii* subsp. *verrucosa*, *Tecticornia* spp. and *Austrostipa juncifolia*. Flowers September to October (Sage & Shepherd 2007).
Hakea rigida	P2 (DBCA list)	45.1 km WSW of study area	Open mallee woodlands over mixed heath/shrublands with *Allocasuarina*, *Grevillea* and *Hakea* spp. in plains and on kopi dunes in yellow sand. Flowers September to October (WA Herbarium 1998).
Allocasuarina eriochlamys subsp. *grossa*	P3 (DBCA list)	18.0 km SE of study area	Occurs in mallee woodlands and heath/shrublands on lateritic and granite hills and breakaways in stony loam and laterite clays (WA Herbarium 1998).
Alyxia tetanifolia	P3 (DBCA list)	27.8 km SSW of study area	*Casuarina* pauper woodland or Chenopod shrubland in sandy clay, loam, concretionary gravel or granite on drainage lines near lakes or lateritic low rises and breakaways. Recorded flowering May to June and November (WA Herbarium 1998).

Species	Status	Proximity to study area	Habitat
Angianthus prostratus	P3 (DBCA list)	544 m N of study area	*Tecticornia* low heath over open herbs or dense low grass in red clay or loamy soils in saline depressions on beach edge of salt lake. Flowers July to September (WA Herbarium 1998).
Austrostipa turbinata	P3 (DBCA list)	41.0 km SSE of study area	*Eucalyptus* woodlands on hillslopes and claypan with crabholes in sandy loam to cracking clay soils. Flowers September to October (WA Herbarium 1998; Williams 2022).
Chrysocephalum apiculatum subsp. *norsemanense*	P3 (DBCA list)	49.8 km SW of study area	Open *Eucalyptus* woodlands, shrublands in various soil types including yellow or red sand, yellow sandy clay, and calcareous soil (Wilson 2016) on sandplains, undulating plains, valley floors and hill slopes. Recorded flowering in August to October (WA Herbarium 1998)
Cyathostemon verrucosus	P3 (DBCA list)	14.1 km S of study area	Found on yellow sand plains, recorded in shrublands, sometimes dominated by mallees or *Banksia* (Trudgen & Rye 2014). Flowers mainly from late September to early December, also recorded in early March (Trudgen & Rye 2014).
Gompholobium cinereum	P3 (DBCA list)	43.8 km WSW of study area	Open mallee woodlands and shrublands in yellow sand, yellow/brown clayey sand on flat plains. Recorded flowering from August to November (WA Herbarium 1998).
Isolepis australiensis	P3 (DBCA list)	33.0 km S of study area	*Melaleuca* open shrubland or *Casuarina*/*Eucalyptus* open woodland in silty sand, sandy clay and red clay on lake margins, pools or granite outcrop. Recorded flowering in June and September (WA Herbarium 1998).
Lepidium fasciculatum	P3 (DBCA list)	17.3 km S of study area	Open *Acacia* or *Maireana* shrubland in brown cracking clay on plain or red loam on dry lakebed. Recorded in fruit in September (WA Herbarium 1998).
Melaleuca coccinea	P3 (DBCA list)	22.2 km S of study area	*Acacia* or *Melaleuca* shrubland in sandy loam over granite on granite outcrops, sandplain and river valleys. Recorded flowering from September to November and in January (WA Herbarium 1998).
Notisia intonsa	P3 (DBCA list)	27.0 km SW of study area	*Eucalyptus* woodlands over shrubland in red-orange clayey sand with ironstone and quartz gravel on plains, floodplains and shallow depressions. Recorded flowering September to November (WA Herbarium 1998).
Eremophila caerulea subsp. *merrallii*	P4 (DBCA list)	39.5 km SW of study area	Open *Eucalyptus* woodland over shrubland in sand, clay or loam with ironstone/quartz pebbles on undulating plains. Recorded flowering from October to December (WA Herbarium 1998).
Eucalyptus jutsonii subsp. *jutsonii*	P4 (DBCA list)	30.9 km NW of study area	Open *Eucalyptus* mallee woodland with spinifex grassland in red, yellow or orange deep sands on sandplain, undulating areas and on dunes. Recorded flowering April to March and November (WA Herbarium 1998).

Species	Status	Proximity to study area	Habitat
Eucalyptus x *brachyphylla*	P4 (DBCA list)	18.5 km S of study area	Sandy loam. Granite outcrops. Red loam over granite, on slope. *Eucalyptus* mallee woodland over shrubland in sandy loam or clay loam on granite outcrops. Recorded flowering in December with buds recorded in January (WA Herbarium 1998).
Frankenia glomerata	P4 (DBCA list)	16.6 km S of study area	Associated primarily with waterways and saline areas in particular salt lake/pan edges in shrublands including samphire shrublands in sandy to clay loam soils. Recorded flowering August to December (WA Herbarium 1998).
Streptoglossa aff. *cylindriceps*	sp. nov.	20.2 km SSE of study area	Along drainage lines and on undulating depressions (crabhole gilgai) in red clay/loam soils (Phoenix 2021a, b, c, 2022b)



Northern Star Resources Ltd
Crossroads Project

Project No	1552
Date	9/03/2023
Drawn by	BK
Map author	GW

0 35 70
Kilometer

1:1,341,900 (at A4) GDA 1994 MGA Zone 51

Study area

Status

- P1
- P2
- P3
- P4
- T

Figure 5-1

Desktop records of significant flora and vegetation

PHOENIX ENVIRONMENTAL SCIENCES

5.1.3 Introduced flora

The desktop assessment identified records for 75 weed species near the study area (Appendix 4). Seven of the species are Declared Pests and six are WoNS (Table 5-2).

Botanica (2008) did not record any introduced flora in their survey within the study area. Phoenix (2018a) recorded 5 introduced flora, none were a Declared Pest of WoNS. Phoenix (2019a) did not record any introduced flora.

Table 5-2 Significant weed species identified by the desktop review

Family	Species	Declared Pest/WoNS
Boraginaceae	**Echium plantagineum*	Declared Pest, S22(2) (C3)
Cactaceae	**Cylindropuntia fulgida* var. *mamillata*	Declared Pest, S22(2) (C3); WoNS
Cactaceae	**Cylindropuntia imbricata*	Declared Pest, S22(2) (C3); WoNS
Cactaceae	**Cylindropuntia kleiniae*	Declared Pest, S22(2) (C3); WoNS
Cactaceae	**Opuntia elata*	Declared Pest, S22(2) (C3); WoNS
Cactaceae	**Opuntia ficus-indica*	Declared Pest, S22(2) (C3); WoNS
Fabaceae	**Alhagi maurorum*	Declared Pest, S22(2) (C3)
Solanaceae	**Lycium ferocissimum*	WoNS

5.1.4 Vegetation associations

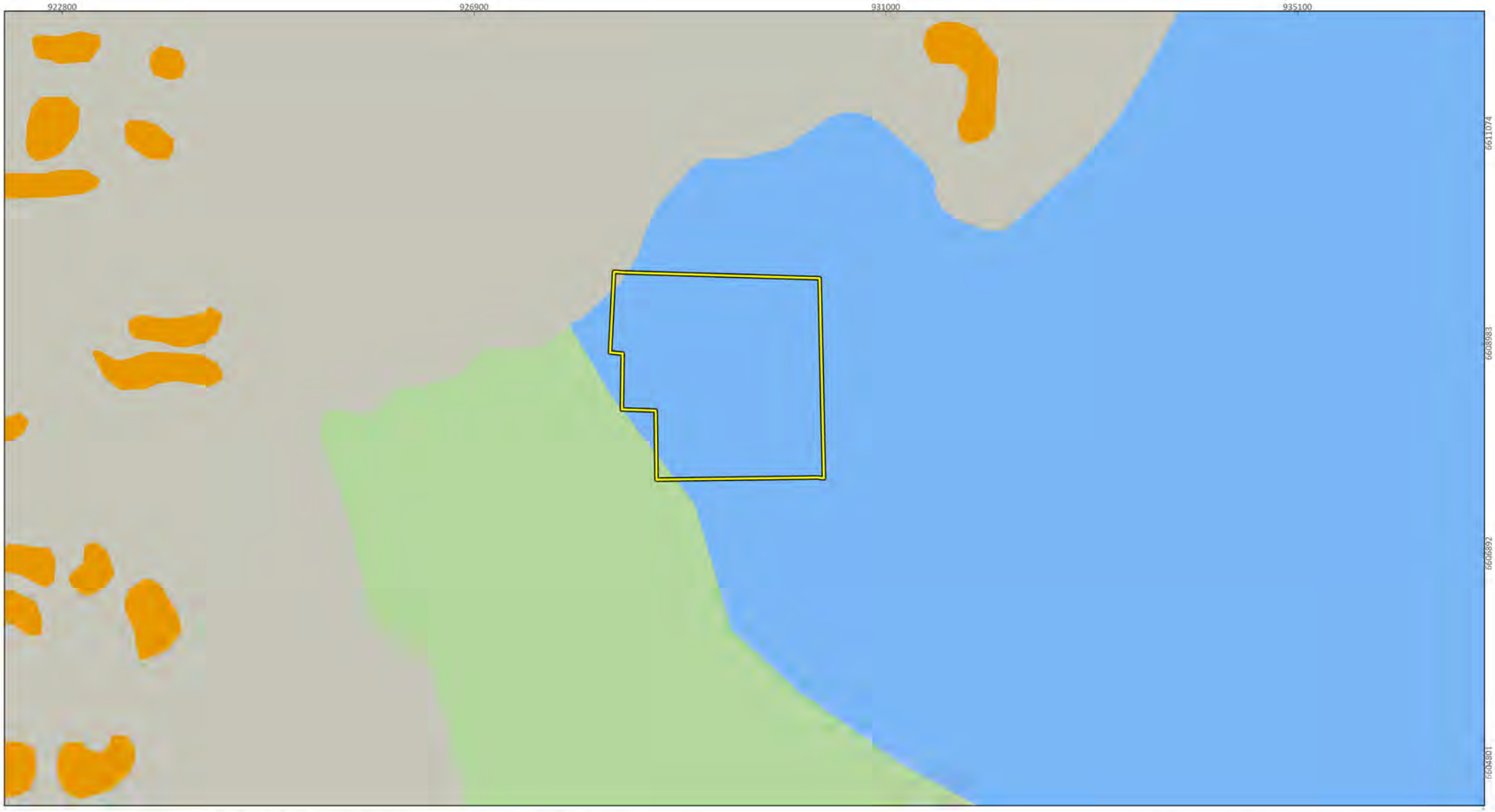
Regional scale pre-European vegetation mapping for Western Australia (Beard *et al.* 2013; DPIRD 2018) mapped 3 vegetation associations in the study area (Table 5-3; Figure 5-2).

The remaining extent of all vegetation associations at the Statewide scale exceeds 98% (Government of Western Australia 2019) and they are therefore considered of Least Concern (Table 5-3).

Table 5-3 Statewide extent of Pre-European vegetation associations present in the study area (Government of Western Australia 2019)

Vegetation association	Pre-European extent (ha)	Current extent (ha)	Remaining (%)	Current extent in DBCA lands (%)	% of study area
20, Low woodland; mulga mixed with *Allocasuarina cristata*[1] & *Eucalyptus* sp.	1,295,103.39	1,292,474.58	99.8	19.42	99.01
468, Medium woodland; salmon gum (*Eucalyptus salmonophloia*) & goldfields blackbutt (*Eucalyptus lesouefii*)	592,022.32	583,902.76	98.63	23.15	0.64
540, Succulent steppe with open low woodland; sheoak over saltbush	202,423.88	200,158.84	98.88	28.18	0.34

1 *Allocasuarina cristata* is now known as *Allocasuarina pauper*



Northern Star Resources Ltd
Crossroads Project

Project No	1552
Date	8/03/2023
Drawn by	BK
Map author	GW

0 1.25 2.5
Kilometer

1:51,000 (at A4) GDA 1994 MGA Zone 51

Study area

Vegetation association

- 10,Medium woodland; red mallee group
- 20,Low woodland; mulga mixed with Allocasuarina cristata & Eucalyptus sp.
- 125,Bare areas; salt lakes
- 468,Medium woodland; salmon gum & goldfields blackbutt
- 540,Succulent steppe with open low woodland; sheoak over saltbush

Figure 5-2

Vegetation associations of the study area

PHOENIX ENVIRONMENTAL SCIENCES

5.1.5 Significant vegetation

The DBCA Threatened and Priority Ecological Communities database search identified the presence of no TECs or PECs within the desktop search extent.

Neither Botanica (2008) or Phoenix (2018a) identified any significant vegetation. Phoenix (2019a) considered 2 vegetation types to be locally significant having a role as a refuge for significant flora, CpAcOm, a low *Casuarina pauper* woodland over mid open shrubland over isolated low shrubs, and ElEsAv, a mid *Eucalyptus lesouefii* woodland over mid open shrubland over isolated low shrubs.

5.2 FIELD SURVEY

5.2.1 Flora assemblage

A total of 86 flora taxa representing 21 families and 45 genera identified to species level were recorded in the study area during the field surveys (Appendix 5), 2 specimens could not be identified to species level. Species richness ranged from 11 to 28 species between quadrats (Appendix 2; Appendix 6). The assemblage included 80 native species and 6 introduced species, including 70 perennial species, and 16 annual or short-lived species. The most prominent families recorded were Chenopodiaceae (22 spp.), Asteraceae (9 spp.), Poaceae (9 spp.), Scrophulariaceae (9 spp.) and Myrtaceae (7 spp.).

The near flattening of the species accumulation curve (Figure 5-3) demonstrates an adequate number of sites to capture the flora of the study area present during the time of the survey.

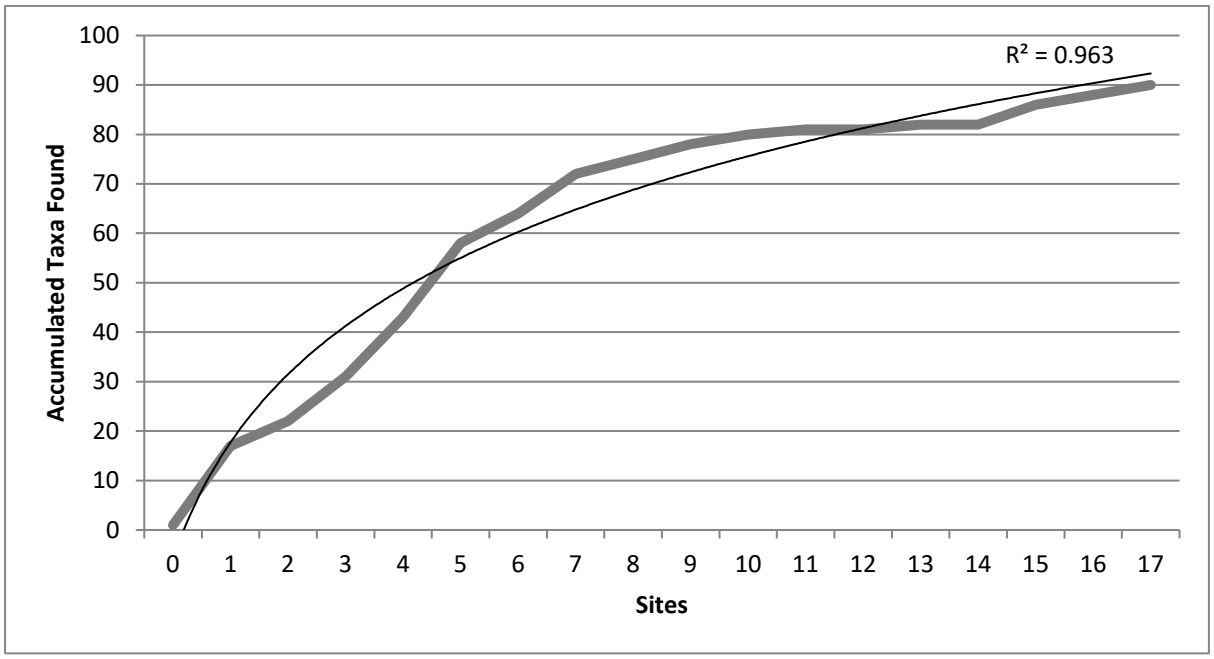


Figure 5-3 Species accumulation curve for flora sites surveyed

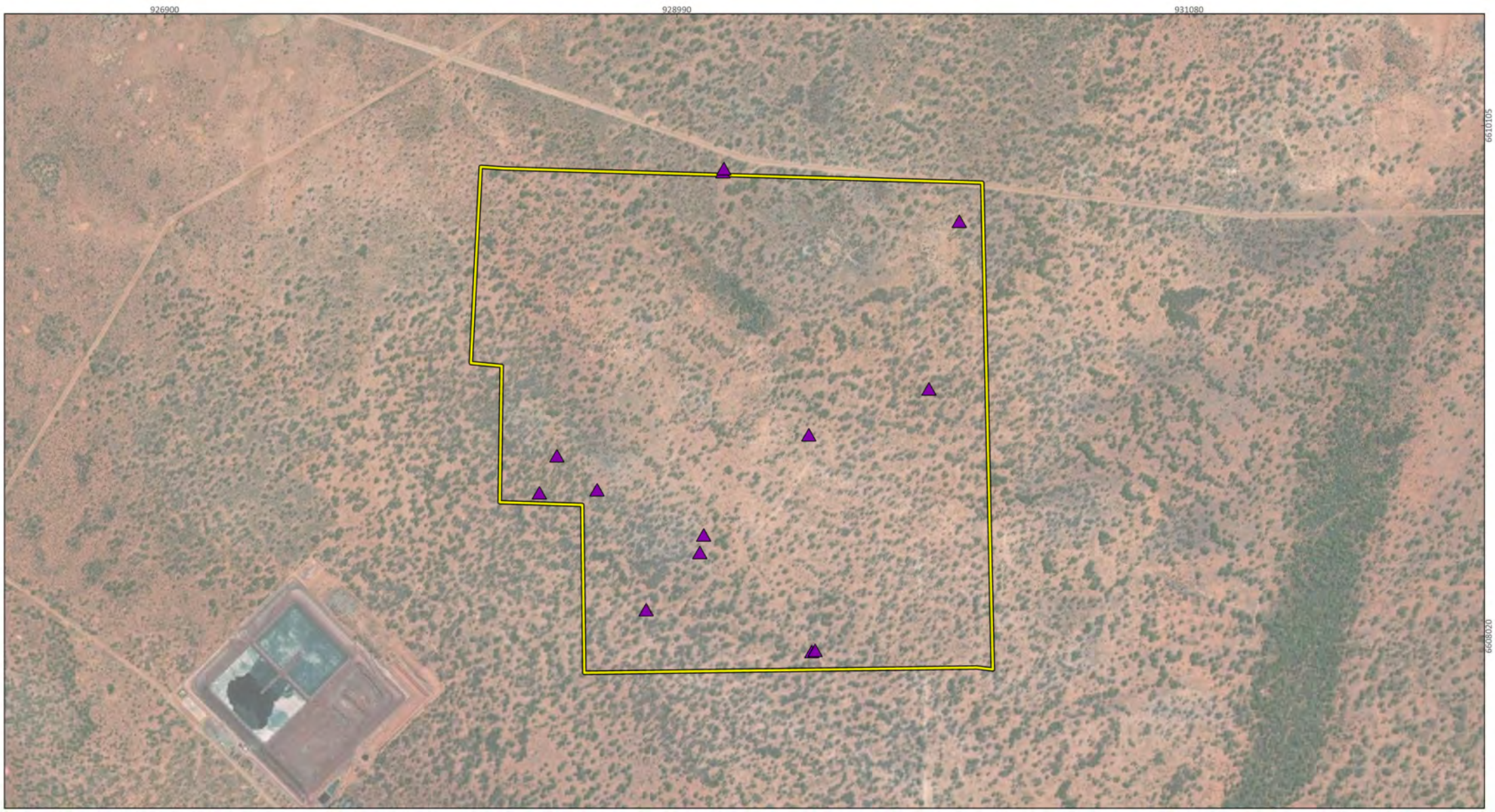
5.2.2 Significant flora

No Threatened flora and one Priority flora were recorded during the field survey, *Eremophila praecox* (P2) (Figure 5-4, Figure 5-4). A total of 13 individual plants were recorded, 11 in the study area and 2 just outside the perimeter of the study area. The plants were recorded in four vegetation types in the study area ElMs, ElsMsMs, ElMsSaf and ElEsTd.

No locally significant species as described in EPA (2016b) were recorded in the study area

The likelihood of occurrence assessment (section 4.2.2.2) for the remaining significant species identified in the desktop review in the 50 km buffer surrounding the study area (section 5.1.2) determined 4 may possibly occur, *Ptilotus procumbens* (P1), *Elachanthus pusillus* (P2), *Notisia intonsa* (P3) and *Streptoglossa* aff *cylindriceps* (sp. nov.). The remaining 24 were unlikely to occur (Table 5-4) as either there was a lack of suitable habitat in the study area and/or the closest record for the species was more than 25 km from the study area.

Figure 5-4 *Eremophila praecox* (P2) recorded in the study area



Northern Star Resources Ltd
Crossroads Project

Project No	1552
Date	16/03/2023
Drawn by	BK
Map author	GW

0 0.5 1
Kilometer

1:20,900 (at A4) GDA 1994 MGA Zone 51

Study area

Status

▲ P2 (DBCA list)

Figure 5-5

Significant flora records from the field survey

PHOENIX ENVIRONMENTAL SCIENCES

Table 5-4 Likelihood of occurrence for significant flora identified in the desktop review

Species	Status	Likelihood of occurrence
Acacia epedunculata	P1 (DBCA list)	Unlikely, lack of suitable habitat in the study area and closest record is almost 25 km away
Calandrinia lefroyensis	P1 (DBCA list)	Unlikely, lack of suitable habitat in the study area and closest records is more than 20 km away
Eremophila xantholaemus	P1 (DBCA list)	Unlikely, lack of suitable habitat in the study area and closest records is more than 25 km away
Phebalium appressum	P1 (DBCA list)	Unlikely, lack of suitable habitat in the study area and closest records is more than 45 km away
Ptilotus procumbens	P1 (DBCA list)	Possible, there is suitable habitat in the study area
Ptilotus rigidus	P1 (DBCA list)	Unlikely, lack of suitable habitat in the study area and closest records is more than 20 km away
Ptilotus sp. Kalgoorlie (J. Jackson & B. Moyle 260)	P1 (DBCA list)	Unlikely, lack of suitable habitat in the study area and closest records is more than 15 km away
Ricinocarpos digynus	P1 (DBCA list)	Unlikely, lack of suitable habitat in the study area and closest records is more than 30 km away
Tecticornia flabelliformis	P1 (DBCA list)	Unlikely, lack of suitable habitat in the study area and closest records is more than 40 km away
Elachanthus pusillus	P2 (DBCA list)	Possible, there is suitable habitat in the study area
Eremophila praecox	P2 (DBCA list)	Recorded
Goodenia salina	P2 (DBCA list)	Unlikely, lack of suitable habitat in the study area and closest records is more than 30 km away
Hakea rigida	P2 (DBCA list)	Unlikely, lack of suitable habitat in study area and closest record is more than 40 km away
Allocasuarina eriochlamys subsp. *grossa*	P3 (DBCA list)	Unlikely, lack of suitable habitat in the study area and closest record is more than 15 km away
Alyxia tetanifolia	P3 (DBCA list)	Unlikely, lack of suitable habitat in the study area and closest records is more than 25 km away
Angianthus prostratus	P3 (DBCA list)	Unlikely, lack of suitable habitat in the study area despite a record in close proximity to study area
Austrostipa turbinata	P3 (DBCA list)	Unlikely, lack of suitable habitat in the study area and closest records is more than 40 km away
Chrysocephalum apiculatum subsp. *norsemanense*	P3 (DBCA list)	Unlikely, lack of suitable habitat in the study area and closest records is almost 50 km away
Cyathostemon verrucosus	P3 (DBCA list)	Unlikely, lack of suitable habitat in the study area and closest records is almost 15 km away
Gompholobium cinereum	P3 (DBCA list)	Unlikely, lack of suitable habitat in the study area and closest records is more than 40 km away
Isolepis australiensis	P3 (DBCA list)	Unlikely, lack of suitable habitat in the study area and closest records is more than 30 km away
Lepidium fasciculatum	P3 (DBCA list)	Unlikely, lack of suitable habitat in the study area and closest record is more than 15 km away
Melaleuca coccinea	P3 (DBCA list)	Unlikely, lack of suitable habitat in the study area and closest records is more than 20 km away
Notisia intonsa	P3 (DBCA list)	Possible, there is suitable habitat in the study area

Species	Status	Likelihood of occurrence
Eremophila caerulea subsp. *merrallii*	P4 (DBCA list)	Unlikely, despite suitable habitat in the study area the closest record is almost 40 km away and the study area is outside of the recorded distribution of the species
Eucalyptus jutsonii subsp. *jutsonii*	P4 (DBCA list)	Unlikely, lack of suitable habitat in the study area and closest records is more than 30 km away
Eucalyptus x *brachyphylla*	P4 (DBCA list)	Unlikely, lack of suitable habitat in the study area and closest record is more than 15 km away
Frankenia glomerata	P4 (DBCA list)	Unlikely, lack of suitable habitat in the study area and closest record is more than 15 km away
Streptoglossa aff. *cylindriceps*	sp. nov.	Possible, there is suitable habitat in the study area

5.2.3 Introduced flora

There were 6 introduced flora species were recorded during the survey, of which none are a WoNS or Declared Pest (Table 5-5).

Table 5-5 Introduced flora recorded in the field survey

Family	Species	Declared Pest	WoNS
Asteraceae	**Centaurea melitensis*	No	No
Asteraceae	**Monoculus monstrosus*	No	No
Asteraceae	**Sonchus oleraceus*	No	No
Brassicaceae	**Carrichtera annua*	No	No
Fabaceae	**Medicago laciniata*	No	No
Lamiaceae	**Salvia verbenaca*	No	No

5.2.4 Unidentified flora

There were 2 specimens collected during the survey that could not be identified to species level (Table 5-6), mainly as a result of insufficient taxonomic characters as plants were sterile (lacking reproductive structures).

Table 5-6 Unidentified taxa recorded during the field survey

Taxon	Comments
Maireana sp.	Sterile
Roepera sp.	Sterile

5.2.5 Vegetation types

There were 8 vegetation types defined for the regional data set from the cluster analysis (Figure 5-5). Of these 6 were represented in the study area (Table 5-7; Figure 5-6). The area was dominated by 5 *Eucalyptus* woodlands, which combined, accounted for 98.9% of the vegetation and a *Eremophila*/chenopod shrubland which accounted for the remaining 1.1% (Table 5-7).

Eucalyptus lesouefii was a dominant component of the tree canopy in all 5 woodlands with *Maireana sedifolia* and *Eremophila scoparia* present in the shrub layer of the woodlands, frequently dominant (*Maireana sedifolia* in all 5 woodlands, *Eremophila scoparia* in 4) in the shrub layers of all woodlands. Vegetation in the study area is therefore primarily *Eucalyptus lesouefii* woodland over mid to low shrubland of *Maireana sedifolia* and *Eremophila scoparia*. The split into the 5 different vegetation types (NVIS, level 5) from this overarching vegetation sub-formation (NVIS, level 4) results primarily

from the variable presence of other *Eucalyptus* spp. and/or the occasional presence of a tall *Melaleuca* or *Casuarina* shrub layer.

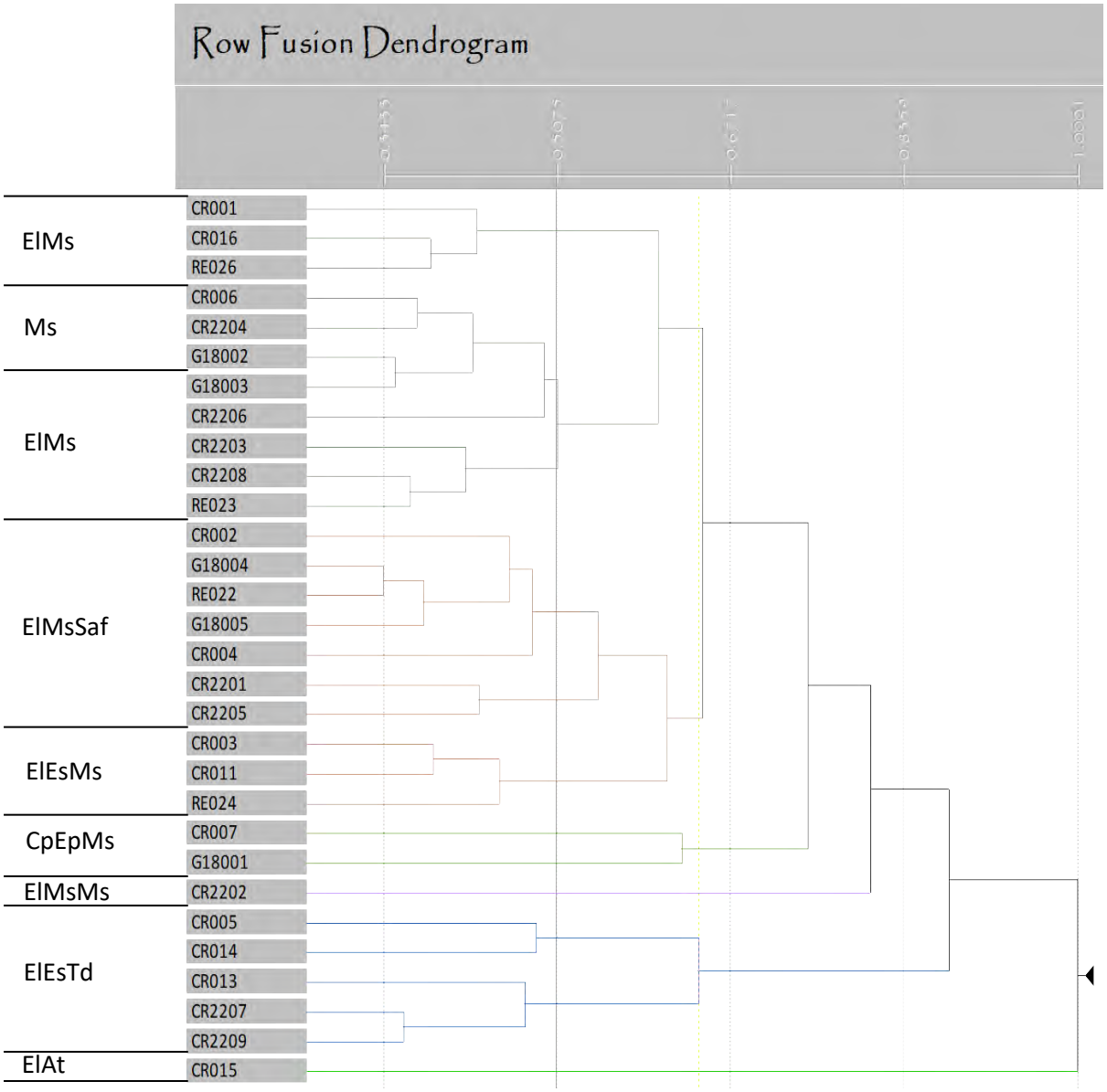


Figure 5-6 Hierarchical clustering (UPGMA) of the flora quadrats of the study area

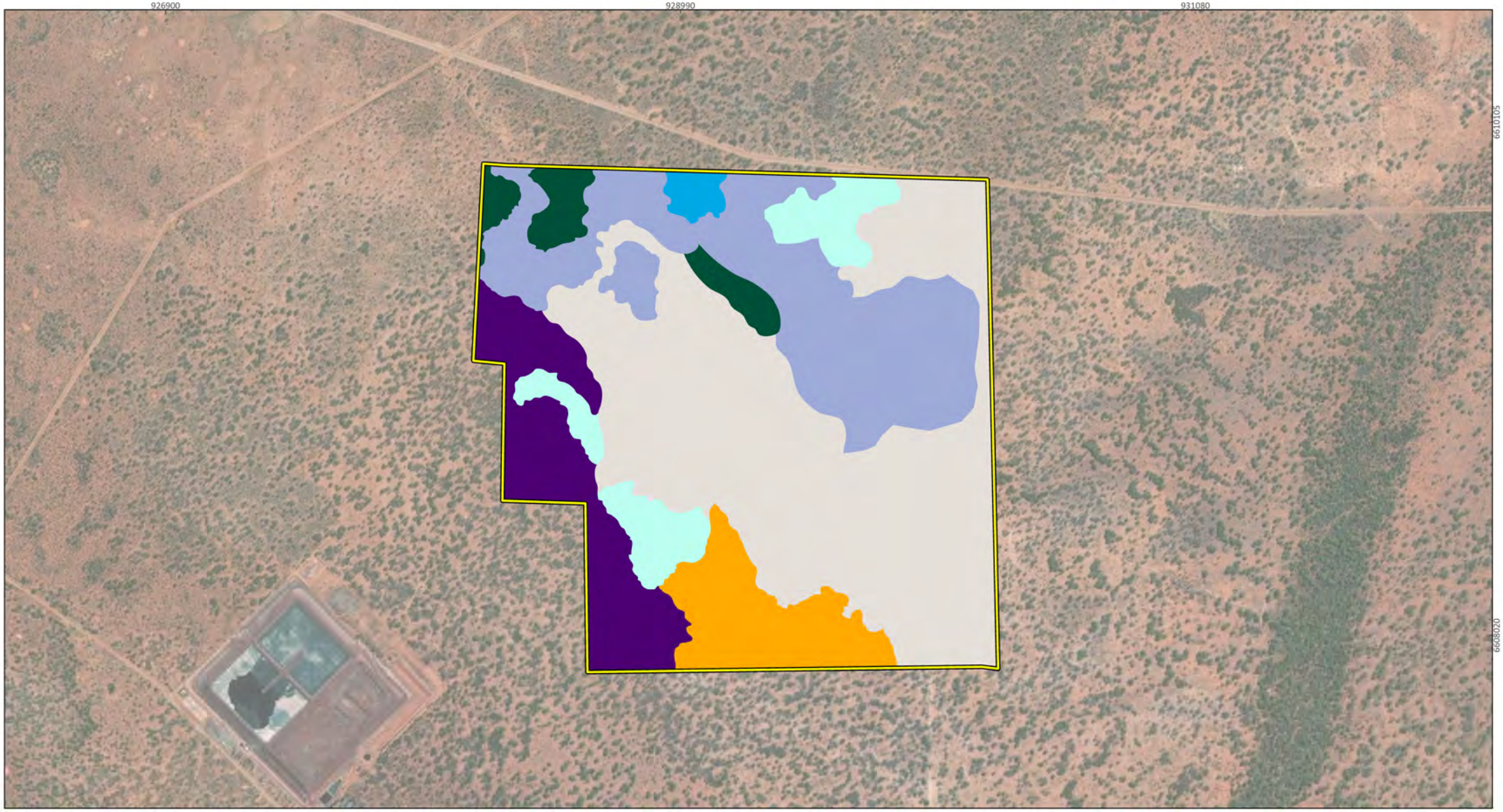
Table 5-7 Vegetation types, description and extent in the study area

Vegetation type	Site/s	Vegetation description	Extent in study area (ha) and % of study area	Representative photograph
ElMs	CR001, CR016, CR2203, CR2206, CR2208, G18003, RE023, RE026	Mid woodlands to forests of *Eucalyptus lesouefii*, with a mosaic of mid to low woodlands of *E. longicornis*, *E. salubris* or *E. oleosa* subsp. *oleosa* over a mid to low open shrubland of *Maireana sedifolia*, *Eremophila scoparia* and *Scaevola spinescens.*	120.7, 31.3%	
Ms	CR006, CR2204, G18002	Mid open shrubland of *Maireana sedifolia*, *Eremophila scoparia* and *E. parvifolia* subsp. *auricampa*.	4.3, 1.1%	

Vegetation type	Site/s	Vegetation description	Extent in study area (ha) and % of study area	Representative photograph
ElMsSaf	CR002, CR004, CR2201, CR2205, G18004, G18005, RE022	Mid woodland of *Eucalyptus lesouefii* over a mid sparse shrubland of *Maireana sedifolia* and *Eremophila scoparia* over a low sparse shrubland of *Senna artemisioides* subsp. *filifolia*, *Scaevola spinescens* and *Cratystylis conocephala.*	26.8, 6.9%	
ElEsMs	CR003, CR011, RE024	Low woodland to open forest of *Eucalyptus lesouefii*, *Eucalyptus salubris* and *Casuarina pauper* over a mid open shrubland of *Eremophila scoparia* over a low open shrubland of *Maireana sedifolia*, Senna *artemisioides* subsp. *filifolia* and *Acacia nyssophylla.*	14.9, 3.9%	

Vegetation type	Site/s	Vegetation description	Extent in study area (ha) and % of study area	Representative photograph
CpEpMs	CR007, G18001	Low woodland of *Casuarina pauper* over mid isolated shrubs of *Eremophila parvifolia* subsp. *auricampa* over a low open shrubland of *Maireana sedifolia*, *Olearia muelleri* and *Atriplex vesicaria.*	Not in study area	
ElMsMs	CR2202	Mid *Eucalyptus lesouefii* and *E. oleosa* subsp. *oleosa* woodland over tall open *Melaleuca sheathiana* shrubland over isolated low *Maireana sedifolia*, *Olearia muelleri* and *Scaevola spinescens* shrubs.	45.2, 11.7%	

Vegetation type	Site/s	Vegetation description	Extent in study area (ha) and % of study area	Representative photograph
ElEsTd	CR005, CR013, CR014, CR2207, CR2209	Mid open woodland of *Eucalyptus lesouefii* or *E. salubris* over mid isolated shrubs of *Eremophila scoparia* over a low open shrubland of *Tecticornia disarticulata*, *Atriplex vesicaria* and *Maireana sedifolia.*	174.0, 45.1%	
ElAt	CR015	Mid open forest of *Eucalyptus lesouefii* over a mid to low shrubland of *Acacia tetragonophylla*, *Eremophila decipiens* and *E. alternifolia.*	Not in study area	



Northern Star Resources Ltd
Crossroads Project

Project No	1552
Date	16/03/2023
Drawn by	BK
Map author	GW

0 0.5 1
Kilometer

1:20,900 (at A4) GDA 1994 MGA Zone 51

Study area

Vegetation type

- ElEsMs
- ElEsTd
- ElMs
- ElMs
- ElMsMs
- ElMsSaf
- Ms

Figure 5-7

Vegetation types recorded in the field survey

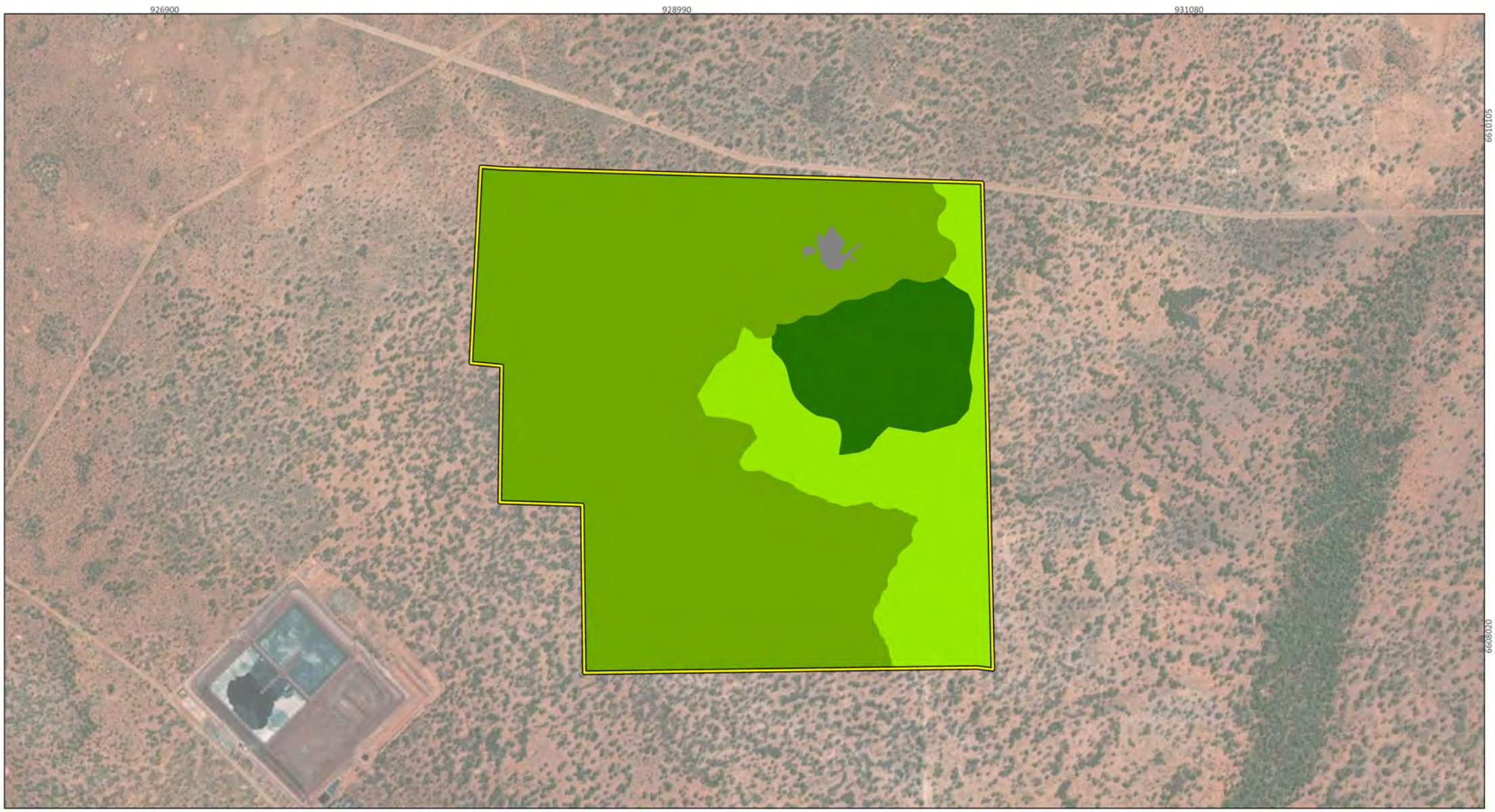
PHOENIX ENVIRONMENTAL SCIENCES

5.2.6 Vegetation condition

The condition of remnant vegetation in the study area was recorded from Degraded to Excellent (Figure 5-7) with the majority (80.02%) as Very Good/Excellent condition (Table 5-8). Areas in Excellent condition showed no evidence of disturbance. Areas in Very Good condition contained vehicle tracks, litter and the presence of some weeds in low numbers. Good areas showed evidence of historic large scale clearing, litter, the presence of weeds and evidence of feral animals. Degraded areas were more recently large scale cleared, contained litter, weeds and evidence of feral animals.

Table 5-8 Vegetation condition – extent of each condition rating in study area

Condition rating	Area (ha)	% of study area
Excellent	40.93	10.61
Very Good	267.78	69.41
Good	75.38	19.54
Degraded	1.7	0.44



Northern Star Resources Ltd
Crossroads Project

Project No	1552
Date	16/03/2023
Drawn by	BK
Map author	GW

0 0.5 1
Kilometer

1:20,900 (at A4) GDA 1994 MGA Zone 51

Study area

Vegetation condition

- Excellent
- Very Good
- Good
- Degraded

Figure 5-8

Vegetation condition in the study area

PHOENIX ENVIRONMENTAL SCIENCES

5.2.7 Significant vegetation

None of the vegetation in the study area was considered representative of a TEC or PEC.

There were 4 vegetation types that may be considered locally significant in having a role as a refuge for the significant flora *Eremophila praecox* (P2).

Table 5-9 Significant vegetation types in the study area

Vegetation type	Significance	Level of significance
ElMs	Represents a refuge for *Eremophila praecox*	Locally significant
ElMsMs	Represents a refuge for *Eremophila praecox*	Locally significant
ElMsSaf	Represents a refuge for *Eremophila praecox*	Locally significant
ElEsTd	Represents a refuge for *Eremophila praecox*	Locally significant

5.3 SURVEY LIMITATIONS

The limitations of the flora and vegetation survey have been considered in accordance with EPA (2016b, c) (Table 5-10).

Table 5-10 Consideration of potential survey limitations

Limitations	Comments
Availability of contextual information at a regional and local scale	There were numerous previous survey reports available and Phoenix have conducted several previous surveys from which a substantial amount of data was available.
Competency/experience of the team carrying out the survey	The field survey was led by Dr Grant Wells who has conducted field surveys in the Murchison bioregions for more than 15 years.
Scope and completeness	The survey was sufficient to identify the botanical values of the study area. The analyses conducted split the vegetation in the study area into 6 types, some of which had less than 3 replicate quadrat surveys. However, the vegetation in the study area primarily represents a single sub-formation that was adequately surveyed.
Proportion of flora recorded and/or collected, any identification issues	The species accumulation curve indicated that a high proportion of the flora was collected. Neither of the 2 species that could not be identified to species level are considered likely to represent any listed significant flora.
Access within the study area	There were no access restrictions all areas of the study area were accessible by either vehicle or by foot.
Timing, rainfall, season	The survey was conducted following above average rainfall at a time of year consistent with recommended survey period for the bioregion.
Disturbance that may have affected the results of the survey	There were no disturbances that would have affected the results of the survey.

6 DISCUSSION

6.1 FLORA ASSEMBLAGE

The number of species recorded in the current survey is comparable to previous surveys with the total number of species recorded slightly lower than the previous survey in the Crossroads area (Phoenix 2018a) but higher than Phoenix (2019a) and (Botanica 2008). The assemblage was also consistent with the dominant families recorded in the current survey also dominant in the previous surveys (Botanica 2008; Phoenix 2018a, 2019a).

6.2 SIGNIFICANT FLORA

Of the 29 significant flora identified from the desktop assessment to possibly occur in the study area, only one, *Eremophila praecox* (P2) was recorded during the field survey. This species was previously recorded in close proximity to the study area (Phoenix 2019a, b, 2020b).

A recent survey for *Eremophila praecox* (Phoenix 2020b) established that the species has a greater distribution than that currently recorded on FloraBase (WA Herbarium 1998) or NatureMap (DBCA 2022a). The species is most frequently recorded in clay loam soils in *Eucalyptus* and/or *Allocasuarina* woodland with a variable understorey, frequently with *Acacia* and *Eremophila* species. Phoenix (2020b) recorded a total of 340 *Eremophila praecox* plants, noting that some records of the species were not visited during the survey as they were not accessible and subsequently the total population size of the species would exceed this figure. Further flora surveys and targeted searches for the species have been conducted (Phoenix 2020a, 2021b, 2022b, c, 2023) and the known population of the species exceeded 481 individuals (Phoenix 2022b) of which 125 plants (ca26%) have been recorded in nature reserves.

The 13 individuals recorded in the current survey increases the known population to in excess of 494 individuals, with the 11 recorded in the study area representing 2.2% of the known population.

Priority 2 species are "Species that are known from one or a few locations (generally five or less), some of which are on lands managed primarily for nature conservation, for example, national parks, conservation parks, nature reserves and other lands with secure tenure being managed for conservation" (DBCA 2020). As recent surveys (Phoenix 2020a, 2021b, 2022b, c, 2023) have identified that *Eremophila praecox* is known from a far greater number of populations than 5 with over a quarter of known plants in conservation reserves the species may be considered more likely to have a status of Priority 3 or lower. Priority 3 species are "Species that are known from several locations and the species does not appear to be under imminent threat or from few but widespread locations with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat" (DBCA 2020).

Assessment of the likelihood of occurrence of significant flora identified in the desktop assessment occurring in the study area determined it was possible that 4 species may occur:

- *Ptilotus procumbens* (P1)
- *Elachanthus pusillus* (P2)
- *Notisia intonsa* (P3)
- *Streptoglossa* aff *cylindriceps* (locally significant)

Ptilotus procumbens is only known from 4 locations in the Coolgardie and Murchison bioregions (WA Herbarium 1998). Information pertaining to population sizes was limited to a record of a single plant. Similarly *Elachanthus pusillus* is known from just 7 records all located within the Coolgardie bioregion (WA Herbarium 1998). Information pertaining to population sizes of *Elachanthus pusillus* was limited to a single record of 'scattered'.

Notisia intonsa has been recorded in the Avon Wheatbelt, Coolgardie, Esperance Plains, Mallee and the Murchison bioregions. The species has been recorded in the Mount Manning – Helena and Aurora Ranges Conservation Park (WA Herbarium 1998). There are 25 records of *Notisia intonsa* (WA Herbarium 1998), with comments on frequency raging from isolated to a few plants. During recent surveys Phoenix (2021c) recorded a total of 326 plants and Phoenix (2022a) in excess of 1800 individuals.

Streptoglossa aff. *cylindriceps* has been recorded in 4 recent surveys (Phoenix 2021a, b, c, 2022b), located approximately 180 km west-southwest, 68 km south, 160 km northwest and 1.9 km south of the study area. In all 4 surveys the species occurred along drainage lines and on undulating depressions (crabhole gilgai). One of the surveys Phoenix (2021c) recorded 3 populations comprising a total of 1290 plants.

6.3 INTRODUCED FLORA

All of the 6 introduced flora recorded during the field survey were identified in the desktop assessment to potentially occur in the study area. Each of the species have a broad distribution in Western Australia and have records in multiple bioregions.

6.4 VEGETATION

The *Eucalyptus* woodlands recorded in the study area are representative of the 468 vegetation association mapped by Shepherd *et al.* (2002) for the study area, that has more than 98% of pre-European extent remaining and covers a large areas (>500,000 ha) (DBCA 2018a).

The shrubland communities are dominated by common species with broad distributions and are likely to be well represented in the broader landscape. The shrubland communities were comprised of species that were in the understorey of the adjacent woodlands. No vegetation in the study area is representative of a TEC or PEC.

Eremophila praecox (P2) was recorded in 4 of the *Eucalyptus* woodlands present in the study area (ElMs, ElMsMs, ElMsSaf, ElEsTd) and these may therefore be considered locally significant providing a refuge for this significant species. The remaining woodland (ElEsMs) also represents suitable habitat for this significant species.

Eremophila praecox has been found to have a broad distribution and is typically found in low densities in *Eucalyptus* and/or *Casuarina* woodlands over a varied shrub layer frequently *Acacia*, *Eremophila*, *Senna* and *Maireana* species on flat to undulating plains in red clay loam soils (Phoenix 2019b). These vegetation types are widespread in the surrounding landscape and it is therefore unlikely that disturbance in the study area would impose any significant impact on the habitat of *Eremophila praecox*.

6.5 CONCLUSION

The key botanical value of the study area is the presence of *Eremophila praecox*, P2 and possible presence of other significant flora, *Ptilotus procumbens* (P1), *Elachanthus pusillus* (P2), *Notisia intonsa* (P3) and *Streptoglossa* aff *cylindriceps* (sp. nov.). Due to the small size of the Project, it is considered to not represent any significant threat to the status of any significant flora or vegetation.

REFERENCES

Australian Weeds Committee. 2007. *The Australian Weeds Strategy. A national strategy for weed management in Australia*. Natural Resource Management Ministerial Council, Australian Weeds Committee, Canberra, ACT. Available at: http://www.environment.gov.au/biodiversity/invasive/weeds/publications/strategies/pubs/weed-strategy.pdf

Australian Weeds Committee. 2012. *Weeds of National Significance 2012*. Department of Agriculture, Fisheries and Forestry, Canberra, ACT.

Beard, J. S., Beeston, G., Harvey, J., Hopkins, A. & Shepherd, D. 2013. *The vegetation of Western Australia at the 1:3,000,000 scale. Explanatory memoir. Second edition.* Department of Agriculture and Food Western Australia.

Belbin, L. 2003. *PATN. A revised user's guide*. Blatant Fabrications Pty Ltd, Bonnet Hill, Tas.

BoM. 2022. *Climate statistics for Australian locations*. Commonwealth of Australia, Bureau of Meterology. Available at: http://www.bom.gov.au/climate/data/

Botanica. 2008. *Flora and vegetation survey of the Cross Roads area tenements M24/462 & E26/124*. Botanica Consulting Pty Ltd, Boulder, WA. Unpublished report prepared for Barrick (Kanowna) Ltd.

Brown, A. & Davis, R. 2019. Eremophila oldfieldii subsp. papula, E. sericea and E. xantholaema (Scrophulariaceae), three new taxa from Western Australia. *Nuytsia* **30**: 25-31.

Cowan, M. 2001a. Coolgardie 3 (COO3—Eastern Goldfields subregion). *In:* May, J. E. & McKenzie, N. L. (eds) *A biodiversity audit of Western Australia's 53 biogeographical subregions in 2002.* Department of Conservation and Land Mangement, Perth, W.A., pp. 156–169.

Cowan, M. 2001b. Murchison 1 (MUR1—East Murchison subregion). *In:* May, J. E. & McKenzie, N. L. (eds) *A biodiversity audit of Western Australia's 53 biogeographical subregions in 2002.* Department of Conservation and Land Management, Perth, WA, pp. 466–479.

Crossman, C. & Li, O. 2015. *Surface Hydrology Polygons (National) in* Australia, G., ed. Geoscience Australia, Canberra, ACT.

DBCA. 2020. *Conservatoin codes for Western Australian flora and fauna*. Department of Biodiversity, Conservation and Attractions, Kensington, WA.

DBCA. 2022a. *NatureMap database*. Department of Biodiversity and Attractions, Perth, WA.

DBCA. 2022b. *Threatened and Priority Ecological Communities database*. Department of Biodiversity, Conservation and Attractions, Kensington, WA.

DBCA. 2022c. *Threatened and Priority flora database*. Department of Biodiversity, Conservation and Attractions, Kensington, WA.

DCCEEW. 2022. *Protected Matters Search Tool*. Available at: pmst.awe.gov.au

DER. 2014. *A guide to the assessment of applications to clear native vegetation, under Part V Division 2 of the Environmental Protection Act 1986*. Department of Environment Regulation, Perth, WA.

DoE. 2016. *Collaborative Australian Protected Area Database (CAPAD)*. Department of Environment, Canberra, ACT. Available at: http://www.environment.gov.au/land/nrs/science/capad

DoEE. 2016. *Maps: Australia's bioregions (IBRA)*. Department of the Environment and Energy, Canberra, ACT. Available at: http://www.environment.gov.au/topics/land/national-reserve-system/science-maps-and-data/australias-bioregions-ibra

DPIRD. 2018. *Pre-European Vegetation – Western Australia (NVIS Compliant version 20110715) in* Department of Primary Industry and Regional Development, ed, Kensington, WA.

DPIRD. 2019. *Western Australian Organism List*. Department of Agriculture and Food, Government of Western Australia, South Perth, WA. Available at: https://www.agric.wa.gov.au/bam/western-australian-organism-list-waol (accessed 18 September 2019).

EPA. 2016a. *Environmental Factor Guideline: Flora and vegetation*. Environmental Protection Authority, Perth, WA. Available at: http://www.epa.wa.gov.au/sites/default/files/Policies_and_Guidance/Guideline-Flora-Vegetation-131216_4.pdf

EPA. 2016b. *Technical Guidance: Flora and vegetation surveys for Environmental Impact Assessment*. Environmental Protection Authority, Perth, WA. Available at: http://www.epa.wa.gov.au/sites/default/files/Policies_and_Guidance/EPA%20Technical%20Guidance%20-%20Flora%20and%20Vegetation%20survey_Dec13.pdf

EPA. 2016c. *Technical Guidance: Terrestrial fauna surveys*. Environmental Protection Authority, Perth, WA. Available at: http://www.epa.wa.gov.au/sites/default/files/Policies_and_Guidance/Tech%20guidance-%20Terrestrial%20Fauna%20Surveys-Dec-2016.pdf

ESCAVI. 2003. *Australian Vegetation Attribute Manual: National Vegetation Information System (Version 6.0)*. Department of Environment and Heritage, Canberra.

Geoscience Australia. 2021. *Elvis - Elevation and Depth - Foundation Spatial Data*. Available at: https://elevation.fsdf.org.au/

Government of Western Australia. 2005. *Environmental Protection (Environmentally Sensitive Areas) Notice 2005*. Government of Western Australia, Perth, Western Australia.

Government of Western Australia. 2018a. *Wildlife Conservation Act 1950 Wildlife Conservation (Rare Flora) Notice 2018*. Government Gazette, WA. Government of Western Australia, Perth, WA.

Government of Western Australia. 2018b. *Wildlife Conservation Act 1950, Wildlife Conservation (Specially Protected Fauna) Notice 2018*. Government Gazette, WA, Perth, WA.

Government of Western Australia. 2019. *2018 Statewide Vegetation Statistics incorporating the CAR Reserve Analysis (Full Report). Current as of March 2019*. Department of Biodiversity, Conservation and Attractions, Perth, WA.

Hislop, M. & Wege, J. A. 2020. A new Wedding Bush from the eastern goldfields of Western Australia (*Ricinocarpos digynus*: Euphorbiaceae). *Nuytsia* **31**: 169-175.

Lally, T. R. 2009. New taxa of *Ptilotus* (Amaranthaceae) from Western Australia. *Nuytsia* **19**: 53-62.

Obbens, F. J. 2018. Three new perennial species of *Calandrinia* (Montiaceae) from southern Western Australia. *Nuytsia* **29**: 193-204.

Payne, A. L. & Leighton, K. A. 2004. Land systems. *In:* van Vreeswyk, A. M. E., Payne, A. L., Leighton, K. A. & Hennig, P. (eds) *Technical Bulletin 9. An inventory and condition survey of the Pilbara region, Western Australia*. Department of Agriculture, Government of Western Australia, South Perth, WA, pp. 175–384.

Phoenix. 2018a. *Flora, vegetation and terrestrial fauna survey of the Crossroads tenements (M24/462, L24/197)*. Phoenix Environmental Sciences Pty Ltd, Balcatta, WA. Unpublished report prepared for Kalgoorlie Consolidated Gold Mines Pty Ltd.

Phoenix. 2018b. *Regional flora and vegetation and terrestrial fauna survey for the Gidji Operations*. Phoenix Environmental Sciences Pty Ltd, Balcatta, WA. Unpublished draft report prepared for Kalgoorlie Consolidated Gold Mines Pty Ltd.

Phoenix. 2019a. *Regional flora, vegetation and terrestrial fauna survey for the Gidji Operations*. Phoenix Environmental Sciences, Balcatta, WA. Unpublished report prepared for KCGM Operations.

Phoenix. 2019b. *Regional survey for Eremophila praecox for the FIM IIE Project*. Phoenix Environmental Sciences, Balcatta, WA. Unpublished report prepared for KCGM Pty Ltd.

Phoenix. 2020a. *Kambalda West regional flora and fauna survey for the St Ives Gold Mine*. Phoenix Environmental Sciences Pty Ltd, Osborne Park, WA. Unpublished report prepared for St Ives Gold Mining Company Pty Ltd.

Phoenix. 2020b. *Regional survey for Eremophila praecox for the FIM IIE Project*. Phoenix Environmental Sciences Pty Ltd, Osborne Park, W.A. Unpublished report prepared for Kalgoorlie Consolidated Mines Pty Ltd.

Phoenix. 2021a. *Baseline flora, vegetation and fauna surveys for the Parker Range Haul Road project - northern extension.* Phoenix Environmental Sciences Pty Ltd. Unpublished report prepared for Mineral Resources Ltd.

Phoenix. 2021b. *Detailed flora and vegetation and basic/detailed fauna surveys for the Larkinville and Eagles Nest Projects*. Phoenix Environmental Sciences Pty Ltd, Osborne Park, WA. Unpublished report prepared for Maximus Resources Ltd.

Phoenix. 2021c. *Targeted searches at Hunt Range*. Pheonix Environmental Sciences Pty Ltd, Osborne Park, WA. Unpublished report prepared for Mineral Resources Ltd.

Phoenix. 2022a. *Desktop assessment and targeted signficant flora and vegetation surveys for the Marda Gold Project*. Phoenix Environmental Sciences Pty ltd, Osborne Park, Western Australia. Unpublished report prepared for Ramelius Resources Limited.

Phoenix. 2022b. *Flora and vegetation assessments for the Fimiston Gold Mine Operations*. Phoenix Environmental Sciences Pty Ltd, Osborne Park, WA.

Phoenix. 2022c. *Reconnaissance flora and vegetation survey for the Kalgoorlie Operations Project*. Phoenix Environmental Sciences Pty Ltd, Osborne Park, Western Australia. Unpublished report prepared for Northrn Star Resources Limited.

Phoenix. 2023. *Recconnaissance flora and vegetation survey for the regional core yard project*. Phoenix environmental Sciences Pty Ltd, Osborne Park, Western Australia. Unpublished report prepared for Northern Star Resources Limited.

Sage, L. W. & Shepherd, K. A. 2007. Five new conservation-listed *Goodenia* (Goodeniaceae) from south Western Australia. *Nuytsia* **17**: 331-346.

Schoknecht, N. R. & Payne, A. L. 2011. *Land systems of the Kimberley region, Western Australia*. Department of Agriculture and Food, Western Australia, Perth.

Shepherd, D. P., Beeston, G. R. & Hopkins, A. J. M. 2002. *Native vegetation in Western Australia. Extent, type and status.* Department of Agriculture, South Perth, WA. Resource Management Technical Report 249.

Trudgen, M. E. & Rye, B. L. 2014. An update to the taxonomy of some Western Australian genera of Myrtaceae tribe Chamelaucieae. 2. *Cyathostemon*. *Nuytsia* **24**.

WA Herbarium. 1998. *FloraBase - the Western Australian Flora*. Department of Biodiversity, Conservation and Attractions. Available at: http://florabase.dpaw.wa.gov.au/

Williams, A. R. 2022. *Austrostipa* (Poaceae) in Western Australia: new species, new records, keys, and character notes. *Nuytsia* **33**: 39-101.

Wilson, P. G. 2016. A taxonomic treatment of Chrysocephalum apiculatum and C. semipapposum (Asteraceae: Gnaphalieae). *Nuytsia* **27**: 33-73.

Appendix 1 Survey site locations

Site Code	latitude	longitude
CR001	-30.572787	121.480727
CR002	-30.572759	121.464947
CR003	-30.566381	121.465979
CR004	-30.566377	121.477853
CR005	-30.574482	121.474767
CR011	-30.569834	121.47365
CR013	-30.575678	121.468559
CR014	-30.567059	121.482389
CR2201	-30.5786	121.470121
CR2202	-30.574385	121.464185
CR2203	-30.567708	121.464281
CR2204	-30.566081	121.471551
CR2205	-30.566786	121.47545
CR2206	-30.581786	121.477115
CR2207	-30.577775	121.476203
CR2208	-30.581247	121.471371
CR2209	-30.577861	121.481601

Site details			
Site	**CR001**	**Position (WGS84)**	-30.572787, 121.480727
Slope	negligible	**Topography**	plain
Soil colour		**Soil texture**	
Rock cover (%)	0	**Rock type**	none

Observation details - visit 1 (08 Nov 2017)	
Sample description	Low *Eucalyptus lesouefii*, *E. salubris* and *E. longicornis* woodland over isolated mid *Eremophila scoparia* shrubs over low *Maireana sedifolia* and *Tecticornia disarticulata* shrubland.

Habitat	woodland		
Disturbance	vehicle tracks,		
Vegetation conditio	Excellent	**Fire age**	not evident
Total veg. cover (%)	50	**Tree cover (%)**	30
Shrub cover (%)	25	**Grass cover (%**	0.1
Herb cover (%)	0.1		

Sample and effort summary				
Sample method	**Visit**	**Sample date**	**Dimensions**	**Observer**
Quadrat	1	08-Nov-2017	20 m x 20 m	Grant Wells
Quadrat	2	30-Nov-2022		Grant Wells

Species (15)	Status	Visit 1		Visit 2	
		Cover (%)	Height (m)	Cover (%)	Height (m)
Eucalyptus lesouefii		20	10		
Tecticornia disarticulata		15	0.7		
Eucalyptus salubris		10	8		
Maireana sedifolia		7	0.8		
Eremophila scoparia		2	1.9		
Eucalyptus longicornis		0.1	10		
Eremophila glabra subsp. *glabra*		0.1	0.7		
Scaevola spinescens		0.1	0.4		
Atriplex vesicaria		0.1	0.4		
Senna artemisioides subsp. *filifolia*		0.1	0.3		
Sclerolaena diacantha		0.1	0.2		
Austrostipa trichophylla		0.1	0.15		
Solanum lasiophyllum				0.1	0.2
Olearia muelleri				0.1	0.3
Maireana trichoptera				0.1	0.15

Site details			
Site	**CR002**	**Position (WGS84)**	-30.572759, 121.464947
Slope	negligible	**Topography**	plain
Soil colour		**Soil texture**	
Rock cover (%)	0	**Rock type**	ferrous – ironstone

Observation details - visit 1 (08 Nov 2017)			
Sample description	Low *Eucalyptus lesouefii* and *E. longicornis* woodland over isolated mid *Eremophila oppositifolia* subsp. *angustifolia* shrubs over low sparse *Maireana sedifolia*, *Eremophila parvifolia* subsp. *auricampa* and *Scaevola spinescens* shrubland.		
Habitat	woodland		
Disturbance	exploration (drill pads and access tracks), grazing – low, historic clearing,		
Vegetation conditio	Very Good	**Fire age**	not evident
Total veg. cover (%)	30	**Tree cover (%)**	25
Shrub cover (%)	5	**Grass cover (%**	0
Herb cover (%)	0		

Sample and effort summary				
Sample method	**Visit**	**Sample date**	**Dimensions**	**Observer**
Quadrat	1	08-Nov-2017	20 m x 20 m	Grant Wells
Quadrat	2	30-Nov-2022		Grant Wells

Species (14)	Status	Visit 1		Visit 2	
		Cover (%)	Height (m)	Cover (%)	Height (m)
Eucalyptus lesouefii		25	9		
Maireana sedifolia		3	0.6		
Eremophila oppositifolia subsp. *angustifolia*		1	1.8		
Eremophila parvifolia subsp. *auricampa*		1	0.5		
Scaevola spinescens		1	0.4		
Eucalyptus longicornis		0.1	7		
Eremophila sp. Mt Jackson (G.J. Keighery 4372)		0.1	2		
Eremophila glabra subsp. *glabra*		0.1	1		
Acacia nyssophylla		0.1	0.4		
Acacia erinacea		0.1	0.4		
Maireana pentatropis		0.1	0.3		
Olearia muelleri		0.1	0.25		
Senna artemisioides subsp. *filifolia*		0.1	0.2		
Eremophila scoparia				0.1	0.7

Site details			
Site	**CR003**	**Position (WGS84)**	-30.566381, 121.465979
Slope	negligible	**Topography**	plain
Soil colour		**Soil texture**	
Rock cover (%)	0	**Rock type**	none

Observation details - visit 1 (08 Nov 2017)	
Sample description	Low *Eucalyptus lesouefii* and *E. longicornis* woodland over mid open *Eremophila scoparia* shrubland over low *Acacia hemiteles*, *Maireana sedifolia* and *Senna artemisioides* subsp. *filifolia* shrubland.

Habitat	woodland		
Disturbance	evidence of feral animals, grazing – low, historic operations, vehicle tracks,		
Vegetation conditio	Very Good	**Fire age**	not evident
Total veg. cover (%)	40	**Tree cover (%)**	15
Shrub cover (%)	35	**Grass cover (%**	0.2
Herb cover (%)	0		

Sample and effort summary				
Sample method	**Visit**	**Sample date**	**Dimensions**	**Observer**
Quadrat	1	08-Nov-2017	20 m x 20 m	Grant Wells
Quadrat	2	30-Nov-2022		Grant Wells

Species (21)	Status	Visit 1		Visit 2	
		Cover (%)	Height (m)	Cover (%)	Height (m)
Eremophila scoparia		12	1.8		
Eucalyptus lesouefii		10	8		
Maireana sedifolia		8	0.6		
Eucalyptus longicornis		5	7		
Senna artemisioides subsp. *filifolia*		5	0.8		
Acacia hemiteles		5	0.5		
Acacia nyssophylla		1	0.8		
Scaevola spinescens		1	0.5		
Casuarina pauper		0.1	6		
Alectryon oleifolius subsp. *canescens*		0.1	2		
Exocarpos aphyllus		0.1	1.2		
Lycium australe		0.1	1		
Eremophila glabra subsp. *glabra*		0.1	1		
Eremophila parvifolia subsp. *auricampa*		0.1	0.5		
Ptilotus obovatus		0.1	0.4		
Austrostipa elegantissima		0.1	0.3		
Olearia muelleri		0.1	0.25		
Paspalidium gracile		0.1	0.15		
Maireana trichoptera		0.1	0.15		
Leichardtia australis				0.1	0.3
Austrostipa trichophylla				0.1	0.15

Site details			
Site	**CR004**	**Position (WGS84)**	-30.566377, 121.477853
Slope	negligible	**Topography**	plain
Soil colour		**Soil texture**	
Rock cover (%)	0	**Rock type**	none

Observation details - visit 1 (08 Nov 2017)	
Sample description	Mid *Eucalyptus lesouefii* woodland over tall open *Melaleuca sheathiana* shrubland over low open *Atriplex stipitata*, *Cratystylis conocephala* and *Maireana sedifolia* shrubland.

Habitat	woodland		
Disturbance	evidence of feral animals, historic clearing, vehicle tracks,		
Vegetation conditio	Very Good	**Fire age**	not evident
Total veg. cover (%)	40	**Tree cover (%)**	20
Shrub cover (%)	20	**Grass cover (%**	0
Herb cover (%)	0.1		

Sample and effort summary				
Sample method	**Visit**	**Sample date**	**Dimensions**	**Observer**
Quadrat	1	08-Nov-2017	20 m x 20 m	Grant Wells
Quadrat	2	30-Nov-2022		Grant Wells

Species (27)	Status	Visit 1		Visit 2	
		Cover (%)	Height (m)	Cover (%)	Height (m)
Eucalyptus lesouefii		15	15		
Cratystylis conocephala		10	1		
Melaleuca sheathiana		5	4		
Atriplex stipitata		3	0.4		
Maireana sedifolia		2	1		
Eremophila scoparia		1	0.7		
Eremophila scoparia		0.1	2.5		
Atriplex nummularia subsp. *spathulata*		0.1	1		
Eremophila glabra subsp. *glabra*		0.1	0.8		
Tecticornia disarticulata		0.1	0.7		
Eremophila parvifolia subsp. *auricampa*		0.1	0.4		
Frankenia fecunda		0.1	0.4		
Maireana pentatropis		0.1	0.4		
Ptilotus obovatus		0.1	0.4		
Scaevola spinescens		0.1	0.4		
Senna artemisioides subsp. *filifolia*		0.1	0.4		
Enchylaena tomentosa var. *tomentosa*		0.1	0.3		
Olearia muelleri		0.1	0.25		
Maireana trichoptera		0.1	0.15		
Roepera apiculata		0.1	0.15		
Sclerolaena diacantha		0.1	0.1		
Roepera ovata		0.1	0.05		
Sclerolaena drummondii				0.1	0.1
Sclerolaena patenticuspis				0.1	0.05
Casuarina obesa				0.1	1
Austrostipa scabra subsp. *scabra*				0.1	0.1
Lycium australe				0.1	0.5

Site details			
Site	**CR005**	**Position (WGS84)**	-30.574482, 121.474767
Slope	negligible	**Topography**	plain
Soil colour		**Soil texture**	
Rock cover (%)	0	**Rock type**	none

Observation details - visit 1 (08 Nov 2017)	
Sample description	Mid *Eucalyptus lesouefii* open woodland over low open *Atriplex vesicaria*, *Maireana trichoptera* and *Tecticornia disarticulata* shrubland over isolated clumps of low *Aristida contorta*, *Eriachne helmsii* and *Enneapogon avenaceus* grasses.
Habitat	open woodland
Disturbance	current operations, excavation, exploration (drill pads and access tracks), grazing – low, historic operations, litter, weed infestation,

Vegetation conditio	Good	**Fire age**	not evident
Total veg. cover (%)	20	**Tree cover (%)**	10
Shrub cover (%)	15	**Grass cover (%**	0.1
Herb cover (%)	0.1		

Sample and effort summary				
Sample method	**Visit**	**Sample date**	**Dimensions**	**Observer**
Quadrat	1	08-Nov-2017	20 m x 20 m	Grant Wells
Quadrat	2	30-Nov-2022		Grant Wells

Species (28)	Status	Visit 1		Visit 2	
		Cover (%)	Height (m)	Cover (%)	Height (m)
Eucalyptus lesouefii		10	12		
Maireana trichoptera		7	0.2		
Atriplex vesicaria		5	0.5		
Tecticornia disarticulata		1	0.6		
Eremophila scoparia		0.1	1		
Maireana sedifolia		0.1	0.5		
**Carrichtera annua*	Weed	0.1	0.4		
Maireana georgei		0.1	0.4		
**Sonchus oleraceus*	Weed	0.1	0.4		
Eremophila glabra subsp. *glabra*		0.1	0.3		
Solanum lasiophyllum		0.1	0.3		
Senna artemisioides subsp. *filifolia*		0.1	0.25		
Roepera eremaea		0.1	0.2		
**Salvia verbenaca*	Weed	0.1	0.15		
Sclerolaena cuneata		0.1	0.15		
Sclerolaena diacantha		0.1	0.1		
Sclerolaena patenticuspis		0.1	0.1		
Aristida contorta		0.1	0.1		
Eriachne helmsii		0.1	0.1		
**Monoculus monstrosus*	Weed	0.1	0.1		
Atriplex codonocarpa		0.1	0.1		
Sida spodochroma		0.1	0.01		
Solanum nummularium				0.1	0.15
Vittadinia humerata				0.1	0.1
**Centaurea melitensis*	Weed			0.1	0.2
Enneapogon avenaceus				0.1	
Austrostipa scabra subsp. *scabra*				0.1	0.1
Atriplex nummularia subsp. *spathulata*				0.1	1.1

Site details			
Site	**CR011**	**Position (WGS84)**	-30.569834, 121.47365
Slope	negligible	**Topography**	drainage line
Soil colour		**Soil texture**	
Rock cover (%)	0	**Rock type**	none

Observation details - visit 1 (08 Nov 2017)			
Sample description	Mid *Eucalyptus lesouefii*, *E. salubris* and *Casuarina pauper* open forest over tall *Eremophila alternifolia*, *E. scoparia* and *Acacia nyssophylla* shrubland over low open *Maireana sedifolia, Olearia muelleri* and *Solanum nummularium* shrubland.		
Habitat	woodland		
Disturbance	evidence of feral animals, grazing – low, historic clearing, vehicle tracks,		
Vegetation conditio	Very Good	**Fire age**	not evident
Total veg. cover (%)	75	**Tree cover (%)**	45
Shrub cover (%)	40	**Grass cover (%**	1
Herb cover (%)	0		

Sample and effort summary				
Sample method	**Visit**	**Sample date**	**Dimensions**	**Observer**
Quadrat	1	08-Nov-2017	20 m x 20 m	Grant Wells
Quadrat	2	30-Nov-2022		Grant Wells

Species (21)	Status	Visit 1		Visit 2	
		Cover (%)	Height (m)	Cover (%)	Height (m)
Eucalyptus lesouefii		30	15		
Casuarina pauper		10	11		
Eremophila scoparia		10	3		
Eucalyptus salubris		5	12		
Eremophila alternifolia		5	3		
Acacia nyssophylla		5	3		
Maireana sedifolia		5	0.6		
Olearia muelleri		5	0.5		
Solanum nummularium		3	0.6		
Senna artemisioides subsp. *filifolia*		2	1.5		
Lycium australe		2	0.8		
Santalum acuminatum		1	3		
Rhagodia drummondii		1	0.5		
Scaevola spinescens		1	0.5		
Exocarpos aphyllus		0.1	1.4		
Eremophila glabra subsp. *glabra*		0.1	1		
Leichardtia australis		0.1	1		
Ptilotus obovatus		0.1	0.4		
Austrostipa elegantissima		0.1	0.3		
Olearia pimeleoides				0.1	1.2
Pimelea microcephala subsp. *microcephala*				0.1	1.4

Site details			
Site	**CR013**	**Position (WGS84)**	-30.575678, 121.468559
Slope	gentle	**Topography**	undulating plain
Soil colour		**Soil texture**	
Rock cover (%)	0	**Rock type**	quartz

Observation details - visit 1 (08 Nov 2017)	
Sample description	Low *Eucalyptus salubris* and *E. celastroides* subsp. *celastroides* woodland over low open *Atriplex vesicaria*, *Maireana sedifolia* and *Tecticornia disarticulata* shrubland over isolated clumps of low *Austrostipa elegantissima* grasses.

Habitat	open woodland		
Disturbance	historic operations, litter, vehicle tracks, weed infestation		
Vegetation conditio	Very Good	**Fire age**	not evident
Total veg. cover (%)	25	**Tree cover (%)**	10
Shrub cover (%)	20	**Grass cover (%**	0.1
Herb cover (%)	0.1		

Sample and effort summary				
Sample method	**Visit**	**Sample date**	**Dimensions**	**Observer**
Quadrat	1	08-Nov-2017	20 m x 20 m	Grant Wells
Quadrat	2	30-Nov-2022		Grant Wells

Species (25)	Status	Visit 1		Visit 2	
		Cover (%)	Height (m)	Cover (%)	Height (m)
Tecticornia disarticulata		15	0.5		
Eucalyptus salubris		8	9		
Maireana sedifolia		5	0.6		
Eucalyptus celastroides subsp. *celastroides*		2	6		
Atriplex vesicaria		2	0.4		
Cratystylis microphylla		1	0.6		
Eremophila glabra subsp. *glabra*		0.1	0.7		
Eremophila scoparia		0.1	0.7		
Eremophila parvifolia subsp. *auricampa*		0.1	0.5		
Austrostipa elegantissima		0.1	0.3		
Olearia muelleri		0.1	0.2		
Frankenia fecunda		0.1	0.15		
Maireana trichoptera		0.1	0.15		
Maireana sp.		0.1	0.15		
Roepera sp.		0.1	0.1		
Sclerolaena diacantha		0.1	0.1		
**Medicago laciniata*	Weed			0.1	0.02
Roepera reticulata				0.1	0.25
Eremophila oppositifolia subsp. *angustifolia*				0.1	1.3
Sclerolaena cuneata				0.1	0.15
Enneapogon caerulescens				0.1	0.1
Enneapogon avenaceus				0.1	0.1
Dodonaea viscosa subsp. *angustissima*				0.1	0.7
Sclerolaena drummondii				0.1	0.05
Maireana pentatropis				0.1	0.3

Site details			
Site	**CR014**	**Position (WGS84)**	-30.567059, 121.482389
Slope	gentle	**Topography**	undulating plain
Soil colour	BLK	**Soil texture**	ALUV
Rock cover (%)	0	**Rock type**	ferrous – ironstone

Observation details - visit 1 (08 Nov 2017)	
Sample description	Isolated low *Eucalyptus lesouefii* and *E. salubris* trees over isolated mid *Atriplex nummularia* shrubs over low *Atriplex* spp. and *Tecticornia disarticulata* shrubland.
Habitat	shrubland
Disturbance	evidence of feral animals, excavation, historic clearing, large-scale clearing, litter, weed infestation,

Vegetation conditio	Good	**Fire age**	not evident
Total veg. cover (%)	45	**Tree cover (%)**	5
Shrub cover (%)	40	**Grass cover (%**	0
Herb cover (%)	0.1		

Sample and effort summary				
Sample method	**Visit**	**Sample date**	**Dimensions**	**Observer**
Quadrat	1	08-Nov-2017	20 m x 20 m	Grant Wells
Quadrat	2	30-Nov-2022		Grant Wells

Species (20)	Status	Visit 1		Visit 2	
		Cover (%)	Height (m)	Cover (%)	Height (m)
Tecticornia disarticulata		20	0.8		
Atriplex vesicaria		20	0.5		
Eucalyptus salubris		3	4		
Eucalyptus lesouefii		2	4		
Atriplex nummularia subsp. *spathulata*		2	2		
Atriplex acutibractea		2	0.4		
Maireana trichoptera		1	0.15		
Maireana sedifolia		0.1	0.8		
Ptilotus obovatus		0.1	0.4		
Maireana georgei		0.1	0.3		
Olearia muelleri		0.1	0.25		
**Sonchus oleraceus*	Weed	0.1	0.25		
Paspalidium gracile		0.1	0.25		
Maireana tomentosa		0.1	0.25		
Sclerolaena cuneata		0.1	0.15		
**Carrichtera annua*	Weed	0.1	0.15		
Ptilotus exaltatus		0.1	0.1		
Sclerolaena diacantha		0.1	0.1		
Atriplex codonocarpa		0.1	0.1		
Maireana pentatropis				0.1	0.3

Site details			
Site	**CR2201**	**Position (WGS84)**	-30.5786, 121.470121
Slope	gentle	**Topography**	undulating plain
Soil colour	red-orange,	**Soil texture**	sandy loam,
Rock cover (%)	0	**Rock type**	quartz, siltstone / mudstone,

Observation details - visit 1 (29 Nov 2022)	
Sample description	Low *Eucalyptus lesoueffii* woodland over isolated tall *Eremophila interstans* subsp. *interstans* shrubs over isolated low *Eremophila parvifolia* subsp. *auricampa*, *Scaevola spinescens* and *Maireana sedifolia* shrubs.

Habitat	woodland		
Disturbance	historic clearing, vehicle tracks,		
Vegetation conditio	Very Good	**Fire age**	not evident
Total veg. cover (%)	25	**Tree cover (%)**	20
Shrub cover (%)	5	**Grass cover (%**	0
Herb cover (%)	0		

Sample and effort summary				
Sample method	**Visit**	**Sample date**	**Dimensions**	**Observer**
Quadrat	1	29-Nov-2022		Grant Wells

Species (14)	Status	Visit 1		Visit 2	
		Cover (%)	Height (m)	Cover (%)	Height (m)
Eucalyptus lesouefii		20	7		
Eremophila interstans subsp. *interstans*		2	2.2		
Scaevola spinescens		1	0.4		
Eremophila parvifolia subsp. *auricampa*		1	0.3		
Maireana sedifolia		0.5	1.1		
Olearia muelleri		0.2	0.5		
Eremophila glabra subsp. *albicans*		0.1	1.5		
Eremophila oppositifolia subsp. *angustifolia*		0.1	1.2		
Cratystylis microphylla		0.1	0.8		
Westringia rigida		0.1	0.5		
Senna artemisioides subsp. *filifolia*		0.1	0.5		
Enchylaena tomentosa var. *tomentosa*		0.1	0.4		
Cratystylis conocephala		0.1	0.4		
Acacia erinacea		0.1	0.3		

Site details			
Site	**CR2202**	**Position (WGS84)**	-30.574385, 121.464185
Slope	gentle	**Topography**	undulating plain
Soil colour	red-orange,	**Soil texture**	sandy loam,
Rock cover (%)	0	**Rock type**	quartz, siltstone / mudstone,

Observation details - visit 1 (29 Nov 2022)			
Sample description	Mid *Eucalyptus lesouefii* and *E. oleosa* subsp. *oleosa* woodland over tall open *Melaleuca sheathiana* shrubland over isolated low *Maireana sedifolia*, *Olearia muelleri* and *Scaevola spinescens* shrubs.		
Habitat	woodland		
Disturbance	historic clearing,		
Vegetation conditio	Very Good	**Fire age**	not evident
Total veg. cover (%)	30	**Tree cover (%)**	35
Shrub cover (%)	2	**Grass cover (%**	0
Herb cover (%)	0		

Sample and effort summary				
Sample method	**Visit**	**Sample date**	**Dimensions**	**Observer**
Quadrat	1	29-Nov-2022		Grant Wells

Species (12)	Status	Visit 1		Visit 2	
		Cover (%)	Height (m)	Cover (%)	Height (m)
Eucalyptus oleosa subsp. *oleosa*		15	15		
Melaleuca sheathiana		15	3.5		
Eucalyptus lesouefii		5	11		
Maireana sedifolia		1	0.7		
Scaevola spinescens		1	0.5		
Olearia muelleri		0.2	0.3		
Eucalyptus salubris		0.1	10		
Casuarina obesa		0.1	4.5		
Santalum acuminatum		0.1	2.2		
Eremophila parvifolia subsp. *auricampa*		0.1	0.6		
Pittosporum angustifolium		0.1	0.4		
Eremophila glabra subsp. *albicans*		0.1	0.3		

Site details			
Site	**CR2203**	**Position (WGS84)**	-30.567708, 121.464281
Slope	negligible	**Topography**	plain
Soil colour	red-orange,	**Soil texture**	sandy loam,
Rock cover (%)	0	**Rock type**	ferrous - ironstone,

Observation details - visit 1 (30 Nov 2022)	
Sample description	Mid open *Eucalyptus lesoueffii* woodland over isolated mid *Eucalyptus yilgarnensis* mallee trees over mid open *Maireana sedifolia*, *Eremophila scoparia* and *Senna artemisioides* subsp. *filifolia* shrubland.

Habitat	open woodland		
Disturbance	evidence of feral animals, historic clearing, vehicle tracks,		
Vegetation conditio	Very Good	**Fire age**	not evident
Total veg. cover (%)	20	**Tree cover (%)**	5
Shrub cover (%)	20	**Grass cover (%**	0.1
Herb cover (%)	0		

Sample and effort summary				
Sample method	**Visit**	**Sample date**	**Dimensions**	**Observer**
Quadrat	1	30-Nov-2022		Grant Wells

Species (14)	Status	Visit 1		Visit 2	
		Cover (%)	Height (m)	Cover (%)	Height (m)
Maireana sedifolia		12	1.2		
Eucalyptus lesouefii		5	12		
Eremophila scoparia		5	1.9		
Atriplex nummularia subsp. *spathulata*		1	1.5		
Eucalyptus yilgarnensis		0.1	4.5		
Scaevola spinescens		0.1	1		
Lycium australe		0.1	0.7		
Acacia hemiteles		0.1	0.7		
Eremophila glabra subsp. *albicans*		0.1	0.6		
Acacia nyssophylla		0.1	0.6		
Eremophila parvifolia subsp. *auricampa*		0.1	0.5		
Olearia muelleri		0.1	0.4		
Ptilotus obovatus		0.1	0.3		
Maireana trichoptera		0.1	0.1		

Site details			
Site	**CR2204**	**Position (WGS84)**	-30.566081, 121.471551
Slope	gentle	**Topography**	undulating plain
Soil colour	red-orange,	**Soil texture**	sandy clay,
Rock cover (%)	0	**Rock type**	ferrous - ironstone, quartz,

Observation details - visit 1 (29 Nov 2022)	
Sample description	Isolated low *Casuarina obesa* and *Alectryon oleifolius* subsp. *canescens* trees over tall sparse *Eremophila scoparia* shrubland over mid *Senna artemisioides* subsp. *filifolia*, *Eremophila scoparia* shrubland over mid *Senna artemisioides* subsp. *filifolia, Eremophila scoparia* and *Maireana sedifolia* shrubland.
Habitat	shrubland
Disturbance	evidence of feral animals, historic clearing,

Vegetation conditio	Very Good	**Fire age**	not evident
Total veg. cover (%)	35	**Tree cover (%)**	6
Shrub cover (%)	37	**Grass cover (%**	0.1
Herb cover (%)	0.1		

Sample and effort summary				
Sample method	**Visit**	**Sample date**	**Dimensions**	**Observer**
Quadrat	1	29-Nov-2022		Grant Wells

Species (11)	Status	Visit 1		Visit 2	
		Cover (%)	Height (m)	Cover (%)	Height (m)
Eremophila scoparia		12	2.5		
Maireana sedifolia		10	1.1		
Senna artemisioides subsp. *filifolia*		6	1.4		
Eremophila parvifolia subsp. *auricampa*		2	0.5		
Casuarina obesa		0.1	5		
Alectryon oleifolius subsp. *canescens*		0.1	4		
Roepera reticulata		0.1	1		
Acacia nyssophylla		0.1	0.6		
Austrostipa elegantissima		0.1	0.5		
Scaevola spinescens		0.1	0.4		
Olearia muelleri		0.1	0.4		

Site details			
Site	**CR2205**	**Position (WGS84)**	-30.566786, 121.47545
Slope	gentle	**Topography**	undulating plain
Soil colour	red-orange,	**Soil texture**	sandy loam,
Rock cover (%)	0	**Rock type**	ferrous - ironstone, quartz,

Observation details - visit 1 (29 Nov 2022)	
Sample description	Mid open *Eucalyptus lesoueffii* woodland over tall open *Casuarina obesa* shrubland over mid sparse *Senna artemisioides* subsp. *filifolia*, *Scaevola spinescens* and *Maireana sedifolia* shrubland.
Habitat	open woodland
Disturbance	evidence of feral animals, exploration (drill pads and access tracks), historic clearing, litter, livestock tracks, vehicle tracks,

Vegetation conditio	Good	**Fire age**	not evident
Total veg. cover (%)	25	**Tree cover (%)**	18
Shrub cover (%)	10	**Grass cover (%**	0
Herb cover (%)	0		

Sample and effort summary				
Sample method	**Visit**	**Sample date**	**Dimensions**	**Observer**
Quadrat	1	29-Nov-2022		Grant Wells

Species (17)	Status	Visit 1		Visit 2	
		Cover (%)	Height (m)	Cover (%)	Height (m)
Casuarina obesa		10	5		
Eucalyptus lesouefii		8	11		
Senna artemisioides subsp. *filifolia*		5	1.5		
Scaevola spinescens		2	1.2		
Acacia erinacea		1	1.5		
Maireana sedifolia		1	1.3		
Olearia muelleri		0.2	0.3		
Alectryon oleifolius subsp. *canescens*		0.1	5		
Eremophila glabra subsp. *albicans*		0.1	0.8		
Austrostipa elegantissima		0.1	0.5		
Pittosporum angustifolium		0.1	0.4		
Ptilotus obovatus		0.1	0.4		
Enchylaena tomentosa var. *tomentosa*		0.1	0.3		
Atriplex vesicaria		0.1	0.3		
Westringia rigida		0.1	0.2		
Maireana radiata		0.1	0.15		
Maireana trichoptera		0.1	0.1		

Site details			
Site	**CR2206**	**Position (WGS84)**	-30.581786, 121.477115
Slope	negligible	**Topography**	plain
Soil colour	red-orange,	**Soil texture**	clay loam, loam,
Rock cover (%)	0	**Rock type**	quartz,

Observation details - visit 1 (29 Nov 2022)	
Sample description	Low *Eucalyptus oleosa* subsp. *oleosa* and *E. salubris* woodland over isolated tall *Eremophila interstans* subsp*. interstans* shrubs over mid open *Maireana sedifolia*, *Senna artemisioides* subsp. *filifolia* and *Tecticornia disarticulata* shrubland.

Habitat	woodland		
Disturbance	historic clearing, vehicle tracks,		
Vegetation conditio	Very Good	**Fire age**	not evident
Total veg. cover (%)	20	**Tree cover (%)**	10
Shrub cover (%)	15	**Grass cover (%**	0.1
Herb cover (%)	0.1		

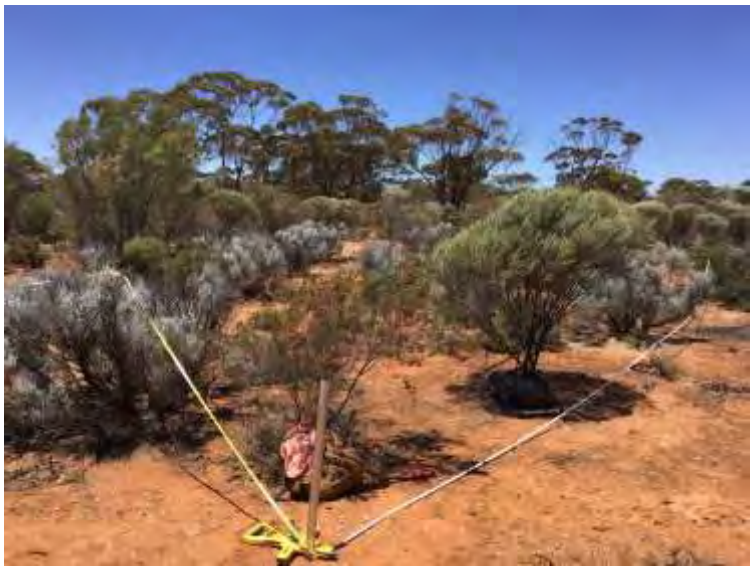
Sample and effort summary				
Sample method	**Visit**	**Sample date**	**Dimensions**	**Observer**
Quadrat	1	29-Nov-2022		Grant Wells

Species (16)	Status	Visit 1		Visit 2	
		Cover (%)	Height (m)	Cover (%)	Height (m)
Eucalyptus oleosa subsp. *oleosa*		10	7		
Maireana sedifolia		6	1.2		
Senna artemisioides subsp. *filifolia*		5	1.5		
Tecticornia disarticulata		2	1		
Eremophila interstans subsp. *interstans*		1	3		
Eremophila scoparia		1	2		
Scaevola spinescens		1	0.8		
Eremophila parvifolia subsp. *auricampa*		0.5	0.4		
Eucalyptus salubris		0.1	7		
Acacia erinacea		0.1	0.7		
Eremophila glabra subsp. *albicans*		0.1	0.7		
Olearia muelleri		0.1	0.5		
Solanum nummularium		0.1	0.4		
Ptilotus obovatus		0.1	0.3		
Lycium australe		0.1	0.2		
Maireana trichoptera		0.1	0.1		

Site details			
Site	**CR2207**	**Position (WGS84)**	-30.577775, 121.476203
Slope	negligible	**Topography**	plain
Soil colour	red-orange, whitish,	**Soil texture**	sandy clay,
Rock cover (%)	0	**Rock type**	quartz,

Observation details - visit 1 (29 Nov 2022)	
Sample description	Isolated tall *Dodonaea viscosa* subsp. *angustissima* shrubs over mid open *Maireana sedifolia*, *Tecticornia disarticulata* and *Eremophila scoparia* shrubland over isolated low *Atriplex vesicaria*, *Frankenia interioris* and *Solanum nummularium* shrubs.

Habitat	shrubland		
Disturbance	evidence of feral animals, historic clearing, weed infestation		
Vegetation conditio	Very Good	**Fire age**	not evident
Total veg. cover (%)	25	**Tree cover (%)**	3
Shrub cover (%)	22	**Grass cover (%**	0.1
Herb cover (%)	0.1		



Sample and effort summary				
Sample method	**Visit**	**Sample date**	**Dimensions**	**Observer**
Quadrat	1	29-Nov-2022		Grant Wells

Species (22)	Status	Visit 1		Visit 2	
		Cover (%)	Height (m)	Cover (%)	Height (m)
Maireana sedifolia		7	1.5		
Tecticornia disarticulata		7	1.3		
Eremophila scoparia		5	1.5		
Dodonaea viscosa subsp. *angustissima*		3	3		
Atriplex vesicaria		1	0.3		
Frankenia interioris		1	0.2		
**Sonchus oleraceus*	Weed	0.1	0.5		
Austrostipa elegantissima		0.1	0.5		
Eremophila parvifolia subsp. *auricampa*		0.1	0.4		
Solanum nummularium		0.1	0.3		
Solanum lasiophyllum		0.1	0.25		
Minuria cunninghamii		0.1	0.2		
Maireana trichoptera		0.1	0.2		
Vittadinia humerata		0.1	0.2		
Sclerolaena obliquicuspis		0.1	0.15		
Austrostipa scabra subsp. *scabra*		0.1	0.15		
Austrostipa trichophylla		0.1	0.15		
Dodonaea lobulata		0.1	0.15		
Enneapogon caerulescens		0.1	0.1		
Sclerolaena diacantha		0.1	0.1		
Enneapogon avenaceus		0.1	0.07		
Euphorbia philochalix		0.1	0.01		

Site details			
Site	**CR2208**	**Position (WGS84)**	-30.581247, 121.471371
Slope	negligible	**Topography**	plain
Soil colour	red-orange,	**Soil texture**	sandy loam,
Rock cover (%)	0	**Rock type**	quartz,

Observation details - visit 1 (29 Nov 2022)	
Sample description	Low *Eucalyptus lesouefii* woodland over mid sparse *Eremophila scoparia*, *Senna artemisioides* subsp. *filifolia* and *Santalum acuminatum* shrubland over low open *Maireana sedifolia*, *Atriplex vesicaria* and *Eremophila parvifolia* subsp. *auricampa* shrubland.

Habitat	woodland		
Disturbance	historic clearing, vehicle tracks,		
Vegetation conditio	Very Good	**Fire age**	not evident
Total veg. cover (%)	20	**Tree cover (%)**	10
Shrub cover (%)	12	**Grass cover (%**	0
Herb cover (%)	0		

Sample and effort summary				
Sample method	**Visit**	**Sample date**	**Dimensions**	**Observer**
Quadrat	1	29-Nov-2022		Grant Wells

Species (17)	Status	Visit 1		Visit 2	
		Cover (%)	Height (m)	Cover (%)	Height (m)
Eucalyptus lesouefii		10	8		
Maireana sedifolia		10	1		
Eremophila scoparia		4	1.6		
Senna artemisioides subsp. *filifolia*		1	1.5		
Atriplex vesicaria		0.5	0.4		
Eremophila parvifolia subsp. *auricampa*		0.2	0.3		
Santalum acuminatum		0.1	1.5		
Scaevola spinescens		0.1	0.6		
Austrostipa platychaeta		0.1	0.5		
Solanum lasiophyllum		0.1	0.4		
Roepera reticulata		0.1	0.4		
Lycium australe		0.1	0.4		
Solanum nummularium		0.1	0.3		
Maireana trichoptera		0.1	0.2		
Sclerolaena diacantha		0.1	0.2		
Ptilotus obovatus		0.1	0.1		
Eriochiton sclerolaenoides		0.1	0.05		

Site details			
Site	**CR2209**	**Position (WGS84)**	-30.577861, 121.481601
Slope	negligible	**Topography**	plain
Soil colour	red-orange,	**Soil texture**	sandy loam,
Rock cover (%)	0	**Rock type**	quartz,

Observation details - visit 1 (29 Nov 2022)	
Sample description	Isolated mid *Eucalyptus lesouefii* and *E. oleosa* subsp. *oleosa* trees over mid sparse *Eremophila scoparia* shrubland over low open *Tecticornia disarticulata*, *Maireana sedifolia* and *Frankenia interioris* shrubland.
Habitat	shrubland
Disturbance	exploration (drill pads and access tracks), historic clearing, livestock tracks, vehicle tracks,

Vegetation conditio	Good	**Fire age**	not evident
Total veg. cover (%)	20	**Tree cover (%)**	1
Shrub cover (%)	20	**Grass cover (%**	0.1
Herb cover (%)	0.1		

Sample and effort summary				
Sample method	**Visit**	**Sample date**	**Dimensions**	**Observer**
Quadrat	1	29-Nov-2022		Grant Wells

Species (14)	Status	Visit 1		Visit 2	
		Cover (%)	Height (m)	Cover (%)	Height (m)
Tecticornia disarticulata		14	1		
Eremophila scoparia		5	1.9		
Maireana sedifolia		1	0.5		
Frankenia interioris		0.2	2		
Atriplex vesicaria		0.2	0.5		
Eucalyptus oleosa subsp. *oleosa*		0.1	15		
Eucalyptus lesouefii		0.1	10		
Dodonaea viscosa subsp. *angustissima*		0.1	1		
Eremophila oppositifolia subsp. *angustifolia*		0.1	0.9		
Roycea divaricata		0.1	0.2		
Eremophila parvifolia subsp. *auricampa*		0.1	0.2		
Sclerolaena diacantha		0.1	0.15		
Maireana trichoptera		0.1	0.15		
Sclerolaena cuneata		0.1	0.05		

Appendix 3 NVIS hierarchy

Western Australia Current Practice			National Standard		
Hierarchy of terms	**Brief description in WA**	**Indicative scale**	**NVIS Level**	**Description**	**NVIS structural/floristic components required**
Vegetation formation	Structure and growth form – e.g. Forest, Woodland.	1:5 000 000	I	Class	Dominant growth form for the ecologically or structurally dominant stratum.
Vegetation sub-formation	Structural and dominant vegetation layer - Eucalypt Forest, Banksia Woodland.	1:2 500 000 I	II	Structural Formation	Dominant growth form, cover and height for the ecologically or structurally dominant stratum.
Vegetation association	Structural form and dominant species – e.g. Medium woodland; York gum (*Eucalyptus loxophleba*) & Wandoo.	1:1 000 000 to 1:250 000	III	Broad Floristic Formation	Dominant growth form, cover, height and dominant land cover genus for the uppermost or dominant stratum.
Vegetation complex	Structural and floristic description linked to geomorphology – e.g. Quindalup Complex.	1:250 000 to 1:100 000	IV	Sub-Formation	Dominant growth form, cover, height and dominant genus and Family for the three traditional strata. (i.e. Upper, Mid and Ground).
Vegetation type	Floristic definition by strata with structural detail. Often represented with a code and floristic description.	1:100 000 to 1:10 000	V	Association	Dominant growth form, height, cover and up to 3 species for the three traditional strata. (i.e. Upper, Mid and Ground).
Plant community	Basic unit of vegetation classification, site specific and highly localised with detailed floristics for each stratum.	1:10 000	VI	Sub-Association	Dominant growth form, height, cover and up to 5 species for all layers/ strata.
Floristic Community Type	Floristic composition definition; e.g. Northern banksia woodlands over herb rich shrublands on the Swan Coastal Plain.	No absolute scale			

Appendix 4 Introduced flora identified in the desktop review

Family	Species	Declared Pest/WoNS
Aizoaceae	**Galenia pubescens* var. *pubescens*	
Aizoaceae	**Mesembryanthemum crystallinum*	
Aizoaceae	**Mesembryanthemum nodiflorum*	
Amaranthaceae	**Amaranthus viridis*	
Anacardiaceae	**Schinus molle* var. *areira*	
Apocynaceae	**Asclepias curassavica*	
Apocynaceae	**Orbea variegata*	
Asparagaceae	**Agave americana*	
Asteraceae	**Arctotheca calendula*	
Asteraceae	**Carthamus lanatus*	
Asteraceae	**Centaurea melitensis*	
Asteraceae	**Cichorium intybus*	
Asteraceae	**Conyza bonariensis*	
Asteraceae	**Gazania linearis*	
Asteraceae	**Helianthus annuus*	
Asteraceae	**Lactuca serriola* forma *serriola*	
Asteraceae	**Monoculus monstrosus*	
Asteraceae	**Oligocarpus calendulaceus*	
Asteraceae	**Oncosiphon suffruticosum*	
Asteraceae	**Sonchus oleraceus*	
Asteraceae	**Symphyotrichum squamatum*	
Asteraceae	**Xanthium spinosum*	
Boraginaceae	**Buglossoides arvensis*	
Boraginaceae	**Echium plantagineum*	Declared pest, S22(2) (C3)
Boraginaceae	**Heliotropium europaeum*	
Boraginaceae	**Heliotropium supinum*	
Brassicaceae	**Alyssum linifolium*	
Brassicaceae	**Brassica tournefortii*	
Brassicaceae	**Capsella bursa-pastoris*	
Brassicaceae	**Carrichtera annua*	
Brassicaceae	**Sisymbrium irio*	
Brassicaceae	**Sisymbrium orientale*	
Cactaceae	**Cylindropuntia fulgida* var. *mamillata*	Declared pest, S22(2) (C3), WoNS
Cactaceae	**Cylindropuntia imbricata*	Declared pest, S22(2) (C3), WoNS
Cactaceae	**Cylindropuntia kleiniae*	Declared pest, S22(2) (C3), WoNS
Cactaceae	**Opuntia elata*	Declared pest, S22(2) (C3), WoNS

Family	Species	Declared Pest/WoNS
Cactaceae	**Opuntia ficus-indica*	Declared pest, S22(2) (C3), WoNS
Caryophyllaceae	**Spergularia diandra*	
Chenopodiaceae	**Chenopodium album*	
Chenopodiaceae	**Chenopodium murale*	
Cucurbitaceae	**Cucumis myriocarpus*	
Didiereaceae	**Portulacaria afra*	
Fabaceae	**Alhagi maurorum*	Declared pest, S22(2) (C3)
Fabaceae	**Caesalpinia gilliesii*	
Fabaceae	**Medicago laciniata*	
Fabaceae	**Medicago minima*	
Fabaceae	**Medicago polymorpha*	
Geraniaceae	**Erodium aureum*	
Geraniaceae	**Erodium cicutarium*	
Lamiaceae	**Salvia reflexa*	
Lamiaceae	**Salvia verbenaca*	
Malvaceae	**Malva parviflora*	
Oxalidaceae	**Oxalis bowiei*	
Oxalidaceae	**Oxalis pes-caprae*	
Papaveraceae	**Argemone ochroleuca* subsp. *ochroleuca*	
Poaceae	**Bromus diandrus*	
Poaceae	**Cenchrus ciliaris*	
Poaceae	**Cenchrus setaceus*	
Poaceae	**Ehrharta villosa*	
Poaceae	**Hordeum glaucum*	
Poaceae	**Hordeum leporinum*	
Poaceae	**Rostraria pumila*	
Poaceae	**Schismus arabicus*	
Poaceae	**Schismus barbatus*	
Poaceae	**Sorghum halepense*	
Polygonaceae	**Polygonum aviculare*	
Polygonaceae	**Rumex vesicarius*	
Solanaceae	**Datura ferox*	
Solanaceae	**Datura inoxia*	
Solanaceae	**Lycium ferocissimum*	WoNS
Solanaceae	**Nicotiana glauca*	
Solanaceae	**Solanum nigrum*	
Urticaceae	**Urtica urens*	

Family	Species	Declared Pest/WoNS
Verbenaceae	**Phyla canescens*	
Zygophyllaceae	**Tribulus terrestris*	

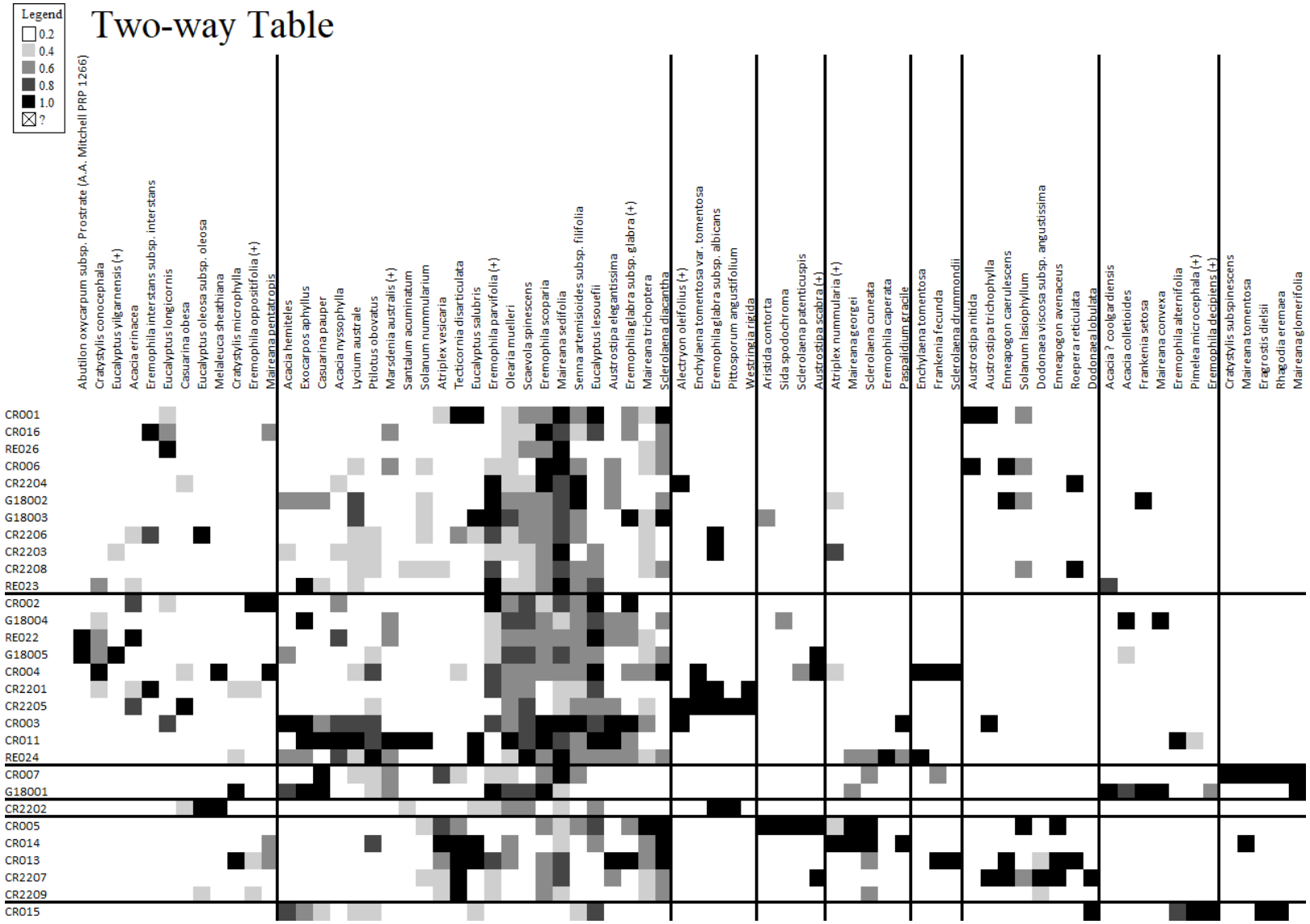
Appendix 5 Flora species inventory

Family	Taxon	Status
Amaranthaceae	*Ptilotus exaltatus*	
Amaranthaceae	*Ptilotus obovatus*	
Apocynaceae	*Leichardtia australis*	
Asteraceae	**Centaurea melitensis*	Weed
Asteraceae	**Monoculus monstrosus*	Weed
Asteraceae	**Sonchus oleraceus*	Weed
Asteraceae	*Cratystylis conocephala*	
Asteraceae	*Cratystylis microphylla*	
Asteraceae	*Minuria cunninghamii*	
Asteraceae	*Olearia muelleri*	
Asteraceae	*Olearia pimeleoides*	
Asteraceae	*Vittadinia humerata*	
Brassicaceae	**Carrichtera annua*	Weed
Casuarinaceae	*Casuarina obesa*	
Casuarinaceae	*Casuarina pauper*	
Chenopodiaceae	*Atriplex acutibractea*	
Chenopodiaceae	*Atriplex codonocarpa*	
Chenopodiaceae	*Atriplex nummularia* subsp. *spathulata*	
Chenopodiaceae	*Atriplex stipitata*	
Chenopodiaceae	*Atriplex vesicaria*	
Chenopodiaceae	*Enchylaena tomentosa* var. *tomentosa*	
Chenopodiaceae	*Eriochiton sclerolaenoides*	
Chenopodiaceae	*Maireana georgei*	
Chenopodiaceae	*Maireana pentatropis*	
Chenopodiaceae	*Maireana radiata*	
Chenopodiaceae	*Maireana sedifolia*	
Chenopodiaceae	*Maireana* sp.	
Chenopodiaceae	*Maireana tomentosa*	
Chenopodiaceae	*Maireana trichoptera*	
Chenopodiaceae	*Rhagodia drummondii*	
Chenopodiaceae	*Roycea divaricata*	
Chenopodiaceae	*Sclerolaena cuneata*	
Chenopodiaceae	*Sclerolaena diacantha*	
Chenopodiaceae	*Sclerolaena drummondii*	
Chenopodiaceae	*Sclerolaena obliquicuspis*	
Chenopodiaceae	*Sclerolaena patenticuspis*	
Chenopodiaceae	*Tecticornia disarticulata*	
Euphorbiaceae	*Euphorbia philochalix*	
Fabaceae	**Medicago laciniata*	Weed
Fabaceae	*Acacia erinacea*	

Fabaceae	*Acacia hemiteles*	
Fabaceae	*Acacia nyssophylla*	
Fabaceae	*Senna artemisioides* subsp. *filifolia*	
Frankeniaceae	*Frankenia fecunda*	
Frankeniaceae	*Frankenia interioris*	
Goodeniaceae	*Scaevola spinescens*	
Lamiaceae	**Salvia verbenaca*	Weed
Lamiaceae	*Westringia rigida*	
Malvaceae	*Sida spodochroma*	
Myrtaceae	*Eucalyptus celastroides* subsp. *celastroides*	
Myrtaceae	*Eucalyptus lesouefii*	
Myrtaceae	*Eucalyptus longicornis*	
Myrtaceae	*Eucalyptus oleosa subsp. oleosa*	
Myrtaceae	*Eucalyptus salubris*	
Myrtaceae	*Eucalyptus yilgarnensis*	
Myrtaceae	*Melaleuca sheathiana*	
Pittosporaceae	*Pittosporum angustifolium*	
Poaceae	*Aristida contorta*	
Poaceae	*Austrostipa elegantissima*	
Poaceae	*Austrostipa platychaeta*	
Poaceae	*Austrostipa scabra* subsp. *scabra*	
Poaceae	*Austrostipa trichophylla*	
Poaceae	*Enneapogon avenaceus*	
Poaceae	*Enneapogon caerulescens*	
Poaceae	*Eriachne helmsii*	
Poaceae	*Paspalidium gracile*	
Santalaceae	*Exocarpos aphyllus*	
Santalaceae	*Santalum acuminatum*	
Sapindaceae	*Alectryon oleifolius* subsp. *canescens*	
Sapindaceae	*Dodonaea lobulata*	
Sapindaceae	*Dodonaea viscosa* subsp. *angustissima*	
Scrophulariaceae	*Eremophila alternifolia*	
Scrophulariaceae	*Eremophila glabra* subsp. *albicans*	
Scrophulariaceae	*Eremophila glabra* subsp. *glabra*	
Scrophulariaceae	*Eremophila interstans* subsp. *interstans*	
Scrophulariaceae	*Eremophila oppositifolia* subsp. *angustifolia*	
Scrophulariaceae	*Eremophila parvifolia* subsp. *auricampa*	
Scrophulariaceae	*Eremophila praecox*	P2 (DBCA list),
Scrophulariaceae	*Eremophila scoparia*	

Scrophulariaceae	*Eremophila* sp. Mt Jackson (G.J. Keighery 4372)	
Solanaceae	*Lycium australe*	
Solanaceae	*Solanum lasiophyllum*	
Solanaceae	*Solanum nummularium*	
Thymelaeaceae	*Pimelea microcephala* subsp. *microcephala*	
Zygophyllaceae	*Roepera reticulata*	
Zygophyllaceae	*Roepera eremaea*	
Zygophyllaceae	*Roepera ovata*	
Zygophyllaceae	*Roepera* sp.	

Appendix 6 Flora species by site matrix



PHOENIX
ENVIRONMENTAL SCIENCES

Appendix B. 1551-CP-NSR-FAU_Basic-Fauna-Report_final.

PHOENIX
ENVIRONMENTAL SCIENCES

Basic and Targeted Fauna Survey for the Crossroads Project

Prepared for Northern Star Resources Ltd

January 2023

Final

Basic and Targeted Fauna Survey for the Crossroads Project
Prepared for Northern Star Resources Ltd

Version history

Author/s	Reviewer/s	Version	Version number	Date submitted	Submitted to
J. Scanlon	A. Jacks	Draft for client comments	0.1	22-Dec-22	Yvonne Hynes (NSR)
J. Scanlon	A. Jacks	Final	1.0	16-Jan-23	Yvonne Hynes (NSR)

Phoenix Environmental Sciences Pty Ltd
2/3 King Edward Road OSBORNE PARK WA 6017
P: 08 6323 5410
E: admin@phoenixenv.com.au
Project code: 1551-CP-NSR-FAU

EXECUTIVE SUMMARY

Northern Star Resources Ltd (NSR) is conducting studies for the Crossroads Project (the Project), located approximately 20 km north of Kalgoorlie-Boulder in the Eastern Murchison subregion. Phoenix Environmental Sciences was commissioned by NSR in October 2022 to undertake basic and targeted terrestrial fauna surveys for the study area of approximately 386 hectares.

Surveys were conducted in late spring (15-17 November 2022), comprising

- habitat description and mapping
- assessment of habitat values for conservation significant vertebrates (with targeted searches where appropriate)
- identification of vertebrate fauna species in the study area based on direct sightings, calls, tracks, scats and other signs
- sampling invertebrate groups that include short-range endemic (SRE) species.

Targeted surveys for habitat of two significant butterfly species were conducted concurrently, reported in a separate Memo.

No Environmentally Sensitive Areas, Threatened Ecological Communities or Priority Ecological Communities occur within the study area. Flora and vegegation surveys are reported separately.

A search of relevant databases, combined with information from reports of other surveys in the region, were used to determine the significant fauna potentially occurring in the study area. The identified regional fauna assemblage included 348 vertebrate species; 29 of these are listed as conservation significant, none of which have previously been recorded within the study area or in adjacent surveyed sites.

The study area can be described as a single broad habitat type characterised as:

- *Eucalyptus lesouefii* and *Casuarina pauper* woodland with (variably present) other tree and mallee eucalypt species, *Acacia, Melaleuca, Eremophila* and other mid shrubs, over low chenopod shrubland of *Maireana, Atriplex, Cratystylis* and *Tecticornia* spp., on gently undulating pediplain of sandy loam, minor amounts of clay, and surface scatter of angular volcanic and quartz fragments, ironstone pebbles, and calcrete pisoliths.

This broad habitat type is subdivided and mapped based on variation in vegetation structure and topography; the most extensive unit comprises open eucalypt woodland with little or no *Casuarina* or other tall shrubs present; mixed eucalypt/*Casuarina* woodlands are split into four types, three differing in canopy density and one representing areas of disturbance with cleared understorey; three types of open to sparse *Casuarina* (lacking eucalypts) with different mid/understorey vegetation; and a small area is dominated by tall *Melaleuca* shrubs.

No suitable habitat exists in the study area for migratory shorebirds (though numerous species may visit salt lakes a few kilometres north or west). No features were identified as potential refugia or denning sites for medium-sized mammals: the study area has no rocky breakways or distinct drainage lines, and (due to apparent historical removal of large trees and exploitation for firewood) very few hollows in logs or standing trees. The lack of tree hollows also reduces the value of the habitat for many birds and bats. An attribute-scoring tool for Malleefowl (*Leipoa ocellata*, Vulnerable) was applied at 21 sites, of which two had High suitability (score 6 of maximum 8), 14 Medium (scores 4-5) and five Low (2-3); no sign of former or recent presence of Malleefowl was observed, and no mappable units were identified as critical habitat for this species.

During the field fauna survey, 48 vertebrate species were recorded within or just outside the study area, comprising 13 reptiles, 28 birds, and seven mammals, of which three were introduced species. This assemblage represents approximately 14% of those potentially occurring in the region. No conservation significant vertebrate species were recorded.

One species recorded in the fauna survey had not been identified in the desktop review: Common Brushtail Possum (*Trichosurus vulpecula*) is not listed in any conservation categories, but until recently has been considered regionally extinct in most of the arid zone (limited to Southwest, Pilbara and Kimberley populations). Other recent records near Koolyanobbing, Leonora and Kambalda are outside the desktop search area used here, so it is considered a significant range extension. It is inferred from the relative age of tracks and other signs that several mammal species, including the Common Brushtail Possum, occur only intermittently in the study area during dispersal or as part of a larger individual foraging range. This may also apply to other species including several likely to occur in less disturbed habitat nearby: Malleefowl (*Leipoa ocellata*, Vulnerable), Peregrine Falcon (*Falco peregrinus*, Specially Protected), Western Rosella inland form (*Platycercus icterotis xanthogenys*, Priority 4), Chuditch (*Dasyurus geoffroii*, Vulnerable) and Central Long-eared Bat (*Nyctophilus major tor*, Priority 3). These species may occasionally use the habitats of the study area for foraging and dispersal, but it is unlikely to provide breeding habitat for any of them.

At longer intervals, some species may occur that are not resident in the region but could use the habitat for foraging, and are known to make long individual movements, e.g. Grey Falcon (*Falco hypoleucos*, Vulnerable), Princess Parrot (*Polytelis alexandrae*, Vulnerable/Priority 4), and Fork-tailed Swift (*Apus pacificus*, Migratory). There are no records suggesting that Night Parrot (*Pezoporus occidentalis*, Critically Endangered) has occurred so far south in Western Australia in modern times; chenopod shrublands in the study area may represent potential foraging habitat, but while some ring-forming patches of *Triodia* hummock grass occur in the study area they do not enclose sufficient space for roosting or nesting by this species.

A total of three conservation listed invertebrates, seven confirmed SRE species and 97 potential SREs were identified in the desktop search extent, and a further 49 invertebrate taxa of uncertain SRE status. The listed species are Arid Bronze Azure Butterfly (*Ogyris subterrestris petrina*, Critically Endangered), Inland Hairstreak Butterfly (*Jalmenus aridus*, Priority 1) and a crustacean associated with salt lakes (*Branchinella denticulata*, Priority 3). Of the 104 confirmed or potential SREs, five are formally named species while 99 are referred to by morphospecies codes as applied by the WA Museum, or not identified to species level.

No habitats likely to support relictual invertebrate populations (e.g. south-facing slopes, breakaway outcrop, creeklines) were identified in the study area. Sixteen specimens from potential SRE groups (pseudoscorpions, scorpion, centipede, isopod) were collected during the field survey. Three pseudoscorpion taxa and the isopod are considered Potential SREs; one pseudoscorpion and the scorpion are known but undescribed widespread (non-SRE) species; the centipede was identified only to family level and its SRE status is uncertain.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

1. INTRODUCTION

Northern Star Resources Ltd (NSR) is seeking to develop the Crossroads Project (the Project), located approximately 20 km north of Kalgoorlie, Western Australia (WA; Figure 1-1). The Project forms part of the Kalgoorlie Operations.

In October 2022, Phoenix Environmental Sciences Pty Ltd (Phoenix) was commissioned by NSR to undertake Basic and targeted fauna surveys for the Project.

The purpose of the surveys was to identify survey requirements for approvals of future developments.

The study area is located in the City of Kalgoorlie-Boulder, and the Eremaean Botanical Province and Climatic Region as defined by EPA (2016b).

1.1. BACKGROUND

The study area is located within the known range of several conservation significant species, including the following:

Malleefowl (*Leipoa ocellata*, Vulnerable)
Malleefowl have previously been recorded at many locations near Kalgoorlie and are considered to occur at low density throughout the surrounding landscape (Phoenix 2022b). Aerial imagery and land system descriptions indicate that the study area includes suitable Malleefowl habitat.

Chuditch (*Dasyurus geoffroii,* Vulnerable)
A single record of Chuditch is known from 20 km south of the study area (Phoenix 2022b), with the next closest record known from Kambalda, approximately 70 km south. The study area covers woodland that potentially represents suitable habitat for Chuditch.

Arid Bronze Azure Butterfly (ABAB*; Ogyris subterrestris petrina*, Critically Endangered)
The ABAB has been listed as Critically Endangered under the EPBC Act since 2015, but detailed survey guidelines were not published until September 2020 (DBCA 2020a, b). Few populations are known. The butterfly is difficult to survey because adults are present only for a few weeks each year and may disperse through habitat unsuitable for breeding. Caterpillars of the ABAB are found only within nests of a sugar ant *Camponotus* sp. nr. *terebrans,* associated with smooth-barked eucalypt woodlands. ABAB has been near the study area.

Inland Hairstreak Butterfly (IHB, *Jalmenus aridus*, P1)
Prior to 2021, all known populations had disappeared since its discovery in 1983 and the species had not been recorded since 1999. The butterfly feeds on the leaves and flowers of *Senna artemisioides* and *Acacia tetragonophylla*, both widespread species*.* The larvae are attended by the ant species *Frogatella kirbii* which is also widespread. The Inland Hairstreak Butterfly was recorded within 23 km south of the study area in 2021 (Phoenix 2022b) and it is considered likely that the species occurs in suitable habitat throughout the Kalgoorlie district. Most specimens have been collected/recorded in October to November and as such, this is considered the best time to survey for adults (Phoenix 2022d). Surveys for ABAB and IHB habitat are reported separately.

The study area may also include suitable habitat for conservation significant birds such as the Peregrine Falcon and Western Rosella (inland subspecies), which are known from the area.

Additionally, a number of confirmed and potential short range endemic invertebrate (SRE) taxa are known from the study area and surrounds (Phoenix 2022b).

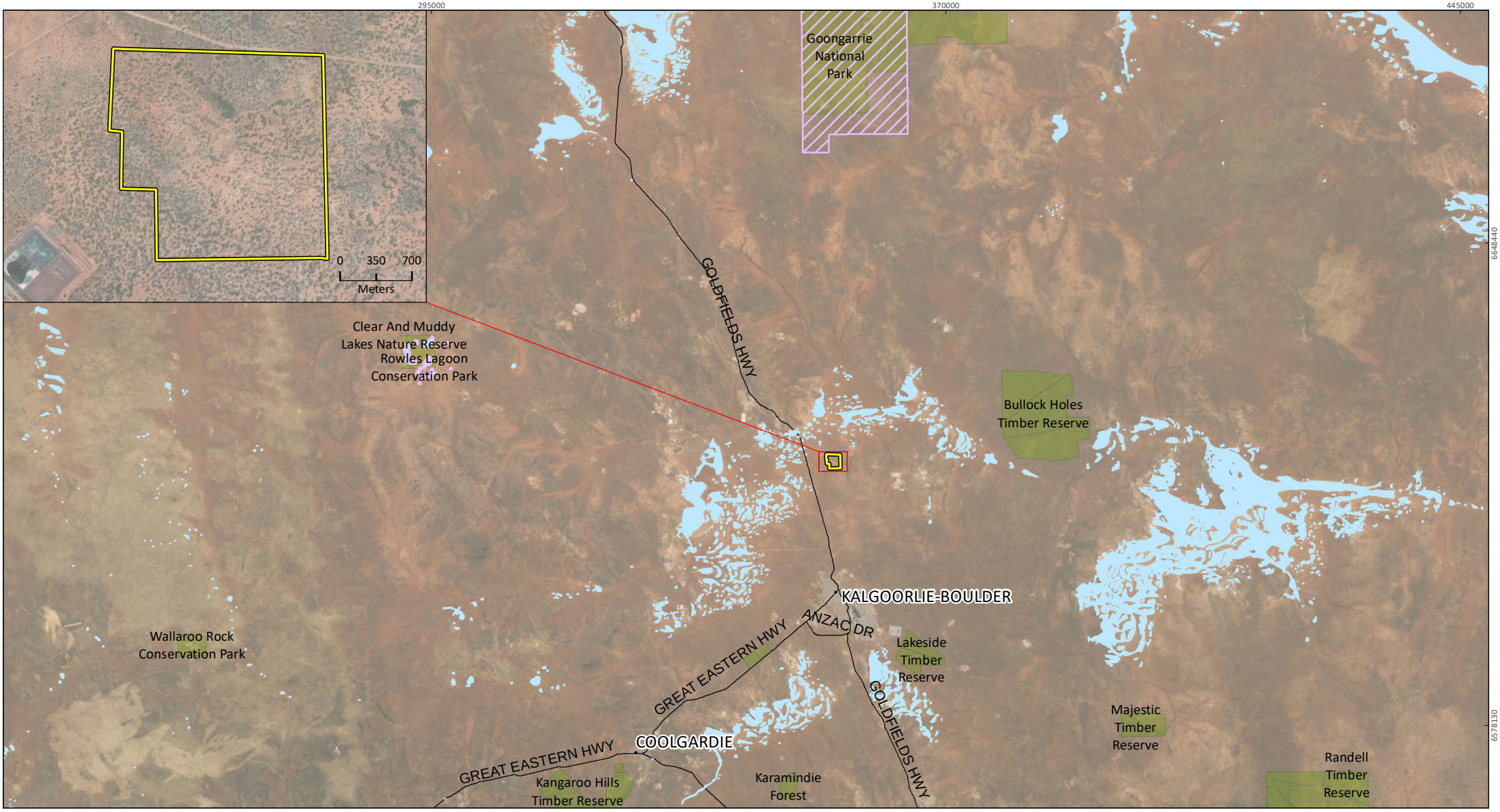
1.2. SCOPE OF WORK

The scope of work for the Basic and targeted fauna surveys was as follows:

- desktop study (vertebrates and invertebrates) – to gather contextual information on the study area
- basic vertebrate and invertebrate fauna survey (including avifauna) – to collect broad fauna and habitat information on the study area, including
    - habitat assessment and mapping
    - opportunistic and low intensity fauna sampling
    - determine if further surveys are required
- targeted significant vertebrate fauna survey – to collect detailed information on Malleefowl and Chuditch, comprising
    - targeted survey for evidence of Malleefowl presence/ Malleefowl mounds
    - motion sensitive camera trapping for Chuditch
- targeted survey for ABAB host ant and *J. aridus*, including
    - habitat assessments for ABAB
    - ant surveys for *Camponotus sp. nr. terebrans* (ABAB host ant) if suitable habitat present
    - targeted survey for *J. aridus*
    - determine if surveys for butterflies are required during flight season.

1.3. STUDY AREA

The study area (386 ha) is located adjacent to the Gidji tailings facility, approximately 19 km north of Kalgoorlie (Figure 1-1).



Northern Star Resources Ltd
Crossroads Project

Project No	1551
Date	19/12/2022
Drawn by	BK
Map author	JS

0 15 30
Kilometers

1:750,000 (at A4) GDA 1994 MGA Zone 51

P:\Data\Projects\KCGM Superpit\1551-CR-KO-FAU\GIS\Mapping\MapDocuments\Figures\Figure_1_1_Project_location.mxd

- Study area
- Environmentally sensitive areas
- Lake
- DBCA managed land

Figure 1-1

Project location and study area

PHOENIX ENVIRONMENTAL SCIENCES

2. LEGISLATIVE CONTEXT

The protection of flora and fauna in WA is principally governed by three acts:

- Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)
- State *Biodiversity Conservation Act 2016* (BC Act)
- State *Environmental Protection Act 1986* (EP Act).

The BC Act came into full effect on 1 January 2019 and replaced the functions of the *Wildlife Conservation Act 1950* (WC Act).

2.1. COMMONWEALTH

The EPBC Act is administered by the Federal Department of Climate Change, Energy, the Environment and Water (DCCEEW). The EPBC Act provides for the listing of Threatened fauna as matters of National Environmental Significance (NES). Under the EPBC Act, actions that have, or are likely to have, a significant impact on a matter of NES, require approval from the Australian Government Minister for the Environment through a formal referral process.

Conservation categories applicable to Threatened fauna species under the EPBC Act are as follows:

- Extinct (EX)[1] – there is no reasonable doubt that the last individual has died
- Extinct in the Wild (EW) – taxa known to survive only in captivity
- Critically Endangered (CR) – taxa facing an extremely high risk of extinction in the wild in the immediate future
- Endangered (EN) – taxa facing a very high risk of extinction in the wild in the near future
- Vulnerable (VU) – taxa facing a high risk of extinction in the wild in the medium-term
- Conservation Dependent (CD)[1] – taxa whose survival depends upon ongoing conservation measures; without these measures, a conservation dependent taxon would be classified as Vulnerable, Endangered or Critically Endangered.

The EPBC Act is also the enabling legislation for protection of Migratory species as matters of NES under several international agreements:

- Japan-Australia Migratory Bird Agreement (JAMBA)
- China-Australia Migratory Bird Agreement (CAMBA)
- Convention on the Conservation of Migratory Species of Wild Animals (Bonn)
- Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA).

2.2. STATE

2.2.1. Threatened and Priority species

In WA, the BC Act provides for the listing of Threatened fauna species (Government of Western Australia 2018a, b)[2] in the following categories:

[1] Species listed as Extinct and Conservation Dependent are not matters of NES and therefore do not trigger the EPBC Act.

[2] The *Wildlife Conservation (Specially Protected Fauna) Notice 2018* and the *Wildlife Conservation (Rare Flora) Notice 2018* have been transitioned under regulations 170, 171 and 172 of the *Biodiversity Conservation Regulations 2018* to be the lists of Threatened, Extinct and Specially Protected species under Part 2 of the BC Act.

- Critically Endangered (CR) – species facing an extremely high risk of extinction in the wild in the immediate future[3]
- Endangered (EN) – species facing a very high risk of extinction in the wild in the near future[3]
- Vulnerable (VU) – species facing a high risk of extinction in the wild in the medium term future[3].

Species may also be listed as specially protected (SP) under the BC Act in one or more of the following categories:

- species of special conservation interest (conservation dependent fauna, CD) – species with a naturally low population, restricted natural range, of special interest to science, or subject to or recovering from a significant population decline or reduction in natural range
- migratory species (Mig.), including birds subject to international agreement
- species otherwise in need of special protection (OS).

The Department of Biodiversity, Conservation and Attractions (DBCA) administers the BC Act and also maintains a non-statutory list of Priority fauna. Priority species are still considered to be of conservation significance – that is they may be Threatened – but cannot be considered for listing under the BC Act until there is adequate understanding of threat levels imposed on them. Species on the Priority fauna list are assigned to one of four Priority (P) categories, P1 (highest) – P4 (lowest), based on level of knowledge/concern.

2.2.2. Critical habitat

Under the BC Act, habitat is eligible for listing as critical habitat if it is critical to the survival of a Threatened species or a TEC and its listing is otherwise in accordance with the ministerial guidelines.

2.2.3. Other significant fauna

Under the EPA's environmental factor guidelines, fauna may be considered significant for a range of reasons other than listing as a Threatened or Priority species.

In addition to listing as Threatened or Priority, EPA (2016a) identifies the following attributes that constitute significant fauna:

- species with restricted distribution (see also section 2.2.4)
- species subject to a degree of historical impact from threatening processes
- providing an important function required to maintain the ecological integrity of a significant ecosystem.

2.2.4. Short-range endemic invertebrates

Short-range endemic (SRE) fauna are defined as animals that display restricted geographic distributions, nominally less than 10,000 km^2, that may also be disjunct and highly localised (Harvey 2002). EPA (2016a) identifies species with restricted distributions as being significant fauna in the context of environmental impact assessments (EIA). SRE fauna need to be considered in EIA as localised, small populations of species that are generally at greater risk of changes in conservation status due to environmental change than other, more widely distributed taxa.

[3] As determined in accordance with criteria set out in the ministerial guidelines.

Short-range endemism in terrestrial invertebrates is believed to have evolved through two primary processes (Harvey 2002):

- Relictual – where the drying climate reduced the area of suitable habitat available to a species, forcing a range contraction. Such habitats typically maintain historic mesic conditions (e.g. south-facing rock faces or slopes of mountains or gullies).
- Habitat speciality – where species settled in particular isolated habitat types (e.g. rocky outcrops) by means of dispersal and evolved in isolation into distinct species.

SRE invertebrates have however also been reported in more widespread habitats such as spinifex plains or woodlands, mainly in groups with low dispersal capabilities, for example mygalomorph spiders and millipedes (see for example Car & Harvey 2014; Rix et al. 2018).

There can be uncertainty in categorising a specimen as an SRE due to several factors including poor regional survey density, lack of taxonomic research and problems of identification, i.e. specimens that may represent SREs cannot be identified to species level based on the life stage. For example, in contrast to mature males, juvenile and female millipedes, mygalomorph spiders and scorpions cannot be identified to species level. Molecular techniques such as 'barcoding' (Hebert *et al.* 2003a; Hebert *et al.* 2003b) are routinely employed to overcome taxonomic or identification problems.

3. EXISTING ENVIRONMENT

3.1. INTERIM BIOGEOGRAPHIC REGIONALISATION OF AUSTRALIA

The Interim Biogeographic Regionalisation of Australia (IBRA) classifies Australia's landscapes into large 'bioregions' and 'subregions' based on climate, geology, landform, native vegetation and species information (DoEE 2016).

The study area is located on the southern margin of the Eastern Murchison subregion (MUR1) of the Murchison bioregion (Figure 3-1), which is characterised by its internal drainage, and extensive areas of elevated red desert sandplains with minimal dune development; salt lake systems associated with the occluded Paleodrainage system; broad plains of red-brown soils and breakaway complexes as well as red sandplains. Vegetation is dominated by Mulga Woodlands often rich in ephemerals; hummock grasslands, saltbush shrublands and samphire (*Tecticornia*, formerly *Halosarcia*) shrublands; arid climate, with mainly winter rainfall (200 mm) (Cowan 2001b).

The study area lies immediately north of the Eastern Goldfield subregion (COO3) of the Coolgardie bioregion, characterised as: subdued relief, comprising gently undulating plains interrupted in the west with low hills and ridges of Archaean greenstones and in the east by a horst of Proterozoic basic granulite. The underlying geology is of gneisses and granites eroded into a flat plane covered with tertiary soils and with scattered exposures of bedrock. Calcareous earths are the dominant soil group and cover much of the plains and greenstone areas. A series of large playa lakes in the western half are the remnants of an ancient major drainage line. The vegetation is of Mallees, Acacia thickets and shrubheaths on sandplains. Diverse Eucalyptus woodlands occur around salt lakes, on ranges, and in valleys. Salt lakes support dwarf shrublands of samphire. Woodlands and Dodonaea shrubland occur on basic graninulites of the Fraser Range. The area is rich in endemic Acacias. The climate is Arid to Semi-arid with 200-300 mm of rainfall, sometimes in summer but usually in winter (Cowan 2001a).

3.2. LAND SYSTEMS AND SURFACE GEOLOGY

DPIRD undertakes land system mapping for WA using a nesting soil-landscape mapping hierarchy (Schoknecht & Payne 2011). While the primary purpose of the mapping is to inform pastoral and agricultural land capability, it is also useful for informing biological assessments. Under this hierarchy, land systems are defined as areas with recurring patterns of landforms, soils, vegetation and drainage (Payne & Leighton 2004).

The study area lies entirely within the Gumland System, characterised as: Extensive pedeplains supporting eucalypt woodlands with halophytic and non-halophytic shrub understoreys (Figure 3-2). To the north and northwest is the Carnegie System (Salt lakes with fringing saline alluvial plains, kopi dunes and sandy banks, supporting halophytic shrublands and acacia tall shrublands) extending to within 350 m of the study area.

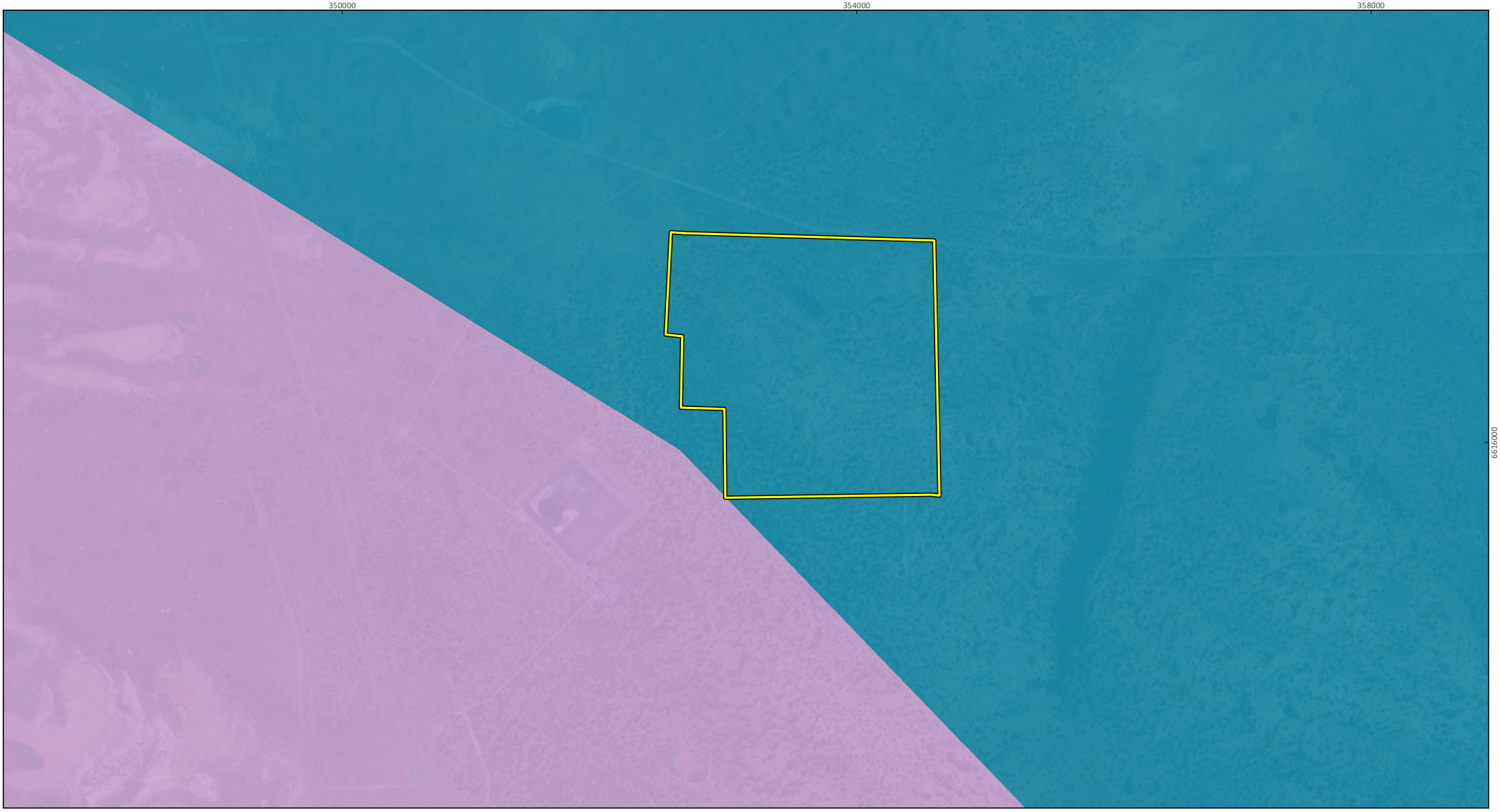
According to the Surface Geology of Australia 1:1,000,000 scale, Western Australia database (Stewart et al. 2008), the study area intersects four geological formations (Table 3-1; Figure 3-2).

The Geoscience Australia surface hydrology dataset (Crossman & Li 2015) shows no surface water features in the study area, but it is partly encircled by ephemeral playa lakes in a paleodrainage channel to the north and west, the nearest small lake occurring 1.6 km northwest of the study area (Figure 1-1).

Topographic relief across the study area is minor and gradual (347 – 365 m AHD; Geoscience Australia 2021), highest in the southeast and lowest in the northwest.

Table 3-1 Surface geology of the study area, extent by deposit type

Surface geology	Abbreviation	Description	Area (ha)	% of study area
mafic extrusive rocks 74248	Abe	Basalt, high-Mg basalt, minor mafic intrusive rocks; some andesite; agglomerate; mafic schist; amphibolite; dolerite; komatiitic basalt; carbonated basalt; basaltic andesite; mafic rock interleaved with minor granitic rock	79.32	20.56
felsic volcanic and volcaniclastic rocks 74288	Afe	Quartz-feldspar (meta-) porphyry, porphyritic microgranite; rhyolite, dacite, rhyodacite, andesite; agglomerate, breccia tuff; felsic schist; felsic volcanic and volcaniclastic rocks; dacite and rhyodacite tuff; dacite porphyry	162.16	42.03
lunette dunes 72955	Qdlu	Quartz and gypsum dunes and mounds (kopi); may include minor silt, sand, gravel, and clay flats adjacent to playas; locally includes some playa sediments	0.08	0.02
colluvium 38491	Qrc	Colluvium, sheetwash, talus; gravel piedmonts and aprons over and around bedrock; clay-silt-sand with sheet and nodular kankar; alluvial and aeolian sand-silt-gravel in depressions and broad valleys in Canning Basin; local calcrete, reworked laterite	144.23	37.39
Total			**385.79**	**100.00**



Northern Star Resources Ltd
Crossroads Project

Project No	1551
Date	19/12/2022
Drawn by	BK
Map author	JS

0 1 2
Kilometers

1:40,000(at A4) GDA 1994 MGA Zone 51

P:\Data\Projects\KCGM Superpit\1551-CR-KO-FAU\GIS\Mapping\MapDocuments\Figures\Figure_3_1_IBRA.mxd

Study area

IBRA region, subregion

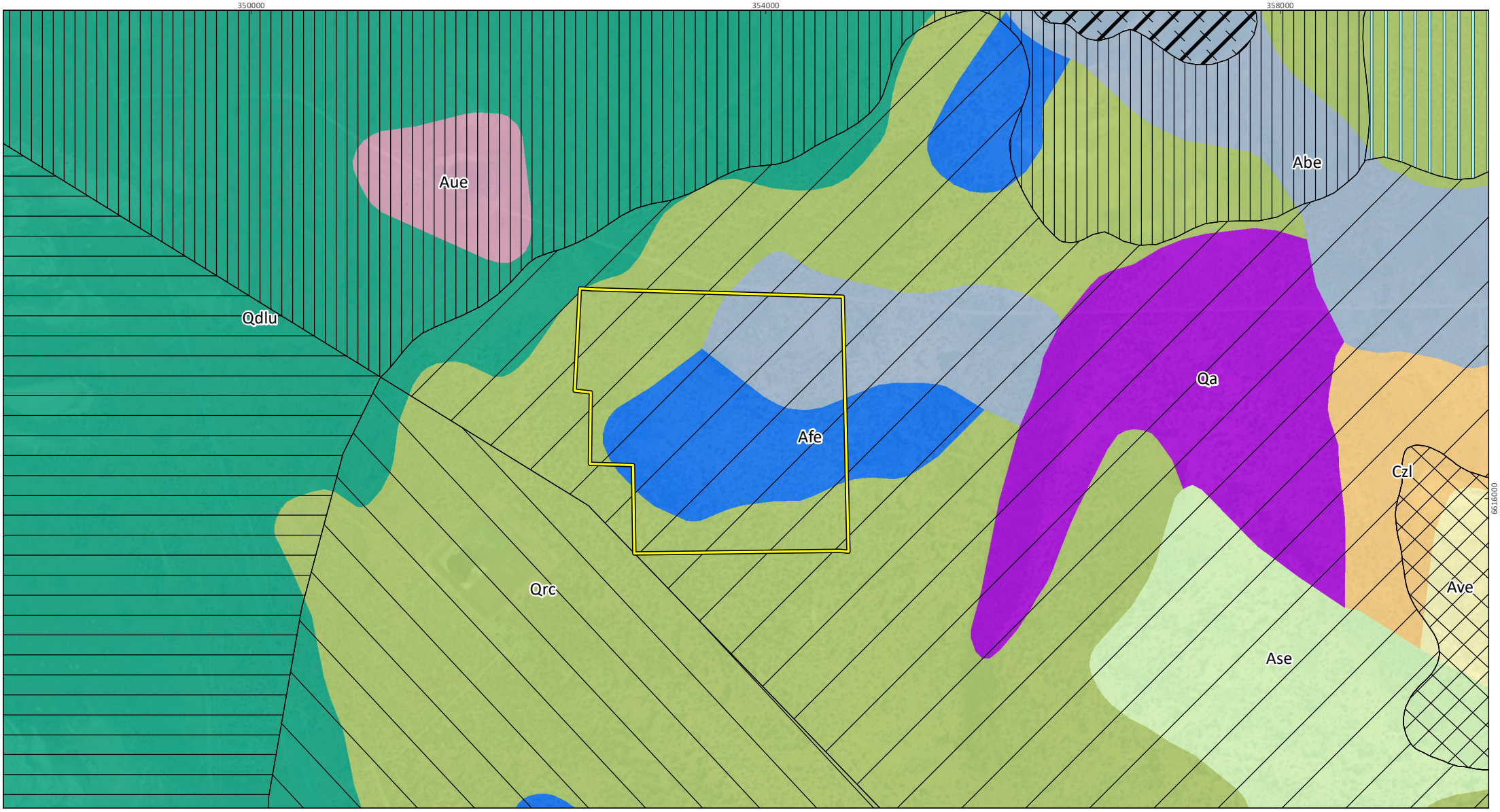
Coolgardie, Eastern Goldfield

Murchison, Eastern Murchison

Figure 3-1

Study area in relation to IBRA bioregions and subregions

PHOENIX ENVIRONMENTAL SCIENCES



Northern Star Resources Ltd
Crossroads Project

Project No	1551
Date	19/12/2022
Drawn by	BK
Map author	JS

0 1 2
Kilometers

1:40,000(at A4) GDA 1994 MGA Zone 51

P:\Data\Projects\KCGM Superpit\1551-CR-KO-FAU\GIS\Mapping\MapDocuments\Figures\Figure_3_2_LS_SG.mxd

Study area

Land system

Carnegie System
Doney System
Gumland System
Lawrence System
Moriarty System
Mx43
SV15

Surface geology

Abe
Afe
Ase
Aue
Ave
Czl
Qa
Qdlu
Qrc

Figure 3-2

Land systems and surface geology in the study area

PHOENIX ENVIRONMENTAL SCIENCES

3.3. CLIMATE AND WEATHER

The climate of the Eastern Murchison subregion is described as arid, with mainly winter rainfall (~200 mm) (Cowan 2001b). The climate of the Eastern Goldfields subregion is characterised by arid to semi-arid with 200-300 mm of rainfall annually, sometimes falling in summer but usually winter (Cowan 2001a).

The nearest Bureau of Meteorology (BoM) weather station with comprehensive data collection and recent historic climate data is Kalgoorlie-Boulder Airport (no. 012038; Latitude: 30.78°S Longitude 121.45°E), located 22 km south of the study area.

Kalgoorlie-Boulder Airport records the highest mean maximum monthly temperature (33.7°C) in January (lowest in July, 16.9°C) and the lowest minimum mean monthly temperature (5.1°C) in July (highest in January, 18.3°C) (BoM 2022) (Figure 3-3). Median annual rainfall is 254 mm with July, June and May recording the highest monthly median (20.0, 18.6 and 18.6 mm respectively; Figure 3-3).

Daily mean temperatures at Kalgoorlie-Boulder Airport preceding the surveys were up to several degrees higher than long-term average in December 2021-January 2022, lower than average in March-June, then 2-3 degrees above average in September-November up to and including the survey (Figure 3-3).

Records from Kalgoorlie-Boulder Airport show rainfall was below long-term average in December 2021-March 2022 and May-June, but well above average in August and the first half of September; October was again relatively dry except for 8.4 mm recorded in the last two days. During the month of survey, there were falls of 4.0 and 4.6 mm on Nov 8 and 9, and 7.0 mm overnight (associated with extensive thunderstorm activity) preceding the last day of survey Nov 17 (Figure 3-3).

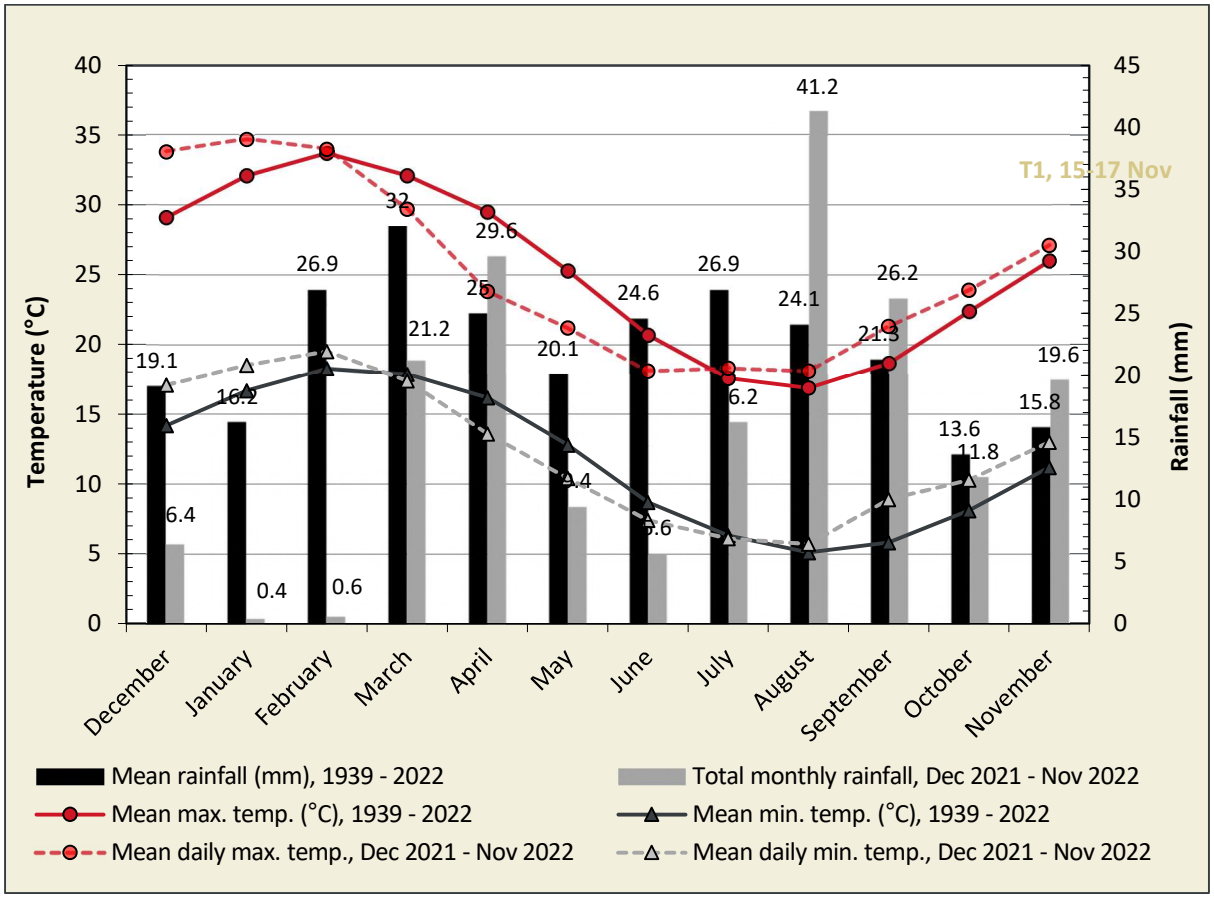


Figure 3-3 **Annual climate and weather data for Kalgoorlie-Boulder Airport (no. 012038) and mean monthly data for the 12 months preceding the survey (BoM 2022)**

3.4. LAND USE

Grazing on native pastures is described as the dominant land use within the Eastern Murchison subregion, occupying 85.47% of the area. Unallocated Crown Lands and Crown Reserves constitute a further 11.34% of the subregion. Conservation land use, most of which falls outside of the IUCN I-IV categories, accounts for 1.4% of the subregion. There is also a substantial amount of interest in nickel and gold mining in the area, however most mining leases remain subject to the pastoral lands act and are therefore still required to be stocked (Cowan 2001b).

Land use within the study area (Department of Environment 2016) consists of grazing native vegetation (99.52%) as part of a pastoral lease. A corridor extending west-northwest into the study area from the centre of its eastern edge is designated as Other minimal use/Conservation and natural environments (20 x 900 m, 0.47%), and a small area classified as intensive uses consists of a section of road within the north eastern corner of the study site (0.007%).

3.5. CONSERVATION RESERVES AND ESAS

Other than the corridor within the study site allocated to conservation and natural environments as mentioned above, no conservation reserves intersect the study area. The closest conservation reserves under the CALM Act 1984 include the Bullock Holes timber reserve (approximately 27 km east of study area), the Lakeside Timber Reserve (approximately 25 km southeast), Kurrawang Nature reserve (approximately 27 km southwest), Kalgoorlie arboretum (approximately 17.5 km south), and Goongarrie National park (approximately 50 km north of the study area) (Figure 1-1).

4. METHODS

The insert survey description survey was conducted in accordance with relevant survey guidelines and guidance, including:

- *EPA Environmental Factor Guideline: Terrestrial fauna* (EPA 2016a)
- *EPA Technical Guidance: Terrestrial vertebrate fauna surveys for environmental impact assessment* (EPA 2020)
- *EPA Technical Guidance: Sampling of short range endemic invertebrate fauna* (EPA 2016c).

4.1. DESKTOP REVIEW

Searches of several biological databases were undertaken to identify and prepare lists of significant flora, vegetation and fauna that may occur within the study area (Table 4-1). A literature search was conducted for accessible reports for biological surveys conducted within 60 km of the study area to build on the lists developed from the database searches (Table 4-2).

Table 4-1 Database searches conducted for the desktop review

Database	Target group/s	Search coordinates and extent
Protected Matters Search Tool (DCCEEW 2022a)	EPBC Act Threatened flora, fauna and ecological communities	Study area polygon as shapefile (buffers are included in modelled distribution of Protected Matters)
DBCA Threatened and Priority Fauna Database (DBCA 2022b)	Threatened and Priority fauna	Study area plus a 40 km buffer
DBCA NatureMap Database (DBCA 2022a)	Vertebrate fauna	Study area plus a 40 km buffer
Atlas of Living Australia (ALA 2022)	Vertebrate fauna	Study area plus a 40 km buffer
WA Museum Arachnid and Myriapod Database, Mollusca Database (WAM 2022)	Arachnid, myriapod and mollusc SREs	100 km radius of the study area

Table 4-2 Survey reports included in the desktop review

Report author	Survey description	Project	Location relative to study area
Phoenix (2018b)	Fauna survey, Crossroads	KCGM Crossroads Tenements	Same location
Keith Lindbeck and Associates (2009)	Fauna survey, Crossroads	Barrick Kanowna Crossroads Project	Same location
Phoenix (2018c)	Fauna survey, Gidgi	KCGM Gidgi Operations	Adjacent to W
Phoenix (2022a)*	Fauna survey, NE Kalgoorlie	Northern Star Kalgoorlie Operations	~10 km SE
Phoenix (2022b)*	Fauna survey, Fimiston	KCGM Fimiston Mine Operations	~15 km S
Phoenix (2022f)*	Fauna survey, N Kalgoorlie	Northern Star Kalgoorlie Operations proposed Regional Coreyard	~13 km S
Botanica Consulting (2020) including data from Bamford (2012)	Fauna Survey, Goldfields Highway	Bardoc Gold Highway and Railway Realignment	~30 km NW

Report author	Survey description	Project	Location relative to study area
Phoenix (2019a)	Fauna survey, Cutters Ridge	Mungardi Operations Cutters Ridge Project	~29 km SW
Phoenix (2022e)	Fauna survey, S Lake Goongarrie	Auroch Minerals Saints Project	~51 km NNW
ABRS (2015)	Fauna survey, Credo	Bush Blitz, Credo Station Reserve WA 2011	~55 km W

*overlapping study areas, results combined in Appendix 3.

4.2. FIELD SURVEY

4.2.1. Survey timing

Field survey was conducted on 15-17 November 2022.

4.2.2. Terrestrial fauna

Field methods for the fauna survey of the survey area included:

- habitat assessment (see 4.2.2.1)
- active diurnal searches (4.2.2.2)
- avifauna surveys (4.2.2.3)
- Malleefowl habitat assessment (4.2.2.4)
- SRE invertebrate sampling (4.2.2.5)

A total of 21 survey sites were sampled (Table 4-3, Figure 4-1; Appendix 1).

4.2.2.1. Habitat assessment

Initial habitat characterisation was undertaken using various remote geographical tools, including aerial photography (Google Earth®), land system maps and topographic maps, and vegetation mapping from previous survey reports for overlapping and nearby sites. Habitats with the potential to support significant terrestrial fauna species were identified based on known habitats of such species within the Murchison bioregion. Tentative sites were selected for the terrestrial fauna survey to represent all habitat types. Final survey site selection was conducted after ground-truthing of site characteristics.

At the broadest scale, site selection considered aspect, topography and land systems. At the finer scale, consideration was given to proximity to water bodies (drainage lines and creek), vegetation complexes and condition and soil type. Sites were primarily chosen to represent the best example of distinct habitats within the broader habitat associations of the study area with a focus on species of conservation significance identified in the desktop review. Habitat descriptions and characteristics were recorded at all survey sites (Table 4-3, Figure 4-1; Appendix 1, Appendix 2).

Table 4-3 Terrestrial fauna survey effort

Site	Foraging (hrs)	Birding (hrs)	SRE foraging (hrs)	SRE litter/soil sieve (#)	Malleefowl habitat assessment
CF001	0.5	0.33	0.5		✓
CF002	0.5		0.5		✓
CF003	1	0.33	1	3	✓
CF004	0.33		0.33		✓
CF005					✓
CF006	1	0.33	1		✓
CF007	0.5	0.66	0.5		✓
CF008	1	0.66	1	3	✓
CF009		0.33			✓
CF010	0.5		0.5		✓
CF011	0.5		0.5	3	✓
CF012					✓
CF013	0.5	0.33	0.5	3	✓
CF014	0.5	0.33	0.5	3	✓
CF015	0.5	0.33	0.5		✓
CF016	0.5	0.33	0.5	3	✓
CF017					✓
CF018	0.5	0.33	0.5		✓
CF019	0.5	0.33	0.5		✓
CF020	1	0.33	1		✓
CF021	1	0.33	1		✓
Total	**10.83**	**5.28**	**10.83**	**18**	**21**

4.2.2.2. Active searches

Active searches were undertaken at most fauna sites throughout the study area (Figure 4-1). Active searches primarily targeted diurnal herpetofauna and mammals from direct sightings and secondary evidence. Searches focused primarily on signs or habitat for significant species identified in the desktop review as potentially occurring within the study area, including Chuditch, Malleefowl and Central Long-eared Bat.

Searches were undertaken in any observable microhabitats considered likely to support mammals, reptiles and amphibians. Techniques included: raking leaf and bark litter, overturning logs, searching beneath the bark of trees, investigating dead trees and logs, investigating burrows, investigating infrastructure ruins or disused building materials such as tin piles and identifying any secondary evidence including tracks, diggings, scats, fur or sloughs (shed skins), predation or feeding sites, and fauna constructed structures such as pebble mounds or nests. In most cases 0.5 person hour was spent active searching at each site (with repeat visits to some sites) for a total of 10.8 hours over the duration of the field survey (Table 4-3).

4.2.2.3. Avifauna surveys

Twenty-minute avifauna surveys were undertaken at 14 sites, and repeated at two sites). Avifauna surveys were confined to the habitat type (up to 2 ha) represented by each site to collect assemblage

data for each habitat. Avifauna surveys were undertaken throughout the day with a focus on periods of higher activity around sunrise and sunset. Surveys consisted of bird records from visual sightings and call recognition. A total of 5.3 person hours of avifauna census was undertaken during the field survey (Table 4-3).

Additional avifauna observations were also recorded at opportunistically while other field work was being completed, including observations made during travel and active searches.

4.2.2.4. Malleefowl habitat assessment

Malleefowl habitat was assessed in the field using a set of environmental variables based on features of critical Malleefowl habitat in Western and Central Australia, as described in the National Recovery Plan (Benshemesh 2007). Individual sites were assessed with a numerical score as a basis for mapping areas of suitable habitat in the study area. The score used is an unweighted sum of binary values (0 absent, one present) for the following attributes:

- sandy substrate (sand/sandy loam/sandy clay)
- litter (leaf litter forming distinct patches under trees/shrubs or - rarely in this area - continuous blanket over soil)
- canopy (tall shrubs or trees forming more or less continuous canopy, contributing to suitable ground microclimates and screen from aerial predators)
- level (ground approximately level, tending to prevent disturbance of soil and litter by rainfall runoff)
- mallee (presence of any mallee-form *Eucalyptus* sp.)
- *Melaleuca* (presence of any *Melaleuca* sp.)
- mulga s.l. (presence of any *Acacia* sp. of subgenus *Juliflorae*)
- *Triodia* (presence of any *Triodia* sp.).

Scores of four or greater (meaning a site contained at least 50% of features that comprise critical Malleefowl habitat) were considered to represent potential Malleefowl habitat. Sites that attained a value of four or greater were applied to vegetation type polygons and the entire polygon (usually) assigned as potential Malleefowl habitat. Where two or more sites were assessed within a single polygon, the higher score was applied unless features of the lower-scored site(s) were more representative. Where no site occurred within a polygon, polygons were classified based on scores for similar vegetation nearby and inspection of relative vegetation density.

4.2.2.5. SRE invertebrate sampling

Sampling for SRE invertebrates was conducted at 17 sites (Figure 4-1), in areas identified as (relatively) suitable habitat for SREs. Sampling comprised the following methods:

- active foraging
- litter/soil sieving.

Active foraging for SRE invertebrate groups comprised inspection of logs, larger plant debris, the underside of bark of larger trees and the underside of rocks. Methodical searches were conducted amongst the leaf litter of shade-bearing tall shrubs and trees, including raking of litter, and spinifex bases were inspected thoroughly. Rocks and rock crevices were inspected, particularly for pseudoscorpions.

A standardised approach was undertaken whereby each site was sampled for 0.5 person hour (concurrently with active searches for vertebrate fauna), a total search effort of approximately 10.8 hours (Table 4-3). Trapdoor spider burrows identified during the searches were excavated if they were

considered inhabited. Excavation involved removing soil from around the burrow to carefully expose the burrow chamber and remove the spider.

Combined litter/soil sifts were undertaken at six sites, with three sifts conducted at each site. In total, 18 sifts were undertaken (Table 4-3). The collection of leaf litter samples was standardised volumetrically by the diameter and height (310 mm x 50 mm = 1.55 L) of the sieves which were completely filled with compressed litter and the upper layers of underlying soil. Samples were sieved through three stages of decreasing mesh size over a round tray and invertebrates were picked from the sieves and tray with forceps. These samples particularly targeted small spiders (Araneomorphae), pseudoscorpions, buthid scorpions, millipedes, centipedes (in particular Geophilomorpha and Cryptopidae), smaller species of molluscs (e.g. Pupillidae) and slaters.

4.2.2.6.SRE potential habitat rating

Fauna habitat mapping was assessed for its potential to support endemic SRE species and communities. Potential SRE habitat was rated as follows:

- High – defined/known areas of habitat that contain elements that often give rise to specialisation or dependency in invertebrate fauna, such as aspect (e.g. south-facing slopes, geological features (e.g. granite), soil types that retain water (e.g. clay, loam). These habitats may also include habitat isolates which have the capacity to restrict dispersal.
- Low – areas of largely in-tact native vegetation that occur broadly across the landscape, are less incised and typically link more restricted habitats. This may include land that was cleared but has since been rehabilitated or is in the process of being rehabilitated.
- None – land that has been previously cleared for other uses that no longer contains native vegetation.

4.2.2.7.SRE status rating

Currently, there is no accepted system to determine the likelihood that a species is an SRE. The WA Museum applies three categories: Confirmed, Potential, and Widespread. Confirmed SREs are taxa for which the distribution is known to be less than 10,000 km^2, the taxonomy is well known, and the group is well represented in collections and/ or via comprehensive sampling (WAM 2013). Potential SREs include those taxa for which there is incomplete knowledge of the geographic distribution of the group and its taxonomy, and the group is not well represented in collections. Phoenix applies four categories based on the WA Museum criteria (Table 4-4).

Table 4-4 Short-range endemic categories

SRE category	Criteria
Confirmed	Distribution <10,000 km^2. Taxonomy of the group is well known (but not necessarily published); group is well represented in collections, in particular from the region in question; high levels of endemism exist in documented species; inference is often possible from immature specimens.
Potential	Distribution <10,000 km^2. Taxonomically poorly resolved group; patchy distribution, often common in certain micro-habitats, but no other regional records; congeners (= species in the same genus) both widespread and restricted in distribution.
Widespread	Distribution >10,000 km^2.
Uncertain	Taxonomy cannot be resolved to species level (i.e. indeterminate species designations due to sex, life stage or damage) and therefore species distribution remains uncertain).

4.2.2.8. SRE taxonomy

Initial higher-level (class, order, family) identifications of specimens are undertaken by Phoenix staff in Phoenix' invertebrate laboratory. Final specials designations are allocated using specialist morphological and/or molecular sequencing. Scorpion and Pseudoscoprpion identifications were undertaken by Erich Volschenk (Alacran). Where possible identifications are on compared with reference material from the WA Museum and/or taxonomist reference collections.

Genomic analysis was undertaken for all specimens for which morphological identification didn't provide sufficient taxonomic resolution. A total of six isopod specimens were sent for molecular analyses. Tissue from each specimen was obtained in Phoenix' laboratory and sequenced by Genotyping Australia.

Sequences were edited and analysed using Geneious 2022.2 (Dotmatics 2022). Sequences for comparison were sourced from GenBank (Benson *et al.* 2012) and Phoenix's DNA database using the megablast search function in Geneious. For each sequence, the most similar ten matches were retrieved. In cases where the retrieved sequences represented a species more than twice, then the two longest sequences were retained and the shorter conspecific sequences discarded. Where megablast results yielded families differing from the morphological assessment, then additional sequences were obtained from GenBank, representing the morphological taxonomic assessment. If all of the resulting blast sequences represented organisms from a different taxonomic class, sequences were discarded as likely contamination.

SRE specimens collected during the survey will be lodged with the WA Museum.

4.2.2.9. Likelihood of occurrence assessment

Following the field survey, the likelihood of occurrence for each significant fauna species identified in the desktop review was assessed and assigned to one of four ratings:

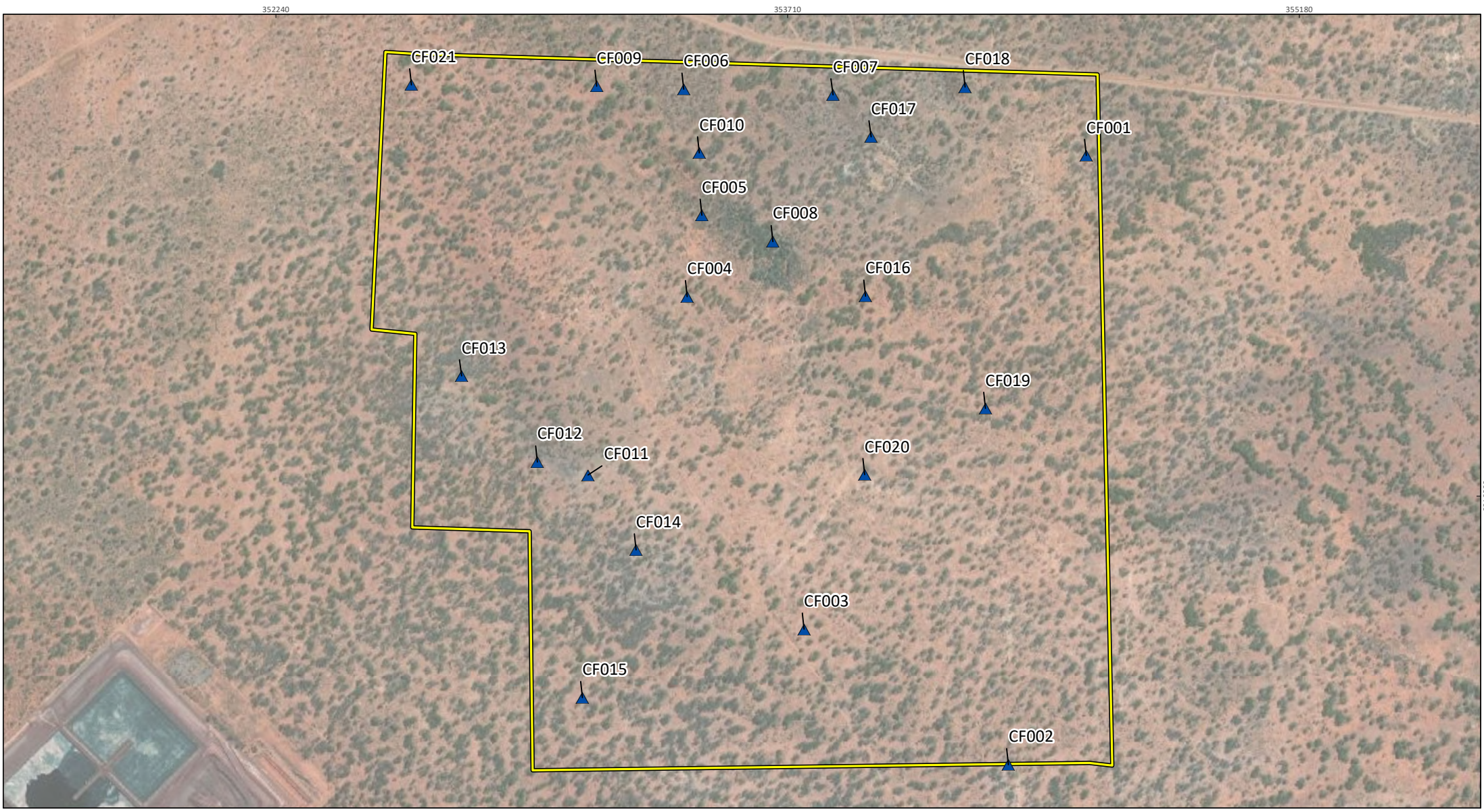
- recorded – species recorded within the study area by previous or current survey
- likely – study area within current known range of species, suitable habitat within the study area and home range of species intersects study area based on known records
- possible – study area within current known range of species, suitable habitat within the study area and home range of species does not intersect study area based on known records
- unlikely – study area outside current known range of species or no suitable habitat present in study area.

4.2.3. Survey personnel

The personnel involved in the surveys are listed in Table 4-5. All survey work was carried out under relevant licences issued by DBCA under the BC Act.

Table 4-5 Survey personnel

Name	Permit	Qualifications	Role/s
J. Scanlon	BA27000761	BSC Hons, PhD (Zoology)	Field lead, data management, GIS habitat mapping, reporting
R. Eastwood		PhD (Env. Sci.)	Fieldwork, targeted ant and butterfly survey
A. Jacks	n/a	BSc (Env. Sci)	Project management
B. Kovar	n/a	BSc (GIS)	GIS map production



Northern Star Resources Ltd
Crossroads Project

Project No	1551
Date	22/12/2022
Drawn by	BK
Map author	JS

0 250 500
Meters

1:14,700(at A4) GDA 1994 MGA Zone 51

P:\Data\Projects\KCGM Superpit\1551-CR-KO-FAU\GIS\Mapping\MapDocuments\Figures\Figure_4_2_Sites.mxd

Study area

Sites

Figure 4-2

Terrestrial fauna survey sites

PHOENIX
ENVIRONMENTAL SCIENCES

5. RESULTS

5.1. DESKTOP REVIEW

5.1.1. Vertebrate fauna

The desktop review identified records of 348 vertebrate species within the desktop search extent. The list comprised two introduced fish species, six frogs, 97 reptiles, 201 birds (including four naturalised species) and 42 mammals (including nine introduced) (Table 5-1; Appendix 3). Three previous surveys within and immediately adjacent to the study area (Keith Lindbeck and Associates 2009; Phoenix 2018b, c) recorded eight reptiles, 35 birds and twelve mammals. No conservation significant species were recorded in the three previous surveys.

Seven reptile species recorded in the desktop search area, including one exotic pest and one Threatened species, were far outside their normal range of occurrence and are inferred to have been passively transported to the Kalgoorlie area with timber, soil or other materials; these records are mostly based on museum voucher specimens (e.g. *Egernia stokesii badia*, WAM R3746), so accidental transport is more likely than misidentification. At least seven recorded bird species are similarly outside their normal range ('extralimital' in Appendix 3); misidentification seems more likely in some of these cases (e.g. eastern Australian endemic species of treecreeper and honeyeater), but some may be vagrants from adjacent regions (cf. Carnaby's Black Cockatoo, with several confirmed sightings within Kalgoorlie-Boulder since 2016).

Twenty-nine significant vertebrate species were identified in the desktop review, comprising 10 species listed as Threatened, Conservation Dependent or Specially Protected under the EPBC Act and/or BC Act; 14 avifauna species listed as Migratory under the EPBC Act and BC Act; and six species listed as Priority by DBCA (Table 5-2). Where distance to nearest record is shown in the Table as '~10 km' without specifying direction, it is based on records mapped in the immediate vicinity of the study area, but with coordinates 'generalised to 10 km' (ALA 2022).

No significant vertebrate species have previously been recorded within the study area (Figure 5-1).

Table 5-1 Summary of terrestrial fauna desktop results

Class	Native	Introduced	Total
Fish	0	2	2
Amphibians	6	0	6
Reptiles	96	1	97
Birds	197	4	201
Mammals	33	9	42
Total	**332**	**16**	**348**

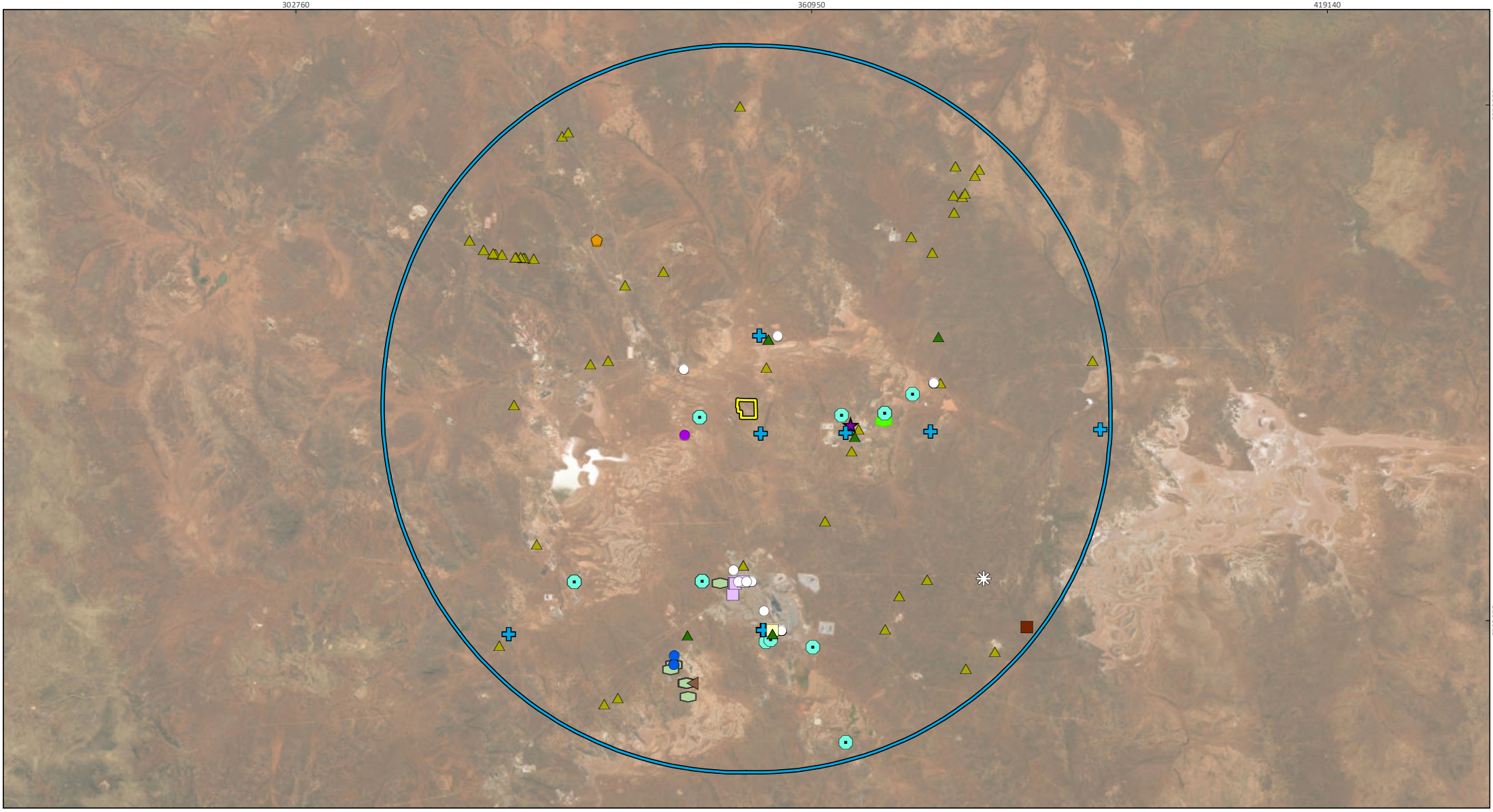
Table 5-2 Significant vertebrate fauna identified in the desktop review

Species	Status	Proximity to study area	Habitat
Reptiles			
Egernia stokesii badia Western Spiny-tailed Skink	EN (EPBC Act), VU (BC Act)	31.5 km SE (all other records >300 km W)	Known to occur in semi-arid areas of south-west WA between Shark Bay and Minnivale, east of Cue (DCCEEW 2022b). The species has been recorded in York Gum, Gimlet and Salmon Gum woodlands with numerous fallen logs, and a dark morph occurs on granite outcrop.
Birds			
Leipoa ocellata Malleefowl	VU (EPBC & BC Acts)	3.9 km N	Malleefowl occur mainly in scrubs and thickets of mallee (*Eucalyptus* spp.), boree (*Melaleuca lanceolata*), bowgada (*Acacia linophylla*), and other dense litter forming shrublands including mulga shrublands (Johnstone & Storr 2004). Nest mounds require sandy soil as well as abundant litter (Benshemesh 2007).
Oxyura australis Blue-billed Duck	P4 (DBCA list)	~24 km S	Highly aquatic; shows seasonal movements between coast and inland sites, using permanent and ephemeral wetlands usually with well-vegetated margins (Johnstone & Storr 1998).
Apus pacificus Fork-tailed Swift	Mig (EPBC & BC Acts)	~60 km WNW	Widespread Migratory species that does not breed in Australia, typically present from October to April. It occurs in a wide range of dry or open habitats across most of WA (DoEE 2020).
Thinornis rubricollis Hooded Plover	P4 (DBCA list)	6.9 km NW	The Hooded Plover population extends from coastal New South Wales to the west coast of WA. Most of the West Australian population is found on the coast from Jurien to the east of Esperance, and a part of the population nests inland (Prószyński 2017). Nesting pairs of Hooded Plovers can be found on the shore of inland salt lakes, freshwater marshes, inlets and coastal sandy beaches.
Actitis hypoleucos Common Sandpiper	Mig (EPBC & BC Acts)	~10 km	Breeds in Eurasia, a small population winters in Australia. Found across all Australian states, they never occur in large flocks, mostly singly. In WA the species is mostly coastal with some inland records (Geering *et al.* 2007). They are found across a wide range of wetlands: small ponds, large inlets and mudflats where they forage on the shore usually close to the vegetation.
Calidris acuminata Sharp-tailed Sandpiper	Mig (EPBC & BC Acts)	4.3 km W	One of the most common Australian shorebirds. They breed in Arctic north-east Siberia and a large population winters in Australia. The distribution in Australia depends on water quantity conditions; some large wetlands may be available inland after important rainfall, but only occasionally. Coastal distribution is more regular, the conditions being more consistent. The species is semi-gregarious and occurs in scattered flocks, mainly on non-tidal flats, often inland.
Calidris alba Sanderling	Mig (EPBC & BC Acts)	26.9 km S	Found mostly on open sandy beaches exposed to open sea-swell, and also on exposed sandbars and spits, shingle banks and beaches that may contain wave-washed rocky outcrops (DCCEEW 2022b).

Species	Status	Proximity to study area	Habitat
Calidris ferruginea Curlew Sandpiper	CR (EPBC & BC Acts), Mig (EPBC Act)	14.6 km E	Mainly occur on intertidal mudflats in sheltered coastal areas, also around non-tidal swamps, lakes, and lagoons near the coast. Less often inland around ephemeral and permanent lakes and waterholes, usually with bare edges of mud or sand (DCCEEW 2022b).
Calidris melanotos Pectoral Sandpiper	Mig (EPBC & BC Acts)	(modelled distribution only)	Found in wetlands, inland as well as on the coast. Occurs on shallow fresh to saline wetlands, usually coastal or near-coastal but occasionally further inland. Prefers wetlands that have open fringing mudflats and low, emergent or fringing vegetation (DCCEEW 2022b).
Calidris ruficollis Red-necked Stint	Mig (EPBC & BC Acts)	17.7 km E	Mostly found in coastal areas, including in sheltered inlets, bays, lagoons and estuaries with intertidal mudflats, often near spits, islets and banks and, sometimes, on protected sandy or coralline shores (DCCEEW 2022b).
Limosa limosa Black-tailed Godwit	Mig (EPBC & BC Acts)	~10 km	Large migratory wader mostly restricted to coastal sites in Australia, but with scattered inland records around shallow, freshwater and saline lakes, swamps, dams and bore-overflows. They also use lagoons in sewage farms and saltworks (DCCEEW 2022b).
Tringa brevipes Grey-tailed Tattler	Mig (EPBC & BC Acts), P4 (DBCA list)	30.6 km S	Occurs on sheltered coasts with reefs and rock platforms or mudflats, and can also be found on reefs or platforms that are exposed at low tide (DCCEEW 2022b).
Tringa glareola Wood Sandpiper	Mig (EPBC & BC Acts)	18.9 km S	Prefers the shallows of wooded lakes or swamps with trees. It also inhabits freshwater swamps, lakes, flooded pastures and occasionally, mangroves (Morcombe 2004).
Tringa nebularia Common Greenshank	Mig (EPBC & BC Acts)	4.4 km W	The species is present in summer across all Australian states, mostly on the coast but sometimes inland. The species is not gregarious. Small groups can sometimes be seen when roosting at high tide (Geering *et al.* 2007). They prefer coastal open mudflats.
Tringa stagnatilis Marsh Sandpiper	Mig (EPBC & BC Acts)	24.6 km S	The Marsh Sandpiper lives in permanent or ephemeral wetlands of varying salinity, including swamps, lagoons, billabongs, saltpans, saltmarshes, estuaries, pools on inundated floodplains, and intertidal mudflats and also regularly at sewage farms and saltworks. They are recorded less often at reservoirs, waterholes, soaks, bore-drain swamps and flooded inland lakes. In Western Australia they prefer freshwater to marine environments (DCCEEW 2022b).
Plegadis falcinellus Glossy Ibis	Mig (EPBC & BC Acts)	18.9 km S	This bird has a nearly global distribution, and in Australia mostly occurs in eastern and northeastern areas, but also patchily in most of WA. It usually occurs in freshwater marshes, floodplains and artificial wetlands, but also uses coastal wetlands including saltmarsh and estuary habitats (DCCEEW 2022b).
Falco hypoleucos Grey Falcon	VU (BC Act)	~150 km S (Norseman	The Grey Falcon is a widespread but rare species inhabiting much of the hot, semi-arid and arid interior of Australia. Occurs in a wide variety of arid habitats including open woodlands and open

Species	Status	Proximity to study area	Habitat
		record with uncertain ID; ALA Kalgoorlie record with photo has been flagged as misidentified *F. cenchroides*)	*Acacia* shrubland, hummock and tussock grasslands and low shrublands, particularly where crossed by tree-lined water courses (Schoenjahn *et al.* 2019; Threatened Species Scientific Committee 2020). Range has contracted northwards in WA, now rarely occurs south of 26°S (Johnstone & Storr 1998).
Falco peregrinus Peregrine Falcon	OS (BC Act)	~25 km S	Preferred habitat includes cliffs and wooded watercourses. Nesting occurs mainly on cliff ledges, granite outcrops, quarries and in trees with old raven or Wedge-tailed Eagle nests (Johnstone & Storr 1998).
Calyptorhynchus latirostris Carnaby's Black Cockatoo	EN (EPBC & BC Acts)	18.6 km S (Kalgoorlie records 2016-2018 only, all others >150 km S/W)	Occurs in uncleared or remnant native eucalypt woodlands, and in shrublands or kwongan heathlands dominated by hakea, dryandra, banksia and grevillea species (DoEE 2020; Garnett & Crowley 2000; Weerheim 2008).
Pezoporus occidentalis Night Parrot	CR (EPBC & BC Acts)	>500 km N/NW	Night Parrot appears to favour areas of dense vegetation comprising old-growth (often > 50 years unburnt) spinifex (*Triodia* spp.) especially hummocks that are ring-forming for roosting and nesting. Such areas may also be associated with dense chenopod shrubs. It is thought that spinifex hummocks that are <40-50 cm in height are not likely to provide adequate shelter for roosting and nesting (DPaW 2017a). Foraging appears to take place in habitats containing various native grasses and herbs in addition to spinifex, and these areas may or may not contain shrubs or low trees. Favoured sites may vary with the season and local conditions, and may not necessarily occur within or adjacent to roosting areas, as they have been observed to fly up to 40 km in a night (DPaW 2017b). *Triodia* species are thought to provide a food resource while flowering and seeding. The succulent genus *Sclerolaena* has also been shown to be a source of food and moisture and other succulent chenopod species are also considered likely to be important. Foraging habitat is likely to be more important if it is adjacent to or within about 10 km of patches of *Triodia* deemed suitable as roosting habitat. Home ranges are up to 3,000 ha (Murphy *et al.* 2017).

Species	Status	Proximity to study area	Habitat
Platycercus icterotis xanthogenys Western Rosella (inland)	P4 (DBCA list)	17.1 km S	The Western Rosella (inland form) is primarily found in eucalypt and casuarina woodlands, preferring Salmon Gum, Wandoo and tall mallees (Johnstone & Storr 1998). They feed on a range of fruits, seeds and marri flowers both on the ground and in trees. Salmon Gum, Gimlet, Wandoo, Marri, Flooded Gum and York Gum are preferentially used for nesting (KLA 2011).
Polytelis alexandrae Princess Parrot	VU (EPBC Act), P4 (DBCA list)	53 km SW	The Princess Parrot is only found in the arid inland sandy desert of central Australia with most of their range extending between the Great Victoria Desert and the Great Sandy Desert in WA. The species is highly irruptive and after significant rainfall, can occur in numbers in areas previously unoccupied. The population is thought to be as low as 1000 mature individuals when the climatic conditions are not optimal for breeding.
Amytornis t. textilis Western Grasswren	P4 (DBCA list)	52.9 km ESE	Occurs in semi-arid shrublands on coastal dunes, calcareous plains and drainage lines (DCCEEW 2022b). Last recorded in southeast WA about 1910, vanishing with arrival of rabbits (Storr 1986).
Motacilla cinerea Grey Wagtail	Mig (EPBC & BC Acts)	(modelled distribution)	A vagrant visitor to Australia that inhabits fast flowing streams and rivers (IUCN 2019).
Mammals			
Dasyurus geoffroii Western Quoll	VU (EPBC & BC Acts)	21.5 km SE	The Chuditch is now confined to southwestern WA, occurring in only 5% of its former range. Prior to European settlement the species occupied approximately 70% of continental Australia (Smith *et al.* 2004; Van Dyck & Strahan 2008). They are now mostly found in woodland, heath and mallee habitats; shelter in hollow logs, crevices and rockpiles in breakaways, or in burrows.
Myrmecobius fasciatus Numbat	EN (EPBC & BC Acts)	18.6 km S	The species is now restricted to two isolate wild populations in south-west Australia and nests in hollow logs, tree hollows or in burrows (DCCEEW 2022b). Last confirmed record in Kalgoorlie district in 1927 (WAM M929, collected as skin/skull; ALA 2022).
Macrotis lagotis Greater Bilby	VU (EPBC & BC Acts)	11.3 km E	Bilby prefers hummock grassland in plains and alluvial areas, open tussock grassland on uplands and hills, and mulga woodland/shrubland on ridges and rises (DCCEEW 2022b), but areas where it is now regionally extinct include many other (mostly open / exposed) habitat types. Disappeared from most of southern WA in the early 1900s (Abbott 2008); last recorded in the Kalgoorlie area in 1973 (WAM M14370, collected as a skeleton; ALA 2022).
Nyctophilus major tor Central Long-eared Bat	P3 (DBCA list)	50 km SW	*Nyctophilus major tor* is poorly known but assumed similar to congeners in foraging ecology, as echolocation calls across Nyctophilus spp. in WA are relatively uniform (Bullen & McKenzie 2002). It has been recorded across the south of WA, within the Goldfields, Wheatbelt and south coast. It inhabits a range of habitats including eucalypt and she-oak woodlands and forests. It roosts in tree hollows, crevices and under loose bark.



Northern Star Resources Ltd
Crossroads Project

Project No	1551
Date	19/12/2022
Drawn by	BK
Map author	JS

0 12.5 25
Kilometers

1:580,700(at A4) GDA 1994 MGA Zone 51

P:\Data\Projects\KCGM Superpit\1551-CR-KO-FAU\GIS\Mapping\MapDocuments\Figures\Figure_5_1_Desktop_vert_fauna_v2.mxd

- Study area

Status

- CR (WA & EPBC status)
- CR (WA status), MI (EPBC status)
- EN (WA & EPBC status)
- MI (WA & EPBC status)
- P1 (WA status)
- P3 (WA status)
- P4 (WA status)
- P4 (WA status), MI (EPBC status)
- VU (WA status), EN (EPBC status)
- VU (WA & EPBC status)
- CR/Mig./CR (EPBC Act; BC Act)
- EN (EPBC & BC Acts)
- EN/VU (EPBC Act; BC Act)
- Mig. (EPBC & BC Acts)
- OS (BC Act)
- P3 (DBCA list)
- P4 (DBCA list)
- VU (BC Act)
- VU (EPBC & BC Acts)

Figure 5-1

Desktop records of significant vertebrate fauna

PHOENIX ENVIRONMENTAL SCIENCES

5.1.2. SRE and significant invertebrate fauna

The desktop review identified records of seven Confirmed SRE taxa and 97 Potential SRE taxa from within the SRE desktop search area, and a further 49 taxa of Uncertain SRE status (Table 5-3; Figure 5-2; Appendix 4).

Of the 104 taxa Confirmed or Potential SRE taxa, 5 are named species (*Buddelundia frontosa, Cylindroiulus brittanicus, Missulena harewoodi, Aurecocrypta lugubris, Synsphyronus mimulus*). The remaining 99 comprise taxa named only to morphospecies codes as applied by the WA Museum or are not identified to Confirmed species level (i.e. "sp." or "cf."). The majority of taxa records of uncertain SRE status are unidentifiable ("sp. indet.", i.e. female or juvenile specimens) or could not be identified to species or morphospecies and may represent new species or other species listed in the same genus where records exist (Table 5-3).

No SRE species have previously been recorded within the study area.

Three conservation significant invertebrate species were returned in the desktop review:

- *Ogyris subterrestris petrina* (Arid Bronze Azure Butterfly) (EPBC Act, BC Act – CR)
- *Jalmenus aridus* (Inland Hairsterak Butterfly) (DBCA – P1)
- *Branchinella denticulata* (a fairy shrimp) (DBCA – P3).

Table 5-3 SRE and Threatened and Priority invertebrate taxa identified in the desktop review

Higher taxon, family	Species	Proximity to study area	SRE category	Source[2]	Comment
Centipedes (3)					
Chilenophilidae	*Sepedonophilus* `sp. G1`	52.8 km NW	Potential	WAM	Recorded outside study area.
	Sepedonophilus `sp. G2`	61.6 km NW	Potential	WAM	Recorded outside study area.
Cryptopidae	*Cryptops* `sp. G1`	61.6 km NW	Potential	WAM	Recorded outside study area.
Isopods (16)					
Armadillidae	*Acanthodillo* '1'	41.5 km SW	Potential	PES	Recorded outside study area in open woodland habitat adjacent Lake Brown.
	Armadillidae 'gen4 sp2'	41.5 km SW	Potential	PES	Recorded outside study area in open woodland habitat adjacent Lake Brown.
	Buddelundia `sp. 72MS`	31.3 km NW	Potential	WAM	Recorded outside study area.
	Buddelundia cf. monticola	69 km S	Potential	Phoenix (2020)	Recorded in woodland habitat for St Ives Gold Mine.
	Buddelundia frontosa	25.5 km S	Potential	Phoenix (2022b)	Recorded outside the study area. Also known from Lake Lefroy and Koolyanobbing.
	Buddelundia 'lefroy A'	62 km S	Potential	Phoenix (2020)	Recorded in drainage line woodland habitat for St Ives Gold Mine.
	Buddelundia 'lefroy B'	66 km S	Potential	Phoenix (2020)	Recorded in woodland habitat for St Ives Gold Mine.
	Buddelundia 'lefroy C'	77.8 km S	Potential	Phoenix (2020)	Recorded in drainage line woodland habitat for St Ives Gold Mine.
	Cubaris 'lefroy'	96 km S	Potential	Phoenix (2014)	Recorded outside study area for St Ives Gold Mine.
	Spherillo 'sp. indet. A1' (fimiston)	19.6 km S	Potential	Phoenix (2022b)	Recorded outside study area for Fimiston Gold Mine Operations.
	Spherillo 'sp. indet. A2' (fimiston)	23.6 km SE	Potential	Phoenix (2022b)	Recorded outside study area for Fimiston Gold Mine Operations.
	Spherillo 'sp. indet. B' (fimiston)	15.5 km SE	Potential	Phoenix (2022b)	Recorded in cut-out area surrounded by study area for Fimiston Gold Mine Operations.
Paraplatyarthridae	*Paraplayarthrus* `sp. G1`	50 km NW	Potential	WAM	Recorded outside study area.
	Paraplayarthrus `sp. G2`	50 km NW	Potential	WAM	Recorded outside study area.

Higher taxon, family	Species	Proximity to study area	SRE category	Source[2]	Comment
Philosciidae	*Philosciidae* `sp. G1`	50 km NW	Potential	WAM	Recorded outside study area.
	Philosciidae 'lefroy'	103 km S	Potential	Phoenix (2018d)	Recorded outside study area adjacent Lake Lefroy. Possibly a riparian species around lake.
Millipedes (8)					
Julidae	*Cylindroiulus brittanicus*	18.5 km S	Potential	WAM	Recorded outside study area.
Paradoxosomatidae	*Antichiropus* `DIP065, binduli 2`	30.9 km S	Confirmed	WAM	Recorded outside study area.
	Antichiropus `DIP067, Broad Arrow`	22.8 km SE	Confirmed	PES (Harewood 2015)	Recorded outside study area in mixed *Eucalyptus* low woodland habitat by Harewood (2015).
	Antichiropus `DIP145, kalgoorlie`	20.2 km SE	Confirmed	WAM	Recorded in open woodland habitat within study area.
	Antichiropus 'DIP176'	20.2 km SE	Confirmed	Phoenix (2019b)	Recorded in open woodland habitat within study area.
	Antichiropus `DIP185, goongarrie`	30.4 km NW	Confirmed	WAM	Recorded outside study area in drainage line woodland habitat.
	Antichiropus `sp. G1`	51.7 km NW	Potential	WAM	Recorded outside study area in drainage line woodland habitat.
Siphonotidae	Siphonotidae `sp. G1`	59.8 km NW	Potential	WAM	Recorded outside study area.
Spiders (48)					
Actinopodidae	*Missulena harewoodi*	14.2 km SE	Confirmed	(Harewood 2015); Phoenix (2022b)	Recorded outside the study area in open woodland habitat. Reported as *Missulena* 'kalgoorlie' in Harewood (2015).
Anamidae	*Aname* `Mt Vetters sp. 03`	19.2 km N	Potential	WAM	Recorded at Mt. Vetters Station, Black Swan Nickel Mine.
	Aname `Mt Vetters sp. 04`	25.5 km NE	Potential	WAM	Recorded at Mt. Vetters Station, Black Swan Nickel Mine.
	Aname `Mt Vetters sp. 05`	26.5 km NE	Potential	WAM	Recorded at Mt. Vetters Station, Black Swan Nickel Mine.
	Aname `Mt Vetters sp. 06`	26.4 km NE	Potential	WAM	Recorded at Mt. Vetters Station, Black Swan Nickel Mine.
	Aname `MYG347`	67.4 km N	Potential	WAM	Recorded at Gindalbie Station.
	Aname `MYG364`	60.5 km NW	Potential	WAM	Recorded outside the study area.
	Aname `MYG738`	48.3 km SE	Potential	WAM	Recorded outside the study area.
	Aname `sp. nov. curved embolus`	9.3 km NW	Potential	WAM	Recorded at Kanowna Homestead, Mt Vetters Station.
	Aname 'MYG181'	113 km SE	Potential	PES	Recorded at Aldiss-Randalls Gold Project.
	Aname 'PES0053'	93 km S	Potential	PES	Recorded at St Ives Gold Mine.

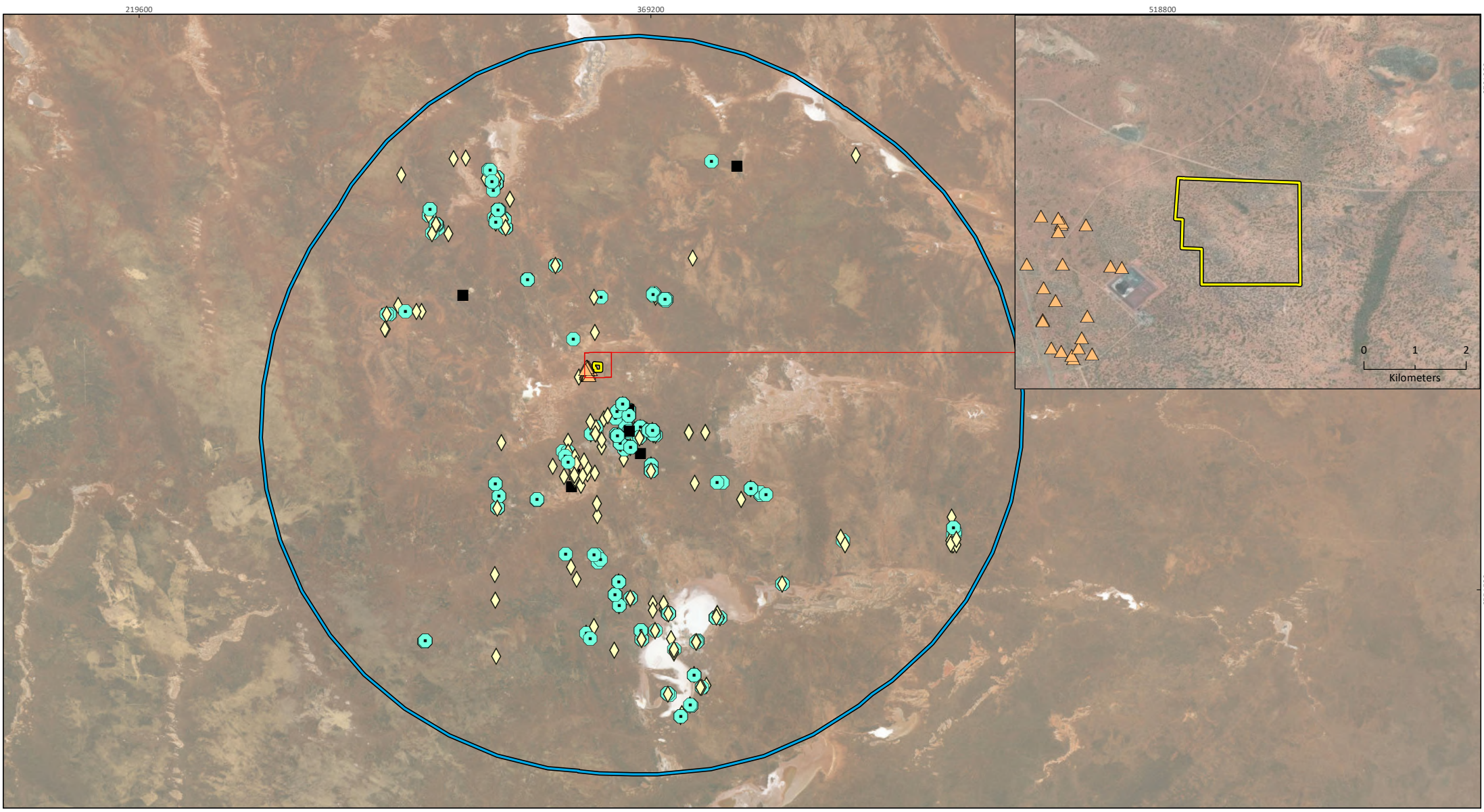
Higher taxon, family	Species	Proximity to study area	SRE category	Source[2]	Comment
	Aname 'SIGM121'	101 km S	Potential	PES	Recorded at St Ives Gold Mine.
	Kwonkan `Mt Vetters sp. 02`	25 km NE	Potential	WAM	Recorded at Mt. Vetters Station, Black Swan Nickel Mine.
	Kwonkan `MYG213`	56 km SE	Potential	WAM	Recorded outside the study area.
	Kwonkan `Phoenix0082`	17.8 km SE	Potential	Phoenix (2022b)	Recorded outside the study area in open woodland habitat.
	Kwonkan `Phoenix0085`	23.1 km SE	Potential	Phoenix (2022b)	Recorded outside the study area in open woodland habitat.
	Kwonkan `SIGM104`	80 km S	Potential	PES	Recorded on bank of Lake Lefroy for St Ives Gold Mine.
	Kwonkan 'MYG263'	113 km ESE	Potential	PES	Recorded at Aldiss-Randalls Gold Project.
	Proshermacha `MYG435`	61 km NW	Potential	WAM	Recorded outside the study area.
	Proshermacha `MYG502`	62 km S	Potential	PES	Recorded in woodland drainage line habitat at St Ives Gold Mine.
	Proshermacha `MYG506`	55.8 km SE	Potential	WAM	Recorded outside the study area.
	Teyl `door-building Diplurid`	31.2 km S	Potential	WAM	Recorded outside the study area.
	Teyl `door-building`	31.2 km S	Potential	WAM	Recorded outside the study area.
	Teyl `double-door`	60 km SE	Potential	WAM	Recorded outside the study area.
	Teyl `Phoenix0081`	11.8 km SE	Potential	Phoenix (2022b)	Collected in open woodland habitat outside the study area.
	Teyl `sp. G1`	53 km NW	Potential	WAM	Recorded outside the study area.
Barychelidae	*Aurecocrypta lugubris*	70 km NE	Confirmed	WAM	Recorded at Gindalbie Station.
	Idiommata `kalgoorlie`	14.6 km S	Potential	Phoenix (2018a) Harewood (2015)	Taxon currently only known from KCGM tenements, however, unlikely to be confined to KCGM Operations. Occurs in two vegetation types. Recorded by Harewood (2015).
	Synothele `Phoenix0083`	11.8 km SE	Potential	Phoenix (2022b)	Recorded outside the study area.
	Synothele `Phoenix0084`	22.7 km SE	Potential	Phoenix (2022b)	Recorded outside the study area.
	Synothele `sp. G1`	58 km NW	Potential	WAM	Recorded outside the study area.
	Synothele 'MYG264'	113 km ESE	Potential	PES	Recorded at Aldiss-Randalls Gold Project.
Euagridae	*Cethegus* `fugax`	87 km SE	Potential	WAM	Recorded outside study area.
	Cethegus `sp. G1`	65 km NW	Potential	WAM	Recorded outside study area.
	Cethegus `sp. G2`	61 km NW	Potential	WAM	Recorded outside study area.

Higher taxon, family	Species	Proximity to study area	SRE category	Source[2]	Comment
Halonoproctidae	*Conothele* `MYG549`	62 km WNW	Potential	WAM	Recorded outside study area at Rowles Lagoon Nature Reserve.
	Conothele `MYG554` ('kalgoorlie')	17.9 km SSE	Potential	Phoenix (2022b) Harewood (2015)	Recorded as *Conothele* 'kalgoorlie' outside study area by Harewood (2015).
Idiopidae	*Bungulla* `MYG677`	62 km S	Potential	Phoenix (2020)	Recorded in woodland drainage lines at St Ives Gold Mine.
	Bungulla `sp. G1`	62 km NW	Potential	WAM	Recorded outside study area.
	Idiosoma `goldfields sp. group`	16.7 km S	Potential	WAM	Recorded outside study area.
	Idiosoma `MYG159`	18.6 km S	Potential	WAM	Recorded outside study area.
	Idiosoma `MYG244`	11.8 km SE	Potential	Phoenix (2022b)	Recorded outside the study area at Rowles Lagoon Nature Reserve.
	Idiosoma `occidentalis sp. group`	16.3 km S	Potential	WAM	Recorded outside study area.
	Idiosoma `Phoenix0086`	11.8 km SE	Potential	Phoenix (2022b)	Recorded outside study area.
	Idiosoma `sp. near MYG224`	55 km S	Potential	WAM	Recorded outside study area.
	Idiosoma `squama`	22.3 km SE	Potential	WAM	Recorded outside study area in open woodland habitat.
	Idiosoma 'kalgoorlie 1'	15.5 km SE	Potential	Phoenix (2022b) Harewood (2015)	Occurs outside study area. Initially reported in the genus *Aganippe* (for genus level change see Rix *et al.* (2017)).
	Idiosoma 'SIGM120'	97 km SSE	Potential	PES	Recorded in drainage line adjacent to Lake Lefroy for St Ives Gold Mine.
Pseudoscorpions (14)					
Cheliferidae	*Cheliferidae* `sp. Fi01`	15.5 km SE	Potential	Phoenix (2022b)	Distribution unknown. Only recorded outside study area.
	Nesidiochernes `sp. Fi01`	19.6 km SSE	Potential	Phoenix (2022b)	Distribution unknown. Only recorded outside study area.
	Nesidiochernes `sp. Fi02`	19.7 km SSE	Potential	Phoenix (2022b)	Distribution unknown. Only recorded outside study area.
	Nesidiochernes `sp. G1`	47.3 km NW	Potential	WAM	Only recorded outside study area.
	Sundochernes `sp. G1`	31.3 km NW	Potential	WAM	Only recorded outside study area.
Garypidae	*Synsphyronus mimulus*	22.3 km SE	Potential	Phoenix (2022b)	Potential SRE owing to taxonomic data deficiency. Distribution unknown. Recorded in open woodland habitat ouside the study area.
	Synsphyronus `cf. mimulus`	62 km S	Potential	Phoenix (2020)	Recorded outside study area in woodland, drainage line and undulating plain habitat at St Ives Gold Mine.

Higher taxon, family	Species	Proximity to study area	SRE category	Source[2]	Comment
	Synsphyronus `PSE216`	94 km SW	Potential	WAM	Recorded outside study area at Victoria Rock Nature Reserve.
	Synsphyronus '7/2 goldfields (PSE117)'	62 km S	Potential	Phoenix (2020)	Recorded outside study area in woodland and drainage line habitat at St Ives Gold Mine.
Olpiidae	*Austrohorus* `salt lake species`	80 km SE	Potential	WAM	Recorded outside study area adjacent to Lake Lefroy.
	Austrohorus `sp. Fi01`	22.1 km SSE	Potential	Phoenix (2022b)	Recorded in shrubland along drainage line habitat at Fimiston Gold Mine Operations. Distribution unknown.
	Beierolpium `8/4-Fi02`	19.6 km SSE	Potential	Phoenix (2022b)	Potential SRE owing to taxonomic data deficiency. Distribution unknown. Previously recorded outside the study area in open woodland habitat.
	Beierolpium `sp. 8/4 small`	66 km S	Potential	Phoenix (2020)	Data deficient. Recorded in woodland, drainage line and undulating plain habitat at St Ives Gold Mine.
	Indolpium `Fi03`	19.6 km SE	Potential	Phoenix (2022b)	Distribution unknown. Recorded at Fimiston Gold Mine Operations.
Scorpions (9)					
Buthidae	*Lychas* `adonis`	53 km NW	Potential	PES	Recorded outside study area.
	Lychas `annulatus complex`	14.5 km SSE	Potential	WAM Harewood (2015)	Recorded outside study area.
	Lychas `bituberculatus complex`	12.9 km SE	Potential	Phoenix (2019b)	Recorded outside the study area.
	Lychas 'SIGM132'	93 km SSE	Potential	WAM	Recorded outside study area adjacent to Lake Lefroy.
Urodacidae	*Urodacus* `magestic`	56 km SE	Potential	WAM	Recorded outside study area.
	Urodacus `sp. G1`	61 km NW	Potential	WAM	Recorded outside study area.
	Urodacus `sp. G2`	61 km NW	Potential	WAM	Recorded outside study area.
	Urodacus 'lefroy'	101 km S	Potential	Phoenix (2014)	Recorded outside study area adjacent to Lake Lefroy at St Ives Gold Mine.
	Urodacus 'SIGM131'	104 km S	Potential	Phoenix (2014)	Recorded outside study area adjacent to Lake Lefroy at St Ives Gold Mine.

Higher taxon, family	Species	Proximity to study area	SRE category	Source[2]	Comment
Snails (6)					
Camaenidae	*Sinumelon* cf. jimberlanensis	54 km S	Potential	WAM	Recorded outside study area in drainage lines and shrubland on rocky hill and open woodland habitat.
	Sinumelon cf. kalgum	57 km WNW	Potential	WAM	Recorded outside study area in shrubland on plain habitat.
	Sinumelon cf. vagente	77 km S	Potential	WAM	Recorded outside study area.
Punctidae	*Westralaoma* cf. expicta	79 km S	Potential	WAM	Recorded outside study area near creek bed.
Pupillidae	*Gastrocopta* aff. margaretae	85 km S	Potential	WAM	Recorded outside study area adjacent Lake Lefroy.
Tomichiidae	*Coxiella* cf. striatula	74 km S	Potential	WAM	Recorded outside study area adjacent Lake Lefroy.
Insects (2)					
Lycaenidae	*Jalmenus aridus*	22.3 km SSE	DBCA – P1	Phoenix (2022c)	Extant populations known from within 25 km.
	Ogyris subterrestris petrina	1.0 km W	EPBC/ BC Act – CR	Phoenix (2022d)	Extant population in close proximity to study area.
Anostracans (1)					
Thamnocephalidae	*Branchinella denticulata*	6.5 km W	DBCA – P3	DBCA (2022b)	Recorded in salt lakes to west of study area.

[2] - PES = Phoenix Environmental Science database, WAM = Western Australia Museum



Northern Star Resources Ltd
Crossroads Project

Project No	1551
Date	19/12/2022
Drawn by	BK
Map author	JS

0 30 60
Kilometers

1:1,496,000 (at A4) GCS GDA 1994

P:\Data\Projects\KCGM Superpit\1551-CR-KO-FAU\GIS\Mapping\MapDocuments\Figures\Figure_5_2_SRE_Desktop_from1532.mxd

Study area

Conservation/SRE status

- P1 (DBCA)
- CR (EPBC/BC Act)
- Confirmed SRE
- Potential SRE
- Uncertain

Figure 5-2

Desktop records of SRE invertebrates

PHOENIX ENVIRONMENTAL SCIENCES

5.2. FIELD SURVEY

5.2.1. Habitats

The study area can be described as a single broad habitat type characterised as:

> *Eucalyptus lesouefii* and *Casuarina pauper* woodland with (variably present) other tree and mallee eucalypt species, *Acacia, Melaleuca, Eremophila* and other mid shrubs, over low chenopod shrubland of *Maireana, Atriplex, Cratystylis* and *Tecticornia* spp., on gently undulating pediplain of sandy loam, minor amounts of clay, and surface scatter of angular volcanic and quartz fragments, ironstone pebbles, and calcrete pisoliths.

To reflect variable suitability as habitat for significant vertebrate fauna species including Chuditch and Malleefowl, the single broad habitat type is here subdivided based on variation in vegetation structure and topography (Table 5-4; Figure 5-3). The most extensive unit comprises open eucalypt woodland with little or no *Casuarina* or other tall shrubs present; mixed eucalypt/*Casuarina* woodlands are split into four types, three differing in canopy density and one representing areas of disturbance with cleared understorey; three types of open to sparse *Casuarina* (lacking eucalypts) with different mid/understorey vegetation; and a small area is dominated by tall *Melaleuca* shrubs.

Topographic relief across the study area is minor and gradual (347 – 365 m AHD), highest in the southeast and lowest in the northwest, with a low rise in the northeast that has been targeted for sand or gravel quarrying. There is no solid rock outcrop, the local high points exposing only low heaps or pavements of angular, cobble-sized volcanic rocks and quartz; ironstone and calcrete occur as local weathering products of the igneous rocks. No natural creeklines or waterbodies are present, but some channeling and pooling of runoff is associated with mining disturbance and vehicle tracks, with some depressions draining internally; presumably a calcrete hardpan layer is widespread in the soil profile (Chen *et al.* 2002), and a few small sinkholes (e.g. near site CF020) show where water drains through gaps in the hardpan. No distinct dune or saltlake habitat is present. Soil textures suggest presence of gypsum, although no distinct surface deposits were observed (cf. Phoenix 2022e).

No mulga (*Acacia aneura* Group) habitat occurs in the study area, and only a few patches of low spinifex (*Triodia* hummock grass) were observed; tussock grasses and herbs (*Solanum, Ptilotus* etc.) occurred only sparsely at the time of survey. Leaf litter is moderately abundant under vegetation, but at most sites shows evidence of transport by sheet runoff during rainfall events. Vegetation structure is clearly affected by surface drainage, with a tendency to form linear groves along contours on slopes, or concentric arrangement of shrubs and trees around shallow depressions. After an overnight storm on the last day of the survey, pools formed in some depressions and wheel ruts, but there was no obvious change in distribution of leaf litter.

There is no evidence of fire in recent decades, with old charring on standing trees only recorded in one site description (CF007), but various signs of relatively recent disturbance by mining exploration and borrow extraction. Collection of firewood (stumps and deadfall) from the study area may also have occurred recently, but none of the sawn logs or stumps observed appeared fresh.

The most significant disturbance to habitat in the study area is the historical clearing of all the largest trees, which presumably occurred during the early 20th Century. Only a few ripped-out stumps, much greater in diameter than the trees still standing, remain to indicate this major alteration of the habitat. As a result, almost no habitat is present for species dependent on logpiles, or hollows in logs or standing trees (only small hollows remain in stumps, or trunks of some older specimens of *Casuarina pauper* and *Melaleuca sheathiana*).

Sites listed in **Table 5-4** include those described in the 2022 survey (CFXXX) and also some described in 2017 (CRXXX, Phoenix 2018b).

Table 5-4 Extent and description of each fauna habitat in the study area

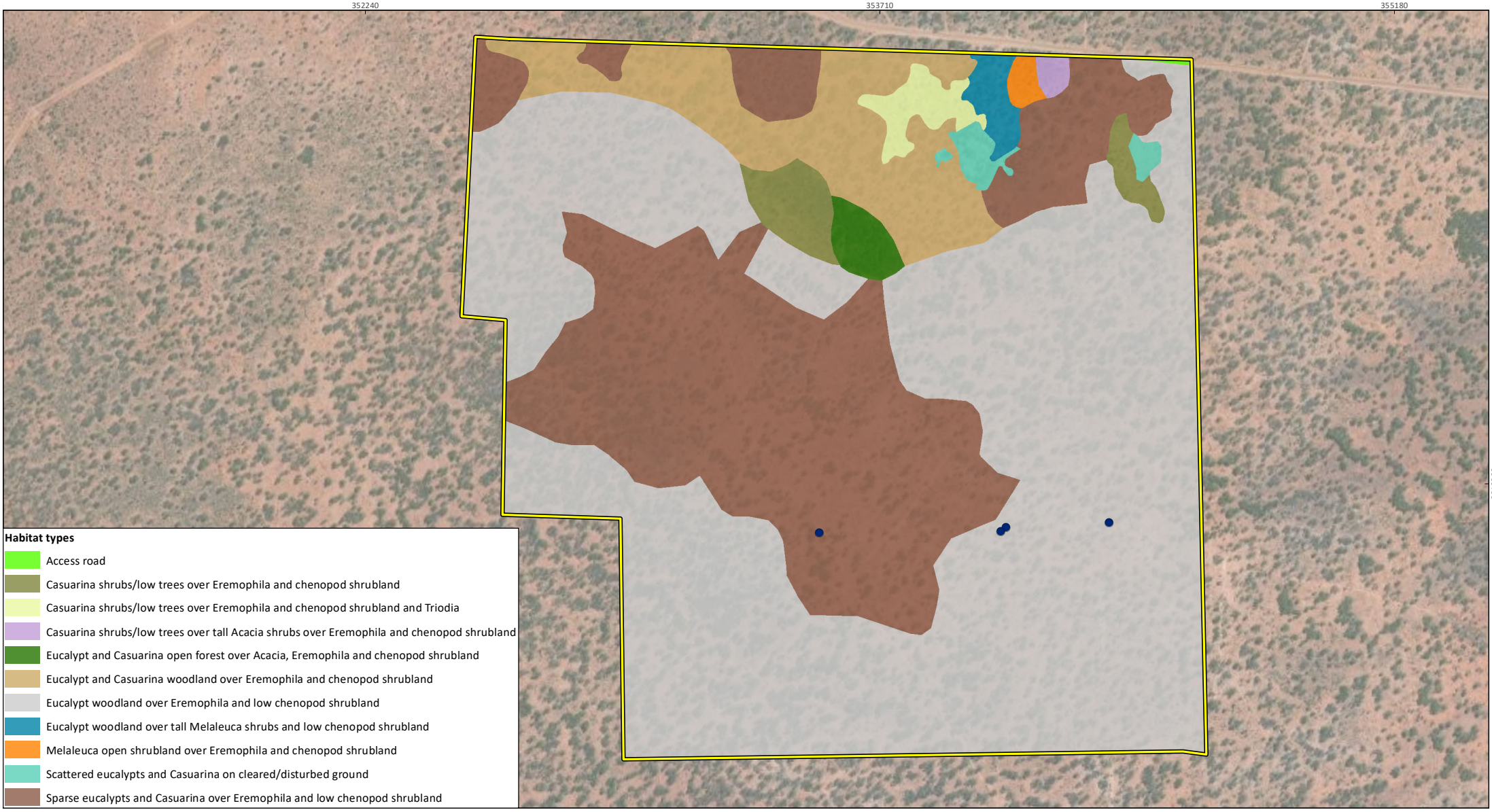
Habitat type	Site/s	Description	Extent in study area and % of study area	Representative photograph
Eucalypt woodland on undulating plain	CF001, CF002, CF004, CF014, CF015, CF016, CF019 CR001, CR003, CR016	*Eucalyptus lesouefii* low open woodland interspersed with other eucalypts (*E. salubris, E. longicornis, E. celastroides*) over *Eremophila* mid shrubs and low chenopod shrubland; gentle slope with low stony rises of quartz and volcanic rock fragments (no solid outcrop), sandy loam to clay loam soils, and calcrete pisoliths at or close to surface	220.86, 57.25%	
Very open/groved eucalypt and Casuarina woodland on internal drainage	CF003, CF006, CF011, CF012, CF013, CF021 CR002, CR005, CR013, CR014	Sparse low woodland of *E. lesouefii*, other eucalypts and *Casuarina pauper* trees or tall shrubs forming linear groves along contours, over *Eremophila*/chenopod shrubland; gentle slope with shallow internally-draining depressions with dense stands of *Melaleuca* or chenopod shrubs; quartz, volcanic rock, ironstone and calcrete form irregular surface scatter	109.73, 28.44%	

Habitat type	Site/s	Description	Extent in study area and % of study area	Representative photograph
Eucalypt and Casuarina woodland on lower slope	CF009, CF010	Open mid woodland of *Eucalyptus lesouefii*, some *E. transcontinentalis*, and *Casuarina pauper* trees forming linear groves along contours, over mid open shrubland of *Eremophila* and *Acacia* spp. over low chenopod shrubs; quartz and ironstone scatter, calcrete not present on surface	32.34, 8.38%	
Eucalypt and Casuarina open forest in shallow depression	CF008 CR011	Mid *Eucalyptus lesouefii, E. salubris* and *Casuarina pauper* open forest over tall open *Eremophila* and *Acacia* shrubland over low open shrubland of *Maireana, Senna* etc.; abundant leaf litter, no rocks apparent	3.28, 0.85%	

Habitat type	Site/s	Description	Extent in study area and % of study area	Representative photograph
Eucalypt woodland over tall Melaleuca shrubs	CR004	Mid open *Eucalyptus lesouefii* woodland over tall open *Melaleuca sheathiana* shrubland over low chenopod shrubs; gentle slope, few or no rocks	3.04, 0.79%	
Casuarina over Acacia shrubland in depression	CF005	Isolated *Casuarina pauper* mid trees over mixed *Acacia* mid-tall shrubs and low-mid *Eremophila*, *Maireana* and *Atriplex* shrubland and scattered *Ptilotus* herbs; surface scatter of quartz, ironstone and calcrete	7.18, 1.86%	

Habitat type	Site/s	Description	Extent in study area and % of study area	Representative photograph
Casuarina over Acacia and spinifex on slope	CF007, CF017	Isolated *Casuarina pauper* low trees and tall shrubs over mixed *Acacia*, *Melaleuca sheathiana*, *Eremophila* and *Dodonaea* mid-tall shrubs and low-mid open shrubland of *Senna, Maireana* and *Atriplex*, with patches of low stage 5 *Triodia* hummock grass; dense surface scatter of ironstone and calcrete (quartz or volcanic rock not seen)	4.15, 1.08%	
Casuarina over Acacia on stony slope	CF018	Isolated *Casuarina pauper* low trees and tall shrubs over *Acacia hemiteles* (or cf.) mid-tall shrubs over low-mid shrubland of mixed *Acacia, Maireana, Santalum, Exocarpos* etc.; sloping depression with gravel of angular volcanic fragments and some quartz, ironstone and calcrete	1.00, 0.26%	

Habitat type	Site/s	Description	Extent in study area and % of study area	Representative photograph
Melaleuca shrubland on sloping depression	none	Tall open *Melaleuca sheathiana* shrubland over low chenopod shrubs on stony slope, upslope from previous type (photo at edge of patch: visible eucalypt and Casuarina belong to different habitat type)	1.19, 0.31%	
Scattered eucalypts and Casuarina on cleared/disturbed ground	none	Remnant eucalypt and *Casuarina* trees lacking understorey due to mining exploration, borrow pit and other ground disturbance	2.77, 0.72%	
Access road	none	Cleared, infrastructure	0.25, 0.06%	
Grand Total			**385.79, 100%**	



Northern Star Resources Ltd
Crossroads Project

Project No	1551
Date	19/12/2022
Drawn by	BK
Map author	JS

0 250 500
Meters

1:14,700(at A4) GDA 1994 MGA Zone 51

P:\Data\Projects\KCGM Superpit\1551-CR-KO-FAU\GIS\Mapping\MapDocuments\Figures\Figure_5_3_Habitats.mxd

Study area

- *Trichosurus vulpecula* (range extension)

Figure 5-3

Fauna habitats and significant fauna records from the field survey

PHOENIX ENVIRONMENTAL SCIENCES

5.2.2. Vertebrate fauna

5.2.2.1. Malleefowl habitat assessments

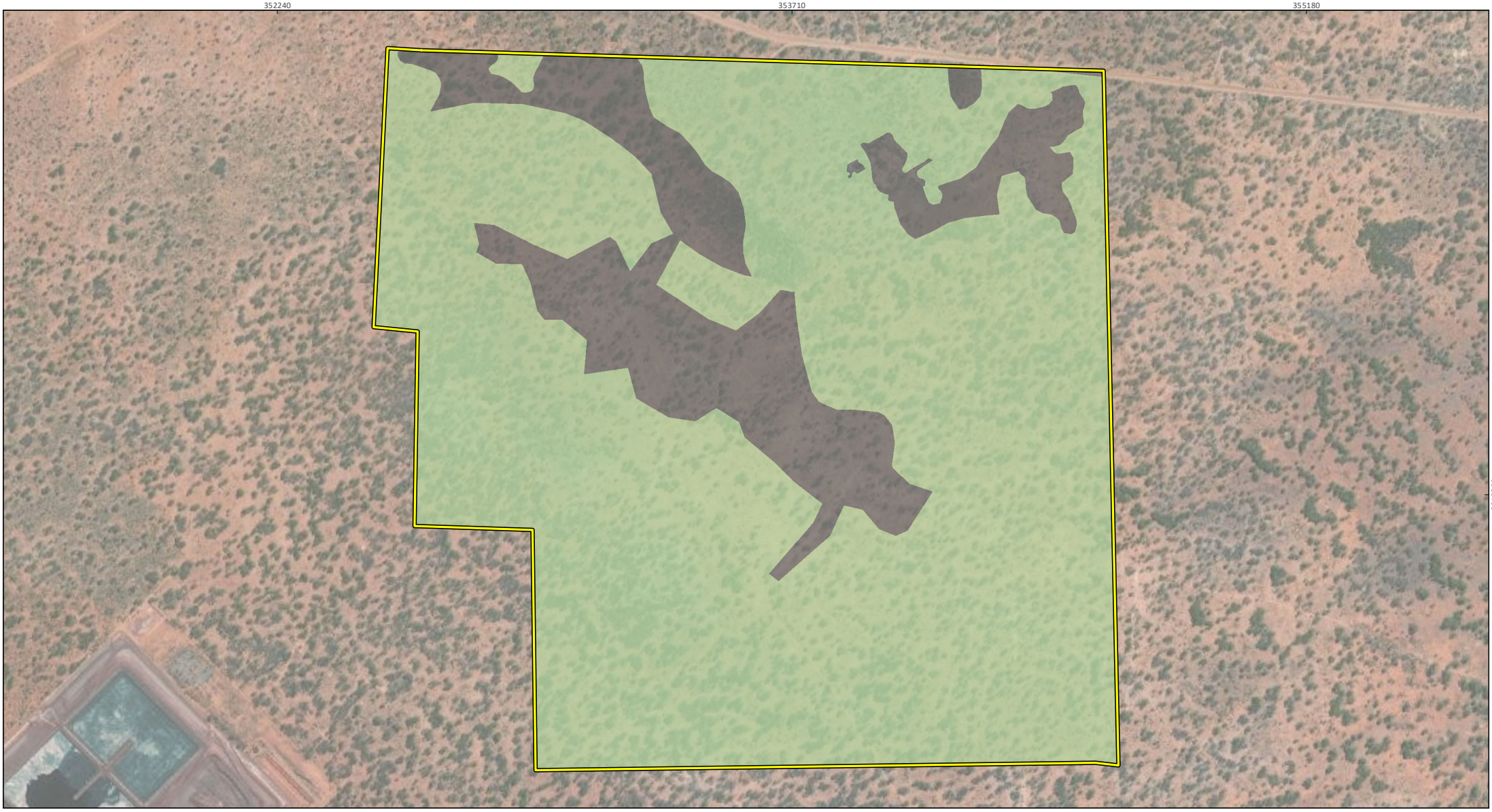
The suitability for habitat to support Malleefowl was assessed at 21 locations (Table 5-5). The habitat was found to be suitable to support the species at 16 of the sites assessed, with two of the sites assessed being classified as High suitability (score six or more). The remaining suitable sites were classified as Medium. No evidence of current or former presence of Malleefowl (e.g. tracks, scats, feathers, sightings, mounds, or foraging traces in leaf litter) was detected during the survey.

Malleefowl habitat suitability scores from assessed sites were used to extrapolate suitability for the entirety of the study area (Figure 5-4). The High suitability sites (CF013, CF016) were located in low eucalypt woodland with discontinuous canopy cover, sandy soil and abundant (but disturbed) leaf litter, while other nearby sites in similar habitat (CF001, CF012, CF019), with more open canopy and less litter, received Medium scores that are considered more representative, and applied to the open-woodland polygons containing these sites. The disturbance of leaf litter by sheet flow during rainfall is visible over most of the study area, and is not consistent with high-value foraging or breeding habitat. A few patches of denser shrubland are very small and would not support resident birds.

Consequently, no part of the study area is assessed as critical habitat with potential for nesting as well as primary foraging. Medium suitability (primary foraging/dispersal habitat) comprises 82.2% of the study area (317 ha), and the remaining 17.7% (68 ha) was assessed as Low suitability (may be used for dispersal or occasional foraging).

Table 5-5 Malleefowl habitat assessment scores

Malleefowl habitat quality	Score	Sites	Total	Total % (Malleefowl habitat %)
Unsuitable/Low suitability	0	Nil	0	0.0
	1	Nil	0	0.0
	2	CF005, CF009, CF017, CF020	4	19.0
	3	CF018	1	4.7
Medium	4	CF002, CF003, CF006, CF007, CF008, CF019, CF021	7	33.3
	5	CF001, CF004, CF010, CF011, CF012, CF014, CF015	7	33.3
High (critical habitat)	6	CF013*, CF016*	2	9.5
	7	Nil	0	0.0
	8	Nil	0	0.0
		Total	**21**	**100**



Northern Star Resources Ltd
Crossroads Project

Project No	1551
Date	19/12/2022
Drawn by	BK
Map author	JS

0 250 500
Meters

1:14,700 (at A4) GDA 1994 MGA Zone 51

P:\Data\Projects\KCGM Superpit\1551-CR-KO-FAU\GIS\Mapping\MapDocuments\Figures\Figure_5_4_Malleefowl_habitat.mxd

Study area

Malleefowl habitat suitability

Medium

Low

Figure 5-4

Malleefowl habitat suitability within the study area

PHOENIX
ENVIRONMENTAL SCIENCES

5.2.2.2. Assemblage

Forty-eight terrestrial vertebrate species representing 27 families were recorded in the study area during the field survey (Appendix 3). The assemblage included 45 native species and three introduced mammal species. The recorded assemblage represents 13.8% of the species identified in the desktop review.

Thirteen reptile species were recorded from six families, the most diverse being Scincidae (skinks, six species). Most were sighted directly and identification confirmed; foraging signs and one fresh track of a medium-sized varanid were referred to Bungarra (*Varanus gouldii*), while one skink was identified provisionally based on tracks representing a robust, sand-swimming species of *Lerista*, likely *L. picturata* (but possibly consistent with *L. macropisthopus*).

Twenty-eight bird species were recorded from 15 families, the most diverse being Meliphagidae (honeyeaters, six species), Artamidae (woodswallow, butcherbirds and currawong, five species) and Petroicidae (robins, three species). All species were positively identified based on sightings or calls. An additional species (Magpie-lark *Grallina cyanoleuca*) was observed a short distance west of the study area during travel to site. Notable absences include Emu, Malleefowl, pigeons, raptors, cockatoos, fairy-wrens, and *Acanthiza* thornbills, which are conspicuous when present and regularly recorded by other surveys in this region (Appendix 3).

Seven mammals (six families, three introduced species) were recorded based on scats, tracks or remains; at least one other rodent or small dasyurid was represented by weathered remains in cat scat, but could not be identified. While signs of Cattle, Rabbit, and Grey Kangaroo were observed frequently during the survey, almost all of these records are based on old, weathered scats. Fresh tracks of a rabbit, a kangaroo and an echidna were seen, but no signs of intermediate age, implying there had been little activity by these species for months prior to the survey. There were also only old signs of Cat, and no evidence of Dingo using the site. Apart from the species with fresh tracks, the others may have been absent from the study area for months (Cattle, Cat) or years (Goat, represented by an old, weathered horn sheath).

Brushtail Possum (*Trichosurus vulpecula*) was the only vertebrate species recorded that was not identified in the desktop review (see next section).

5.2.2.3. Significant vertebrate fauna

No Threatened, Priority, Specially Protected or Migratory vertebrate fauna were recorded in the survey.

The tracks of Common Brushtail Possum (*Trichosurus vulpecula*) were recorded several times, first in hardened mud, then fresh tracks after rainfall. Although the species is not listed in conservation categories, the study area is generally considered to be far outside its current southwestern range after a widespread decline, thought to result from disease, in the late 1880s to early 1900s (Abbott 2012). However, Phoenix has also recorded tracks of this species in other surveys, e.g. approximately 60 km south (near Kambalda) and 230 km north (near Leonora; Phoenix 2020, 2021), suggesting ongoing recovery of populations in some inland areas.

Possum track locations in the study area are marked in Figure 5-3, and an example is shown in Figure 5-5. The track evidence is consistent with a single possum traversing the study area twice in an east-west direction shortly after rainfall, suggesting it may not be a resident. Better refugia and foraging habitat may exist approximately 1 km east of the study area, on a S-N-oriented drainage line with dense shrubland understorey (site CR015 in Phoenix 2018b). A possum mainly residing there might occasionally pass through the sparse woodland of the study area to access water sources or human-modified habitats around the Gidji facility, or along the highway to the west or lakes beyond that.

Figure 5-5 Trackway of Common Brushtail Possum (*Trichosurus vulpecula*), site CF019

The likelihood of occurrence assessment (section 4.2.2.8) for the remaining significant species identified in the desktop review (Table 5-2) determined that one of those species was likely to occur in the study area, seven may possibly occur and 21 are unlikely to occur (Table 5-6). Likely and Possible species are highlighted in grey in Table 5-6; none of these are expected to be resident within or significantly dependent on habitat within the study area. Occurrence per habitat type is not considered in the table because all the species concerned are highly mobile, while the study area is small.

Table 5-6 Likelihood of occurrence for significant vertebrate fauna identified in the desktop review

Species	Status	Likelihood of occurrence
Egernia stokesii badia Western Spiny-tailed Skink	EN (EPBC Act), VU (BC Act)	Unlikely, not native to region and no suitable logpile or granite habitat
Leipoa ocellata Malleefowl	VU (EPBC & BC Acts)	Possible; may occur intermittently as part of wider individual foraging range or during dispersal
Oxyura australis Blue-billed Duck	P4 (DBCA list)	Unlikely, no suitable aquatic habitat
Apus pacificus Fork-tailed Swift	Mig (EPBC & BC Acts)	Likely as occasional visitor, aerial species not limited by terrestrial habitat
Thinornis rubricollis Hooded Plover	P4 (DBCA list)	Unlikely, no suitable salt lake/marsh habitat
Actitis hypoleucos Common Sandpiper	Mig (EPBC & BC Acts)	Unlikely, no suitable salt lake/marsh habitat
Calidris acuminata Sharp-tailed Sandpiper	Mig (EPBC & BC Acts)	Unlikely, no suitable salt lake/marsh habitat
Calidris alba Sanderling	Mig (EPBC & BC Acts)	Unlikely, no suitable salt lake/marsh habitat
Calidris ferruginea Curlew Sandpiper	CR (EPBC & BC Acts), Mig (EPBC Act)	Unlikely, no suitable salt lake/marsh habitat
Calidris melanotos	Mig (EPBC & BC Acts)	Unlikely, no suitable salt lake/marsh habitat

Species	Status	Likelihood of occurrence
Pectoral Sandpiper		
Calidris ruficollis Red-necked Stint	Mig (EPBC & BC Acts)	Unlikely, no suitable salt lake/marsh habitat
Limosa limosa Black-tailed Godwit	Mig (EPBC & BC Acts)	Unlikely, no suitable salt lake/marsh habitat
Tringa brevipes Grey-tailed Tattler	Mig (EPBC & BC Acts), P4 (DBCA list)	Unlikely, no suitable salt lake/marsh habitat
Tringa glareola Wood Sandpiper	Mig (EPBC & BC Acts)	Unlikely, no suitable salt lake/marsh habitat
Tringa nebularia Common Greenshank	Mig (EPBC & BC Acts)	Unlikely, no suitable salt lake/marsh habitat
Tringa stagnatilis Marsh Sandpiper	Mig (EPBC & BC Acts)	Unlikely, no suitable salt lake/marsh habitat
Plegadis falcinellus Glossy Ibis	Mig (EPBC & BC Acts)	Unlikely, no suitable salt lake/marsh habitat
Falco hypoleucos Grey Falcon	VU (BC Act)	Possible, open woodland habitats potentially suitable; rarely recorded in southern WA but may be occasional visitor
Falco peregrinus Peregrine Falcon	OS (BC Act)	Possible; study area does not contain preferred breeding habitat, but all habitats suitable for foraging as part of wide individual home range
Calyptorhynchus latirostris Carnaby's Black Cockatoo	EN (EPBC & BC Acts)	Unlikely; outside known distribution (Kalgoorlie records are outliers) and no suitable foraging or nesting habitat
Pezoporus occidentalis Night Parrot	CR (EPBC & BC Acts)	Unlikely; far south of current known range, no suitable habitat (*Triodia* patches in study area are too low for roosting/nesting)
Platycercus icterotis xanthogenys Western Rosella (inland)	P4 (DBCA list)	Possible, but habitat likely unsuitable for breeding due to historical clearing (lack of adequate tree hollows)
Polytelis alexandrae Princess Parrot	VU (EPBC Act), P4 (DBCA list)	Possible, as occasional visitor during irruptions from core range to north
Amytornis t. textilis Western Grasswren	P4 (DBCA list)	Unlikely; chenopod shrubland potentially suitable habitat but regionally extinct (currently only in Shark Bay region)
Motacilla cinerea Grey Wagtail	Mig (EPBC & BC Acts)	Unlikely, no suitable creek habitat
Dasyurus geoffroii Western Quoll	VU (EPBC & BC Acts)	Possible visitor; woodland habitat could support foraging and dispersal, but suitable refugia (rocky breakaway, hollow logs etc.) appear to be absent
Myrmecobius fasciatus Numbat	EN (EPBC & BC Acts)	Unlikely; regionally extinct, and no suitable refugia (hollow logs)
Macrotis lagotis Greater Bilby	VU (EPBC & BC Acts)	Unlikely; regionally extinct since 1970s or earlier
Nyctophilus major tor Central Long-eared Bat	P3 (DBCA list)	Possible; eucalypt/Casuarina woodlands may be used for foraging but provide few suitable refugia due to clearing

5.2.3. SRE invertebrate fauna

5.2.3.1. Habitats

All habitats within the study area have 'Low' suitability for SRE invertebrates: there are no south-facing slopes, rock outcrops, drainage lines, water-retaining soils, or salt lakes. The Eucalypt and Casuarina open forest in shallow depression patch at site CF008 may be the most suitable SRE habitat due to its lower position in the landscape and denser vegetation structure.

5.2.3.2. SRE records

A total of 16 specimens from SRE groups were collected within the study area (Table 5-7), including four pseudoscorpion taxa, one scorpion, one centipede, and one isopod.

Of these, five species are considered to be Potential SREs, including three pseudoscorpions (*Synsphyronus dorothyae*, *Solinus* sp. indet., *Beierolpium* sp. '8/4') and the single isopod species (*Buddelundia* cf. *frontosa)*. *Synsphyronus dorothyae* and *Buddelundia* cf. *frontosa* are described species known from outside of the study area, while the remaining two species have not been identified to species level but are from groups with known restricted representatives.

One pseudoscorpion and the scorpion were identified as known but undescribed widespread (non-SRE) species and the remaining taxon, a centipede is of Uncertain SRE status due to poor taxonomic resolution.

All specimens were collected from Low Potential SRE habitats which do not have any obvious barriers to dispersal.

Table 5-7 Specimens from SRE groups recorded in the field survey

Higher order/ Family	Taxa	Site/s	Habitat/s	No. specimens	SRE status	Comments
Arachnida – Pseudoscorpiones (Pseudoscorpions)						
Chernetidae	*Conicochernes* 'PSE024'	CF008	Eucalypt/Casuarina open forest, under bark of large *Eucalyptus lesouefii*	3 m, 2 f	Widespread	
Garypidae	*Synsphyronus dorothyae*	CF021	Eucalypt/Casuarina open woodland, under bark of *Eucalyptus celastroides*	1 m	Potential	
Garypinidae	*Solinus* sp.	CF003	Sparse woodland on internal drainage, in leaf litter/soil at base of eucalypt	1 juv	Potential	Potential SRE owing to taxonomic data deficiency.
Olpiidae	*Beierolpium* sp. '8/4 group'	CF011	Sparse woodland on internal drainage, in leaf litter/soil at base of eucalypt	1 f	Potential	Potential SRE owing to taxonomic data deficiency.
Scorpiones (Scorpions)						
Buthidae	*Lychas* 'splendens'	CF020	Sparse woodland on low stony rise, under imbedded stump	1 juv	Widespread	
Crustacea – Isopoda (Slaters)						
Armadillidae	*Buddelundia* cf. *frontosa*	CF003	Sparse woodland on internal drainage, in leaf litter/soil at base of eucalypt	6	Potential	>99% sequence identity to specimen from Fimiston, >15% divergence from other taxa (Phoenix 2022b).
Myriapoda – Chilopoda, Geophilomorpha (Centipedes)						
Mecistocephalidae	Mecistocephalidae sp. indet.	CF003	Sparse woodland on internal drainage, in leaf litter/soil at base of eucalypt	1	Uncertain	Uncertain SRE owing to taxonomic uncertainty.

5.3. SURVEY LIMITATIONS

The limitations of the flora and vegetation survey and terrestrial fauna survey have been considered in accordance with EPA (2016b, d) (Table 5-8).

Table 5-8 Consideration of potential survey limitations

Limitations	Comments
Availability of contextual information at a regional and local scale	Numerous surveys have previously been undertaken within or in the vicinity of the study area which provide adequate contextual information.
Competency/experience of the team carrying out the survey	The field team and report authors have extensive experience in terrestrial fauna surveys within the vicinity of the study area and across WA.
Scope and completeness	Suitable survey methods were used based on EPA technical guidance (EPA 2016b). All target terrestrial fauna groups, conservation significant species and habitats within the study area were surveyed adequately.
Proportion of flora and fauna recorded and/or collected, any identification issues	The fauna survey is considered adequate for a basic survey considering the limited number of habitat types present in the study area relative to those present within the desktop search area. All vertebrate fauna was identified to species level in the field. Invertebrate fauna specimens were submitted to taxonomic specialists on relevant groups for identification.
Access within the study area	The whole of the study area was accessible by vehicle or on foot.
Timing, rainfall, season	Weather preceding and during the survey was comparable to annual averages for previous years. The survey timing was within the optimal timing for reptiles, birds and mammals but was outside the optimal timing for SREs in the Goldfields (May-August); conditions leading up to the survey and during the survey were suitable in terms of adequate rainfall and temperatures for SRE activity.
Disturbance that may have affected the results of the survey	No recent disturbance is considered to have impacted the results.

6. DISCUSSION

6.1. VERTEBRATE FAUNA

The habitats of the study area are (with minor local variation) eucalypt woodlands with mostly halophytic shrub understorey on a pediplain, typical of the Gumland Land System which is widespread and contiguous in the region, extending east and southeast for up to 30 km. The study area includes no significant breakaways, outcrops, south-facing slopes, distinct drainage lines, waterbodies including salt lakes, or dunes, only a few low patches of *Triodia* hummock grass, and has limited diversity of flowering trees and shrubs. Consequently, it is considered to have relatively low value as habitat for many groups of terrestrial vertebrates, and is also unlikely to provide relictual habitat for SREs.

There are signs of disturbance at various times, including the clearing of large eucalypts that occurred many decades ago, and more recent cutting of standing and fallen trees probably for firewood. Living eucalypts in the study area are relatively young, and apparently have not been affected by fire. As a result there are currently few trees or logs containing hollows that might be used as refugia or for breeding. This shortage of hollows limits value of the habitat for species such as Chuditch (*Dasyurus geoffroii*, VU), Western Rosella (*Platycercus icterotis xanthogenys*, P4) and Central Long-eared Bat (*Nyctophilus major tor*, P3), and also for the unexpected Brushtail Possum (*Trichosurus vulpecula*).

The Brushtail Possum record in the study area is the first within the desktop search extent and hence considered a significant range extension (but now one of several recent records in the wider region; Phoenix 2020, 2021). This record is also of interest because the Brushtail Possum has similar body size, omnivorous diet and habitat requirements to Chuditch, and both species underwent a similar (but not simultaneous) decline across the arid parts of their former range (Abbott 2008). The evidence suggests low utilisation of the study area by Brushtail Possum as part of a wider individual home range, and it is inferred that other medium-sized vertebrates (including Chuditch, Malleefowl and other significant species) may show a similar pattern of use, but would not be residents dependent on resources within the study area.

There was no sign of current or former use of the study area by Malleefowl (*Leipoa ocellata*, VU), and the study area is assessed as Medium to Low suitability for this species. Compared to occupied nesting/foraging habitat in other regional surveys, the woodland canopy is relatively sparse (limiting shade, and shelter from aerial predators), soil has poor moisture retention and low biomass, and leaf litter is generally disturbed by surface runoff during storms. Malleefowl may also use the study area occasionally for foraging/dispersal, but is unlikely to breed there.

Some other native and introduced carnivores and grazers provide information on ecological processes in the area (related to the primary human land use, for cattle grazing). These absences may be partly due to ongoing human disturbance, but suggest that productivity of the site for mammalian herbivores has been unusually low recently.

6.2. SRE INVERTEBRATE FAUNA

SRE habitats of the study area comprise generally widespread habitats with no features providing relictual habitat for SREs or geographical barriers inhibiting species dispersal.

A total of four Potential SRE species collected during the survey comprised three pseudoscorpions (*Synsphyronus dorothyae*, *Solinus* sp., *Beierolpium* sp. '8/4') and a single isopod species (*Buddelundia* cf. *frontosa*). *Synsphyronus dorothyae* and *Buddelundia* cf. *frontosa* are known from outside of the study area, however few records exist of these taxa (Harvey 1987).

- *S. dorothyae* (a pseudoscorpion) is also known from its type localities 67 km south of Coolgardie (approx. 90 km south of the study area), and one location in south Australia, as

well as a location 88 km south of the study area near Lake Lefroy, indicating this species may actually be widespread but uncommon.

- *Buddelundia frontosa* has been collected from several sites between 20 to 100 km south of the study area and 100 km west of the study area (Phoenix internal data). The specimens from the survey were sequenced and displayed a 99% match to specimens collected from Fimiston, 20 km south of the study area.
- Representatives of *Beierolpium* sp. '8/4' (a pseudoscorpion) are commonly collected in arid Australia, however due to this species group potentially containing multiple species not morphologically identifiable, this species may be potentially restricted. Representatives of this species have also been collected from nearby locations including Fimiston (20 km south of the study area), St. Ives (Lake Lefroy, 65 km south of the study area), Parker Range, and Koolyanobbing and (170 km west of the study area) (Phoenix internal data).
- *Solinus* (a pseudoscorpion) is much less common and its taxonomy is poorly understood, with only one described species in Australia. Representatives of this genus have been recorded sparsely throughout the south-west of WA between Leonora, Mt Gibson, Kojonup and Eucla (ALA 2022). It is commonly collected in the Pilbara region of WA.

6.3. CONCLUSION

The study area is considered to have relatively low value as habitat for significant fauna species potentially occurring in the vicinity, including Threatened, Migratory, Specially Protected and Priority vertebrates and SRE invertebrates. It is inferred from the relative age of tracks and other signs that several mammal species including the Common Brushtail Possum (range extension) occur intermittently in the study area during dispersal or as part of a larger individual foraging range. This may also apply to other wide-ranging vertebrate species including Malleefowl (VU), Grey Falcon (VU), Peregrine Falcon (OS), Western Rosella (inland) (P4), Princess Parrot (VU/P4), Chuditch (VU) and Central Long-eared Bat (P3); they may occasionally use the habitats of the study area for foraging and dispersal, but it is unlikely to provide breeding habitat for any of these.

No habitats likely to support relictual SRE populations were identified.

REFERENCES

Abbott, I. 2008. Historical perspectives of the ecology of some conspicuous vertebrate species in south-west Western Australia. *Conservation Science of Western Australia* **6**: 1–214.

Abbott, I. 2012. Original distribution of *Trichosurus vulpecula* (Marsupialia:Phalangeridae) in Western Australia, with particular reference to occurrence outside the southwest. *Journal of the Royal Society of Western Australia* **95**: 83-93.

ABRS. 2015. *Credo Station Reserve WA 2011. A Bush Blitz survey report*. ABRS, Canberra. Available at: https://bushblitz.org.au/wp-content/uploads/2016/03/bb-CredoStation-WA-2011.pdf

ALA. 2022. *Atlas of Living Australia*. Available at: http://www.ala.org.au/

Bamford Consulting Ecologists. 2012. *Fauna Assessment of the Excelsior Gold Bardoc Project*. Unpublished report prepared for Excelsior Gold Limited, Kingsley WA.

Benshemesh, J. 2007. *National Recovery Plan for Malleefowl Leipoa ocellata*. South Australian Department of Environment and Heritage, South Australia.

Benson, D. A., Cavanaugh, M., Clark, K., Karsch-Mizrachi, I., Lipman, D., Ostell, J. & Sayers, E. W. 2012. GenBank. *Nucleic Acids Research* **41**: D36–D42.

BoM. 2022. *Climate statistics for Australian locations*. Commonwealth of Australia, Bureau of Meterology. Available at: http://www.bom.gov.au/climate/data/

Botanica Consulting. 2020. *Detailed Flora/Vegetation Survey & Basic Fauna Survey Goldfields Highway and Railway Realignment*. Prepared for Bardoc Gold Limited, Boulder WA. Available at: https://ftp.dwer.wa.gov.au/permit/9113/CPS%209113-1%20-%20Supporting%20information%20-%20Flora%20and%20fauna%20survey.pdf

Bullen, R. D. & McKenzie, N. L. 2002. Differentiating Western Australian *Nyctophilus* (Chiroptera: Vespertilionidae) echolocation calls. *Australian Mammalogy* **23**: 89–93.

Car, C. A. & Harvey, M. S. 2014. The millipede genus *Antichiropus* (Diplopoda: Polydesmida: Paradoxosomatidae), part 2: species of the Great Western Woodlands region of Western Australia. *Records of the Western Australian Museum* **29**: 20–77.

Chen, X. Y., Lintern, M. J. & Roach, I. C. 2002. *Calcrete: characteristics, distribution and use in mineral exploration*. CSIRO, Canberra.

Cowan, M. 2001a. Coolgardie 3 (COO3—Eastern Goldfields subregion). *In:* May, J. E. & McKenzie, N. L. (eds) *A biodiversity audit of Western Australia's 53 biogeographical subregions in 2002.* Department of Conservation and Land Mangement, Perth, W.A., pp. 156–169.

Cowan, M. 2001b. Murchison 1 (MUR1—East Murchison subregion). *In:* May, J. E. & McKenzie, N. L. (eds) *A biodiversity audit of Western Australia's 53 biogeographical subregions in 2002.* Department of Conservation and Land Management, Perth, WA, pp. 466–479.

Crossman, C. & Li, O. 2015. *Surface Hydrology Polygons (National) in* Australia, G., ed. Geoscience Australia, Canberra, ACT.

DBCA. 2020a. *Arid bronze azure butterfly (ABAB) survey in Western Australia additional information*. Department of Biodiversity, Conservation and Attractions. Available at: https://www.dpaw.wa.gov.au/plants-and-animals/threatened-species-and-communities/threatened-animals/562-arid-bronze-azure-butterfly

DBCA. 2020b. *Guideline for the survey of arid bronze azure butterfly (ABAB) in Western Australia*. Government of Western Australia. Available at: https://www.dpaw.wa.gov.au/images/Guideline%20for%20the%20survey%20of%20arid%20bronze%20azure%20butterfly%20Version%201.pdf

DBCA. 2022a. *NatureMap database*. Department of Biodiversity and Attractions, Perth, WA.

DBCA. 2022b. *Threatened and Priority fauna database*. Department of Biodiversity, Conservation and Attractions, Kensington, WA.

DCCEEW. 2022a. *Protected Matters Search Tool*. Available at: pmst.awe.gov.au

DCCEEW. 2022b. *Species Profile and Threats Database*. Department of Agriculture, Water and Environment, Canberra, ACT. Available at: http://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl

Department of Environment. 2016. *Collaborative Australian Protected Area Database (CAPAD)*. Department of Environment, Canberra, ACT. Available at: http://www.environment.gov.au/land/nrs/science/capad

DoEE. 2016. *Maps: Australia's bioregions (IBRA)*. Department of the Environment and Energy, Canberra, ACT. Available at: http://www.environment.gov.au/topics/land/national-reserve-system/science-maps-and-data/australias-bioregions-ibra

DoEE. 2020. *Species Profile and Threats Database*. Department of the Environment and Energy, Australian Government, Canberra, ACT. Available at: http://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl

Dotmatics. 2022. *Geneious 2022.2*. https://www.geneious.com.

DPaW. 2017a. *Interim guideline for preliminary surveys of Night Parrot (Pezoporus occidentalis) in Western Australia*. Department of Parks and Wildlife, Kensington, WA. Available at: https://www.dpaw.wa.gov.au/images/documents/plants-animals/animals/interim_guideline_for_night_parrot_survey.pdf

DPaW. 2017b. *Night Parrot*. Department of Parks and Wildlife, Kensington, WA. Available at: https://www.dpaw.wa.gov.au/plants-and-animals/threatened-species-and-communities/threatened-animals/487-night-parrot (accessed 9 June 2017).

EPA. 2016a. *Environmental Factor Guideline: Terrestrial fauna*. Environmental Protection Authority, Perth, WA. Available at: http://www.epa.wa.gov.au/sites/default/files/Policies_and_Guidance/Guideline-Terrestrial-Fauna-131216_3.pdf

EPA. 2016b. *Technical Guidance: Flora and vegetation surveys for Environmental Impact Assessment*. Environmental Protection Authority, Perth, WA. Available at: http://www.epa.wa.gov.au/sites/default/files/Policies_and_Guidance/EPA%20Technical%20Guidance%20-%20Flora%20and%20Vegetation%20survey_Dec13.pdf

EPA. 2016c. *Technical Guidance: Sampling of short range endemic invertebrate fauna*. Environmental Protection Authority, Perth, WA. Available at: http://www.epa.wa.gov.au/sites/default/files/Policies_and_Guidance/Tech%20guidance-%20Sampling-SREs-Dec-2016.pdf

EPA. 2016d. *Technical Guidance: Terrestrial fauna surveys*. Environmental Protection Authority, Perth, WA. Available at: http://www.epa.wa.gov.au/sites/default/files/Policies_and_Guidance/Tech%20guidance-%20Terrestrial%20Fauna%20Surveys-Dec-2016.pdf

EPA. 2020. *Technical Guidance: Terrestrial vertebrate fauna surveys for environmental impact assessment*. Environmental Protection Authority, Perth, WA. Available at: https://epa.wa.gov.au/sites/default/files/Policies_and_Guidance/EPA-Technical-Guidance-Vertebrate-Fauna-Surveys.pdf

Garnett, S. & Crowley, G. M. 2000. *The action plan for Australian birds*. Environment Australia, Canberra.

Geering, A., Agnew, L. & Harding, S. 2007. *Shorebirds of Australia*. CSIRO Publishing, Collingwood, Vic.

Geoscience Australia. 2021. *Elvis - Elevation and Depth - Foundation Spatial Data*. Available at: https://elevation.fsdf.org.au/

Government of Western Australia. 2018a. *Wildlife Conservation Act 1950 Wildlife Conservation (Rare Flora) Notice 2018*. Government Gazette, WA. Government of Western Australia, Perth, WA.

Government of Western Australia. 2018b. *Wildlife Conservation Act 1950, Wildlife Conservation (Specially Protected Fauna) Notice 2018*. Government Gazette, WA, Perth, WA.

Harewood, G. 2015. *Fauna survey (Level 2 - Phase 1 and 2). Proposed Tails Storage Facility Expansion*. Bunbury, WA. Unpublished report prepared for Kalgoorlie Consolidated Gold Mines Pty Ltd and Botanica Consulting Pty Ltd.

Harvey, M. S. 1987. A revision of the genus *Synsphyronus* Chamberlin (Garypidae: Pseudoscorpionida: Arachnida). *Australian Journal of Zoology, Supplement* **126**: 1–99.

Harvey, M. S. 2002. Short-range endemism among the Australian fauna: some examples from non-marine environments. *Invertebrate Systematics* **16**: 555–570.

Hebert, P. D. N., A., C., Ball, S. L. & de Waard, J. R. 2003a. Biological identifications through DNA barcodes. *Proceedings of the Royal Society London B* **270**: 313–321.

Hebert, P. D. N., Ratnasingham, S. & de Waard, J. R. 2003b. Barcoding animal life: Cytochrome c oxidase subunit 1 divergences among closely related species. *Proceedings of the Royal Society London B, Supplement* **270**: 96–99.

IUCN. 2019. *The IUCN Red List of Threatened Species*.

Johnstone, R. E. & Storr, G. M. 1998. *Handbook of Western Australian birds. Volume 1: Non-passerines (Emu to Dollarbird)*. Western Australian Museum, Perth, WA.

Johnstone, R. E. & Storr, G. M. 2004. *Handbook of Western Australian birds. Volume 2: Passerines (Blue-winged Pitta to Goldfinch)*. West Australian Museum, Perth, WA.

Keith Lindbeck and Associates. 2009. *Barrick Kanowna Crossroads Project. Level 1 fauna survey*. Keith Lindbeck and Associates, Bullcreek, WA.

KLA. 2011. *Targeted survey for Western Rosella at Mt Caudan within the Parker Range region*. Keith Lindbeck and Associates, Bullcreek, WA. Unpublished report prepared for Cazaly Resources Ltd.

Morcombe, M. 2004. *Field guide to Australian birds. Complete compact edition*. Steve Parish Publishing, Archerfield, QLD.

Murphy, S. A., Silcock, J., Murphy, R., Reid, J. & Austin, J. J. 2017. Movements and habitat use of the night parrot *Pezoporus occidentalis* in south-western Queensland. *Austral Ecology* **42**: 858-868 10.1111/aec.12508.

Payne, A. L. & Leighton, K. A. 2004. Land systems. *In:* van Vreeswyk, A. M. E., Payne, A. L., Leighton, K. A. & Hennig, P. (eds) *Technical Bulletin 9. An inventory and condition survey of the Pilbara region, Western Australia*. Department of Agriculture, Government of Western Australia, South Perth, WA, pp. 175–384.

Phoenix. 2014. *Terrestrial invertebrate fauna monitoring for the St Ives Gold Mine – annual survey 2013*. Phoenix Environmental Sciences Pty Ltd, Balcatta, W.A. Unpublished report prepared for St Ives Gold Mining Pty Ltd.

Phoenix. 2018a. *Flora and SRE review for the Fimiston II Tailings Storage Facility Expansion Project*. Phoenix Environmental Sciences Pty Ltd, Balcatta, WA. Unpublished report prepared for Kalgoorlie Consolidated Gold Mines Pty Ltd.

Phoenix. 2018b. *Flora, vegetation and terrestrial fauna survey of the Crossroads tenements (M24/462, L24/197)*. Phoenix Environmental Sciences Pty Ltd, Balcatta, WA. Unpublished report prepared for Kalgoorlie Consolidated Gold Mines Pty Ltd.

Phoenix. 2018c. *Regional flora and vegetation and terrestrial fauna survey for the Gidji Operations*. Phoenix Environmental Sciences Pty Ltd, Balcatta, WA. Unpublished draft report prepared for Kalgoorlie Consolidated Gold Mines Pty Ltd.

Phoenix. 2018d. *Terrestrial fauna survey for the St Ives Gold Mine Beyond 2018 Project*. Phoenix Environmental Sciences Pty Ltd, Balcatta, WA. Unpublished report prepared for St Ives Gold Mining Company Pty Ltd.

Phoenix. 2019a. *Fauna survey for Mungari Gold Operations Cutter's Ridge Project*. Phoenix Environmental Sciences, Balcatta, WA. Unpublished report prepared for Evolution Mining Ltd.

Phoenix. 2019b. *Targeted flora and SRE survey for the FIM IIE Project*. Phoenix Environmental Sciences Pty Ltd, Balcatta, WA. Unpublished report prepared for Kalgoorlie Consolidated Gold Mines Pty Ltd.

Phoenix. 2020. *Kambalda West regional flora and fauna survey for the St Ives Gold Mine*. Phoenix Environmental Sciences Pty Ltd, Osborne Park, WA. Unpublished report prepared for St Ives Gold Mining Company Pty Ltd.

Phoenix. 2021. *Terrestrial fauna survey for the Redcliffe Gold Project*. Unpublished report for Dacian Gold Limited.

Phoenix. 2022a. *Basic and Targeted Terrestrial Fauna Survey for the Kalgoorlie Operations*. Prepared for Northern Star Resources Limited, Osborne Park, WA.

Phoenix. 2022b. *Basic fauna and SRE survey and targeted SRE survey for the Fimiston Gold Mine Operations*. Phoenix Environmental Sciences Pty Ltd, Osborne Park, WA.

Phoenix. 2022c. *Memo report: Gidji survey for Camponotus sp. nr. terebrans and ABAB*. Phoenix Environmental Sciences Pty Ltd, Osborne Park, WA.

Phoenix. 2022d. *Memo report: records of Jalmenus aridus at Fimiston*. Phoenix Environmental Sciences Pty Ltd, Osborne Park, WA.

Phoenix. 2022e. *Terrestrial fauna report for the Saints Study Area*. Phoenix Environmental Sciences Pty Ltd, Osborne Park, Western Australia. Unpublished report prepared for Auroch Minerals Ltd.

Phoenix. 2022f. *Terrestrial fauna survey of the proposed Regional Coreyard for the Kalgoorlie Operations*. Phoenix Environmental Sciences Pty Ltd, Osbourne Park, WA. Unpublished report for Northern Star Resources.

Prószyński, J. 2017. Pragmatic classification of the world's Salticidae (Araneae). *Ecologica Montenegrina* **12**: 1–133.

Rix, M. G., Huey, J. A., Cooper, S. J. B., Austin, A. D. & Harvey, M. S. 2018. Conservation systematics of the shield-backed trapdoor spiders of the *nigrum*-group (Mygalomorphae, Idiopidae, *Idiosoma*): integrative taxonomy reveals a diverse and threatened fauna from south-western Australia. *Zookeys* **756**: 1–121 http://dx.doi.org/10.3897/zookeys.756.24397.

Rix, M. G., Raven, R. J., Main, B. Y., Harrison, S. E., Austin, A. D., Cooper, S. J. B. & Harvey, M. S. 2017. The Australasian spiny trapdoor spiders of the family Idiopidae (Mygalomorphae: Arbanitinae): a relimitation and revision at the generic level. *Invertebrate Systematics* **31**: 566–634.

Schoenjahn, J., Pavey, C. R. & Walter, G. H. 2019. Ecology of the Grey Falcon *Falco hypolecucos* - current and required knowledge. *Emu* **120**: 74-82 10.1080/01584197.2019.1654393.

Schoknecht, N. R. & Payne, A. L. 2011. *Land systems of the Kimberley region, Western Australia*. Department of Agriculture and Food, Western Australia, Perth.

Smith, J. A., Wright, L. J. & Morris, K. D. 2004. BiblioChuditch: The Chuditch, *Dasyurus geoffroii* (Gould 1841), a Wildlife Science Library subject-specific bibliography. *Conservation Science of Western Australia* **5**: 6–19.

Storr, G. M. 1986. Birds of the South-eastern interior of Western Australia. *Records of the Western Australian Museum*: 1-60.

Threatened Species Scientific Committee. 2020. *Conservation Advice Falco hypoleucos Grey Falcon*. Threatened Species Scientific Committee, Canberra, ACT. Available at: http://www.environment.gov.au/biodiversity/threatened/species/pubs/929-conservation-advice-09072020.pdf

Van Dyck, S. & Strahan, R. 2008. *The mammals of Australia*. New Holland Publishers, Sydney, NSW.

WAM. 2013. *WAM short-range endemic categories and sub-categories*. Western Australian Museum, Welshpool.

WAM. 2022. *WA Museum Arachnology/Myriapodology, Crustacea, Mollusca and Entomology database*, Welshpool, WA.

Weerheim, M. S. 2008. *Distribution patterns and habitat use of black cockatoos (Calyptorhynchus spp.) in modified landscapes in the south-west of Western Australia.* Master of Science (Environmental Management) thesis. School of Natural Sciences, Edith Cowan University, Perth, WA.

Appendix 1 Survey site locations

Fauna site	Latitude (S)	Longitude (E)
CF001	-30.5676	121.4835
CF002	-30.5833	121.4809
CF003	-30.5798	121.4748
CF004	-30.5711	121.4715
CF005	-30.569	121.472
CF006	-30.5657	121.4715
CF007	-30.5659	121.4759
CF008	-30.5697	121.4741
CF009	-30.5656	121.4689
CF010	-30.5674	121.4719
CF011	-30.5757	121.4684
CF012	-30.5753	121.4669
CF013	-30.5731	121.4647
CF014	-30.5777	121.4699
CF015	-30.5815	121.4682
CF016	-30.5712	121.4768
CF017	-30.567	121.4771
CF018	-30.5658	121.4799
CF019	-30.5741	121.4804
CF020	-30.5758	121.4767
CF021	-30.5655	121.4633

Appendix 2 Terrestrial fauna survey site descriptions

Site details			
Site	**CF001**	**Position (WGS84)**	-30.5675938307, 121.483484097
Topography	plain	**Soil texture**	sandy loam
Slope	negligible	**Rock type**	calcrete,granite - rocks
Soil colour	orange	**Rock cover (%)**	

Site description - visit 1 (15 Nov 2022)			
Mid E*ucalyptus lesouefii, E. salubris* and *Casuarina* open forest over tall open *Eremophila* and *Acacia* shrubland over low open shrubland of *Maireana, Senna* etc.			
Habitat	open woodland		
Disturbance	exploration (drill pads and access tracks),vehicle tracks,litter		
Vegetation condition	Very Good	**Fire age**	not evident
Total veg. cover (%)	50	**Litter distribution**	
Tree cover (%)	20	**Litter depth(cm)**	2
Shrub cover (%)	30	**Litter cover (%)**	30
Grass cover (%)	0		
Herb cover (%)	0		

Site details			
Site	**CF002**	**Position (WGS84)**	-30.5833524792, 121.480924348
Topography	undulating plain	**Soil texture**	sandy loam
Slope	gentle	**Rock type**	calcrete,quartz
Soil colour	orange	**Rock cover (%)**	

Site description - visit 1 (15 Nov 2022)			
Mid *Eucalyptus longicornis* open woodland over *Eremophila*, *Maireana* and *Tecticornia* low-mid shrubs			
Habitat	open woodland		
Disturbance	vehicle tracks,exploration (drill pads and access tracks),current operations		
Vegetation condition	Very Good	**Fire age**	not evident
Total veg. cover (%)	46	**Litter distribution**	under vegetation
Tree cover (%)	15	**Litter depth(cm)**	2
Shrub cover (%)	30	**Litter cover (%)**	25
Grass cover (%)	0		
Herb cover (%)	1		

Site details			
Site	**CF003**	**Position (WGS84)**	-30.5798017374, 121.474909913
Topography	drainage line	**Soil texture**	sandy loam,sandy clay
Slope	gentle	**Rock type**	quartz,calcrete,ferrous - ironstone
Soil colour	orange	**Rock cover (%)**	

Site description - visit 1 (15 Nov 2022)			
Isolated patches of *Eucalyptus lesouefii* and *E. salubris* over isolated *Casuarina* tall shrubs and *Eremophila* mid shrubs over *Tecticornia* and *Maireana* low-mid shrubs			
Habitat	open woodland		
Disturbance	vehicle tracks,livestock tracks		
Vegetation condition	Very Good	**Fire age**	not evident
Total veg. cover (%)	35	**Litter distribution**	
Tree cover (%)	10	**Litter depth(cm)**	1
Shrub cover (%)	25	**Litter cover (%)**	5
Grass cover (%)	0		
Herb cover (%)	0		

Site details			
Site	**CF004**	**Position (WGS84)**	-30.5710951612, 121.471509207
Topography	undulating plain	**Soil texture**	sandy loam
Slope	gentle	**Rock type**	calcrete,quartz
Soil colour	orange	**Rock cover (%)**	

Site description - visit 1 (15 Nov 2022)			
Linear SE-NW strip of *Eucalyptus lesouefii* and *E. salubris* woodland and *E. celastroides* mallees over isolated mid *Eremophila* shrubs and *Santalum* low trees over low open *Maireana* and *Tecticornia* shrubland			
Habitat	woodland		
Disturbance	vehicle tracks,exploration (drill pads and access tracks)		
Vegetation condition	Excellent	**Fire age**	not evident
Total veg. cover (%)	60	**Litter distribution**	under vegetation
Tree cover (%)	40	**Litter depth(cm)**	2
Shrub cover (%)	20	**Litter cover (%)**	
Grass cover (%)	0		
Herb cover (%)	0		

Site details			
Site	**CF005**	**Position (WGS84)**	-30.56869034, 121.47176754
Topography	depression	**Soil texture**	clay loam
Slope	negligible	**Rock type**	ferrous - ironstone,quartz,calcrete
Soil colour	orange	**Rock cover (%)**	

Site description - visit 1 (15 Nov 2022)			
Isolated *Casuarina* mid trees over mixed *Acacia* mid-tall shrubs and low-mid *Eremophila, Maireana* and *Atriplex* shrubland and scattered *Ptilotus* herbs			
Habitat	open woodland		
Disturbance	livestock tracks		
Vegetation condition	Excellent	**Fire age**	not evident
Total veg. cover (%)	61	**Litter distribution**	transported
Tree cover (%)	10	**Litter depth(cm)**	1
Shrub cover (%)	50	**Litter cover (%)**	5
Grass cover (%)	0		
Herb cover (%)	1		

Site details			
Site	**CF006**	**Position (WGS84)**	-30.5657299469, 121.471468555
Topography	depression	**Soil texture**	clay,clay loam
Slope	negligible	**Rock type**	calcrete,ferrous - ironstone,quartz
Soil colour	whitish,orange	**Rock cover (%)**	

Site description - visit 1 (15 Nov 2022)			
Scattered patches of *Eucalyptus lesouefii*, mulga, and *Casuarina* trees over *Eremophila, Melaleuca, Maireana*, *Atriplex* and *Senna* mid open shrubland			
Habitat	open woodland		
Disturbance	vehicle tracks		
Vegetation condition	Very Good	**Fire age**	not evident
Total veg. cover (%)	50	**Litter distribution**	
Tree cover (%)	10	**Litter depth(cm)**	1
Shrub cover (%)	40	**Litter cover (%)**	5
Grass cover (%)	0		
Herb cover (%)	0		

Site details			
Site	**CF007**	**Position (WGS84)**	-30.5659354292, 121.475947341
Topography	depression	**Soil texture**	clay loam
Slope	negligible	**Rock type**	calcrete,ferrous - ironstone
Soil colour	light-brown,orange	**Rock cover (%)**	

Site description - visit 1 (15 Nov 2022)			
Scattered *Casuarina* trees and tall shrubs over mixed *Acacia* and *Eremophila* mid-tall shrubs, low-mid open shrubland of *Senna, Maireana* and *Atriplex*, over patch of low stage 5 *Triodia* hummock grass			
Habitat	shrubland		
Disturbance	evidence of feral animals		
Vegetation condition	Excellent	**Fire age**	long-unburnt (>10 years)
Total veg. cover (%)	46	**Litter distribution**	under vegetation
Tree cover (%)	5	**Litter depth(cm)**	5
Shrub cover (%)	40	**Litter cover (%)**	
Grass cover (%)	0		
Herb cover (%)	1		

Site details			
Site	**CF008**	**Position (WGS84)**	-30.5697831, 121.4740765
Topography	depression	**Soil texture**	clay,clay loam
Slope	negligible	**Rock type**	
Soil colour	light-brown,orange	**Rock cover (%)**	

Site description - visit 1 (15 Nov 2022)			
Mixed Euc and Casuarina forest over mid-tall mixed Acacia, Eremophila, Senna etc. shrubs			
Habitat	forest		
Disturbance	vehicle tracks,livestock tracks,evidence of feral animals		
Vegetation condition	Excellent	**Fire age**	not evident
Total veg. cover (%)	80	**Litter distribution**	even/continuous
Tree cover (%)	50	**Litter depth(cm)**	3
Shrub cover (%)	30	**Litter cover (%)**	80
Grass cover (%)	0		
Herb cover (%)	0		

Site details			
Site	**CF009**	**Position (WGS84)**	-30.5656030448, 121.468831943
Topography	depression	**Soil texture**	sandy clay,sandy loam
Slope	negligible	**Rock type**	quartz,ferrous - ironstone
Soil colour	orange	**Rock cover (%)**	

Site description - visit 1 (15 Nov 2022)			
Mid-tall *Eucalyptus transcontinentalis* trees ringing sandy claypan with scattered mid *Eremophila* shrubs over *Atriplex*, *Senna* and *Tecticornia* low-mid shrubland			
Habitat	open woodland		
Disturbance	historic clearing,livestock tracks		
Vegetation condition	Excellent	**Fire age**	not evident
Total veg. cover (%)	41	**Litter distribution**	
Tree cover (%)	10	**Litter depth(cm)**	1
Shrub cover (%)	30	**Litter cover (%)**	10
Grass cover (%)	0		
Herb cover (%)	1		

Site details			
Site	**CF010**	**Position (WGS84)**	-30.5674004183, 121.47191288
Topography	plain	**Soil texture**	clay loam
Slope	negligible	**Rock type**	quartz,ferrous - ironstone
Soil colour	orange	**Rock cover (%)**	

Site description - visit 1 (16 Nov 2022)			
Mid *Eucalyptus lesouefii* woodland with scattered *E. salubris* over isolated *Casuarina* trees and tall shrubs, over *Eremophila* and *Maireana* mid open shrubland with scattered low *Acacia* shrubs			
Habitat	open woodland		
Disturbance	vehicle tracks,historic clearing		
Vegetation condition	Very Good	**Fire age**	not evident
Total veg. cover (%)	50.5	**Litter distribution**	under vegetation
Tree cover (%)	20	**Litter depth(cm)**	1
Shrub cover (%)	30	**Litter cover (%)**	20
Grass cover (%)	0		
Herb cover (%)	0.5		

Site details			
Site	**CF011**	**Position (WGS84)**	-30.5757188704, 121.468429947
Topography	plain	**Soil texture**	sandy loam,clay loam
Slope	negligible	**Rock type**	quartz,calcrete,ferrous - ironstone,granite - rocks
Soil colour	orange	**Rock cover (%)**	

Site description - visit 1 (16 Nov 2022)			
Low *Eucalyptus salubris* and *E. celastroides* woodland over scattered mid *Eremophila* and *Senna* shrubs over low open *Atriplex, Maireana* and *Tecticornia* shrubland on claypan with patchy pavement of angular quartz fragments and other rocks			
Habitat	open woodland		
Disturbance	historic clearing		
Vegetation condition	Very Good	**Fire age**	not evident
Total veg. cover (%)	40	**Litter distribution**	
Tree cover (%)	20	**Litter depth(cm)**	2
Shrub cover (%)	20	**Litter cover (%)**	10
Grass cover (%)	0		
Herb cover (%)	0		

Site details			
Site	**CF012**	**Position (WGS84)**	-30.5752977217, 121.466914667
Topography	depression	**Soil texture**	sandy clay,clay loam
Slope	negligible	**Rock type**	calcrete,quartz,ferrous - ironstone
Soil colour	orange,light-brown	**Rock cover (%)**	

Site description - visit 1 (16 Nov 2022)			
Low-mid *Eucalyptus lesouefii* and *E. salubris* woodland over sparse *Eremophila* mid shrubs over *Atriplex* and *Maireana* low open shrubland, with patches of dense small-leaf *Melaleuca* mid-tall shrubland in shallow depression			
Habitat	shrubland		
Disturbance	historic clearing,vehicle tracks		
Vegetation condition	Very Good	**Fire age**	not evident
Total veg. cover (%)	40	**Litter distribution**	transported
Tree cover (%)	10	**Litter depth(cm)**	2
Shrub cover (%)	30	**Litter cover (%)**	5
Grass cover (%)	0		
Herb cover (%)	0		

Site details			
Site	**CF013**	**Position (WGS84)**	-30.5730414391, 121.464709221
Topography	plain	**Soil texture**	sandy loam
Slope	negligible	**Rock type**	quartz,calcrete,ferrous - ironstone
Soil colour	orange	**Rock cover (%)**	

Site description - visit 1 (16 Nov 2022)			
Low *Eucalyptus lesouefii, E. salubris* and *E. longicornis* woodland over sparse *Senna, Melaleuca* and *Exocarpos* mid-tall shrubs, interspersed with low-mid shrubland of *Eremophila, Maireana* and *Tecticornia*			
Habitat	woodland		
Disturbance			
Vegetation condition	Very Good	**Fire age**	
Total veg. cover (%)	55	**Litter distribution**	
Tree cover (%)	40	**Litter depth(cm)**	
Shrub cover (%)	15	**Litter cover (%)**	
Grass cover (%)	0		
Herb cover (%)	0		

Site details			
Site	**CF014**	**Position (WGS84)**	-30.5776789785, 121.4698656
Topography	undulating plain	**Soil texture**	sandy loam,rocks
Slope	gentle	**Rock type**	calcrete,granite - rocks
Soil colour	brown,orange	**Rock cover (%)**	

Site description - visit 1 (16 Nov 2022)			
Low *Eucalyptus lesouefii* patchy woodland on low stony rise over patches of tall *Melaleuca* shrubs and low-mid *Eremophila* and *Maireana* shrubland			
Habitat	open woodland		
Disturbance	historic clearing,exploration (drill pads and access tracks),litter		
Vegetation condition	Very Good	**Fire age**	not evident
Total veg. cover (%)	56	**Litter distribution**	
Tree cover (%)	30	**Litter depth(cm)**	2
Shrub cover (%)	25	**Litter cover (%)**	30
Grass cover (%)	0		
Herb cover (%)	1		

Site details			
Site	**CF015**	**Position (WGS84)**	-30.581502216, 121.468211683
Topography	plain	**Soil texture**	sandy loam
Slope	negligible	**Rock type**	calcrete,quartz,ferrous - ironstone
Soil colour	orange	**Rock cover (%)**	

Site description - visit 1 (16 Nov 2022)			
Mid *Eucalyptus lesouefii, E. longicornis* and *E. celastroides* woodland over scattered mid *Eremophila* shrubs over low open *Maireana* and *Tecticornia* shrubland with other scattered shrubs and herbs			
Habitat	open woodland		
Disturbance	vehicle tracks		
Vegetation condition	Very Good	**Fire age**	not evident
Total veg. cover (%)	51	**Litter distribution**	under vegetation
Tree cover (%)	30	**Litter depth(cm)**	2
Shrub cover (%)	20	**Litter cover (%)**	20
Grass cover (%)	0		
Herb cover (%)	1		

Site details			
Site	**CF016**	**Position (WGS84)**	-30.5711696344, 121.476849485
Topography	undulating plain	**Soil texture**	clay loam
Slope	negligible	**Rock type**	quartz
Soil colour	orange	**Rock cover (%)**	

Site description - visit 1 (16 Nov 2022)			
Low *Eucalyptus salubris, E. lesouefii* and *E. celastroides* woodland over scattered mid *Eremophila* and *Senna* shrubs over low open *Atriplex, Maireana* and *Tecticornia* shrubland			
Habitat	open woodland		
Disturbance	livestock tracks,historic clearing,exploration (drill pads and access tracks)		
Vegetation condition	Very Good	**Fire age**	not evident
Total veg. cover (%)	60	**Litter distribution**	
Tree cover (%)	30	**Litter depth(cm)**	1
Shrub cover (%)	30	**Litter cover (%)**	30
Grass cover (%)	0		
Herb cover (%)	0		

Site details			
Site	**CF017**	**Position (WGS84)**	-30.5670252443, 121.477047717
Topography	hill slope	**Soil texture**	clay loam,rocks
Slope	gentle	**Rock type**	ferrous - ironstone
Soil colour	orange	**Rock cover (%)**	

Site description - visit 1 (16 Nov 2022)			
Scattered low *Casuarina* trees over spiny *Acacia* mid shrubs over sparse low *Atriplex* and *Maireana* shrubs and sparse, low stage 5 *Triodia* hummock grass on slope adjacent to north end of gravel pit			
Habitat	open woodland		
Disturbance	current operations,vehicle tracks,historic clearing		
Vegetation condition	Good	**Fire age**	not evident
Total veg. cover (%)	40	**Litter distribution**	under vegetation
Tree cover (%)	15	**Litter depth(cm)**	1
Shrub cover (%)	20	**Litter cover (%)**	2
Grass cover (%)	5		
Herb cover (%)	0		

Site details			
Site	**CF018**	**Position (WGS84)**	-30.5657467945, 121.479812656
Topography	hill slope	**Soil texture**	sandy loam,rocks
Slope	gentle	**Rock type**	granite - rocks,calcrete,quartz
Soil colour	orange	**Rock cover (%)**	

Site description - visit 1 (16 Nov 2022)			
Scattered *Casuarina* tall shrubs over *Acacia hemiteles* (or cf.) mid-tall shrubs over low-mid shrubland of mixed *Acacia*, *Maireana, Santalum, Exocarpos* etc. on stony slope			
Habitat	shrubland		
Disturbance	historic clearing,current operations		
Vegetation condition	Very Good	**Fire age**	not evident
Total veg. cover (%)	65	**Litter distribution**	under vegetation
Tree cover (%)	5	**Litter depth(cm)**	1
Shrub cover (%)	60	**Litter cover (%)**	15
Grass cover (%)	0		
Herb cover (%)	0		

Site details			
Site	**CF019**	**Position (WGS84)**	-30.5740767299, 121.48037374
Topography	hill slope	**Soil texture**	sandy loam
Slope	gentle	**Rock type**	calcrete
Soil colour	orange	**Rock cover (%)**	

Site description - visit 1 (16 Nov 2022)			
Low *Eucalyptus longicornis, E. lesouefii* and *E. salubris* woodland over isolated mid *Eremophila* shrubs over low *Maireana* and *Tecticornia* shrubland on gentle sandy slope			
Habitat	open woodland		
Disturbance			
Vegetation condition	Very Good	**Fire age**	not evident
Total veg. cover (%)	61	**Litter distribution**	under vegetation
Tree cover (%)	30	**Litter depth(cm)**	2
Shrub cover (%)	30	**Litter cover (%)**	15
Grass cover (%)	0		
Herb cover (%)	1		

Site details			
Site	**CF020**	**Position (WGS84)**	-30.5757729756, 121.476723338
Topography	undulating plain	**Soil texture**	sand,sandy loam,rocks
Slope	gentle	**Rock type**	quartz
Soil colour	orange	**Rock cover (%)**	

Site description - visit 1 (16 Nov 2022)			
Mid *Eucalyptus lesouefii* woodland over isolated *Eremophila* mid shrubs over low open *Atriplex, Maireana* and *Tecticornia* shrubland on low flat quartz hill			
Habitat	open woodland		
Disturbance	exploration (drill pads and access tracks)		
Vegetation condition	Very Good	**Fire age**	not evident
Total veg. cover (%)	35	**Litter distribution**	under vegetation
Tree cover (%)	15	**Litter depth(cm)**	1
Shrub cover (%)	20	**Litter cover (%)**	5
Grass cover (%)	0		
Herb cover (%)	0		

Site details			
Site	**CF021**	**Position (WGS84)**	-30.5655430723, 121.46334515
Topography	plain	**Soil texture**	sandy loam
Slope	negligible	**Rock type**	none
Soil colour	orange	**Rock cover (%)**	

Sample and effort summary

Visit	Sample method	Sample quant. (hrs)	Repli-cation	Date start	Date stop
1	SRE foraging	0	0	17 Nov 2022	17 Nov 2022

Site description - visit 1 (17 Nov 2022)

Isolated *Casuarina* and *Eucalyptus lesouefii* trees over sparse mid *Eremophila* shrubs over low shrubland of *Atriplex*, spiny *Acacia* and small-leaf *Melaleuca*

Habitat	shrubland		
Disturbance	historic clearing		
Vegetation condition	Very Good	**Fire age**	not evident
Total veg. cover (%)	51	**Litter distribution**	under vegetation
Tree cover (%)	10	**Litter depth(cm)**	1
Shrub cover (%)	40	**Litter cover (%)**	
Grass cover (%)	0		
Herb cover (%)	1		

Appendix 3 Vertebrate fauna desktop and field survey results

Family	Species name	Common name	Introduced	Status	PMST	ALA records #	NatureMap	DBCA TPFA	KLA (2009) Crossroads	ABRS (2015) Credo	Botanica (2020) Bardoc	Phoenix (2019) C. Ridge	Phoenix (2022) Saints	Harewood (2015) Fim	Phoenix (2018,22) KO	Phoenix (2019) Gidgi	Phoenix (2018) Crossr	This survey (# sites)
Fish																		
Cyprinidae	*Carassius auratus*	Goldfish	●			2	●											
Poeciliidae	*Gambusia holbrooki*	Mosquito Fish	●			1								●				
Amphibians																		
Hylidae	*Litoria moorei*	Motorbike Frog				8	●											
Limnodynastidae	*Neobatrachus kunapalari*	Kunapalari Frog				25	●			●	●			●				
	Neobatrachus pelobatoides	Humming Frog				1	●											
	Neobatrachus sutor	Shoemaker Frog				51	●							●				
	Neobatrachus wilsmorei	Plonking Frog				2	●											
Myobatrachidae	*Pseudophryne occidentalis*	Western Toadlet				18	●			●	●			●				
Reptiles																		
Chelidae	*Chelodina oblonga* (ex *C. colliei*)	Oblong Turtle		extralimital (transported)		1	●											
Agamidae	*Ctenophorus infans*	Laverton Ring-tailed Dragon		southern limit (ex *C. caudicinctus*)		1	●							●				
	Ctenophorus cristatus	Bicycle Dragon				33	●			●		●		●	●			3
	Ctenophorus fordi	Mallee Sand Dragon				4	●											
	Ctenophorus isolepis	Central Military Dragon				8	●			●								
	Ctenophorus maculatus	Spotted Military Dragon				1						●						
	Ctenophorus nuchalis	Central Netted Dragon				1	●											
	Ctenophorus ornatus	Ornate Crevice Dragon								●								
	Ctenophorus pictus	Painted Dragon				1												
	Ctenophorus reticulatus	Western Netted Dragon				51	●			●								
	Ctenophorus salinarum	Salt Lake Dragon				15	●			●			●					
	Ctenophorus scutulatus	Lozenge-marked Dragon				13	●			●	●		●		●	●	●	1
	Diporiphora amphiboluroides	Mulga Dragon								●								
	Moloch horridus	Thorny Devil				23	●			●								
	Pogona minor	Western Bearded Dragon				20	●			●			●		●	●		
	Tympanocryptis pseudopsephos	Goldfields Pebble-mimic Dragon		(some records under other names)		18	●			●					●			
Gekkonidae	*Christinus marmoratus*	Marbled Gecko		northern limit		1						●						
	Gehyra purpurascens	Purplish Dtella				14	●			●				●				
	Gehyra variegata	Tree Dtella				37	●			●			●	●	●			3
	Hemidactylus frenatus	Asian House Gecko	●	extralimital (transported)		3	●											
	Heteronotia binoei	Bynoe's Gecko				110	●			●	●			●	●	●	●	1

Family	Species name	Common name	Introduced	Status	PMST	ALA records #	NatureMap	DBCA TPFA	KLA (2009) Crossroads	ABRS (2015) Credo	Botanica (2020) Bardoc	Phoenix (2019) C. Ridge	Phoenix (2022) Saints	Harewood (2015) Fim	Phoenix (2018,22) KO	Phoenix (2019) Gidgi	Phoenix (2018) Crossr	This survey (# sites)
Carphodactylidae	*Nephrurus laevissimus*	Pale Knob-tailed Gecko				1	●											
	Nephrurus vertebralis	Midline Knob-tailed Gecko				1	●											
	Underwoodisaurus milii	Barking Gecko				63	●			●	●			●				1
Diplodactylidae	*Crenadactylus ocellatus*	Southwestern Clawless Gecko				1												
	Diplodactylus conspicillatus	Variable Fat-tailed Gecko				3												
	Diplodactylus granariensis	Western Stone Gecko				34	●			●				●				
	Diplodactylus pulcher	Fine-faced Gecko				23	●			●				●				
	Hesperoedura reticulata	Reticulated Velvet Gecko				19	●			●				●				
	Lucasium damaeum	Beaded Gecko				3	●											
	Lucasium maini	Main's Ground Gecko				27	●							●				
	Rhynchoedura ornata	Western Beaked Gecko				7	●			●				●				
	Strophurus assimilis	Goldfields Spiny-tailed Gecko				3	●							●				
	Strophurus elderi	Jewelled Gecko				5	●											
	Strophurus wellingtonae	Western Shield Spiny-tailed Gecko								●								
Pygopodidae	*Aprasia repens*	Sand-plain Worm Lizard		extralimital (transported)		1												
	Delma australis	Marble-faced Delma				9	●			●		●		●		●	●	
	Delma butleri	Butler's Delma				2	●											
	Lialis burtonis	Burton's Legless Lizard				3				●					●			
	Pygopus lepidopodus	Common Scaly Foot				4	●											
	Pygopus nigriceps	Hooded Scaly Foot				3	●											
Scincidae	*Cryptoblepharus buchananii*	Buchanan's Snake-eyed Skink				7	●			●		●						
	Cryptoblepharus plagiocephalus	Peron's Snake-eyed Skink				5	●							●		●	●	
	Ctenotus atlas	Southern Mallee Ctenotus				9	●											
	Ctenotus calurus	Blue-tailed Ctenotus											●					
	Ctenotus leonhardii	Leonhard's Ctenotus				5	●			●								
	Ctenotus schomburgkii	Barred Wedgesnout Ctenotus				2	●			●		●	●					
	Ctenotus u. uber	Spotted Ctenotus				10	●			●		●		●				
	Ctenotus xenopleura	Wide-striped Sandplain Ctenotus								●								
	Cyclodomorphus melanops	Spinifex Slender Bluetongue				5	●											
	Egernia depressa	Southern Pygmy Spiny-tailed Skink				21	●			●	●							1
	Egernia formosa	Goldfields Crevice Skink				22	●			●	●							
	Egernia richardi	Bight Crevice Skink				5												

Family	Species name	Common name	Introduced	Status	PMST	ALA records #	NatureMap	DBCA TPFA	KLA (2009) Crossroads	ABRS (2015) Credo	Botanica (2020) Bardoc	Phoenix (2019) C. Ridge	Phoenix (2022) Saints	Harewood (2015) Fim	Phoenix (2018,22) KO	Phoenix (2019) Gidgi	Phoenix (2018) Crossr	This survey (# sites)
	Egernia stokesii badia	Western Spiny-tailed Skink		EN (EPBC Act), VU (BC Act); extralimital (transported)		1	●	●										
	Eremiascincus richardsonii	Broad-banded Sandswimmer				12	●			●								
	Hemiergis initialis	Southwestern Earless Skink				19	●							●				
	Hemiergis peronii	Lowlands Earless Skink				1	●											
	Lerista kingi	King's Three-toed Slider				2	●											
	Lerista macropisthopus	Unpatterned Robust Slider								●								
	Lerista picturata	Southern Robust Slider				80	●			●			●	●				1
	Lerista stictopleura	Spotted Broad-blazed Slider		extralimital (transported/misID)			●											
	Lerista timida	Timid Slider				63	●			●				●	●			2
	Liopholis inornata	Desert Skink				13	●			●			●					1
	Liopholis striata	Night Skink				1												
	Menetia greyii	Common Dwarf Skink				36	●			●		●	●	●	●	●	●	2
	Morethia adelaidensis	Saltbush Morethia Skink				10	●			●								
	Morethia butleri	Woodland Morethia Skink				20	●			●								
	Morethia obscura	Shrubland Morethia Skink				2	●											
	Tiliqua occipitalis	Western Bluetongue				1	●			●		●		●	●			
	Tiliqua rugosa	Bobtail				11	●			●		●	●	●	●			1
Varanidae	*Varanus caudolineatus*	Stripe-tailed Pygmy Monitor				7	●			●				●				
	Varanus giganteus	Perentie								●								
	Varanus gouldii	Gould's Monitor				14	●			●	●	●	●	●	●	●	●	9
	Varanus tristis	Black-headed Monitor				8	●					●	●					
Typhlopidae	*Anilios australis*	Southern Blindsnake				17	●			●								
	Anilios bicolor	Dark-spined Blindsnake				4	●											
	Anilios bituberculatus	Prong-snouted Blindsnake				24	●			●								
	Anilios hamatus	Pale-headed Blindsnake				1	●											
	Anilios waitii	Beaked Blindsnake				2	●											
Pythonidae	*Morelia spilota imbricata*	Southwestern Carpet Python				3	●											
Elapidae	*Acanthophis pyrrhus*	Desert Death Adder		southern limit		2	●											
	Brachyurophis fasciolatus	Narrow-banded Shovel-nosed Snake				1	●											
	Brachyurophis semifasciatus	Southern Shovel-nosed Snake				8	●							●				
	Demansia psammophis	Yellow-faced Whipsnake				4	●							●				
	Echiopsis curta	Bardick		northern limit		1	●											
	Furina ornata	Moon Snake				1	●			●								
	Neelaps bimaculatus	Black-naped Snake				8	●											

Family	Species name	Common name	Introduced	Status	PMST	ALA records #	NatureMap	DBCA TPFA	KLA (2009) Crossroads	ABRS (2015) Credo	Botanica (2020) Bardoc	Phoenix (2019) C. Ridge	Phoenix (2022) Saints	Harewood (2015) Fim	Phoenix (2018,22) KO	Phoenix (2019) Gidgi	Phoenix (2018) Crossr	This survey (# sites)
	Pseudechis australis	Mulga Snake				6	●			●			●	●				
	Pseudonaja affinis	Dugite		northern limit		1	●					●						
	Pseudonaja mengdeni	Western Brown Snake				33	●			●			●	●				
	Pseudonaja modesta	Ringed Brown Snake				21	●									●		1
	Simoselaps bertholdi	Jan's Banded Snake				18	●			●				●				
	Suta fasciata	Rosen's Snake				9	●											
	Suta gouldii	Gould's Hooded Snake		northern limit		9	●											
	Suta monachus	Monk Snake				14	●			●								
	Suta suta	Curl Snake		extralimital (transported)		4												
Birds																		
Casuariidae	*Dromaius novaehollandiae*	Emu				86	●			●	●	●	●	●	●	●	●	
Anatidae	*Anas castanea*	Chestnut Teal				1												
	Anas gracilis	Grey Teal				184	●			●		●	●	●				
	Anas platyrhynchos	Mallard	●			1	●											
	Anas superciliosa	Packfic Black Duck				178	●			●				●				
	Aythya australis	Hardhead				55	●			●								
	Biziura lobata	Musk Duck				64	●			●								
	Chenonetta jubata	Australian Wood Duck				46	●			●				●	●			
	Cygnus atratus	Black Swan				99	●			●								
	Malacorhynchus membranaceus	Pink-eared Duck				47	●			●								
	Oxyura australis	Blue-billed Duck		P4 (DBCA list)		2				●								
	Spatula rhynchotis	Australasian Shoveler				23	●			●								
	Stictonetta naevosa	Freckled Duck				5	●			●								
	Tadorna tadornoides	Australian Shelduck				154	●			●				●				
Megapodiidae	*Leipoa ocellata*	Malleefowl		VU (EPBC & BC Acts)	Li	5	●	●		●		●	●		●			
Phasianidae	*Coturnix pectoralis*	Stubble Quail				2												
Podargidae	*Podargus strigoides*	Tawny Frogmouth				18	●			●	●	●	●	●				
Caprimulgidae	*Eurostopodus argus*	Spotted Nightjar				20	●											
Aegothelidae	*Aegotheles cristatus*	Australian Owlet-nightjar				13	●											
Apodidae	*Apus pacificus*	Fork-tailed Swift		Mig (EPBC & BC Acts)	Li					●								
Otididae	*Ardeotis australis*	Australian Bustard				6	●			●								
Cuculidae	*Cacomantis flabelliformis*	Fan-tailed Cuckoo				3	●			●								5
	Chalcites basalis	Horsfield's Bronze Cuckoo				44	●			●				●	●			1
	Chalcites osculans	Black-eared Cuckoo			Li	16	●			●		●	●		●	●	●	
	Heteroscenes pallidus	Pallid Cuckoo				34	●			●		●			●	●	●	
Columbidae	*Columba livia*	Domestic Pigeon	●			106	●							●				

Family	Species name	Common name	Introduced	Status	PMST	ALA records #	NatureMap	DBCA TPFA	KLA (2009) Crossroads	ABRS (2015) Credo	Botanica (2020) Bardoc	Phoenix (2019) C. Ridge	Phoenix (2022) Saints	Harewood (2015) Fim	Phoenix (2018,22) KO	Phoenix (2019) Gidgi	Phoenix (2018) Crossr	This survey (# sites)
	Ocyphaps lophotes	Crested Pigeon				226	●			●	●		●	●	●	●	●	
	Phaps chalcoptera	Common Bronzewing				47	●			●	●	●		●	●			
	Spilopelia chinensis	Spotted Turtle-dove	●			9												
	Spilopelia senegalensis	Laughing Turtle-dove	●			77	●											
Rallidae	*Fulica atra*	Eurasian Coot				89	●			●								
	Porzana fluminea	Australian Spotted Crake				3	●			●								
	Tribonyx ventralis	Black-tailed Native-hen				20	●			●								
Podicipedidae	*Podiceps cristatus*	Great Crested Grebe								●								
	Poliocephalus poliocephalus	Hoary-headed Grebe				112	●			●								
	Tachybaptus novaehollandiae	Australasian Grebe				54	●			●								
Turnicidae	*Turnix velox*	Little Button Quail				6	●			●			●		●			
Recurvirostridae	*Cladorhynchus leucocephalus*	Banded Stilt				11	●			●		●						
	Himantopus himantopus	Black-winged Stilt				51	●			●								
	Recurvirostra novaehollandiae	Red-necked Avocet				53	●			●								
Charadriidae	*Charadrius ruficapillus*	Red-capped Plover				26	●		●	●		●						
	Elseyornis melanops	Black-fronted Dotterel				65	●			●		●						
	Erythrogonys cinctus	Red-kneed Dotterel				32	●			●								
	Thinornis rubricollis	Hooded Plover		P4 (DBCA list)		2	●	●										
	Vanellus tricolor	Banded Lapwing				29	●			●								
Scolopacidae	*Actitis hypoleucos*	Common Sandpiper		Mig (EPBC & BC Acts)	May	7	●	●										
	Calidris acuminata	Sharp-tailed Sandpiper		Mig (EPBC & BC Acts)	May	10	●	●										
	Calidris alba	Sanderling		Mig (EPBC & BC Acts)		1	●	●										
	Calidris ferruginea	Curlew Sandpiper		CR (EPBC & BC Acts), Mig (EPBC Act)	May	1	●	●										
	Calidris melanotos	Pectoral Sandpiper		Mig (EPBC & BC Acts)	May													
	Calidris ruficollis	Red-necked Stint		Mig (EPBC & BC Acts)		5	●	●		●								
	Limosa limosa	Black-tailed Godwit		Mig (EPBC & BC Acts)		1												
	Tringa brevipes	Grey-tailed Tattler		Mig (EPBC & BC Acts), P4 (DBCA list)			●	●										
	Tringa glareola	Wood Sandpiper		Mig (EPBC & BC Acts)		29	●	●										
	Tringa nebularia	Common Greenshank		Mig (EPBC & BC Acts)		8	●	●										
	Tringa stagnatilis	Marsh Sandpiper		Mig (EPBC & BC Acts)		6												
Laridae	*Chlidonias hybrida*	Whiskered Tern				1												
	Larus novaehollandiae	Silver Gull				12	●		●									
Anhingidae	*Anhinga novaehollandiae*	Australasian Darter				3	●											
Phalacrocoracidae	*Microcarbo melanoleucos*	Little Pied Cormorant				30	●			●								
	Phalacrocorax sulcirostris	Little Black Cormorant				17	●											

Family	Species name	Common name	Introduced	Status	PMST	ALA records #	NatureMap	DBCA TPFA	KLA (2009) Crossroads	ABRS (2015) Credo	Botanica (2020) Bardoc	Phoenix (2019) C. Ridge	Phoenix (2022) Saints	Harewood (2015) Fim	Phoenix (2018,22) KO	Phoenix (2019) Gidgi	Phoenix (2018) Crossr	This survey (# sites)
Threskiornithidae	*Platalea flavipes*	Yellow-billed Spoonbill				11	●			●								
	Plegadis falcinellus	Glossy Ibis		Mig (EPBC & BC Acts)		1		●										
	Threskiornis molucca	Australian White Ibis				7				●								
	Threskiornis spinicollis	Straw-necked Ibis				15	●			●								
Ardeidae	*Ardea alba*	Great Egret				5	●											
	Ardea pacifica	White-necked Heron				29	●			●								
	Bubulcus coromandus	Cattle Egret			May	1												
	Egretta novaehollandiae	White-faced Heron				85	●			●								
	Nycticorax caledonicus	Nankeen Night-heron				3	●											
Pelecanidae	*Pelecanus conspicillatus*	Australian Pelican				3	●											
Accipitridae	*Accipiter cirrocephalus*	Collared Sparrowhawk				11	●											
	Accipiter fasciatus	Brown Goshawk				18	●			●	●							
	Aquila audax	Wedge-tailed Eagle				75	●			●	●	●	●	●				
	Circus assimilis	Spotted Harrier				11				●								
	Elanus axillaris	Black-shouldered Kite				56	●					●		●	●			
	Haliastur sphenurus	Whistling Kite				25				●					●			
	Hamirostra melanosternon	Black-breasted Buzzard				1							●					
	Hieraaetus morphnoides	Little Eagle				25	●			●								
	Lophoictinia isura	Square-tailed Kite				8				●								
	Milvus migrans	Black Kite				1												
Tytonidae	*Tyto alba*	Eastern Barn Owl				11	●			●								
Strigidae	*Ninox boobook*	Boobook Owl				10	●			●								
Alcedinidae	*Todiramphus pyrrhopygius*	Red-backed Kingfisher				42	●			●				●				
	Todiramphus sanctus	Sacred Kingfisher				6	●			●		●						
Meropidae	*Merops ornatus*	Rainbow Bee-eater			May	71	●		●	●		●	●	●	●	●	●	3
Falconidae	*Falco berigora*	Brown Falcon				54	●			●	●		●	●	●	●	●	
	Falco cenchroides	Nankeen Kestrel				109	●			●	●			●	●			
	Falco hypoleucos	Grey Falcon		VU (BC Act)	May	1												
	Falco longipennis	Australian Hobby				47	●			●				●				
	Falco peregrinus	Peregrine Falcon		OS (BC Act)		3		●		●			●					
	Falco subniger	Black Falcon				2												
Cacatuidae	*Cacatua pastinator*	Western Long-billed Corella		extralimital (vagrant or misID)		1												
	Cacatua sanguinea	Little Corella				21	●											
	Calyptorhynchus latirostris	Carnaby's Black Cockatoo		EN (EPBC & BC Acts); NE limit at Kalgoorlie			●	●										
	Eolophus roseicapilla	Galah				284	●			●		●	●	●	●			
	Lophochroa leadbeateri	Major Mitchell's Cockatoo				1												

Family	Species name	Common name	Introduced	Status	PMST	ALA records #	NatureMap	DBCA TPFA	KLA (2009) Crossroads	ABRS (2015) Credo	Botanica (2020) Bardoc	Phoenix (2019) C. Ridge	Phoenix (2022) Saints	Harewood (2015) Fim	Phoenix (2018,22) KO	Phoenix (2019) Gidgi	Phoenix (2018) Crossr	This survey (# sites)
	Nymphicus hollandicus	Cockatiel				20	●			●								
Psittaculidae	*Barnardius zonarius*	Australian Ringneck				489	●		●	●	●	●	●	●	●	●	●	3
	Neophema splendida	Scarlet-chested Parrot													●			
	Parvipsitta porphyrocephala	Purple-crowned Lorikeet				58	●			●	●			●	●			
	Melopsittacus undulatus	Budgerigar				16	●			●					●			
	Pezoporus occidentalis	Night Parrot		CR (EPBC & BC Acts); far south of known range	May													
	Platycercus icterotis xanthogenys	Western Rosella (inland)		P4 (DBCA list); most records not referred to subspecies		7	●											
	Polytelis alexandrae	Princess Parrot		P4 (DBCA list); southern limit		3												
	Polytelis anthopeplus	Regent Parrot				2	●			●		●						
	Psephotus varius	Mulga Parrot				54	●			●	●		●	●				
Ptilonorhynchidae	*Chlamydera guttata*	Western Bowerbird		southern limit		2												
Climacteridae	*Climacteris affinis*	White-browed Treecreeper				15	●			●								
	Climacteris erythrops	Red-browed Treecreeper		extralimital (misID)		1												
	Climacteris rufus	Rufous Treecreeper				21	●			●								
Maluridae	*Amytornis purnelli*	Dusky Grasswren		extralimital (misID or wrong location)		1												
	Amytornis t. textilis	Western Grasswren		P4 (DBCA list)		16	●	●										
	Malurus leucopterus	White-winged Fairy-wren				134	●			●	●		●	●	●			
	Malurus pulcherrimus	Blue-breasted Fairy-wren				5	●											
	Malurus splendens	Splendid Fairy-wren				91	●			●	●	●		●	●	●	●	
Meliphagidae	*Acanthagenys rufogularis*	Spiny-cheeked Honeyeater				364	●			●	●	●	●	●	●	●	●	3
	Acanthorhynchus superciliosus	Western Spinebill		extralimital (vagrant?)		1												
	Anthochaera carunculata	Red Wattlebird				549	●		●	●	●	●	●	●	●			8
	Anthochaera lunulata	Western Little Wattlebird		extralimital (misID or wrong location)		1												
	Certhionyx variegatus	Pied Honeyeater				14												
	Epthianura albifrons	White-fronted Chat				81	●			●		●						
	Epthianura aurifrons	Orange Chat				5												
	Epthianura tricolor	Crimson Chat				50	●			●		●	●		●			
	Gavicalis virescens	Singing Honeyeater				534	●			●	●	●	●	●	●	●	●	4
	Gliciphila melanops	Tawny-crowned Honeyeater				3												
	Lichenostomus cratitius	Purple-gaped Honeyeater				2												
	Lichmera indistincta	Brown Honeyeater				450	●			●	●	●	●	●	●	●	●	7

Family	Species name	Common name	Introduced	Status	PMST	ALA records #	NatureMap	DBCA TPFA	KLA (2009) Crossroads	ABRS (2015) Credo	Botanica (2020) Bardoc	Phoenix (2019) C. Ridge	Phoenix (2022) Saints	Harewood (2015) Fim	Phoenix (2018,22) KO	Phoenix (2019) Gidgi	Phoenix (2018) Crossr	This survey (# sites)
	Manorina flavigula	Yellow-throated Miner				374	●		●	●	●	●	●	●	●	●	●	4
	Melithreptus chloropsis	Gilbert's Honeyeater		(under old names)		5												
	Melithreptus brevirostris	Brown-headed Honeyeater				79	●			●	●			●				
	Nesoptilotis leucotis	White-eared Honeyeater				203	●			●	●	●		●	●	●	●	
	Phylidonyris niger	White-cheeked Honeyeater				3												
	Phylidonyris novaehollandiae	New Holland Honeyeater				13												
	Plectorhyncha lanceolata	Striped Honeyeater		extralimital (misID or wrong location)		3												
	Ptilotula ornata	Yellow-plumed Honeyeater				237	●			●	●	●	●	●	●	●		5
	Ptilotula penicillata	White-plumed Honeyeater		southern limit		1												
	Ptilotula plumula	Grey-fronted Honeyeater				84	●				●			●		●		
	Purnella albifrons	White-fronted Honeyeater				166	●			●	●	●		●	●	●	●	
	Sugomel nigrum	Black Honeyeater				5	●			●								
Pardalotidae	*Pardalotus punctatus*	Spotted Pardalote				3	●											
	Pardalotus striatus	Striated Pardalote				408	●		●	●	●	●	●	●	●	●	●	10
Acanthizidae	*Acanthiza apicalis*	Inland Thornbill				142	●			●	●		●	●				
	Acanthiza chrysorrhoa	Yellow-rumped Thornbill				159	●			●	●	●	●	●				
	Acanthiza inornata	Western Thornbill				4												
	Acanthiza iredalei	Samphire Thornbill		southern limit		1												
	Acanthiza robustirostris	Slaty-backed Thornbill		southern limit			●											
	Acanthiza uropygialis	Chestnut-rumped Thornbill				145	●			●	●	●	●	●	●	●	●	
	Aphelocephala leucopsis	Southern Whiteface				39	●			●				●		●		
	Calamanthus campestris	Rufous Fieldwren				2												
	Gerygone fusca	Western Gerygone				15	●			●					●	●	●	
	Hylacola cauta whitlocki	Shy Groundwren				2	●					●						
	Pyrrholaemus brunneus	Redthroat				142	●			●	●	●	●	●	●			
	Sericornis maculatus	Spotted Scrubwren		extralimital (misID or wrong location)		1												
	Smicrornis brevirostris	Weebill				570	●		●	●	●	●	●	●	●	●	●	12
Psophodidae	*Psophodes occidentalis*	Western Wedgebill				3												
Pomatostomidae	*Pomatostomus superciliosus*	White-browed Babbler				123	●			●	●	●	●	●	●	●		3
Cinclosomatidae	*Cinclosoma clarum*	Western Chestnut Quail-thrush		(ex *C. castanotum*)		53	●			●		●		●	●			
	Cinclosoma marginatum	Western Quail-thrush		(ex *C. castaneothorax*)		4												
Artamidae	*Artamus cinereus*	Black-faced Woodswallow				117	●			●	●		●		●	●		
	Artamus cyanopterus	Dusky Woodswallow				38	●			●				●	●			2
	Artamus minor	Little Woodswallow				9												
	Artamus personatus	Masked Woodwallow				25	●			●					●			

Family	Species name	Common name	Introduced	Status	PMST	ALA records #	NatureMap	DBCA TPFA	KLA (2009) Crossroads	ABRS (2015) Credo	Botanica (2020) Bardoc	Phoenix (2019) C. Ridge	Phoenix (2022) Saints	Harewood (2015) Fim	Phoenix (2018,22) KO	Phoenix (2019) Gidgi	Phoenix (2018) Crossr	This survey (# sites)
	Artamus superciliosus	White-browed Woodswallow				1												
	Cracticus nigrogularis	Pied Butcherbird				242	●		●	●		●	●	●	●	●	●	2
	Cracticus torquatus	Grey Butcherbird				215	●			●	●	●	●	●	●			3
	Gymnorhina tibicen	Australian Magpie				252	●			●	●	●	●	●	●			1
	Strepera versicolor	Grey Currawong				207	●			●	●		●	●	●	●	●	6
Neosittidae	*Daphoenositta chrysoptera*	Varied Sittella				16	●			●				●				
Oreoicidae	*Oreoica gutturalis*	Crested Bellbird				273	●			●	●	●	●	●	●	●	●	6
Pachycephalidae	*Colluricincla harmonica*	Grey Shrike-thrush				149	●		●	●	●	●	●	●	●			9
	Pachycephala inornata	Gilbert's Whistler				19	●			●	●		●	●				
	Pachycephala occidentalis	Western Golden Whistler				1	●											
	Pachycephala rufiventris	Rufous Whistler				67	●			●	●	●	●	●	●	●	●	2
Falcunculidae	*Falcunculus frontatus*	Crested Shriketit				2												
Campephagidae	*Coracina maxima*	Ground Cuckoo-shrike				17	●			●		●						
	Coracina novaehollandiae	Black-faced Cuckoo-shrike				245	●			●	●	●	●	●	●		●	3
	Lalage tricolor	White-winged Triller				1	●			●				●				
Rhipiduridae	*Rhipidura albiscapa*	Grey Fantail				14	●			●								
	Rhipidura leucophrys	Willie Wagtail				318	●		●	●		●	●	●	●	●	●	4
Monarchidae	*Grallina cyanoleuca*	Magpie-lark				408	●			●		●		●	●	●	●	(●)
Corvidae	*Corvus bennetti*	Little Crow				134	●			●		●	●		●	●	●	1
	Corvus coronoides	Australian Raven				395	●			●	●	●		●	●	●		
	Corvus orru	Torresian Crow				18	●								●			
Petroicidae	*Drymodes brunneopygia*	Southern Scrub-robin								●								
	Eopsaltria griseogularis	Western Yellow Robin				3	●								●			
	Melanodryas cucullata	Hooded Robin				52	●			●								1
	Microeca fascinans	Jacky Winter				90	●			●	●			●				4
	Petroica goodenovii	Red-capped Robin				144	●		●	●	●	●	●	●	●			1
Hirundinidae	*Cheramoeca leucosterna*	White-backed Swallow				96	●			●			●	●				
	Hirundo neoxena	Welcome Swallow				215	●			●				●				
	Petrochelidon ariel	Fairy Martin				27	●											
	Petrochelidon nigricans	Tree Martin				133	●			●				●				
Zosteropidae	*Zosterops lateralis*	Silvereye				55	●											
Dicaeidae	*Dicaeum hirundinaceum*	Mistletoebird				36	●			●	●		●	●				
Estrildidae	*Taeniopygia guttata*	Zebra Finch				72	●			●		●	●		●			
Locustellidae	*Cincloramphus cruralis*	Brown Songlark				37	●			●								
	Cincloramphus mathewsi	Rufous Songlark				33	●			●			●					1
Motacillidae	*Anthus australis*	Australian Pipit				156	●			●				●				
	Motacilla cinerea	Grey Wagtail		Mig (EPBC & BC Acts)	May													

Family	Species name	Common name	Introduced	Status	PMST	ALA records #	NatureMap	DBCA TPFA	KLA (2009) Crossroads	ABRS (2015) Credo	Botanica (2020) Bardoc	Phoenix (2019) C. Ridge	Phoenix (2022) Saints	Harewood (2015) Fim	Phoenix (2018,22) KO	Phoenix (2019) Gidgi	Phoenix (2018) Crossr	This survey (# sites)
Mammals																		
Tachyglossidae	*Tachyglossus aculeatus*	Short-beaked Echidna				2	●		●	●	●	●		●	●			1
Dasyuridae	*Antechinomys laniger*	Kultarr				1	●											
	Dasyurus geoffroii	Chuditch, Western Quoll		VU (EPBC & BC Acts); eastern limit	May			●							●			
	Ningaui ridei	Wongai Ningaui				1	●											
	Ningaui yvonneae	Southern Ningaui				6	●			●								
	Pseudantechinus woolleyae	Woolley's Pseudantechinus				1	●			●								
	Sminthopsis crassicaudata	Fat-tailed Dunnart				48	●			●								
	Sminthopsis dolichura	Little Long-tailed Dunnart				14	●			●				●				
	Sminthopsis gilberti	Gilbert's Dunnart				3	●											
	Sminthopsis ooldea	Ooldea Dunnart				4	●			●				●				
Myrmecobiidae	*Myrmecobius fasciatus*	Numbat		EN (EPBC & BC Acts)		1	●	●										
Thylacomyidae	*Macrotis lagotis*	Greater Bilby		VU (EPBC & BC Acts)		3	●	●										
Burramyidae	*Cercartetus concinnus*	Western Pygmy Possum				32	●			●				●				
Macropodidae	*Macropus fuliginosus*	Western Grey Kangaroo				7	●		●	●	●	●	?	●	●	●	●	8
	Osphranter robustus	Euro				1	●			●			?					
	Osphranter rufus	Red Kangaroo					●			●		●	●	●	●			
Potoroidae	*Bettongia lesueur graii*	Burrowing Bettong, Boodie				1												
Phalangeridae	*Trichosurus vulpecula*	Common Brushtail Possum		(regionally significant)														2
Molossidae	*Austronomus australis*	White-striped Freetail Bat				6	●			●	●	●	●	●	●	●	●	
	Ozimops kitcheneri	Southwestern Freetail Bat				16						●				●		
	Ozimops petersi	Inland Freetail Bat				3	●				●		●	●	●	●	●	
Vespertilionidae	*Chalinolobus gouldii*	Gould's Wattled Bat				16	●			●	●	●	●	●	●	●	●	
	Chalinolobus morio	Chocolate Wattled Bat				63	●						●	●	●	●	●	
	Nyctophilus geoffroyi	Lesser Long-eared Bat				4	●			●			●	●	●	●	●	
	Nyctophilus major tor	Central Long-eared Bat		P3 (DBCA list); under old names		3	●											
	Scotorepens balstoni	Inland Broad-nosed Bat				5	●						●	●	●	●	●	
	Taphozous hilli	Hill's Sheathtail-bat					●						●	●				
	Vespadelus baverstocki	Inland Forest Bat				1	●					●		●	●			
	Vespadelus finlaysoni	Finlayson's Cave Bat					●							●				
	Vespadelus regulus	Southern Forest Bat				6	●							●	●	●	●	
Leporidae	*Oryctolagus cuniculus*	Rabbit	●			1	●			●	●	●	●	●	●	●	●	4
Muridae	*Mus musculus*	House Mouse	●			31	●			●	●			●				
	Notomys mitchelli	Mitchell's Hopping-mouse								●		●						
	Pseudomys albocinereus	Ash-grey Mouse				1	●											
	Pseudomys bolami	Bolam's Mouse				16	●			●				●				

Family	Species name	Common name	Introduced	Status	PMST	ALA records #	NatureMap	DBCA TPFA	KLA (2009) Crossroads	ABRS (2015) Credo	Botanica (2020) Bardoc	Phoenix (2019) C. Ridge	Phoenix (2022) Saints	Harewood (2015) Fim	Phoenix (2018,22) KO	Phoenix (2019) Gidgi	Phoenix (2018) Crossr	This survey (# sites)
	Pseudomys hermannsburgensis	Sandy Inland Mouse				12	●											
Bovidae	*Bos taurus*	European Cattle	●				●					●	●	●	●	●	●	8
	Capra hircus	Goat	●			3	●			●	●			●				1
	Ovis aries	Sheep	●				●							●				
Camelidae	*Camelus dromedarius*	Camel	●							●								
Canidae	*Canis familiaris*	Dog/Dingo	●			20	●			●		●	●	●	●			
	Vulpes vulpes	Red Fox	●							●	●				●			
Felidae	*Felis catus*	Cat	●			1	●			●	●		●	●	●			1

Appendix 4 Short-range endemic invertebrate desktop results

Family	Taxon	SRE Status
Centipedes		
Chilenophilidae	Sepedonophilus `sp. G1`	Potential
Chilenophilidae	Sepedonophilus `sp. G2`	Potential
Chilenophilidae	Sepedonophilus `sp. indet.`	Uncertain
Cryptopidae	Cryptops `sp. G1`	Potential
Mecistocephalidae	Mecistocephalus `sp. indet.`	Uncertain
Scolopendridae	Arthrorhabdus paucispinus	Not SRE
Scolopendridae	Cormocephalus bungalbinensis	Not SRE
Scolopendridae	Cormocephalus strigosus	Not SRE
Scolopendridae	Cormocephalus turneri	Not SRE
Scolopendridae	Ethmostigmus curtipes	Not SRE
Scolopendridae	Ethmostigmus rubripes	Not SRE
Scolopendridae	Scolopendra laeta	Not SRE
Scolopendridae	Scolopendra morsitans	Not SRE
Scolopendromorpha	Scolopendromorpha `sp. indet.`	Uncertain
Scutigeridae	Allothereua maculata	Not SRE
Scutigeridae	Thereuopoda lesueurii	Not SRE
Isopods (slaters)		
Armadillidae	Acanthodillo '1'	Potential
Armadillidae	Armadillidae 'gen4 sp2'	Potential
Armadillidae	Buddelundia `sp. 39`	Not SRE
Armadillidae	Buddelundia `sp. 72MS`	Potential
Armadillidae	Buddelundia `sp. indet.`	Uncertain
Armadillidae	Buddelundia cf. monticola	Potential
Armadillidae	Buddelundia frontosa	Potential
Armadillidae	Buddelundia 'lefroy A'	Potential
Armadillidae	Buddelundia 'lefroy B'	Potential
Armadillidae	Buddelundia 'lefroy C'	Potential
Armadillidae	Buddelundia sulcata	Not SRE
Armadillidae	Cubaris 'lefroy'	Potential
Armadillidae	Pseudodiploexochus `sp. indet.`	Uncertain
Armadillidae	Spherillo 'sp. indet. A1' (fimiston)	Potential
Armadillidae	Spherillo 'sp. indet. A2' (fimiston)	Potential
Armadillidae	Spherillo 'sp. indet. B' (fimiston)	Potential
Paraplatyarthridae	Paraplatyarthrus `sp. indet.`	Uncertain
Paraplatyarthridae	Paraplayarthrus `sp. G1`	Potential
Paraplatyarthridae	Paraplayarthrus `sp. G2`	Potential
Philosciidae	Philosciidae `sp. G1`	Potential
Philosciidae	Philosciidae ‘lefroy’	Potential
Philosciidae	Philosciidae `sp. indet.`	Uncertain
Porcellionidae	Porcellionides pruinosus	Not SRE

Millipedes		
Julidae	Cylindroiulus brittanicus	Potential
Paradoxosomatidae	Antichiropus `DIP065, binduli 2`	Confirmed
Paradoxosomatidae	Antichiropus `DIP067, Broad Arrow`	Confirmed
Paradoxosomatidae	Antichiropus `DIP145, kalgoorlie`	Confirmed
Paradoxosomatidae	Antichiropus `DIP185, goongarrie`	Confirmed
Paradoxosomatidae	Antichiropus `sp. G1`	Potential
Paradoxosomatidae	Antichiropus `sp. indet.`	Uncertain
Paradoxosomatidae	Antichiropus 'DIP176'	Confirmed
Polyxenidae	Unixenus mjoebergi	Not SRE
Siphonotidae	Siphonotidae `sp. G1`	Potential
Siphonotidae	Siphonotidae `sp. indet.`	Uncertain
Spiders		
Actinopodidae	Missulena `sp. indet.`	Uncertain
Actinopodidae	Missulena harewoodi	Confirmed
Actinopodidae	Missulena occatoria	Not SRE
Anamidae	Aname `mainae`	Not SRE
Anamidae	Aname `Mt Vetters sp. 03`	Potential
Anamidae	Aname `Mt Vetters sp. 04`	Potential
Anamidae	Aname `Mt Vetters sp. 05`	Potential
Anamidae	Aname `Mt Vetters sp. 06`	Potential
Anamidae	Aname `MYG212`	Not SRE
Anamidae	Aname `MYG347`	Potential
Anamidae	Aname `MYG364`	Potential
Anamidae	Aname `MYG738`	Potential
Anamidae	Aname `sp. indet.`	Uncertain
Anamidae	Aname `sp. nov. curved embolus`	Potential
Anamidae	Aname lillianae	Not SRE
Anamidae	Aname 'MYG181'	Potential
Anamidae	Aname 'PES0053'	Potential
Anamidae	Aname 'SIGM121'	Potential
Anamidae	Aname simoneae	Not SRE
Anamidae	Aname tepperi	Not SRE
Anamidae	Aname whitei	Not SRE
Anamidae	Kwonkan `Mt Vetters sp. 02`	Potential
Anamidae	Kwonkan `MYG213`	Potential
Anamidae	Kwonkan `Phoenix0082`	Potential
Anamidae	Kwonkan `Phoenix0085`	Potential
Anamidae	Kwonkan `SIGM104`	Potential
Anamidae	Kwonkan `sp. indet.`	Uncertain
Anamidae	Kwonkan 'MYG175'	Not SRE
Anamidae	Kwonkan 'MYG263'	Potential
Anamidae	Nemesiidae `sp. indet.`	Uncertain
Anamidae	Proshermacha `MYG435`	Potential

Anamidae	Proshermacha `MYG502`	Potential
Anamidae	Proshermacha `MYG506`	Potential
Anamidae	Proshermacha `sp. indet.`	Uncertain
Anamidae	Teyl `door-building Diplurid`	Potential
Anamidae	Teyl `door-building`	Potential
Anamidae	Teyl `double-door`	Potential
Anamidae	Teyl `MYG021`	Not SRE
Anamidae	Teyl `Phoenix0081`	Potential
Anamidae	Teyl `sp. G1`	Potential
Anamidae	Teyl `sp. indet.`	Uncertain
Anamidae	Teyl luculentus	Not SRE
Anamidae	Teyl 'MYG021'	Not SRE
Barychelidae	Aurecocrypta lugubris	Confirmed
Barychelidae	Barychelidae `sp. indet.`	Uncertain
Barychelidae	Idiommata `kalgoorlie`	Potential
Barychelidae	Idiommata `sp. indet.`	Uncertain
Barychelidae	Idiommata blackwalli	Not SRE
Barychelidae	Mandjelia 'MYG035'	Not SRE
Barychelidae	Synothele `Phoenix0083`	Potential
Barychelidae	Synothele `Phoenix0084`	Potential
Barychelidae	Synothele `sp. G1`	Potential
Barychelidae	Synothele meadhunteri	Not SRE
Barychelidae	Synothele 'MYG264'	Potential
Euagridae	Cethegus `fugax`	Potential
Euagridae	Cethegus `MYG050`	Not SRE
Euagridae	Cethegus `sp. G1`	Potential
Euagridae	Cethegus `sp. G2`	Potential
Euagridae	Cethegus `sp. indet.`	Uncertain
Euagridae	Cethegus ischnotheloides	Not SRE
Euagridae	Cethegus 'MYG050'	Not SRE
Halonoproctidae	Conothele `MYG549`	Potential
Halonoproctidae	Conothele `MYG554`	Potential
Halonoproctidae	Conothele `sp. indet.`	Uncertain
Idiopidae	Bungulla `MYG677`	Potential
Idiopidae	Bungulla `sp. G1`	Potential
Idiopidae	Gaius `sp. indet.`	Uncertain
Idiopidae	Gaius austini	Not SRE
Idiopidae	Gaius villosus	Not SRE
Idiopidae	Idiopidae `sp. indet.`	Uncertain
Idiopidae	Idiosoma `goldfields sp. group`	Potential
Idiopidae	Idiosoma `MYG159`	Potential
Idiopidae	Idiosoma `MYG244`	Potential
Idiopidae	Idiosoma `MYG256`	Not SRE
Idiopidae	Idiosoma `occidentalis sp. group`	Potential

Idiopidae	Idiosoma `Phoenix0086`	Potential
Idiopidae	Idiosoma `sp. near MYG224`	Potential
Idiopidae	Idiosoma `squama`	Potential
Idiopidae	Idiosoma 'kalgoorlie 1'	Potential
Idiopidae	Idiosoma 'MYG721'	Not SRE
Idiopidae	Idiosoma 'SIGM120'	Potential
Theraphosidae	Selenotholus foelschei	Not SRE
Pseudoscorpions		
Atemnidae	Oratemnus `sp. indet.`	Uncertain
Cheiridiidae	Cheiridiidae `sp. indet.`	Uncertain
Cheliferidae	Cheliferidae `sp. Fi01`	Potential
Cheliferidae	Protochelifer `sp. indet.`	Uncertain
Chernetidae	Chernetidae `sp. indet.`	Uncertain
Chernetidae	Conicochernes `PSE024`	Not SRE
Chernetidae	Conicochernes `sp. indet.`	Uncertain
Chernetidae	Haplochernes `sp. indet.`	Uncertain
Chernetidae	Nesidiochernes `sp. Fi01`	Potential
Chernetidae	Nesidiochernes `sp. Fi02`	Potential
Chernetidae	Nesidiochernes `sp. G1`	Potential
Chernetidae	Nesidiochernes `sp. indet.`	Uncertain
Chernetidae	Sundochernes `sp. G1`	Potential
Chernetidae	Sundochernes `sp. indet.`	Uncertain
Chthoniidae	Austrochthonius `sp. indet.`	Uncertain
Garypidae	Amblyolpium `sp. indet.`	Uncertain
Garypidae	Synsphyronus `cf. mimulus`	Potential
Garypidae	Synsphyronus `PSE216`	Potential
Garypidae	Synsphyronus `sp. indet.`	Uncertain
Garypidae	Synsphyronus '7/2 goldfields (PSE117)'	Potential
Garypidae	Synsphyronus callus	Not SRE
Garypidae	Synsphyronus dorothyae	Not SRE
Garypidae	Synsphyronus lathrius	Not SRE
Garypidae	Synsphyronus mimulus	Potential
Garypinidae	Amblyolpium `sp. indet.`	Uncertain
Geogarypidae	Geogarypus taylori	Not SRE
Olpiidae	Austrohorus `salt lake species`	Potential
Olpiidae	Austrohorus `sp. Fi01`	Potential
Olpiidae	Austrohorus `sp. indet.`	Uncertain
Olpiidae	Beierolpium `8/4-Fi02`	Potential
Olpiidae	Beierolpium `sp. 8/4 small`	Potential
Olpiidae	Beierolpium `sp. 8/4`	Not SRE
Olpiidae	Beierolpium `sp. indet.`	Uncertain
Olpiidae	Indolpium `Fi03`	Potential
Olpiidae	Indolpium `sp. indet.`	Uncertain
Olpiidae	Olpiidae `sp. indet.`	Uncertain

Olpiidae	Xenolpium `sp. indet.`	Uncertain
Sternophoridae	Afrosternophorus `sp. indet.`	Uncertain
Scorpions		
Bothriuridae	Cercophonius `sp. indet.`	Uncertain
Bothriuridae	Cercophonius michaelseni	Not SRE
Buthidae	Buthidae `sp. indet.`	Uncertain
Buthidae	Isometroides `goldfields1`	Not SRE
Buthidae	Isometroides `sp. indet.`	Uncertain
Buthidae	Isometroides `vescus`	Not SRE
Buthidae	Lychas `adonis`	Potential
Buthidae	Lychas `annulatus complex`	Potential
Buthidae	Lychas `bituberculatus complex`	Potential
Buthidae	Lychas `sp. indet.`	Uncertain
Buthidae	Lychas annulatus	Not SRE
Buthidae	Lychas 'annulatus grp'	Not SRE
Buthidae	Lychas jonesae	Not SRE
Buthidae	Lychas 'pilbara1'	Not SRE
Buthidae	Lychas 'SIGM132'	Potential
Buthidae	Lychas splendens	Not SRE
Urodacidae	Urodacus `armatus`	Not SRE
Urodacidae	Urodacus `magestic`	Potential
Urodacidae	Urodacus `sp. G1`	Potential
Urodacidae	Urodacus `sp. G2`	Potential
Urodacidae	Urodacus `sp. indet.`	Uncertain
Urodacidae	Urodacus hoplurus	Not SRE
Urodacidae	Urodacus 'lefroy'	Potential
Urodacidae	Urodacus 'SIGM131'	Potential
Urodacidae	Urodacus similis	Not SRE
Urodacidae	Urodacus yaschenkoi	Not SRE
Snails		
Bothriembryontidae	Bothriembryon `sp. indet.`	Uncertain
Camaenidae	Sinumelon `sp. indet.`	Uncertain
Camaenidae	Sinumelon cf. jimberlanensis	Potential
Camaenidae	Sinumelon cf. kalgum	Potential
Camaenidae	Sinumelon cf. vagente	Potential
Camaenidae	Sinumelon jimberlanensis	Not SRE
Camaenidae	Sinumelon kalgum	Not SRE
Punctidae	Westralaoma cf. expicta	Potential
Punctidae	Westralaoma expicta	Not SRE
Pupillidae	Gastrocopta `sp. indet.`	Uncertain
Pupillidae	Gastrocopta aff. margaretae	Potential
Pupillidae	Gastrocopta bannertonensis	Not SRE
Pupillidae	Gastrocopta cf. bannertonensis	Not SRE
Pupillidae	Gastrocopta margaretae	Not SRE

Pupillidae	Pupilla cf. ficulnea	Not SRE
Pupillidae	Pupoides `sp. indet.`	Uncertain
Pupillidae	Pupoides adelaidae	Not SRE
Pupillidae	Pupoides cf. beltianus	Not SRE
Pupillidae	Pupoides cf. myoporinae	Not SRE
Pupillidae	Pupoides myoporinae	Not SRE
Succineidae	Succinea `sp. indet.`	Uncertain
Tomichiidae	Coxiella cf. striatula	Potential

Appendix C. 1551_CampoABAB-IHB-survey_Memo_final.

Memo Report

PHOENIX ENVIRONMENTAL SCIENCES

To: Yvonne Hynes, NSR

From: John Scanlon

Date: 20 December 2022

Scope: Memo report: Crossroads survey for *Camponotus* sp. nr. *terebrans*, Arid Bronze Azure Butterfly (ABAB, *Ogyris subterrestris petrina*, CR) and Inland Hairstreak Butterfly (*Jalmenus aridus*, P1)

Dear Yvonne,

Phoenix Environmental Sciences (Phoenix) is pleased to present this memo report summarising the results of the survey for the ant species *Camponotus* sp. nr. *terebrans* (host of the Critically Endangered Arid Bronze Azure Butterfly (ABAB), *Ogyris subterrestris petrina*), and Priority 1 Inland Hairstreak Butterfly (IHB, *Jalmenus aridus*) within the Crossroads study area (Figure 1).

1. Background

A baseline survey of flora, vegetation and fauna values for part of the study area was previously undertaken by Phoenix Environmental Sciences in 2017 (Phoenix 2018b). The ABAB and IHB were returned in the desktop review for the assessment based on now-extinct sub-populations in dissimilar habitat southeast of Kalgoorlie; the 2017 survey did not especially target these species, and based on limited knowledge of their distribution they were not expected to occur. In the context of recent regional records of both species, and new applicable survey guidelines for ABAB, a targeted survey was undertaken during November 2022.

A Basic terrestrial fauna survey of the Crossroads study area was conducted concurrently and is reported separately (Phoenix in prep.).

ABAB

The ABAB has been listed as Critically Endangered under Western Australia's *Wildlife Conservation Act 1950* (WC Act, now superseded by the *Biodiversity Conservation Act 2016* (BC Act)) since 2008, and under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) since 2015.

As of 2020, populations were only known to have existed at Lake Douglas southwest of Kalgoorlie (extinct since 1993), Barbalin NR near Mukinbudin (Gamblin *et al.* 2009), and one other undisclosed location in the Wheatbelt (DBCA 2020a). Both of these extant populations are over 300 km west of the study area.

In December 2020, an adult female ABAB was photographed by Greg Harewood (Zootopia Environmental Services, subcontracting for Botanica Consulting) during a Malleefowl survey at an undisclosed location on Goongarrie Station, between Kalgoorlie and Menzies (pers. comm. to R. Eastwood by A.A.E. Williams, DBCA); the host ant colony for this population has since been confirmed by Phoenix.

In October 2021, presence of ABAB was confirmed within the bounds of the ant colony at Gidji, with multiple sightings between 1.0 and 2.7 km west of the Crossroads study area (Phoenix 2022a).

The butterfly is difficult to survey because adults are present only for a few weeks each year and may disperse through habitat unsuitable for breeding. Caterpillars of the ABAB are known to live only within nests of an undescribed species of sugar ant (now referred to as *Camponotus* sp. nr. *terebrans*), associated with smooth-barked eucalypt woodlands or mallee woodlands on sandy soil.

Detailed survey guidelines were published in September 2020 (DBCA 2020b, c). They include a map of potential habitat for the host ant in WA, which includes large areas of woodland across the State. All significant *Camponotus* sp. nr. *terebrans* colonies are assumed to be critical habitat for ABAB; the status of habitat is dynamic, as ABAB can disperse across the landscape and (presumably) become established at new ant colonies, while existing colonies can also decline over time.

The survey approach now recommended is to survey first for the ant and look for the butterfly only at sites with large colonies of the host ant. This ant species was previously also only known to exist at two sites in WA, but a number of additional records have recently been reported, including from woodlands near Marvel Loch (Williams *et al.* 2018), Koolyanobbing, Goongarrie Station (Phoenix 2021), and at Gidgi immediately west of Crossroads (Phoenix 2022a).

IHB

Until recently, *J. aridus* was only known from its type locality at Lake Douglas approximately 12 km SW of Kalgoorlie. It was discovered in November 1983 breeding on a single *Acacia tetragonophylla,* but soon after its discovery the tree started to die and the butterflies disappeared. Over the following decade entomologists regularly searched the immediate surrounds and collected several specimens on a second *A. tetragonophylla*, and a few specimens from a *Senna nemophila* (= *S. artemisioides* ssp. *filifolia*) less than 1 km from the original tree (Williams *et al.* 1998). The last sighting of *J. aridus* at Lake Douglas was in 1999 (P. Samson pers. comm. 2021). A single specimen was found at Ngaanyatjarra approximately 460 km NE of Laverton in 1987 (ALA 2022).

Nine new populations have recently been discovered north and east of Kalgoorlie, (Dr R Eastwood (unpublished); A.A.E. Williams (DBCA; pers. comm. 2021);(Phoenix 2022b).

The habitat description for *J. aridus* given in Braby (2005) was based on the single known site at Lake Douglas and is given as: "*Acacia shrubland in the eastern goldfields and wheat belt of WA, favouring young bushes of the Senna food plant, up to 1.5 m high, or old mature trees of the Acacia food plant, up to 4 m high, growing in shallow gullies with gentle slope*." However, since the description was based on a single site there is no guarantee that it is typical for the species, and the species may also have a broader food plant range.

The *Senna* food plant is common around Kalgoorlie. It is thought that the butterfly larvae feed preferentially on the *Senna* flowers, which bloom in springtime from August to September. Adults would then be flying from late September to November. However, larvae feeding on *A. tetragonophylla* foliage may not be so constrained and so adults could be found at other times of year. Most specimens have been recorded/collected in October to November, but there are a few records from mid January and April (Braby 2005; WAM 2022). *Jalmenus* species are known to have strong site fidelity (Braby 2011; Pierce & Nash 1999) and can persist at a site for more than 30 years (R. Eastwood, cited in Braby 2011) and may feed on a single tree/shrub for at least 12 years and perhaps as long as 24 years (Braby 2011).

Jalmenus aridus has a mutualistic association with the small dolichoderine ant *Froggattella kirbii* (Graham & Moulds 1988). The butterfly larvae feed on the flowers and/or leaves of their food plant while the ants are in constant attendance. The larvae produce sweet secretions in the form of amino acids and sugars from the Newcomer's organ on the seventh abdominal segment, from which the ants feed via trophallaxis (Maschwitz *et al.* 1975; Pierce 1988). In return, the presence of the ants protects the butterfly larvae from parasitoids and predators. Larvae may have an attrition rate of 100% in the absence of their attendant ants (Pierce 1988).

There are no guidelines for surveying *J. aridus* butterflies since it is difficult to predict when and where they might occur. Their attendant ant species, *F. kirbii*, has a wide distribution throughout open

woodland areas across most of Australia (Shattuck 1999), so the presence of ants cannot predict the likely presence of the butterfly, as is the case with *Ogyris subterrestris petrina* (Arid Bronze Azure Butterfly; ABAB) and its host ant *Camponotus* sp. nr. *terebrans*. The larval food plant of *J. aridus*, *Senna artemisioides* ssp. *filifolia*, also has a distribution that covers most of WA and the distribution of their *A. tetragonophylla* food plant is even broader (WA Herbarium 1998).

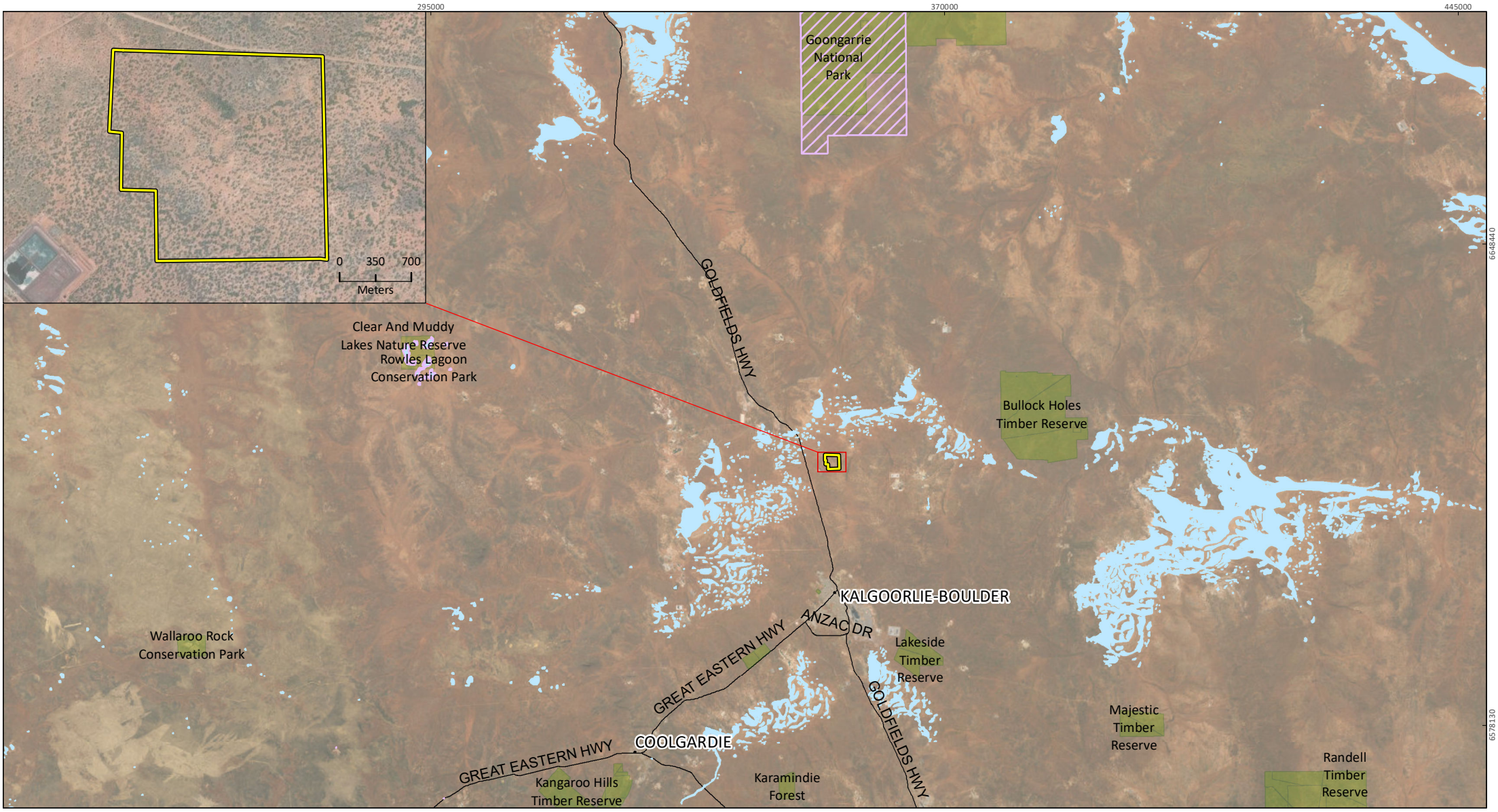
Furthermore, complex egg diapause regimes influenced by local environmental conditions also contribute to the highly irregular appearance of adults, in common with other *Jalmenus* species (Sands & New 2002).

The Department of Biodiversity, Conservation and Attractions (DBCA 2019) categorises Priority 1 species as: "*Poorly-known species: Species that are known from one or a few locations (generally five or less) which are potentially at risk. All occurrences are either: very small; or on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, road and rail reserves, gravel reserves and active mineral leases; or otherwise under threat of habitat destruction or degradation. Species may be included if they are comparatively well known from one or more locations but do not meet adequacy of survey requirements and appear to be under immediate threat from known threatening processes. Such species are in urgent need of further survey*".

2. Scope

The scope of work was as below:

- conduct a desktop assessment of habitat suitability across the study area based on available vegetation mapping, producing maps and shapefile of potentially suitable habitat for the ant species *Camponotus* sp. nr. *terebrans*
- conduct a targeted survey for *C.* sp. nr. *terebrans* in all areas of suitable habitat in the study area, applying the formula for number and spacing of sample trees given by Department of Biodiversity, Conservation and Attractions (DBCA), based on area of suitable habitat
- conduct a targeted survey for *J. aridus* in areas of suitable habitat
- determine if surveys for ABAB are required during flight season.



Northern Star Resources Ltd
Crossroads Project

Project No	1551
Date	21/12/2022
Drawn by	BK
Map author	JS

0 15 30
Kilometers

1:750,000 (at A4) GDA 1994 MGA Zone 51

P:\Data\Projects\KCGM Superpit\1551-CR-KO-FAU\GIS\Mapping\Map Documents\Figures\Ant&butterfly Memo\Figure_1_1_Project_location.mxd

- Study area
- Environmentally sensitive areas
- Lake
- DBCA managed land

Figure 1

Project location and study area

PHOENIX ENVIRONMENTAL SCIENCES

3. Study area

The study area (386 ha) is located just east of the Gidji tailings facility, approximately 19 km north of Kalgoorlie (Figure 1), with access from the Goldfields Highway via the Kanowna road.

4. Methods

4.1 Identification of potential habitat for ABAB host ant and IHB

Based on vegetation mapping undertaken by Phoenix (Phoenix 2018b, c), five vegetation units containing eucalypts occupy in the study area. Based on known association with the host ant at Gidgi, all vegetation types with *E. salubris* and/or *E. lesouefii* were identified as having smooth-barked eucalypts and are therefore considered potential habitat for *C.* sp. nr *terebrans*, and the mapped extent of these vegetation units was adopted as the study area for the survey (Table 1; Figure 2). Approximately 30% of the present study area had not been mapped for vegetation types, but review of aerial imagery suggested similar woodland vegetation extended into this area. Therefore the whole study area was identified as potential habitat.

Table 1 Vegetation units previously described in study area

Veg. code	Vegetation description	ABAB habitat	IHB habitat	Area (ha)
ElEaMs	Mid *Eucalyptus lesouefii, E. salubris* and *Casuarina pauper* open forest over tall *Eremophila alternifolia, E. scoparia* and *Acacia nyssophylla* shrubland over low open *Maireana sedifolia, Olearia muelleri* and *Solanum nummularium* shrubland	Yes	Uncertain	5.23
ElEsA	Mosaic of low *Eucalyptus lesouefii, E. salubris, E. celastroides* subsp. *celastroides* and *E. longicornis* trees woodland over isolated mid *Eremophila scoparia* shrubs over low *Atriplex* spp., *Maireana* spp. and *Tecticornia doliiformis* shrubland	Yes	Uncertain	188.35
ElEsAv	Low to mid *Eucalyptus lesouefii* and *E. longicornis* woodland over isolated mid to tall *Eremophila* spp. shrubs over low *Maireana sedifolia* shrubland	Yes	Uncertain	5.56
ElEsAv Gidgi	Mid *Eucalyptus lesouefii* woodland, occasionally with *E. longicornis*, over mid sparse to open *Eremophila scoparia*, *Maireana sedifolia* and *Senna artemisioides* subsp *filifolia* shrubland over isolated low *Atriplex vesicaria*, *Olearia muelleri* and *Scaevola spinescens* shrubs.	Yes	Yes	55.84
ElMsAs	Mid *Eucalyptus lesouefii* woodland over tall open *Melaleuca sheathiana* shrubland over low open *Atriplex stipitata*, *Cratystylis conocephala* and *Maireana sedifolia* shrubland	Yes	Uncertain	11.34
EsMsAu	Mid open *Eremophila scoparia* shrubland over low *Maireana sedifolia* and *Senna artemisioides* subsp. *filifolia* shrubland over isolated clumps of low *Austrostipa elegantissima* and *Enneapogon caerulescens* grasses	No	Yes	4.21
Unmapped	unmapped vegetation	Uncertain	Uncertain	115.27
Cleared	Infrastructure and access	No	No	0.25
Total				**385.79**

4.2 Survey for *Camponotus* sp. nr. *terebrans*

Survey for *C.* sp. nr. *terebrans* was conducted on 15-17 November 2022 by lepidopterist Dr. Rod Eastwood, who is a Research Associate at the WA Museum and has extensive field and research experience with myrmecophilous lycaenid butterflies (e.g. Eastwood *et al.* 2008a; Eastwood & Fraser 1999; Eastwood *et al.* 2008b). He has conducted fieldwork at Barbalin NR for ABAB, numerous other sites with *Ogyris-Camponotus* associations across Australia, and has identified additional colonies of the host ant, significantly increasing its known area of occupation (Phoenix 2021).

Field methods followed those described in the DBCA survey guidelines (DBCA 2020b, c). Suitable habitat was identified using vegetation mapping (Phoenix 2018a). Vegetation types recorded as or potentially containing smooth-barked eucalypt species were identified with reference to site descriptions and mapping and the EUCLID database (Centre for Australian National Biodiversity Research 2015).

A set of sampling points (Figure 2) was created prior to the survey to cover potentially suitable habitat in the each study area, based on a square grid of points, and saved to field devices.

The area of potential suitable habitat was exptrapolated based on existing vegetation mapping (Table 1). The formulae for number and spacing of sample tree locations (DBCA 2020c) were applied to the area of potentially suitable habitat:

No. sample trees = 10 x √ (site area in hectares)

Spacing = √ [(site area in hectares x 10,000) / No. sample trees]

To include a margin of safety, a 100 m buffer was applied to the outer boundaries of the study area. Due to the known presence of *C.* sp. nr. *terebrans* in the adjacent Gidji study area, the number and spacing of sampling trees in the additional study area was adjusted for finer scale, consistent with the original survey. Part of the present study area (southwestern corner) was previously surveyed as part of the Gidji survey (Phoenix 2022a).

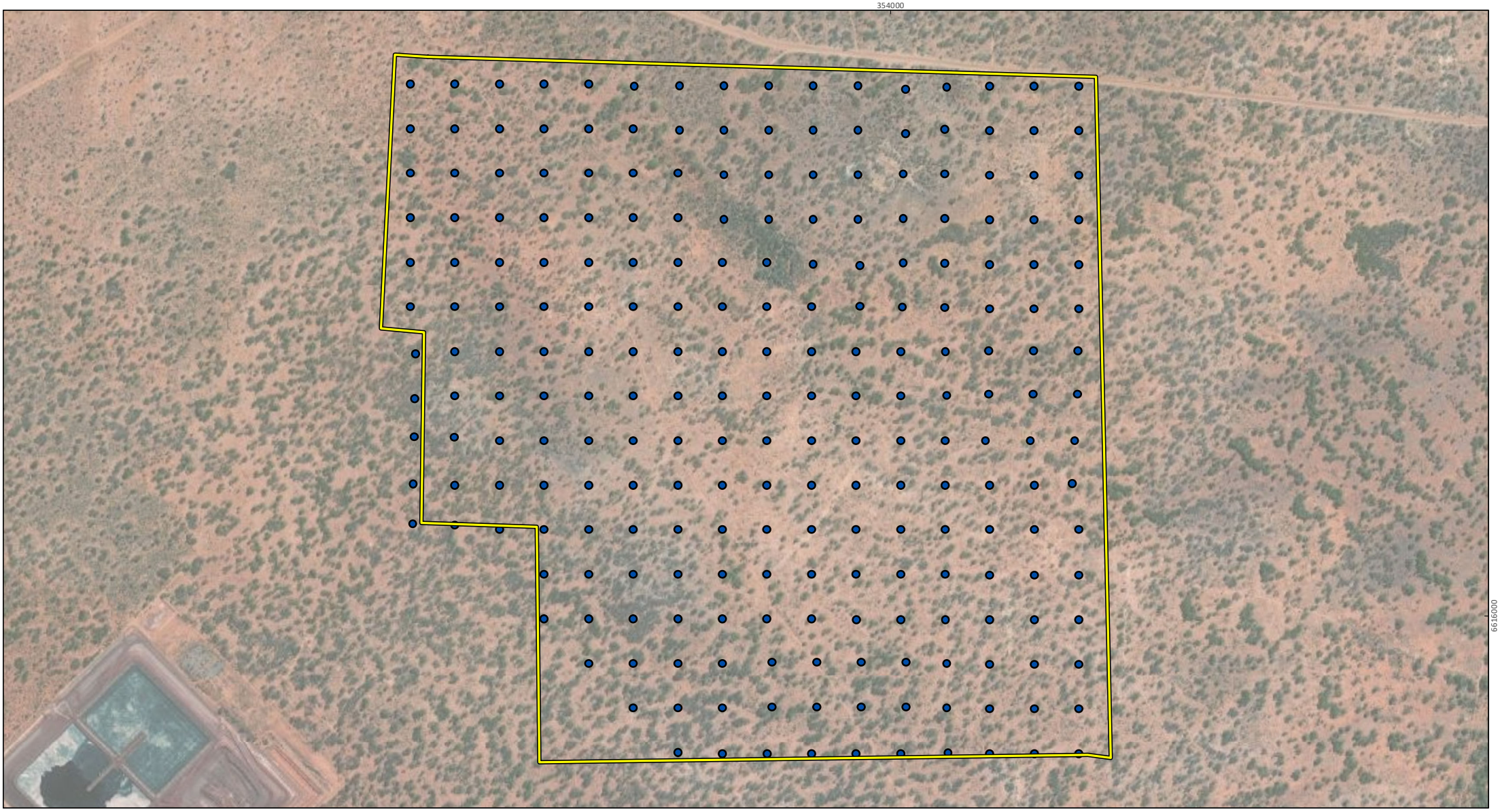
For navigation and data collection in the field, GPS-capable tablets loaded with base data including aerial photography, study area boundary, vegetation mapping, and the grid of pre-selected sites were used. Garmin GPS devices loaded with the grid of pre-selected sites.

All pre-selected points were visited during walked transects. At each point, multiple trees (usually ~10 or more) were inspected in the vicinity (within 50 m); if no *Camponotus* ant nests were identified, the point was scored 'absent'.

If *Camponotus* ant nests were found at any tree in the vicinity of the pre-selected point, the following data were recorded using a Mobile Data Studio app: GPS location, tree species (if determined), diameter at breast height (DBH), soil type, and notes and photographs of the tree, nest, and ants. The point was scored 'present' (coloured in GISPro on the tablet).

If *C.* sp. nr. *terebrans* were present, two worker ants were collected from representative nests within each study area and preserved with numbered label in 100% ethanol to confirm identification, and offered to the Western Australian Museum (WAM) as voucher specimens. Species identifications were confirmed by WAM ant taxonomist Brian Heterick. None were found in the southwest part of the study area, previously surveyed by Phoenix (2022a).

Camponotus ants were collected under Fauna Taking Licence number BA27000761.



Northern Star Resources Ltd
Crossroads Project

Project No	1551
Date	22/12/2022
Drawn by	BK
Map author	JS

0 400 800
Meters

1:15,000(at A4) GDA 1994 MGA Zone 51

P:\Data\Projects\KCGM Superpit\1551-CR-KO-FAU\GIS\Mapping\MapDocuments\Figures\Ant&butterfly Memo\Figure_2_Camponotus.mxd

Study area

Sampling locations for *Camponotus sp. nr. terebrans*

Figure 2

Potential habitat and pre-selected sampling locations for *Camponotus* sp. nr. *terebrans*

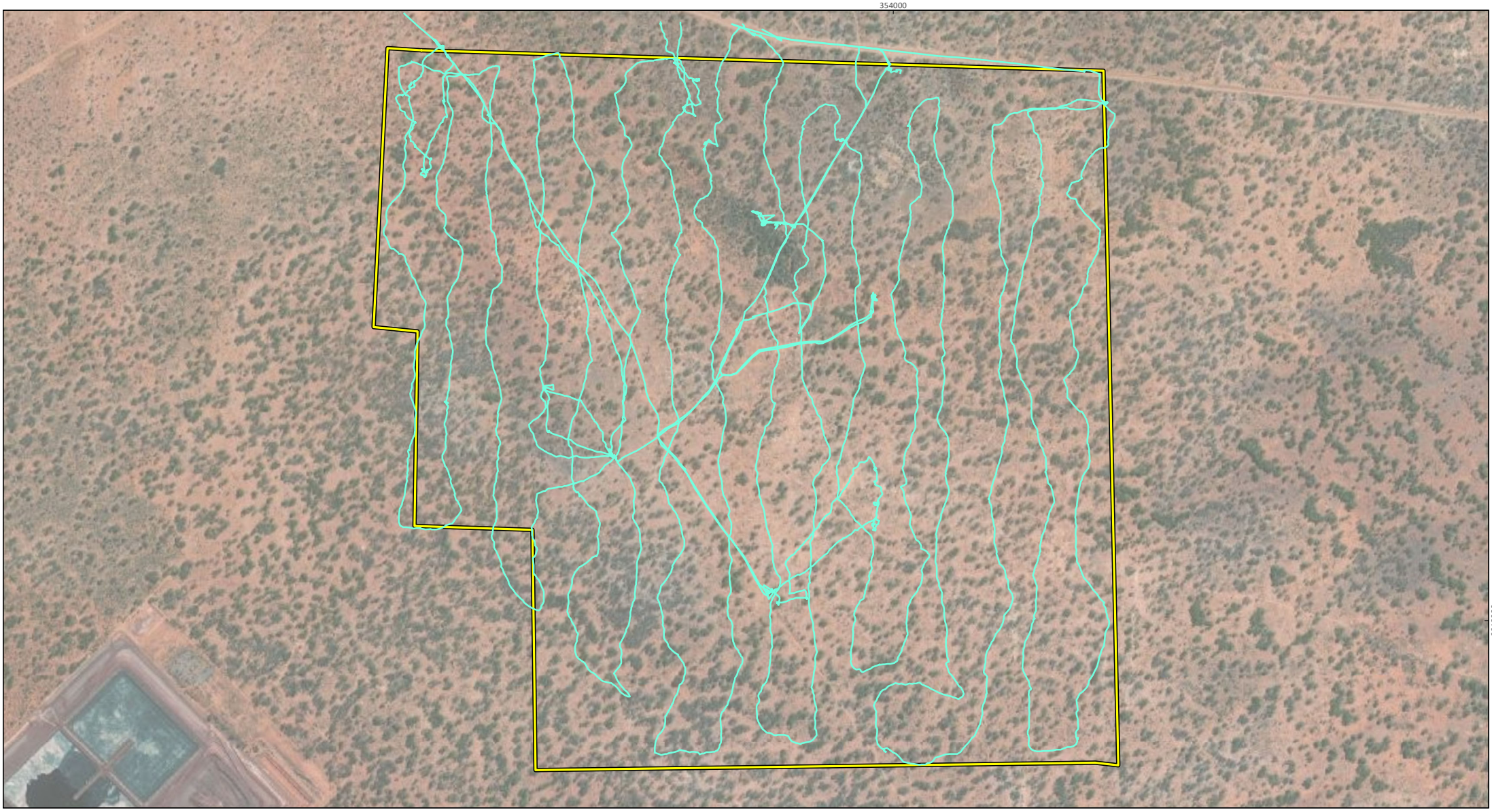
PHOENIX
ENVIRONMENTAL SCIENCES

Table 2 Local weather conditions during surveys at Crossroads

Date	Temps*		Wind speed max.*	Rainfall (mm)
	Min °C	Max °C		
15 November 2022	10.5	25.0	37	0
16 November 2022	13.5	30.4	46	0
17 November 2022	15.2	26.3	80**	7.0

* Weather data drawn from Kalgoorlie-Boulder Airport (station 012038) (BoM 2022).

** Max. wind speed during storm at 2:10 am.



Northern Star Resources Ltd
Crossroads Project

Project No	1551
Date	21/12/2022
Drawn by	BK
Map author	JS

0 400 800
Meters

1:14,700(at A4) GDA 1994 MGA Zone 51

P:\Data\Projects\KCGM Superpit\1551-CR-KO-FAU\GIS\Mapping\MapDocuments\Figures\Ant&butterfly Memo\Figure_3_Tracks.mxd

Study area
Tracks

Figure 3

Targeted *Camponotus* sp. nr. *terebrans*, host ant of the ABAB, survey transects

PHOENIX ENVIRONMENTAL SCIENCES

5. Results and discussion

5.1 *Camponotus* sp. nr. *terebrans* survey

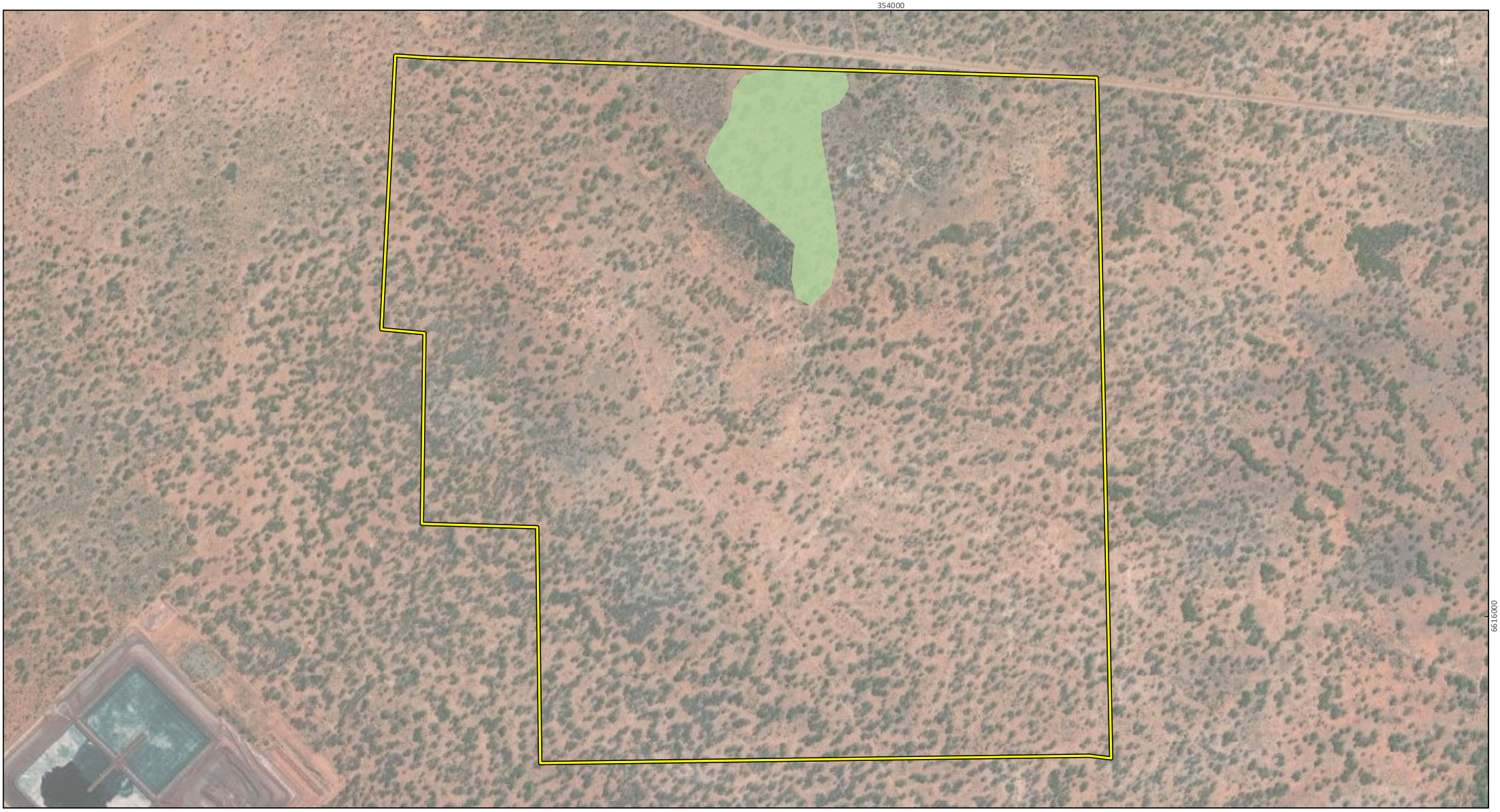
Smooth-barked eucalypts occurred through most parts of the study area, including *Eucalyptus salubris* (common) and *E. transcontinentalis* (uncommon). The most abundant eucalypt species throughout the study area was *E. lesouefii*, which is smooth above a 'collar' of rough bark to approximately 1 m above ground, but is known to be associated with *C.* sp. nr. *terebrans* nests in the Gidji colony (Phoenix 2022a).

No nests of *Camponotus* sp. nr. *terebrans* were identified in the study area during the survey. In the absence of a nest colony of the host ant within the study area, no habitat is considered to exist for ABAB.

5.2 IHB survey

No adult or larval *J. aridus* were observed during the survey despite good weather conditions and this species likely to be active during the survey period, but part of the study area is considered to be potential habitat for this species.

Acacia tetragonophylla was previously found to be abundant at a site about 1 km east (CR015, Phoenix 2018b) but otherwise occurs sparsely if at all in the study area. *Senna artemisioides* ssp. *filifolia* occurs sparsely in the understorey of eucalypt woodlands across the study area (Phoenix 2018b, in prep.), and more abundantly in the mid-north where a patch of approximately 16.2 ha was identified as potential habitat for IHB (Figure 4).



Northern Star Resources Ltd
Crossroads Project

Project No	1551
Date	22/12/2022
Drawn by	BK
Map author	JS

0 400 800
Meters

1:15,000(at A4) GDA 1994 MGA Zone 51

P:\Data\Projects\KCGM Superpit\1551-CR-KO-FAU\GIS\Mapping\MapDocuments\Figures\Ant&butterfly Memo\Figure_4_Jalmenus_aridus_potential_habitat.mxd

Study area
Potential habitat

Figure 4

***Jalmenus aridus* potential habitat**

PHOENIX
ENVIRONMENTAL SCIENCES

6. Conclusion

The study area has been adequately searched for both *C*. sp. nr. *terebrans* and *Jalmenus aridus*. It is concluded that *C*. sp. nr. *terebrans* are absent, and consequently no part of the study area represents habitat for the ABAB, while 16.2 ha of the study representents potentially suitable habitat for *Jalmenus aridus*; however, this species was not recorded therefore unlikely to be present at the site.

7. References

ALA. 2022. *Atlas of Living Australia*. Available at: http://www.ala.org.au/

BoM. 2022. *Climate statistics for Australian locations*. Commonwealth of Australia, Bureau of Meterology. Available at: http://www.bom.gov.au/climate/data/

Braby, M. F. 2005. *The complete field guide to butterflies of Australia*. CSIRO Australia, Collingwood, Vic.

Braby, M. F. 2011. Observations on site fidelity in the Imperial Hairstreak, *Jalmenus evagoras* (Donovan, 1805) (Lepidoptera: Lycaenidae), at Toorourong Reservoir, Victoria. *Australian Entomologist* **38**: 161-166.

Centre for Australian National Biodiversity Research. 2015. *EUCLID Eucalypts of Australia in* Slee, A. V., Brooker, M. I. H., Duffy, S. M. & West, J. G., eds.

DBCA. 2019. *Conservation codes for Western Australian flora and fauna*. Department of Biodiversity, Conservation and Attractions, Kensington, WA. Available at: https://www.dpaw.wa.gov.au/plants-and-animals/threatened-species-and-communities

DBCA. 2020a. *Arid bronze azure butterfly*. Department of Biodiversity, Conservation and Attractions, Kensington, WA. Available at: https://www.dpaw.wa.gov.au/plants-and-animals/threatened-species-and-communities/threatened-animals/562-arid-bronze-azure-butterfly (accessed 31/03/2021).

DBCA. 2020b. *Arid bronze azure butterfly (ABAB) survey in Western Australia additional information*. Department of Biodiversity, Conservation and Attractions. Available at: https://www.dpaw.wa.gov.au/plants-and-animals/threatened-species-and-communities/threatened-animals/562-arid-bronze-azure-butterfly

DBCA. 2020c. *Guideline for the survey of arid bronze azure butterfly (ABAB) in Western Australia*. Government of Western Australia. Available at: https://www.dpaw.wa.gov.au/images/Guideline%20for%20the%20survey%20of%20arid%20bronze%20azure%20butterfly%20Version%201.pdf

Eastwood, R., Braby, M. F., Lohman, D. J. & King, A. 2008a. New ant-lycaenid associations and biological data for some Australian butterflies (Lepidoptera: Lycaenidae). *The Australian Entomologist* **35**: 47-56.

Eastwood, R. & Fraser, A. M. 1999. Associations between lycaenid butterflies and ants in Australia. *Australian Journal of Ecology* **24**: 503-537.

Eastwood, R., Pierce, N. E., Kitching, R. L. & Hughes, J. M. 2008b. 2008. Do ants enhance diversification in lycaenid butterflies? Phylogeographic evidence from a model myrmecophile, *Jalmenus evagoras*. *Evolution* **60**: 315-327.

Gamblin, T., Williams, M. R., Williams, A. A. E. & Richardson, J. 2009. *The ant, the butterfly and the bulldozer: a summary of baseline data for the pale form of the sand-dwelling sugar ant Camponotus terebrans associated with the critically endangered arid bronze azure butterfly (Ogyris subterrestris petrina) and recommendations for recovery*. Department of Environment and Conservation, Kensington, WA. Available at: https://www.dpaw.wa.gov.au/images/documents/about/science/pubs/posters/ant-bulldozer.pdf

Graham, A. J. & Moulds, M. S. 1988. A new species of Jalmenus Hubner (Lepidoptera: Lycaenidae) from Western Australia. *General and Applied Entomology* **20**: 57–62.

Maschwitz, U., Wüster, M. & Schurian, K. 1975. Bläulingsraupen als Zuckerlieferanten für Ameisen. *Oecologia* **18**: 17-21.

Phoenix. 2018a. *Flora and vegetation, and terrestrial fauna survey for proposed infrastructure within the Development Envelope of the Fimiston Gold Mine Operations*. Phoenix Environmental

Sciences Pty Ltd, Balcatta, WA. Unpublished report prepared for Kalgoorlie Consolidated Gold Mines Pty Ltd.

Phoenix. 2018b. *Flora, vegetation and terrestrial fauna survey of the Crossroads tenements (M24/462, L24/197)*. Phoenix Environmental Sciences Pty Ltd, Balcatta, WA. Unpublished report prepared for Kalgoorlie Consolidated Gold Mines Pty Ltd.

Phoenix. 2018c. *Regional flora and vegetation and terrestrial fauna survey for the Gidji Operations*. Phoenix Environmental Sciences Pty Ltd, Balcatta, WA. Unpublished draft report prepared for Kalgoorlie Consolidated Gold Mines Pty Ltd.

Phoenix. 2021. *Parker Range Haul Road survey for Camponotus sp. nr. terebrans*. Unpublished memo report prepared for Mineral Resources Ltd, Osborne Park WA.

Phoenix. 2022a. *Memo report: Gidji survey for Camponotus sp. nr. terebrans and ABAB*. Phoenix Environmental Sciences Pty Ltd, Osborne Park, WA.

Phoenix. 2022b. *Memo report: records of Jalmenus aridus at Fimiston*. Phoenix Environmental Sciences Pty Ltd, Osborne Park, WA.

Phoenix. in prep. *Basic and Targeted Fauna Survey for the Crossroads Project*. Osborne Park WA.

Pierce, N. E. 1988. Butterfly-ant mutualisms. *In:* Grubb, P. J. & Whittaker, J. B. (eds) *Towards a more exact ecology, 30th Symposium of the British Ecological Society London 1988*. Blackwell Scientific Publications, Oxford., St. Catherine's College, Oxford, pp. 299-324.

Pierce, N. E. & Nash, D. R. 1999. *The Imperial Blue, Jalmenus evagoras (Lycaenidae)*. Sydney, NSW.

Sands, D. P. A. & New, T. R. 2002. *The Action Plan for Australian Butterflies*. Environment Australia, Canberra, ACT.

Shattuck, S. O. 1999. *Australian Ants: their biology and identification*. CSIRO Publishing, Collingwood, VIC.

WA Herbarium. 1998. *FloraBase - the Western Australian Flora*. Department of Biodiversity, Conservation and Attractions. Available at: http://florabase.dpaw.wa.gov.au/

WAM. 2022. *WA Museum Arachnology/Myriapodology, Crustacea, Mollusca and Entomology database*, Welshpool, WA.

Williams, A. A. E., Williams, M. R. & Coppen, R. 2018. *Conservation of the Arid Bronze Azure Butterfly (Ogyris subterrestris petrina) and host sugar ant (Camponotus terebrans): Survey results from Camponotus terebrans sites GIM 01, GIM 03, GIM 09, GIM 10, GIM 11, GIM 13, GIM 14, GIM 51, GIM 66, and GIM 68 south of Southern Cross (2014), and from C. terebrans site east of Merredin*. Department of Biodiversity, Conservation and Attractions. Available at: https://library.dbca.wa.gov.au/static/FullTextFiles/072251.pdf

Williams, M., Williams, W. D. & Lundstrom, T. 1998. Jewels of the West. *Landscope* **13**: 49-53.

Memo Report

PHOENIX
ENVIRONMENTAL SCIENCES

2/3 King Edward Road Osborne Park, WA
08 6323 5410