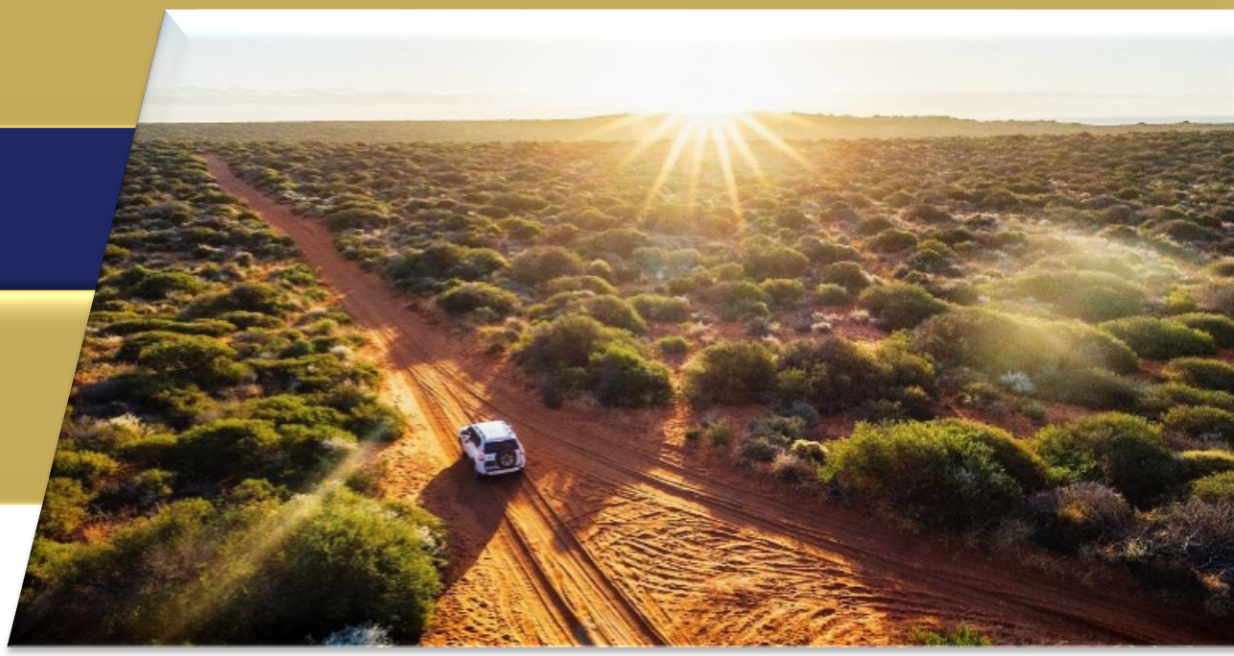

CATALYST METALS LTD

TRIDENT AND K2 PROJECTS | NATIVE VEGETATION CLEARING PERMIT APPLICATION: SUPPORTING DOCUMENT

Tenements: M52/217, M52/218, M52/233, M52/183, M52/269
Revision No: 0
Date: 17/04/2026

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File name	Trident and K2 Projects | Native Vegetation Clearing Permit Application: Supporting Document
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Revision number	0
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DOCUMENT CONTROL

Revision	Author	Reviewer		Approved for issue		
		Name	Signature	Name	Signature	Date
0	P. Cochran	R. Houlihan				

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ABBREVIATIONS AND DEFINITIONS

Abbreviation	Definition
ACHIS	Aboriginal Cultural Heritage Inquiry System
AEP	Annual Exceedance Period
AHD	Australian Height Datum
AHIS	Aboriginal Heritage Inquiry System
ANZECC	Australia and New Zealand Environmental Conservation Council
BC	Biodiversity Conservation
BoM	Bureau of Meteorology
CEC	Cation Exchange Capacity
CYL	Catalyst
DBCA	Department of Biodiversity, Conservation and Attractions
DMPE	Department of Mines, Petroleum and Energy
DPLH	Department of Planning, Lands, and Heritage
EC	Electrical conductivity
EP	Environmental Protection
EPA	Environmental Protection Authority
EPBC	Environment Protection and Biodiversity Conservation
GDP	Ground Disturbance Permit
ha	Hectares
ILUA	Indigenous Land Use Agreement
K2	Keillor 2
MCP	Mine Closure Plan
NVCP	Native Vegetation Clearing Permit
P1	Priority 1
PEC	Priority Ecological Community
Q2	Quarter 2

Abbreviation	Definition
ROM	Run-of-mine
SRE	Short-Range Endemics
TDS	Total dissolved solids
TEC	Threatened Ecological Communities
TO	Traditional Owner
TSF	Tailing storage facility
VU	Vulnerable
WoNS	Weed of National Significance
WRD	waste rock dumps

1 INTRODUCTION

Catalyst Metals Ltd (Catalyst) intends to expand its operations at the Keillor 2 (K2) Project and the Trident Complex (the Project) through its subsidiary company Dampier (Plutonic) Pty Ltd and Vango Mining Limited (Vango). K2 is located on tenements M52/183, M52/233 and M52/269 (K2 Project area), and the Trident Complex is located on M52/217 and M52/218 (Trident Project area). The Project is located 200 km northeast of Meekatharra and 200 km south of Newman, Western Australia (WA).

Green Values Australia (Green Values) was commissioned by Catalyst to prepare an *Environmental Protection Act 1986* (EP Act) Part V Native Vegetation Clearing Permit (NVCP) application to the Department of Mines, Petroleum and Energy (DMPE) to seek approval for clearing native vegetation on mining tenements M52/217, M52/218, M52/183, M52/233 and M52/269 to facilitate the Project's resources development.

This document has been prepared to support the NVCP application, which seeks approval for the clearing of up to 63 ha of native vegetation within a proposed Purpose Permit Area. A description of the proposed Project activities is provided in Section 2.

An existing NVCP was approved for the Trident Complex (CPS 10355/1) for 53.4 hectares (ha), this new NVCP application does not supersede the existing application.

1.1 Document Purpose

Information is provided to enable assessment of the impacts of the proposed clearing on each of the ten 'Land Clearing Principles' described within Schedule 5 of the EP Act. This document presents the existing ecological information and environmental impact management and mitigation measures for the proposed clearing.

This NVCP document is aimed at and structured to provide the following:

- Provide a description and map of the proposed Purpose Permit Area proposed for clearing regarding location, size and purpose.
- Site overview, with a brief description of local climate, biogeographic region, geology, land use, soils, hydrology, and hydrogeology.
- Provide a description of the proposed Purpose Permit Area to be cleared regarding vegetation type, condition and representation in a regional context.
- Presence of significant flora species, including within the proposed Purpose Permit Area.
- Description of the broad fauna habitat within the proposed Purpose Permit Area.

- Provide a discussion of proposed vegetation clearing concerning the EP Act *Schedule 5 – Principles for clearing native vegetation*.

1.2 Background

Mining at Marymia Group began in 1993, and the site has been operated by multiple proponents. Dampier (Plutonic) Pty Ltd (Dampier) purchased the tenements in 2010 and was subsequently acquired by Vango Mining Pty Ltd (Vango) in 2024. Catalyst acquired Dampier and Vango in 2023. The Marymia Group was in care and maintenance since 2006 until Catalyst recommenced mining activities at Trident in 2025. Catalyst is currently operating at the Plutonic Gold Mine (Plutonic), 45km from the K2 Project and the Trident Complex. The Project forms part of the wider Marymia Gold Area (Marymia Group) and involves mining along the Plutonic – Marymia Gold Belt. The Project is located within the Shire of Meekatharra, with the main access to the Project via the Great Northern Highway. The location of the Project is shown in Figure 1-1.

1.3 The Proponent

The proponent's details are provided below; all compliance and regulatory requirements regarding this assessment document should be forwarded by email or post to the following details.

Proponent Details		
Company Name:		Dampier (Plutonic) Pty Ltd
ABN:		94 131 670 963
Address:		Level 9, 150 St Georges Terrace, Perth, WA 6000
Postal Address:		PO Box 7161, Cloisters Square PO WA 6850
Company Name:		Catalyst (Plutonic) Pty Ltd
ABN:		34 613 900 922
Address:		Level 9, 150 St Georges Terrace, Perth, WA 6000
Postal Address:		As above.
Key Contact Representative	Name:	Mr. Anthony Buckingham
	Position:	Manager – Group Projects
	Phone Number:	+61 408 740 668
	Email:	Anthony.Buckingham@catalystmetals.com.au

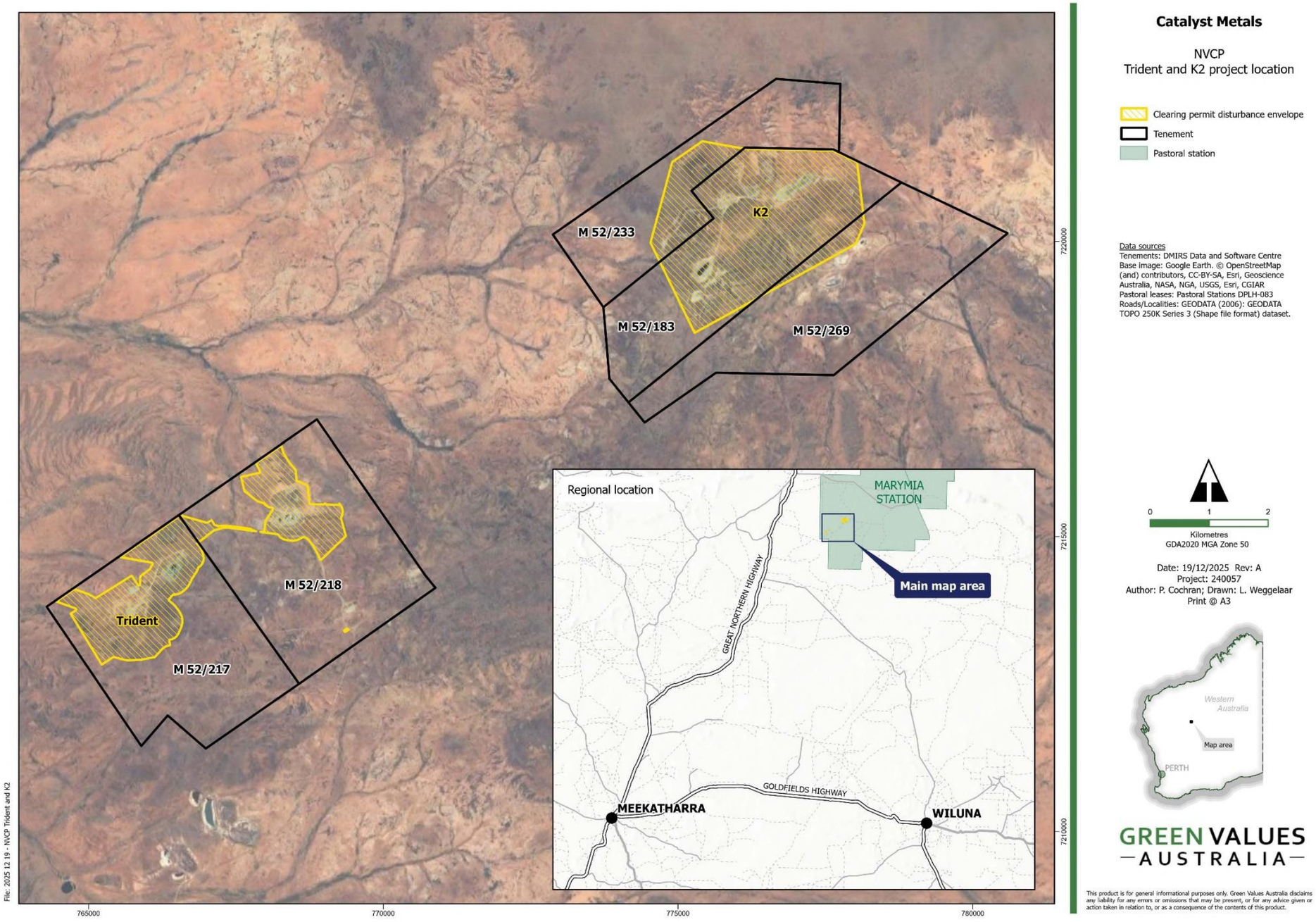


Figure 1-1: Project Location

2 PLANNED MINING ACTIVITIES

Catalyst will undertake clearing to support their proposed expansion at K2 and Trident. Both Project areas have existing infrastructure from the previous operators and are in operation under the relevant approvals. Catalyst has applied for the relevant approvals to commence mining of K2 Stage 2 and Trident Stage 3 as the next stages of mining. These next stages will require additional vegetation clearing under this NVCP application.

K2 consists of three open pits and Catalyst has commenced underground mining as part of Stage 1. Stage 2 includes additional mining activities outside of the existing disturbed areas through an expansion, including the establishment of an additional in-pit underground portal and expansion of associated supporting infrastructure. Stage 2 will involve the expansion of waste rock dumps (WRD), of the Marymia camp, run-of-mine (ROM) and other mining activities. An indicative infrastructure layout is shown in Figure 2-1.

The Trident Complex consists of open pits for Trident, Mareast and Marwest. Trident is in operations under existing approvals, including an existing NVCP (CPS 10355/1 for 53.4 ha). The existing approvals cover mining activities at the Trident West Pit, underground mine and associated supporting infrastructure. Stage 3 of the Trident Complex will be undertaken and includes additional mining activities outside of existing disturbance and existing NVCP, through expansion of the Trident West Pit and supporting infrastructure. An indicative infrastructure layout is shown in Figure 2-2.

Dewatering of the open pits will occur at both Project areas; however, no discharge of water into the environment will be undertaken. Catalyst will discharge either into existing open pits, or utilise the water for dust suppression and other mining activities.

Surface water management infrastructure, such as bunds and culverts, will be built to ensure that any flooding is directed around the infrastructure and minimise flood risk and impacts to the environment. This infrastructure, as well as sedimentation ponds, will ensure the separation of clean and dirty water.

2.1 Estimated Vegetation Disturbance Requirements

The Project will result in the 63 ha of native vegetation being cleared within a proposed 1314.96 ha Purpose Permit Area to allow for the proposed infrastructure and activities. A total of 23 ha will be cleared on M52/217 and M52/218 (Trident Complex) (Figure 2-1) and 40 ha on M52/183, M52/233, and M52/269 (K2 Project) (Figure 2-2). The area has extensive historical disturbance; Catalyst have tried to utilise existing disturbed areas where possible.

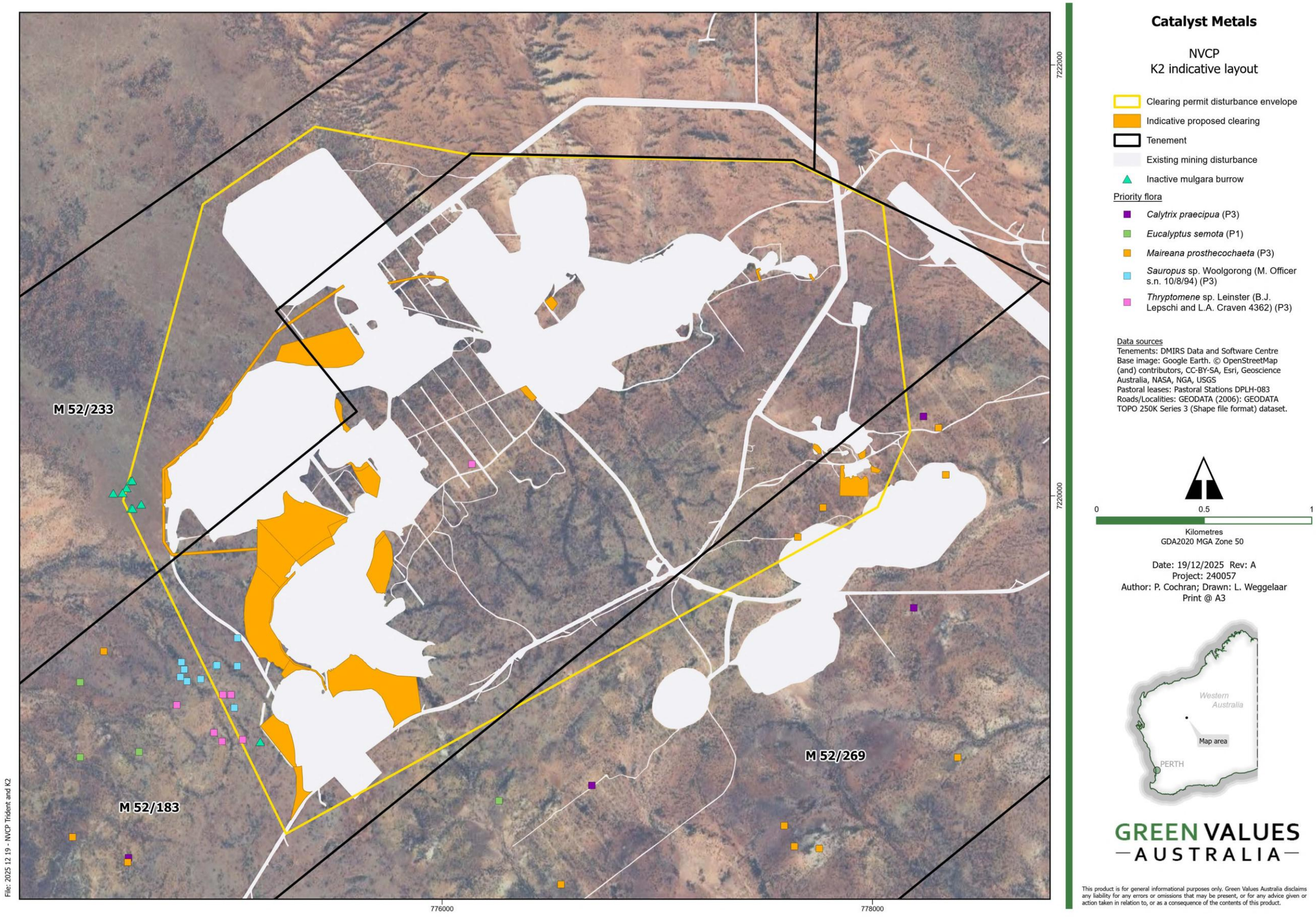
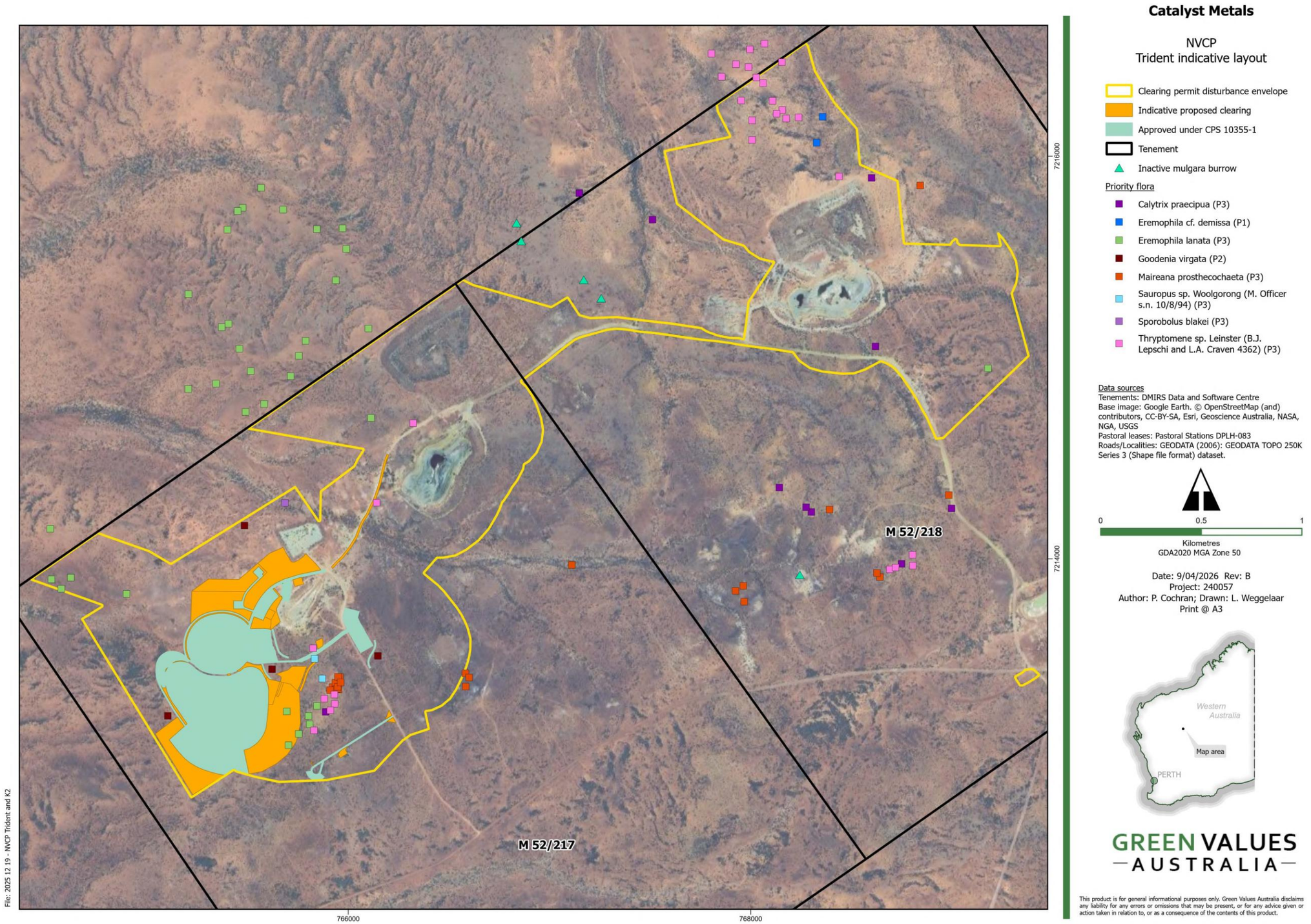


Figure 2-1: Indicative K2 Project Layout Development Envelope Footprint



Catalyst Metals

NVCP
Trident indicative layout

- Clearing permit disturbance envelope
- Indicative proposed clearing
- Approved under CPS 10355-1
- Tenement
- Inactive mulgara burrow

Priority flora

- Calytrix praecipua (P3)
- Eremophila cf. demissa (P1)
- Eremophila lanata (P3)
- Goodenia virgata (P2)
- Maireana prosthecochaeta (P3)
- Sauropus sp. Woolgorong (M. Officer s.n. 10/8/94) (P3)
- Sporobolus blakei (P3)
- Thryptomene sp. Leinster (B.J. Lepschi and L.A. Craven 4362) (P3)

Data sources
Tenements: DMIRS Data and Software Centre
Base image: Google Earth. © OpenStreetMap (and) contributors, CC-BY-SA, Esri, Geoscience Australia, NASA, NGA, USGS
Pastoral leases: Pastoral Stations DPLH-083
Roads/Localities: GEODATA (2006): GEODATA TOPO 250K Series 3 (Shape file format) dataset.

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Kilometres
GDA2020 MGA Zone 50

Date: 9/04/2026 Rev: B
Project: 240057
Author: P. Cochran; Drawn: L. Weggelaar
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GREEN VALUES AUSTRALIA

Figure 2-2: Indicative Trident Project Layout Development Envelope Footprint

2.2 Indicative Time

Catalyst proposes to commence vegetation clearing in Q2 2026. Clearing activities will be implemented progressively over the life of mine, which will be three to four years at K2 and seven years for Trident from 2026.

2.3 Method of Vegetation Clearing

The following methods of vegetation clearing will be implemented during the construction phase of the Project:

- Prior to clearing, a project-specific internal Ground Disturbance Permit (GDP) will be completed and signed off by the Catalyst Manager - Projects.
- Clearing areas will be delineated under the project-specific internal GDP, and the clearing boundary will be surveyed and demarcated with survey pegs and flagging tape.
- Threatened flora and fauna and Aboriginal Cultural Heritage values will be identified through the GDP process and avoidance mitigation measures will be implemented where applicable.
- Vegetation will be removed before topsoil stripping. Vegetation will generally be cleared ‘blade up’ with bulldozers or graders within the proposed Purpose Permit Area. Diggers and loaders may be used around drainage lines as required.
- Vegetation will typically be stripped and stored to the side of each disturbed area for use in rehabilitation works. Areas with thicker vegetation may need to have the vegetation pushed into piles and mulched.
- Topsoil will be salvaged to a depth of 0.2 m and placed in stockpiles. Topsoil shall be paddock dumped not greater than 2 m in height with adequate distance between them to create a series of mounds and troughs. Cleared scrub material shall be co-located with the topsoil stockpiles.
- Subsoil may also be stripped and stockpiled separately to ensure adequate capping material and growth medium are collected.
- Machinery operators will aim to minimise the frequency and intensity of disturbance, so they do not compromise the structural integrity of the soils. Handling of topsoil will be minimised as much as possible, especially when wet.
- Soil stripping is planned to occur as close as possible to the time when the proposed mining is scheduled to commence.

2.4 Operational Controls

The Flora and Vegetation survey (Onshore Environmental 2019) identified two weed species within the Marymia group, *Bidens bipinnata* and *Portulaca pilosa.* The *Bidens bipinnata* species was identified within the Trident Complex area, it was not identified in the K2 area. This species is an annual herb that is easily spread by livestock and other animals, preferring moist habitats such as drainage lines. The following was determined:

- No weed species listed as declared under the *Biosecurity and Agricultural Management Act 2007* were recorded.
- No plant species listed as a Weed of National Significance (WoNS) under the Australian Weeds Strategy were encountered in the Project area.

Management and control measures will be implemented to ensure that weed species do not occur and spread in the Project area. These include hygiene inspections of all vehicles prior to entering the Project area, seasonal weed inspections and ongoing control measures during operations.

The Fauna survey (Bamford, 2019) identified ten introduced fauna species on site, including cats, fox, rabbit, cattle, horse and camel recorded in 2018/2019 survey. Catalyst undertakes feral fauna control programs at Plutonic, which are being implemented at Marymia Group. This reduces the risk of introduced fauna species in the are which adversely impact native fauna species through competition and predation. Other management measures to be implemented include appropriate storage or disposal of domestic waste (i.e. food), regular monitoring and recording.

2.5 Rehabilitation and Maintenance

In areas where topsoil has been disturbed, it will be spread back over the area and rehabilitated according to the specifications of Catalyst's Mine Closure Plan (MCP) and seeded with locally endemic species. Rehabilitation monitoring will be undertaken on all substantial rehabilitation areas within one year of seeding to determine whether germination and establishment have been successful.

Ongoing monitoring will determine if further management measures are required, including re-seeding or other interventions, and will be managed in accordance with the MCP.

3 EXISTING ENVIRONMENT BASELINE

This section provides a brief overview of existing studies relevant to the work proposed.

3.1 Climate

The climate within the proposed Purpose Permit Area is classified as Arid and characterised by low rainfall, hot, dry summers, and mild winters. Rainfall is evenly distributed between the summer and winter months, however, thunderstorm activity in the summer months results in slightly larger monthly averages. Evaporation exceeds rainfall in all months and averages over 3,000 mm per year. The Meekatharra Airport meteorological station (No. 007045) was used to estimate the baseline conditions at the Project site. The highest mean maximum temperature is 29.2 °C annually, with the highest temperatures during January and the minimum temperature is 16 °C annually with the lowest temperatures during July (BoM, 2025). The average rainfall is 232.1 mm annually, with the heaviest rainfall seen in February, March and June (**Error! Reference source not found.**).

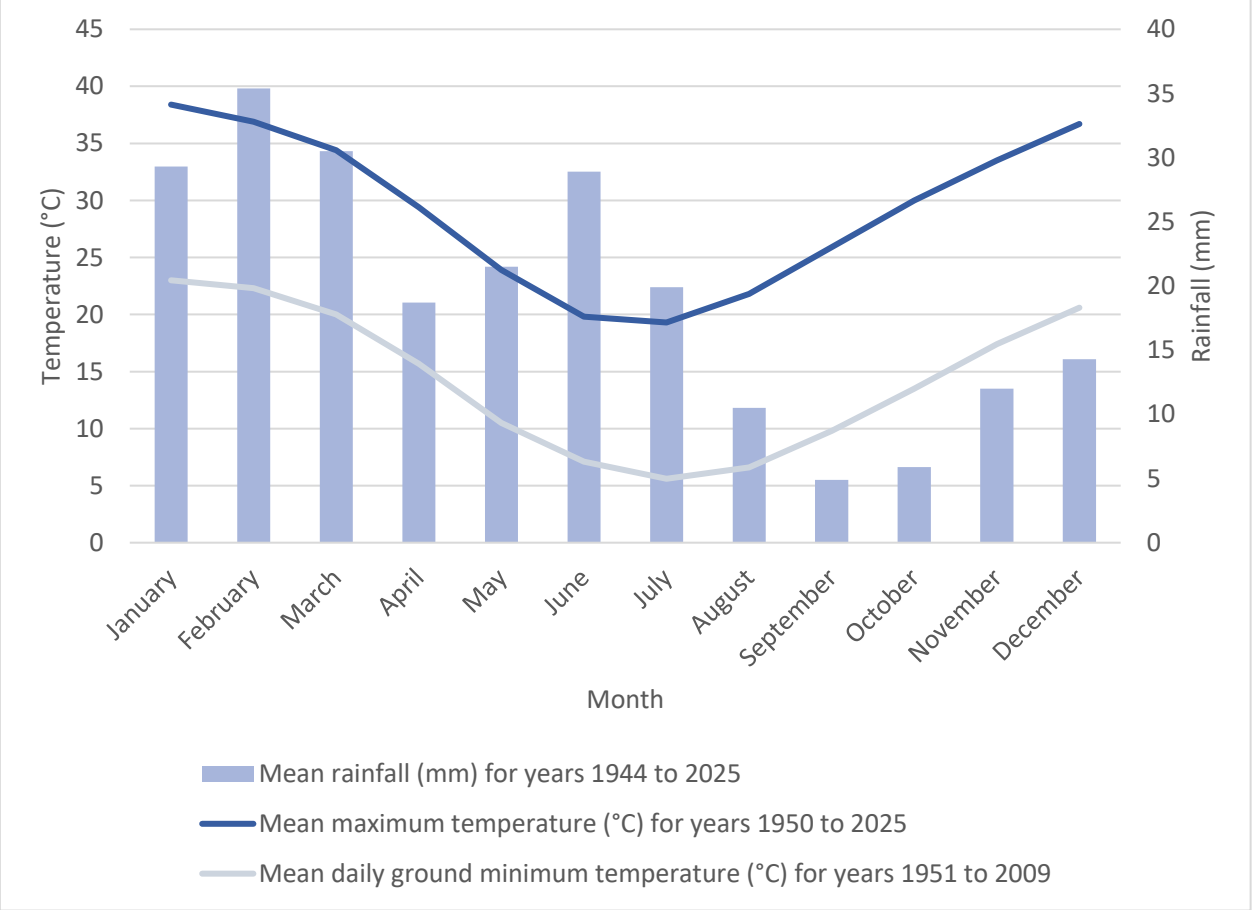


Figure 3-1: Monthly Weather for Meekatharra Meteorological Station (No. 007045). Source: BoM, 2025

3.2 Hydrology

Rockwater Pty Ltd (Rockwater) completed a hydrology and surface water assessment of various Marymia deposits in 2019, including K2 and the Trident Complex. Carrick Consulting (WA) Pty Ltd undertook a high-level surface water assessment in 2025 for Plutonic, including K2 and the Trident underground mine. The Marymia Group lies on a drainage divide that separates the headwaters of the westward-flowing Gascoyne River system from those flowing south in the Lake Gregory inland drainage system. No significant watercourses exist in the Marymia Group.

The minor creeks and drainage lines in the activity envelope are ephemeral and only flow for short periods following heavy rainfall. Runoff flows off-site in a north-westerly direction via a combination of sheet flow and shallow concentrated flow.

Floodline modelling of the 1%, 2%, 5%, 10%, 20% and 50% Annual Exceedance Probability (AEP)-72 hours indicated that the flood prediction will be moderately high flow and extent. Carrick recommended that the K2 in-pit portal be constructed above the 1% AEP-72-hour event and a 1m high protective bund be constructed along the southern edge of the Trident Pit to prevent flooding into the pit. The predicted pit inflows per AEP event are presented in Table 3-1 (Carrick, 2025).

Table 3-1: Estimated In-Pit Runoff Flow for the K2 Catchment (Carrick, 2025)

Rainfall Event (AEP)	In-Pit Runoff Volume (m^3)
K2	
50% AEP-72 hours	7,100
20% AEP-72 hours	11,400
10% AEP-72 hours	14,300
5% AEP-72 hours	17,300
2% AEP-72 hours	21,100
1% AEP-72 hours	23,900
Trident Complex	
50% AEP-72 hours	2,300
20% AEP-72 hours	3,700
10% AEP-72 hours	4,600
5% AEP-72 hours	5,600
2% AEP-72 hours	6,800
1% AEP-72 hours	7,600

3.3 Hydrogeology

A dewatering assessment was undertaken by Rockwater in 2019 for the Trident Pit, including the K2 area (Rockwater, 2019).

Two types of aquifers are found in the Marymia Group: alluvial and fractured rock. Alluvial aquifers are recharged by direct infiltration of rainfall or by infiltration of surface water during periodic stream flows. Water abstracted (and discharged) under this Project is associated with the Alluvial aquifer.

Groundwater quality and quantity monitoring at Trident and K2 have been ongoing since 2024 and continue on a monthly/quarterly basis. K2 has three monitoring bores, and three monitoring bores surround the Trident West Pit with an additional five bores for the Mareast Pit. Monitoring of water quality is compared to baseline data and was compared to the Australia and New Zealand Environmental Conservation Council (ANZECC) (2000) Livestock Drinking Water Guideline trigger value.

K2 experiences high total dissolved solids (TDS) and electrical conductivity (EC), and slightly alkaline pH with some exceedances of sulphate and sodium in 2024 and 2025. This indicated that K2 is more saline and is consistent with the groundwater at Marymia being generally brackish, slightly alkaline and bicarbonate-rich with low concentrations of dissolved metals. Trident typically has a low TDS and EC with neutral to alkaline pH with low concentrations of dissolved metals (except for exceedances in magnesium). This indicates that the groundwater surrounding the Trident West Pit is relatively fresh. In comparison to the Marwest and Mareast, which historically have had elevated TDS, indicating more brackish groundwater.

The dewatering requirement is considered low for K2 (864 kL/d) and medium for Trident (2,559 kL/d). Water levels sit at approximately 30-40 metres above the Australian Height Datum (m AHD). The closest sensitive receptor is the Priority Ecological Community (PEC) Frederick Land System, which is 7 km from the activity envelope. There are no other sensitive receptors, such as homesteads or settlements, within 5 km of the Project. Groundwater drawdown is not considered to be significant due to the low water demand of the Project and no sensitive receptors.

A dewatering assessment is ongoing for the Trident underground mine by Worley Consulting and will be completed in 2026.

3.3.1 Excess Water Management

Excess water will either be discharged to existing pits for disposal, or utilised for dust suppression or other mining activities.

No discharge to the environment is planned from this mining operation.

3.4 Soils and Land Use

A soils and landform assessment was undertaken by MBS Environmental in 2019 (MBS Environmental, 2019) for the Marymia Group, including the K2 and Trident Complex.

The Marymia Group Is located within the Paroo Uplands Zone of the Ashburton Province are characterised by hills, hardpan wash plains and stony plains (with sandplains) on Yerrida, Bryah and Padbury Basin sedimentary rocks and Marymia Inlier granitic and volcanic rocks. The K2 Project area was characterised by shallow gravel (Soil Group 304) consisting of loose loamy sand surface soil grading into either sandy loams or sandy clay matrix through underlying horizons and the Trident Complex was classified as red-brown shallow loam (Soil Group 523) (MBS Environmental, 2019). The other soil type was disturbed land (Soil Group 701).

3.4.1 Physical and Chemical Characteristics

Overall, topsoils were suitable as a growth medium, subsoils (>200mm) were suitable for gentle sloping surfaces as they were non-dispersive, and subsoils (>1000mm) were not suitable for rehabilitation as they were highly dispersive and sodic. Subsoils at K2 (>1000 mm) were moderately to highly dispersive and sodic, which could be related to the presence of kaolinite clay (low activity clay) as indicated by low Cation Exchange Capacity (CEC) values for subsoils of Soil Group 304 (MBS Environmental, 2019). These will be stockpiled separately from the other subsoils. Subsoils at Trident were moderately dispersive (Emerson Class 3) and non-sodic; these will be used as a cover material for flat surfaces but not intended to be placed on slopes.

Surface soils were non-sodic and generally non-dispersive. These are considered suitable for the rehabilitation of flat or gently sloping (less than 2˚ degrees) surfaces such as the top of WRDs or upper TSF surfaces. The red-brown duplex loam (Soil Group 523) and shallow gravel (Soil Group 304) are similar in nature and do not need to be separated. These are the preferred soil types for the rehabilitation of mine waste landforms such as embankments.

All soils had a low water holding capacity and had typical nutrient levels and low toxic metals concentrations.

3.5 Flora and Vegetation

Onshore Environmental Consultants (Onshore) (2019) undertook the flora and vegetation survey covering the Marymia Group in 2018 and 2019.

A total of 13 vegetation associations were recorded within the K2 Project area and 20 associations at Trident Project area (Figure 3-2 and Figure 3-3). The most abundant associated within the K2 activity envelope was *Eremophila* Shrubland (SS EffEsEc Tb). Other vegetation associated with the K2 Project area includes *Acacia* Low Open Forest in floodplains (FP Ai ArlPlGb EffSeEf TxEe Cs),

Acacia High Open Shrubland (SP Ai EfSgEff PsPoSl), *Acacia* Low Closed Forest (SP AptAi AclSgl EmSsPo), *Triodia* Hummock Grassland (SS Tb AiAp Ar EcEs) and *Triodia* Hummock Grassland (SS Tb ScSe AaAkEff).

The most abundant association within the Trident Project area was *Acacia* high open shrubland (SP Ai EfSgEff PsPoSl) consisting of *Acacia subcontorta* and *Acacia incurvaneura* Open Shrubland of *Thryptomene sp.* and *Acacia subcontorta*. *Acacia* Low Open Forest (FP Ai ArlPlGb EffSeEf TxEe) within floodplains was also abundant within the Trident Project area.

Further details on the characteristics of these vegetation associations are in APPENDIX 1. None of these associations corresponded to Threatened Ecological Community (TEC) listed under the Federal *Environmental Protection and Biodiversity Conservation* (EPBC) Act 1999, Western Australian Biodiversity Conservation (BC) Act 2016, or are PEC.

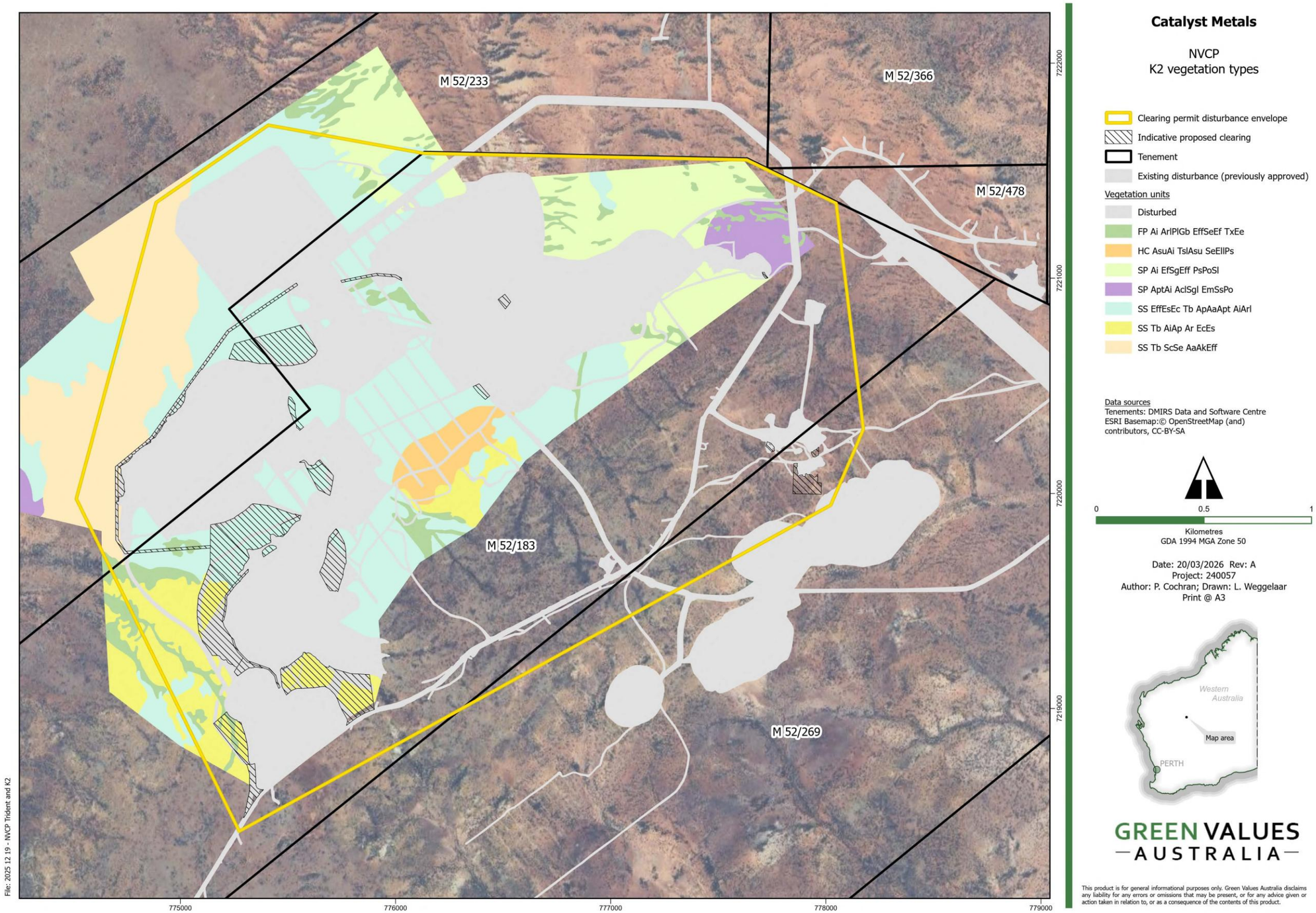


Figure 3-2: Vegetation Types within the K2 Area

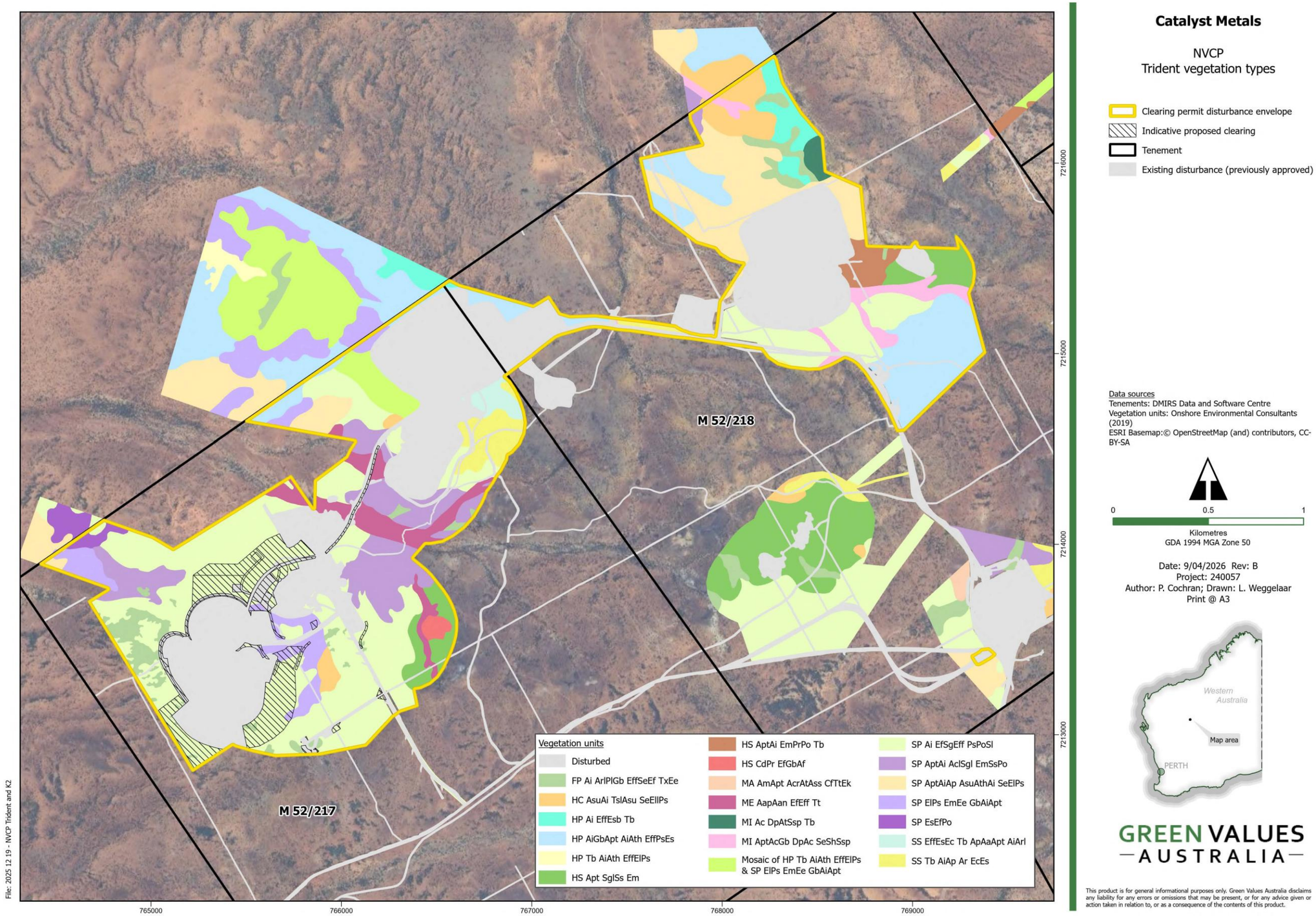


Figure 3-3: Vegetation Types within the Trident Area

3.5.1 Vegetation Conditions

Vegetation condition within the activity envelope ranged from Good to Very Good, with most of the undisturbed areas considered Very Good within the activity envelope. Areas to the north of the Marwest Pit were considered Good, with areas south and surrounding the Trident West Pit are considered Very Good. The K2 area was predominantly Very Good, particularly to the south-west of the activity area and Good to the north-east. The remaining portions of the activity envelope were previously disturbed and impacted by historical mining and exploration activities. The vegetation of the greater Marymia Group showed obvious signs of degradation by cattle grazing, and camels were also present. The vegetation conditions are shown in Figure 3-4.

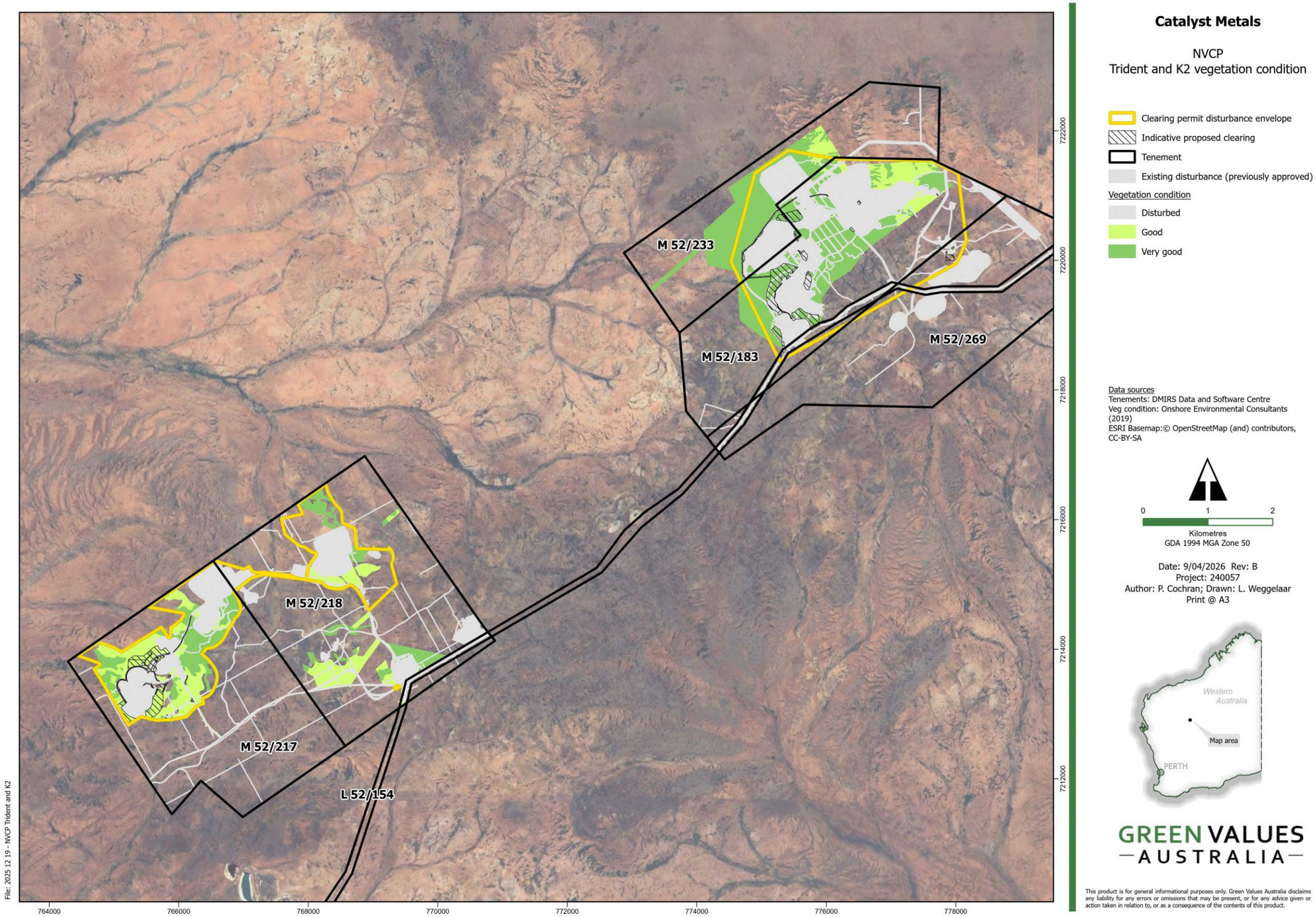


Figure 3-4: Vegetation Conditions within the Disturbance Envelope

3.5.2 Conservation Significant Flora Species

Eight priority species (according to the Department of Biodiversity, Conservation and Attractions (DBCA) were recorded within the Maymia Group (Trident Complex, K2 and Cinnamon), including:

- *Eremophila cf. demissa* (Priority 1);
- *Eucalyptus semota (Priority 1);*
- *Goodenia virgata* (Priority 2);
- *Calytrix praecipua* (Priority 3);
- *Eremophila lanata* (Priority 3);
- *Mairena prosthecochaeta* (Priority 3);
- *Sauropus sp. woolgorong* (Priority 3);
- *Sporobolus blakei* (Priority 3); and
- *Thryptomene sp. Leinster* (Priority 3).

Two Priority-listed flora were recorded from the study area and within the K2 disturbance area: *Sauropus sp. Woolgorong* (Priority 3) and *Thryptomene* sp. Leinster (P3) (Figure 2-1). An additional Priority flora species, *Eucalyptus semota* (Priority 1), was recorded outside the boundary of the study area and the Project activity envelope. Two species were recorded within the immediate vicinity of the Project, *Hibiscus brachychlaenu* (not threatened) and *Thryptomene* sp. Leinster (P3). *Hibiscus brachychlaenu* has a significant range extension within the study area. *Thryptomene* sp. Leinster populations were identified in the activity envelope as P3 species in 2019, however, as of October 2025, these species are not threatened. They occur within a band across the Murchison and Gascoyne bioregions and the populations found within the Marymia Group are the most northeasterly extent of their distribution (Onshore, 2019).

Within the Trident Complex Stage 3 activity envelope, six priority flora were identified within the disturbance envelope and in close proximity to the proposed activities (Figure 2-2). These species include the *Goodenia virgata* (P2), *Eremophila lanata* (P3), *Sauropus sp. woolgorong* (P3), *Maireana prosthecochaeta* (P3), *Thryptomene sp. Leinster* (P3) and *Calytrix praecipua* (P3). Catalyst has implemented management measures to ensure that these priority floras are not disturbed, such as adhering to the conditions set out in the existing NVCP for the Trident Complex (CPS 10355/1), which requires a 10 m buffer around the priority flora and avoiding species where possible.

3.5.3 Threatened and Priority Ecological Communities

No vegetation communities identified corresponded to TEC listed under the Federal EPBC Act or Western Australian BC Act 2016.

The closest Priority Ecological Community (PEC) to the proposed clearing is the land system Frederick Land System (P 3) and is shown in Figure 3-5. The closest Frederick Land Systems to the proposed activities are approximately 7 km west of the Trident Project, and 13 km northeast of the K2 Project. The Frederick Land System is classified as hardpan wash plains with broad, reticulate mulga groves and Wanderrie banks, which support tall Acacia shrublands with a grassy understory (DBCA, 2023b). The PEC is classified as P3 by the DBCA, which is defined as "*comparatively well-known from several localities but do not meet adequacy of survey requirements and/or are not well defined*" (DBCA, 2023a). Threats faced by these PEC landforms (P3) include overgrazing and erosion, as well as disturbance.

It is unlikely any direct or indirect impacts will occur to this land system.

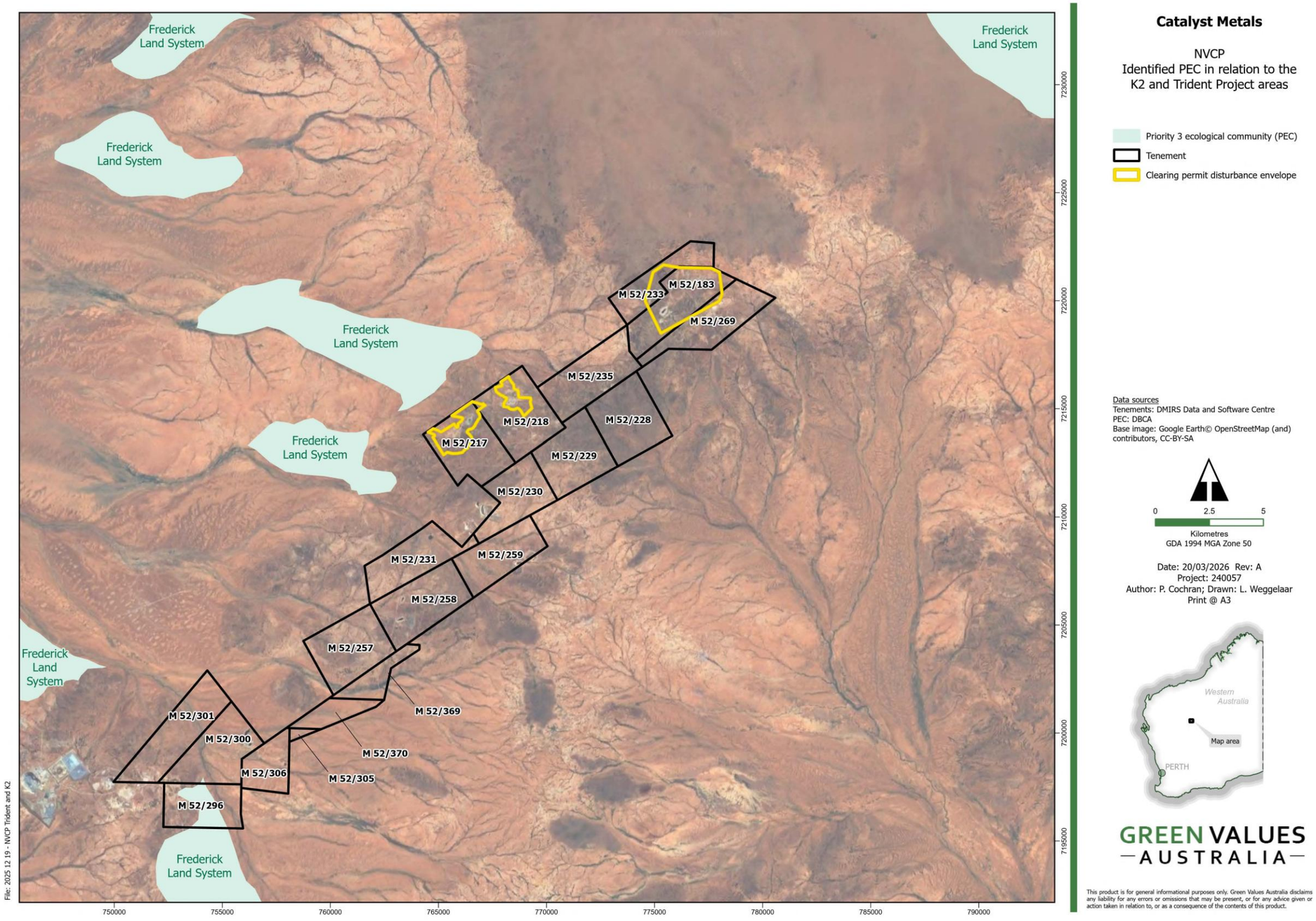


Figure 3-5: Priority Listed Flora Species and TEC/PEC

3.6 Fauna

Bamford Consulting Ecologists (Bamford) (2019) was commissioned to conduct a basic fauna assessment on four areas of the Marymia Gold Project, including the K2 and Trident project areas. Field assessments were undertaken in November 2018 and August 2019 (Bamford, 2019) (APPENDIX 2).

The vegetation type consisted mostly of open Acacia or Mulga shrubland. Six vegetation substrate associations (VSA) were identified (Bamford, 2019):

1. Acacia shrubland on gravelly loam with quartz/ironstone cobbles on flats and slight rises. This is very extensive and variable, with some areas of acacia thickets, but other areas that are very open, and the quartz forms a veneer over open ground.
2. Mulga over shrubs and spinifex on loam to sandy loam flats.
3. Drainage line with Acacia/Mulga thickets on clayey loam. On some drainage lines the acacia is a tall Miniritchi (more in the Trident area).
4. Old mine pits, stockpiles with partial rehabilitation; areas of good rehabilitation are similar to VSA 1. Some of these old pits contain water.

Drainage lines, Mulga thickets and mulga over spinifex could support some significant fauna species that are restricted in the area.

During the 2018/2019 survey, 150 species were recorded, 27 mammal species (10 are non-native), 91 birds, 29 reptile and 3 amphibian species. The conservation significant species, which were expected to occur on the site and the findings from the survey are presented in Table 3-2 and Figure 3-6.

The field survey did not find any *Leiopoa ocellata* (Malleefowl) mounds, suggesting that it is not a breeding resident at Marymia; however, individual birds may visit (Bamford, 2019). Burrows of the Mulgara species were identified. Initially, the burrows were identified as the Crest-tailed Mulgara (*Dasycercus cristicauda*) (Least Concern) and were later identified as burrows for the Brush-tailed Mulgara (*Dasycercus blythi*) (not listed as threatened under the EPBC Act but listed as Priority 4 in WA under DBCA). These burrows were identified in the K2 Project area, on the western border of the Project's activity envelope. All burrows were found to be inactive, which is typical of the species as they can vary in abundance from year to year (Bamford, 2019). The K2 Project area was found to have a wide range of environments and extensive habitat for the Brush-tailed Mulgara, although of limited suitability. Four burrows were identified outside of the Trident Complex and outside of the activity envelope (between Marwest and Mareast). The Brush-tailed Mulgara has been the subject of long-term monitoring at Marymia due to early surveys recording the species incorrectly as the Crest-tailed Mulgara, which was a threatened species at the time.

Six bat species were identified on bat detectors in 2018 and 2019 surveys by Bamford and all are classed as residents in the activity envelope. Three bat species were recorded at the K2 underground portal, including call frequencies from *Taphozous georgianus* and *Vespadelus finlaysoni.* The call frequencies contained social calls and feeding buzzes, indicating that these species were roosting in the portal. Similarly, social calls and feeding buzzes from Saccolaimus *flaviventris*, *Vespadelus finlaysoni* and *Scotorepens balstoni* were identified, suggesting these species were inhibiting surrounding pits (near the exploration camps) (Bamford, 2019). None of the identified species is conservation significant.

No conservation-significant species under the EPBC and BC Act were identified within the proposed Project's activity envelope. The area has experienced disturbance and habitat loss, which results in the loss or dispersion of fauna species. The most important environment for fauna richness is the Mulga over spinifex on sandy loam and Mulga thickets along the drainage lines. Other impacts to fauna include habitat fragmentation (particularly of the drainage lines and Mulga), degradation of habitat due to invasive weeds, direct fauna mortality due to anthropogenic activities, invasive fauna species (such as foxes or cats) and hydrologic changes.

Table 3-2: Conservation Significant Fauna Species

Species	Common Name	Status*	Expected Occurrence	Bamford Findings (2018 – 2019)
Leiopoa ocellata	Malleefowl	V, S3	Irregular Visitor	Mounds were not identified in the exploration areas; the area is an unlikely breeding site. Individual birds may visit the activity envelope, favouring Mulga thickets and dense vegetation, which are found in the area.
Apus pacificus	Fork-tailed Swift	M, S5	Visitor	Non-breeding migrant, less nomadic, therefore its occurrence is unpredictable.
Ardea modesta	Eastern Great Egret	M, S5	Irregular Visitor	Waterbird species visiting wetlands along the drainage lines throughout the area and could visit flooded mine pits. Numbers would be low.
Falco hypoleucos	Grey Falcon	S3	Vagrant	Not recorded.
Falco peregrinus	Peregrine Falcon	S7	Resident	A pair of Peregrine Falcons was observed at a surrounding activity envelope (Triple P) in 2019. They were likely nesting in the area, due to their being site faithful, they may be long-term residents. Although their nesting location could not be confirmed, most breeding territories have two or three alternative nesting sites.
Calidris acuminata	Sharp-tailed Sandpiper	M, S5	Irregular Visitor	Waterbird species visiting wetlands along the drainage lines throughout the area and could visit flooded mine pits. Numbers would be low.
Calidris ruficollis	Red-necked Stint	M, S5	Irregular Visitor	Waterbird species visiting wetlands along the drainage lines throughout the area and could visit flooded mine pits. Numbers would be low.
Calidris melanotos	Pectoral Sandpiper	M, S5	Vagrant	Waterbird species visiting wetlands along the drainage lines throughout the area and could visit flooded mine pits. Numbers would be low.
Actitis hypoleucos	Common Sandpiper	M, S5	Irregular Visitor	Not recorded.
Lophochroa leadbeateri	Major Mitchell's Cockatoo	LS	Vagrant	Not recorded.
Neophema splendida	Scarlet-chested Parrot	LS	Vagrant	Not recorded.
Polytelis alexandrae	Princess Parrot	V, P4	Vagrant	Not recorded.
Pezoporus occidentalis	Night Parrot	E, S1	Vagrant	It is unlikely that the species will occur in the activity envelope, as the species has been reported in the salt lakes systems 100 km away. There is some evidence that it favours the spinifex/samphire ecotone and potentially rocky hills.

Species	Common Name	Status*	Expected Occurrence	Bamford Findings (2018 – 2019)
Ardeotis australis	Australian Bustard	LS	Resident	Moderately common in the region. The Marymia Group is at the edge of where the species could reside.
Burhinus grallarius	Bush Stone-curlew	LS	Irregular Visitor	Present in small numbers across Murchison and Gascoyne. This species was not recorded in the activity envelope but may be present occasionally as it favours the dense thickets along drainage lines found in the Marymia area.
Amytornis striatus striatus	Inland Striated Grasswren	P4	Vagrant	Not recorded.
Conopophila whitei	Grey Honeyeater	LS	Visitor	The species has been recorded in Doolgunna and may be a visitor in the activity envelope. It favours tall, dense Mulga, which is present in the Marymia Group.
Hirundo rustica	Barn Swallow	M, S5	Visitor	Non-breeding migrant that occurs irregularly around some of the Pilbara towns.
Dasycercus blythi	Brush-tailed Mulgara	P4	Resident	The species prefers the spinifex on sandy to sandy-loam soils, which are present in the K2 activity envelope. Inactive burrows were found in the activity envelope in 2018 (south-west of the tenement area) however, no additional burrows were identified in 2019. The species is common in the Marymia Group and is subject to long-term project monitoring.
Antechinomys laniger	Kultarr	LS	Resident	Rarely recorded and widespread, however recorded in the Marymia Group in 1991 (by ecologia). It is associated with gravelly and rocky plains with sparse vegetation.
Sminthopsis longicaudata	Long-tailed Dunnart	P4	Resident	Usually associated with rock environments and was recorded near the Marymia camp in 2015. It is considered likely to be resident in the region with occasional visits. However rocky landscape created by mining may provide a potential habitat.
Macrotis lagotis	Greater Bilby	V, S3	Vagrant	The species was reintroduced 100 km to the east (Matwa /Lorna Glen Station), and it might pass over the activity envelope. The species could colonise drainage lines in the sandplain environment that exists within the area.

* EPBC Act - E = Endangered, V = Vulnerable, M = Migratory

WA Biodiversity Conservation Act 2018 listings: S1 to S7 = Schedules 1 to 7
DBCA Priority species: P1 to P4 = Priority 1 to 4

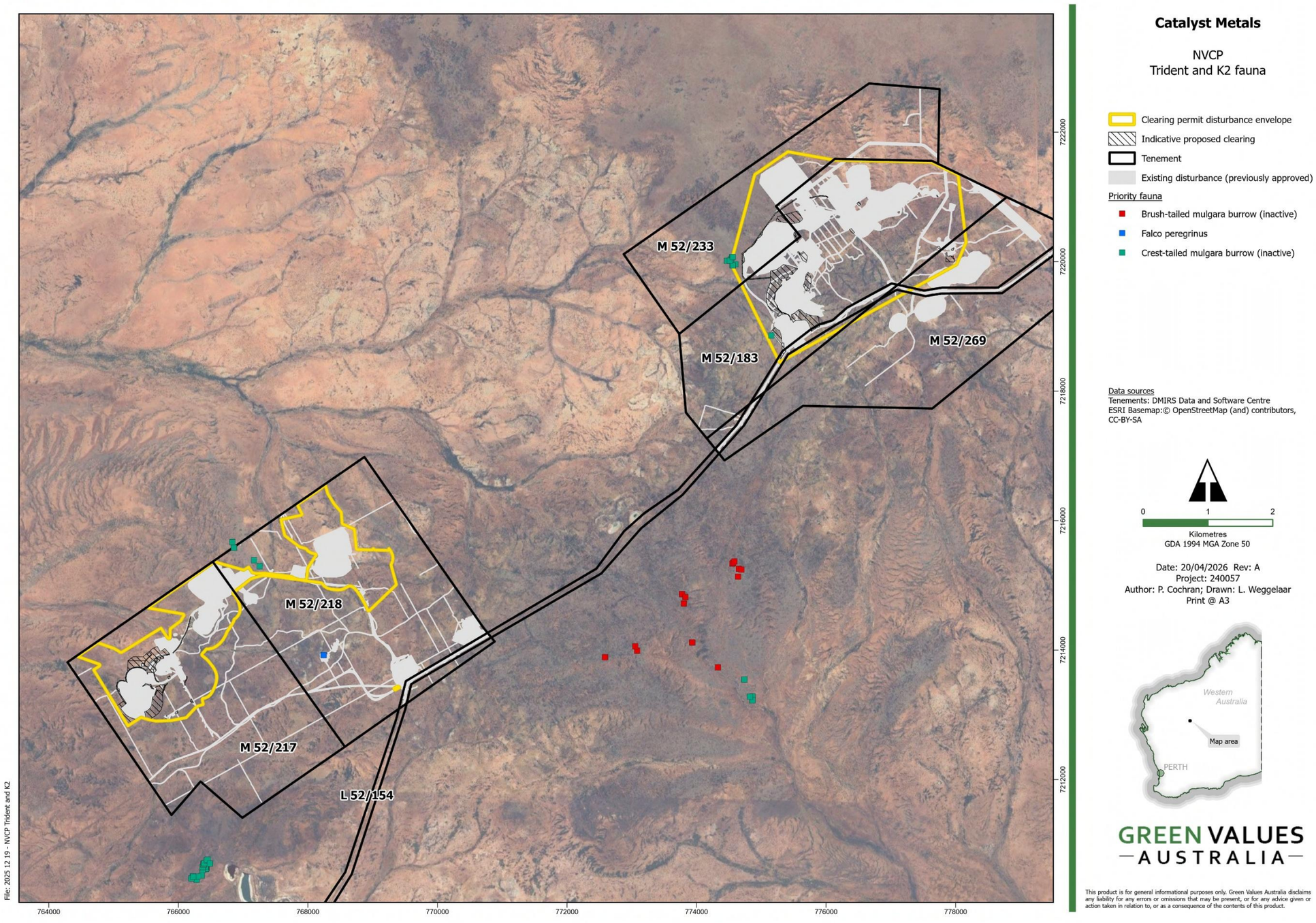


Figure 3-6: Fauna Surveys for the Project

3.7 Subterranean Fauna

Bennelongia Environmental Consultants (Bennelongia) was commissioned to undertake a desktop assessment in 2019 of the four deposits located at the Marymia Group, including the K2 and Trident Project area (APPENDIX 3). Four PECs near Marymia were found to be rich and unique stygal communities in calcrete aquifers. Details are provided in Table 3-3.

Approximately 45 species of stygofauna have been recorded in the wider search area however the known and inferred geographic ranges of the recorded species are highly variable with the five rotifer species having a widespread distribution (Bennelongia, 2019). The other 23 species, such as beetles, syncarids and amphipods which have a smaller geographic range, have a low likelihood of the occurring at the Project, although similar or related species may occur. The remaining six species are higher-order identifications whose ranges cannot be determined due to insufficient taxonomic information.

No targeted sampling for troglofauna has been undertaken in the vicinity of the Project resulting in the absence of troglofauna records in the search area (Bennelongia, 2019).

The most preferred habitat for the stygofauna and potentially troglofauna is the calcrete as well as alluvial and colluvial deposits associate with drainage, valleys and plains providing connectivity within calcretes. As mentioned, the nearest calcrete is 43-56 km from the K2 Project.

Table 3-3: Subterranean Fauna PECs (Bennelongia, 2019)

PEC	Conservation Code	Distance to Project Area (approximately)
Three Rivers calcrete groundwater assemblage types on Gascoyne palaeodrainage on Three Rivers Station.	P1	43-56 km southwest
Three Rivers Plutonic calcrete groundwater assemblage type on Gascoyne palaeodrainage on Three Rivers Station.	P1	48 km south-west
Doolgunna calcrete groundwater assemblage type on Gascoyne palaeodrainage on Doolgunna Station.	P1	58 km southwest

The proposed clearing activities under this NVCP are unlikely to result in any impact to Subterranean Fauna species.

3.8 Short-Range Endemics

Bamford (2019) completed a desktop analysis of Short-Range Endemics (SREs) in 2018 as part of the fauna assessment of the study area (APPENDIX 2). The database results did not return any range-restrictive invertebrates, though this could be from a lack of sampling in the general area. The

landscape of the study areas was not conducive to the presence of SREs, which are more often associated with relictual landscape features and mesic refugia (Bamford, 2019).

One trapdoor spider was collected during the field study and was identified as *Gaius sp*. There were many burrows of adult *Gaius sp*. in the area. This genus is usually widespread, although it was under review at the time of the Report. No past sampling of potential SREs or subterranean invertebrates had occurred (Bamford, 2019).

The proposed disturbance activities under this NVCP are unlikely to result in an impact to SRE species.

3.9 Social Settings

3.9.1 Land Use and Community

The Project is within the Shire of Meekatharra and is within the Marymia Pastoral Station. The Shire is sparsely populated, with an estimated population of 1,200 people. Gold mining is the largest employment industry, followed by beef cattle farming. The nearest residence is the Marymia Homestead, located approximately 45 km northeast of the Project.

Two main industries support the Shire: pastoralism (sheep and cattle grazing) and mining (gold). The Project is accessible from the Great Northern Highway, which is located approximately 40 km west of the activity envelope, and through Plutonic's haul roads. This is a key transport route, linking Perth with the north of WA.

3.9.2 Native Title

The Project lies within the Gingirana Native Title Determination (WCD2017/011) and is managed by the Marputu Aboriginal Corporation (Marputu). Other interests are subject to Order 9 of the Determination, which has been interpreted as the Project not requiring an Indigenous Land Use Agreement (ILUA); however, Catalyst is engaging with the Marputu People throughout the Project development.

3.9.3 Aboriginal Heritage

The Project is located within the Gingirana Native Title Claim, which is registered with the National Native Title Tribunal. According to NOI 4931 and RegID 2909, the following surveys have been completed over the activity envelope:

- Report on an Ethnographic Survey for Aboriginal Sites at 350 Freshwater Project, Three Rivers, by MacIntyre and Dobson in 1992.

- Archaeological survey undertaken by Quartermaine Consultants in 1991, 1992, 1993, 1996 and 2003.
- Ethnographic survey completed by Rory O'Connor in July 2003.

A search of the Department of Planning, Lands, and Heritage (DPLH) Aboriginal Heritage Inquiry System (AHIS) on 2019 April 2024 shows registered Aboriginal heritage sites inside the prescribed premises as detailed in Table 3-4 and displayed for K2 and Trident in **Error! Reference source not found.** and Figure 3-8, respectively.

A Section 18 of *Aboriginal Heritage Act 1972* was approved for disturbance to Minnieritchie 01 in 1995, and Minneritchie 02-11 in 1996 at the Trident Complex by Resolute Resources. Section 18 allowed for subsequent mining activities and ground disturbance. An archaeological survey in 2000 (Quartermine, 2000) identified four archaeological sites along the haul road adjacent to the project site (Figure 3-8). The existing sites within the surveyed areas will not be impacted by the Project.

The K2 (Stage 2) and Trident (Stage 3) Projects proposed activities do not directly impact any registered heritage places, and no new disturbance will impact the registered sites. The activities will utilise existing areas of disturbance as a management measure to minimise any impacts to registered sites (**Error! Reference source not found.**). Engagement with the Marputu Aboriginal Corporation/ Central Desert Native Title Services, who represent the Gingirana People, is ongoing with regards to the Interim Heritage Agreement and Negotiation Protocol, as well as on country surveys.

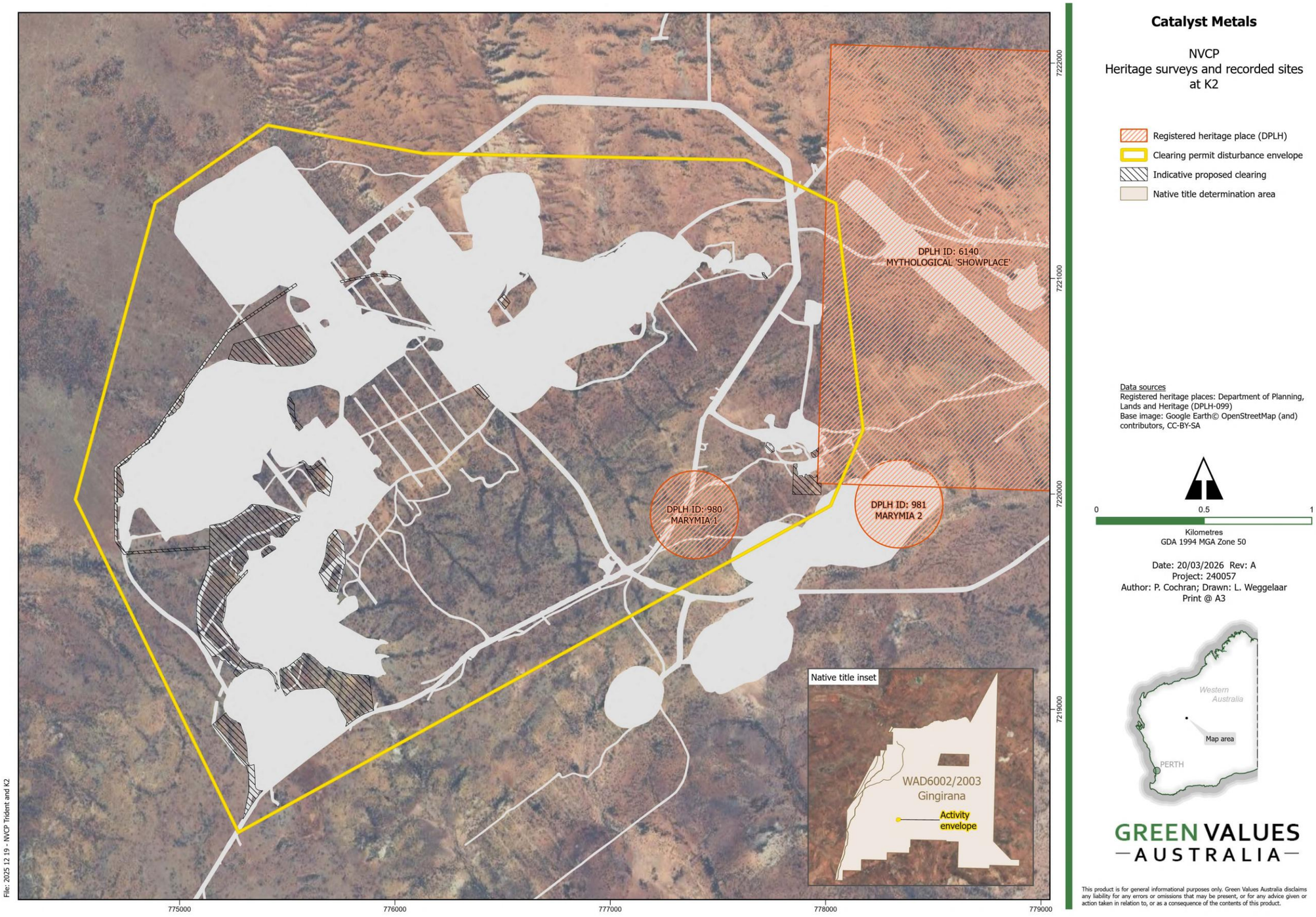
Table 3-4: Registered Aboriginal Heritage Sites

Tenement	Site ID	Name	Type
K2 Tenements			
M52/183	980	MARYMIA 1	Artefacts / Scatter
M52/269	981	MARYMIA 2	Artefacts / Scatter
M52/183, M52/269, M52/478, M52/366	6140	MYTHOLOGICAL 'SHOWPLACE'	Creation / Dreaming Narrative
Trident Complex Tenements			
M52/217	768	MINNIERITCHIE 01	Artefacts / Scatter, Quarry
M52/217	769	MINNIERITCHIE 02	Artefacts / Scatter, Quarry
M52/217	770	MINNIERITCHIE 03	Artefacts / Scatter, Quarry
M52/217	771	MINNIERITCHIE 04	Artefacts / Scatter
M52/217	772	MINNIERITCHIE 05	Artefacts / Scatter
M52/217	773	MINNIERITCHIE 06	Artefacts / Scatter (destroyed)

Tenement	Site ID	Name	Type
M52/217, M52/218	774	MINNIERITCHIE 07	Artefacts / Scatter, Quarry (destroyed)
M52/217, M52/218	775	MINNIERITCHIE 08	Artefacts / Scatter, Quarry
M52/218	776	MINNIERITCHIE 09	Artefacts / Scatter
M52/218	777	MINNIERITCHIE 10	Artefacts / Scatter
M52/218	778	MINNIERITCHIE 11	Artefacts / Scatter
M52/218	779	MINNIERITCHIE 12	Artefacts / Scatter

3.9.4 Non-Aboriginal Heritage

A search of the Heritage Council of Western Australia's State Register of Heritage Places was undertaken on 19 April 2024. No heritage places are registered in the activity envelope.



Catalyst Metals

NVCP
Heritage surveys and recorded sites at K2

- Registered heritage place (DPLH)
- Clearing permit disturbance envelope
- Indicative proposed clearing
- Native title determination area

Data sources
Registered heritage places: Department of Planning, Lands and Heritage (DPLH-099)
Base image: Google Earth© OpenStreetMap (and) contributors, CC-BY-SA

0 0.5 1
Kilometres
GDA 1994 MGA Zone 50

Date: 20/03/2026 Rev: A
Project: 240057
Author: P. Cochran; Drawn: L. Weggelaar
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GREEN VALUES AUSTRALIA

Figure 3-7: Cultural Heritage Sites at K2 Project

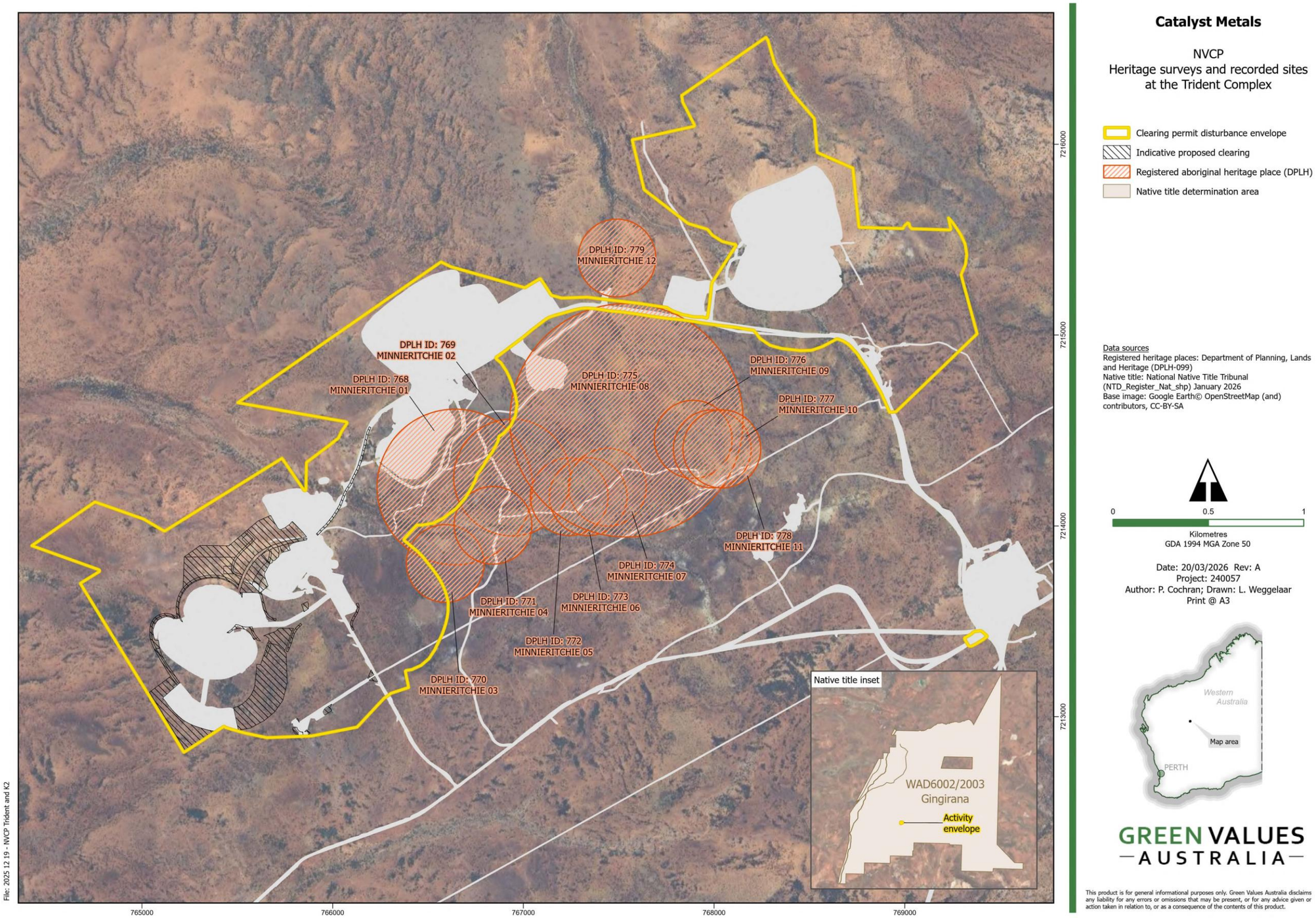

Figure 3-8: Cultural Heritage Sites at the Trident Complex

4 ASSESSMENT AGAINST THE 10 CLEARING PRINCIPLES

4.1 Scale of Proposed Land Clearing

The proposed Purpose Permit Area covers an area of 63.00 ha of native vegetation, which will be cleared. The vegetation and flora survey undertaken by Onshore (2019) covered the majority of the proposed clearing footprint; some areas were not mapped due to vegetation conditions. Approximately 3.83 ha of the proposed disturbance area was not covered by the survey area, and therefore, the vegetation condition was not mapped by Onshore 2019. Of the remaining proposed disturbance area of 59.17 ha, approximately 29.10 ha (49.18%) of vegetation was considered 'Very Good', 18.19 ha (30.74%) was considered 'Good', and 9.09 ha (15.36%) was 'Disturbed'. The proposed clearing will be undertaken within an operational mining area, and therefore, existing disturbance is prevalent.

Figure 2-1 and Figure 2-2 present the proposed Project layout in relation to conservation significant flora and fauna identified. Catalyst has avoided priority flora as far as practical.

4.2 Assessment of 10 Clearing Principles

Clearing applications are to be assessed against 10 principles as outlined in *Schedule 5 of the EP Act*. These principles aim to ensure that all potential impacts resulting from the removal of native vegetation can be assessed in an integrated way and applied to all lands throughout Western Australia. The principles address the four main environmental areas of biodiversity significance, land degradation, conservation estate and ground and surface water quality.

Table 4-1 provides the assessment against the 10 clearing principles.

Table 4-1: Assessment Against the 10 Clearing Principles of Native Vegetation: Clearing of the Project

Clearing Principle	Assessment	Assessed Outcome
Biodiversity Significance		
a) Native vegetation should not be cleared if it comprises a high level of biological diversity.	The vegetation to be cleared is not considered to support a high level of biological diversity. The vegetation communities and fauna habitats are common in the bio-region. No conservation significant fauna was recorded in the proposed Purpose Permit Area. Priority flora has been identified within the Purpose Permit Area; the majority will not be disturbed.	The proposed clearing is unlikely to significantly impact the biodiversity at a local or regional level. Unlikely to be at variance with this principle.
b) Native vegetation should not be cleared if it comprises the whole or part of, or is necessary for the maintenance of, a significant habitat for fauna indigenous to Western Australia.	Three habitat types were identified within the Project footprint, including Acacia shrubland, Mulga over shrubs and spinifex, Drainage lines with Acacia/Mulga thickets and disturbed areas with partial rehabilitation. No conservation-significant species under the EPBC and BC Act were identified within the proposed Purpose Permit Area.	Unlikely to be at variance with this principle.
c) Native vegetation should not be cleared if it includes, or is necessary for the continued existence of, rare flora.	Seven priority flora under the BC Act were recorded within the area, including *Eremophila cf. demissa* (P1), *Eucalyptus semota (P1), Goodenia virgata* (P2), *Calytrix praecipua* (P3), *Eremophila lanata* (P3), *Mairena prosthecochaeta* (P3), *Sauropus sp. woolgorong* (P3), *Sporobolus blakei* (P3); and *Thryptomene sp. Leinster* (P3). No rare flora or threatened flora species protected under state or federal legislation were recorded during the surveys. The project layout was adjusted to ensure that the priority flora species are avoided where possible. Several individuals of *Eremophila lanata* (P3) will be disturbed, which was unavoidable due to the placement of the historical disturbance and currently approved mining activities. This species appeared to be	Unlikely to be at variance with this principle.

Clearing Principle	Assessment	Assessed Outcome
	widespread and recorded around the Trident area. As a P3, the species is poorly known and not in immediate danger of disappearing. All other priority species will be avoided.	
d) Native vegetation should not be cleared if it comprises the whole or a part of, or is necessary for the maintenance of, a PEC/TEC.	The proposed Project will not intersect or impact any PEC/TEC.	Unlikely to be at variance with this 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.	Vegetation of the area is not considered a remnant, with limited clearing in a vastly uncleared environment.	Unlikely to be at variance with this 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.	There are no wetlands or permanent surface water features in the Project area. The minor creeks and drainage lines in the activity envelope are ephemeral and only flow for short periods following heavy rainfall.	Not at Variance with this principle.
Land Degradation		
g) Native vegetation should not be cleared if the clearing of the vegetation is likely to cause appreciable land degradation.	The proposed clearing of 63 ha of native vegetation for the development of the Project is not likely to cause further significant land degradation. The survey area for the Project consists of 'Very Good' (29.10 ha), 'Good' (18.19 ha) and 'Disturbed' (9.09 ha) as delineated by Onshore (2019). Approximately 3.83 ha of the proposed disturbance area was not covered by the survey area and therefore, the vegetation condition was not mapped. The area has existing and historical disturbance from mining operations and therefore the Project is unlikely to cause significant land degradation. The Project looked to avoid natural and undisturbed areas where possible. However, due to the position of the targeted resources, the historical disturbance	Unlikely to be at variance with this principle.

Clearing Principle	Assessment	Assessed Outcome
	and current approved mining activities, alternative placement of the infrastructure was limited. Management measures will be developed and include measures for erosion, weeds, biodiversity loss and rehabilitation.	
Conservation Estate		
h) Native vegetation should not be cleared if the clearing of the vegetation is likely to have an impact on the environmental values of any adjacent or nearby conservation area.	There is no conservation estate in the immediate vicinity.	Not at Variance with this principle.
Ground and Surface Water Quality		
i) Native vegetation should not be cleared if the clearing of the vegetation is likely to cause deterioration in the quality of surface or underground water.	The Marymia Group lies on a drainage divide that separates the headwaters of the westward-flowing Gascoyne River system from those flowing south in the Lake Gregory inland drainage system. No significant watercourses exist in the Marymia Group. Surface water and groundwater resources are unlikely to be significantly impacted by the Project. Surface water management measures will be implemented where required to divert the water flow away from mining infrastructure and ensure no contact water is released into the environment.	Not at Variance with this principle.
j) Native vegetation should not be cleared if clearing the vegetation is likely to cause, or exacerbate, the incidence of flooding.	The proposed Purpose Permit Area is not located within any major drainage lines or watercourses. Therefore, clearing is not expected to alter the hydrological regime of the area, leading to an increase in the frequency or intensity of flooding. Diversion channels have been included in the Trident site layout where required to manage any surface water or flooding risks. A Surface Water Assessment and floodline modelling is being undertaken to ensure that the final Project infrastructure layout is not in the direct line of watercourses or potential flooding events.	Not at Variance with this principle.

5 REHABILITATION

Rehabilitation is the return of disturbed land to a safe, stable, productive, non-polluting and self-sustaining condition in consideration of beneficial uses of the land. Appropriate rehabilitation will ensure that the long-term impacts of mining in the area are minimised. Rehabilitation will be implemented progressively and in conjunction with Catalyst's Plutonic. Rehabilitation of disturbed areas will generally involve:

- Design of landforms to produce safe and stable slopes.
- Design of landforms to manage water, including the construction of water management strategies.
- If required and subject to available material, armouring of final surfaces with cover material to increase surface stability.
- Replacement of available topsoil and vegetation.
- Ripping along the contour to break soil compaction and increase water infiltration ability.
- Seeding/planting with local provenance native species and fertilising as required.
- Monitoring to measure progress against meeting closure criteria.

Rehabilitation, closure monitoring and maintenance programs will be undertaken as described in the Mine Development and Closure Plan from 2020 and which will be updated in 2027 with the objectives of ensuring the success of rehabilitation works, identifying the need for any maintenance works and demonstrating achievement of completion criteria.

6 STAKEHOLDER ENGAGEMENT

A register of the Stakeholder Engagement associated with Trident and K2 projects has been developed and maintained as an ongoing stakeholder engagement management tool. The key engagement is presented in Table 6-1 below.

Table 6-1: Key Stakeholder for Trident and K2

Date	Relevant Project	Stakeholders	Consultation Type	Engagement Topic	Key Discussion Points and Outcome
31-May-23	Marymia	Dept. Of Water and Environmental Regulation (DWER)	Face-to-Face Meeting	Project Update	Meeting to discuss the Marymia project, including History, ownership, resource and exploration potential. Exploration decline -Marwest Project to Trident Project, future approvals pathways.
20-Jul-23	Marymia	Dept of Energy, Mines, Industry Regulation and Safety (DEMIRS)	Face to Face Meeting	Project Update	Meeting to discuss the Marymia project, including: History, ownership, resource and exploration potential. Exploration Decline - Marwest Project to Trident Project. Trident Underground Mining. Approvals pathways and timeframes.
2-Aug-23	Trident	Central Desert Native Title Services (Gingirana - Marputu AC)	E-mail	Mine Planning, Operations &/or Infrastructure	Letter sent from Catalyst to the Marputu Corporation seeking a meeting at their earliest convenience to discuss proposed mine plans for Trident. Multiple email correspondence regarding meeting arrangements and Marputu Corporation availability. Catalyst was advised that the earliest availability for a meeting was November 2023.
18-Jan-24	Marymia (M52/217, M52/218)	Marymia Station Pastoral Leaseholder	Face to Face Meeting	Project Update	Meeting to discuss the Marymia Project including: Definitive Feasibility Study (DFS) status and Project status. Upcoming drilling for potential open-pit excavation, as well as de-risking the underground mine plan. Various permits and approvals are still pending for the Project. Catalyst would look to dewater the underground to the Mareast open pit and/or other localised pits. Catalyst is looking to drill an additional bore within the area to supplement the existing three. Catalyst has completed a Mine Closure Plan (MCP) for the Project and is looking to rehabilitate the area back to its original pastoral land use. Waste landforms would be rehabilitated with native vegetation, though, where possible, vegetation types that were not favourable to cattle grazing. Pits would have abandonment bunds around to avoid access into the pit areas. Catalyst discussed increased traffic along the main haulage way as the project advances into development, with eventual 100t road trains carting ore from the mine to Plutonic Mill
7-Mar-24	Catalyst General Trident	Central Desert Native Title Services (Gingirana - Marputu AC)	E-mail	Negotiation / Heritage Protocol	Meeting organisation with Marputu Board for March 2024 Introduction – Catalyst Metals and acquisition of Vango Mining, Dampier Plutonic, Superior Gold and Billabong Gold and any other relevant subsidiary Project update – previous 6 months and next 6 months Rebuilding the relationship and future negotiations Provision of a presentation by Catalyst for the meeting 19/3/24 (CD) Email - provision of meeting presentation and info re Trident registered sites on M52/217 and M52/218
22-Mar-24	Catalyst General Trident	Marputu Aboriginal Corporation	Face to Face Meeting	Project Update	On 27 February 2024, Marputu replied with an invitation for Catalyst to attend a meeting in Newman on 22 March 2024. Two CYL representatives attended the meeting, where they ran through the current development plan for Trident – including surface requirements, dewatering activities, and life-of-mine plans. They also mentioned Catalyst's desire to develop the broader Plutonic Belt – opening historical mining areas and undertaking exploration drilling in prospective areas.
10-Apr-24	K2	Dept. Of Water and Environmental Regulation (DWER)	Face to Face Meeting	Water	Meeting to present the dewatering of K2 to the department. Prescribed Premises for K2 are separate to Trident. Catalyst to include details of monitoring bores around the K1 pit, which contains some tailings. Discussion around submission timing and assessment timeframes.
10-Apr-24	K2	Dept. of Energy, Mines, Industry Regulation and Safety (DEMIRS)	Face to Face Meeting	Environment	Meeting to present a strategy for an NVCP submission to the department for the K2 Project at Marymia. Discussion of the biological survey effort and the potential for Night Parrot Habitat. Catalyst refining disturbance areas and seeking additional opportunities to minimise. Discussion around submission timing and assessment timeframes.

Date	Relevant Project	Stakeholders	Consultation Type	Engagement Topic	Key Discussion Points and Outcome
10-May-24	Marymia	Marymia Station Pastoral Leaseholder	Telephone Call	Project Update	Phone meeting between Catalyst and the Marymia Station Manager to discuss project development, dewatering, exploration and bore usage. Matters discussed: K1/K2 dewatering license is being established and the proposed dewatering of K2 into K1 pit. Trident West open pit potential and the plan to dewater this area (pit and boreholes) into the neighbouring Mareast open pit. General resource and exploration drilling along the belt. Marymia Station desires to utilise existing bores on L52/52 and L52/48 for ad hoc pastoral requirements.
9-Sep-24	Trident	Central Desert Native Title Services (Gingirana - Marputu AC)	E-mail	Tenement/Pastoral Lease Access	10/5/24 Acknowledgement of CDNTS e-mail 7/5/24. CYL to revert to Marputu re Negotiation Protocol. ConfirmationM52/782 & M52/71 not included in Trident 21/6/24 Acknowledgement of CDNTS e-mail request 25/6/24 Provision of marked-up Negotiation Protocol for Marputu AC Board consideration. Sharing CYL's position that heritage protocol wasn't discussed at the March meeting and the purpose of the negotiation protocol is to guide development of a heritage agreement. Advising CYL to prepare correspondence to the Marputu AC board. 11/7/24 Acknowledgement of meeting request and unavailability due to leave. Advice on alternate dates 27/8/24 Provision of marked-up negotiation protocol from face to face meeting 29/7/24. Correspondence to Marputu Board re negotiation protocol, heritage protocol and HIS submission. Request to meet with the Board to provide project update
12-Sep-24	Marymia	Dept. Of Water and Environmental Regulation (DWER)	Face to Face Meeting	Mine Planning, Operations &/or Infrastructure	Meeting with DWER to discuss planned developments at Marymia, including Trident Underground, Trident West, and K2. Discussion of planned developments at Marymia, including Trident Underground (approved via W6834) and K2 (under assessment). Discussed dewatering of Trident West and Trident Underground. Updated hydrogeology study indicates less water than expected. Works Approval does not have abstraction points for Trident West, but discharge will be the same. DWER requested that the amendment be submitted. This only needs to cover the proposed changes. The Trident Underground Works Approval appeal is proceeding through the process.
25-Nov-24	Trident Plutonic General	Central Desert Native Title Services (Gingirana - Marputu AC)	E-mail	Project Update	Update to Marputu Board on Plutonic Gold Belt activities, including MP and MCP for Trident (M52/218 & M52/217 approved on 22/11/24). Catalyst attended the Appeals Convenor on 21/11/24 to discuss Marputu's Trident Dewatering enquiries. Responses to enquiries attached to e-mail CYL has applied for a similar dewatering licence on M52/183 Offer to meet with Marputu's consultants to discuss further Reiterate Catalysts commitment to heritage protection and hard and soft controls that are in place.
23-Dec-24	Trident	Central Desert Native Title Services (Gingirana - Marputu AC)	E-mail	Project Update	Advice regarding submitting amendment to approved Trident (M52/218 and M52/127) mine proposal (MP) and mining closure plan (MCP). Invite to discuss open pit with Marputu. 8/1/25 - Email Acknowledgement receipt of e-mail 23/12/24 and holiday period restricting instructions being received from Marputu. Request for copy of Trident MP and MCP.
8-Jan-25	Trident	Marputu Aboriginal Corporation	E-mail	Project Update	Advice reinforcing the opportunity to discuss Trident open pit MP Approval amendment with Marputu, and that MP has not been submitted as seeking the opportunity to meet with the group and/or their environmental consultants. Note of Marputu's concerns with appeals convenor on K2 dewatering licence and Catalyst preference to engage with Marputu. 8/1/25 - MP forwarded to CDNTS as per request
13-Jan-25	Trident	Central Desert Native Title Services (Gingirana - Marputu AC)	E-mail	Mine Planning, Operations &/or Infrastructure	Provision of Trident Open Pit Mining Proposal as per CDNTS request (8/1/2025)

Date	Relevant Project	Stakeholders	Consultation Type	Engagement Topic	Key Discussion Points and Outcome
15-Jan-25	Trident	Central Desert Native Title Services (Gingirana - Marputu AC)	E-mail	Project Update	Response to CDNTS correspondence (14/1/25) re Trident MP submission to DMIRS. Confirmation that the MP has been submitted. Sharing that CYL considers a mining area that avoids existing heritage sites and tries to limit the footprint to previously disturbed areas from historical surface drilling and mining disturbance. Invite to Marputu and/or enviro consultants to pre-proposed date - proposed date 22/1/25.
31-Jan-25	K2	Central Desert Native Title Services (CDNTS) (Gingirana -Marputu AC)	E-mail	Water	Project updates advice to CDNTS of the approved dewatering licence at K2 and the intention to commence works at the location in the coming months. Invite Marputu to the meeting to discuss K2 plans - suggested mid-Feb 2025
1-Feb-25	Marymia	Central Desert Native Title Services (Gingirana - Marputu AC)	E-mail	Project Update	Catalyst project updates for Trident/K2, Catalyst requests meeting with environmental advisors (no response)
1-Mar-25	Catalyst General K2, Trident	Central Desert Native Title Services (Gingirana - Marputu AC)	E-mail	Project Update	Catalyst invited Marputu to Plutonic. Catalyst provided project updates for Trident/K2, Catalyst requests a meeting with environmental advisors.
20-Mar-25	Trident	Central Desert Native Title Services (Gingirana - Marputu AC)	E-mail	Project Update	Project update inc. Trident Open Pit MP submitted Jan 2025. Request for information (RFI) received and Catalyst is working through responses Pricing requested from contractors to mine Trident West Open Pit Dewatering activities at K2 to commence in April 2025 Invite to discuss activities with Marputu.
4-Aug-25	Catalyst General K1	Central Desert Native Title Services (Gingirana -Marputu AC)	E-mail	Water Heritage Agreement	As part of the Appeals Convenor review on W6949/2024/1 Works Approval, Catalyst is sharing available water sampling results as a courtesy to Marputu. Sampling results include K1 discharge as well as data on the network of monitoring bores surrounding the pit void Advice that dewatering activities commenced in May, with successful commissioning and testing of the system and expected that a significant portion of the pit to be dewatered by August. Marputu was invited to discuss a plan and the results in upcoming annual meeting.
30-Sep-25	K2 Old Highway Cinnamon	Department of Mines, Petroleum and Exploration (DMPE)	Face-to-Face Meeting	Mine Planning, Operations &/or Infrastructure	Meeting with DMPE to discuss the approach to the K2, Old Highway and Cinnamon Projects MDCP. K2 - Reestablishing some of the existing infrastructure as part of stage 2, is it to be presented as an amendment to the Trident MDCP? Old Highway - new project introduction. Cinnamon - new project presentation. K2 to be presented as its own MDCP, including the new activities and infrastructure changes. Depending on how comfortable Catalyst is with the existing approvals for the infrastructure, or to present updated designs in the new MDCP. To keep any expansion or change of activity as the overall layout of the infrastructure, e.g. an expansion on the waste dump will need to highlight the whole dump. Aiming to have the activities as one document. DMPE will do the transition of the existing approvals. Ongoing underground mining at K2 is under the approved proposals and can be excluded. K2 does not require an NVCP if clearing of 10 ha per financial year per tenement is undertaken. Old Highway - currently in consultations with the Jidi Jidi and the Yungunga Nya Aboriginal groups. Underground has been excluded from the MDCP as it will be undertaken in 4 years' time. One MDCP per MEG at any time, and one Approval statement per MEG within one connecting activity envelope. Presented Cinnamon and the proposed project. K2 and Cinnamon will be part of one MEG. Old Highway will be a new MEG. Surveys are required to be undertaken over the whole activity envelope proposed; otherwise, the activity envelope to be reduced.

Date	Relevant Project	Stakeholders	Consultation Type	Engagement Topic	Key Discussion Points and Outcome
15-Oct-25	K2	Department of Mines, Petroleum and Exploration (DMPE)	Telephone Call	Mine Planning, Operations &/or Infrastructure	K2 Project and Hermes MDCP approach - does the whole activity area need to be included when there is a change to the approved activity? Do existing disturbances already approved need to be included? The whole activity area needs to be included when there is a new proposed activity e.g. a proposed portal; the entire open pit needs to be included. Previously approved areas that will not be involved in the project do not need to be added.
Dec-2025	Catalyst General K2	Central Desert Native Title Services (Gingirana -Marputu AC)	Email	Water samples	Catalyst sent water sampling data to Marputu representatives and invited them to a session with the project team if they wished to discuss the results.
12-Feb-26	Marymia	(Gingirana -Marputu AC)	Email	Project Update	Presenting the Mining Development and Closure Proposal (MDCP) to Marputu, inviting them to review and provide any feedback or queries by the 12th of March. The MDCP is under review by DMPE, any comments provided can be added in new revision.
11-Mar-26	Marymia	Central Desert Native Title Services	Email	Project Update	Marputu Lawyer respond with a letter that does not provide any feedback on the MDCP proposal. The letter indicated that Marputu alleges a lack of engagement by Catalyst and other concerns regarding cultural heritage site disturbance, as well as environmental management and other concerns.

7 CONCLUSION

Catalyst intends to expand its operations at the Trident and K2 Project into the next stages of mining. The expansion required an additional 63 ha of native vegetation clearance within a proposed 1314.96 ha Purpose Permit Area. An existing NVCP was approved for the Trident Complex (CPS 10355/1) for 53.4 hectares (ha), this new NVCP application does not supersede the existing application.

The proposed clearing was assessed against the 10 clearing principles and is unlikely to be at variance with the EP Act Schedule 5 clearing principles. Several priority flora were identified within the Purpose Permit Area. The Project will result in the disturbance of several individuals of *Eremophila lanata* (P3), which was unavoidable due to the placement of the historical disturbance and currently approved mining activities. Other identified priority flora species will be avoided by the proposed clearing. No fauna species of conservation concern were identified within the Project area. The Project is unlikely to cause significant land degradation as the survey area consists of 'Very Good' (29.10 ha), 'Good' (18.19 ha) and 'Disturbed' (9.09 ha) as delineated by Onshore (2019). Approximately 3.83 ha of the proposed disturbance area was not covered by the survey area by Bamford (2019) and therefore, the vegetation condition was not mapped. The Project is not considered to have a significant impact due to the existing disturbance in the area from mining activities.

Catalyst is committed to implementing management measures and rehabilitation to minimise the impacts on native vegetation.

8 REFERENCES

Australian and New Zealand Environment and Conservation Council (ANZECC). (2000). *National Water Quality Management Strategy, Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand.

Bamford Consulting Ecologists. (2019). *Marymia Project Fauna Assessment of exploration areas*. Prepared for Vango Mining Pty Ltd.

Bennelongia Environmental Consultants (Bennelongia). (2019) *Marymia Gold Project: Desktop Assessment of Subterranean Fauna Values*.

Bureau of Meteorology (BoM), (2025). *Climate statistics for Australian locations: Perth Metro*. [online] Available at: http://www.bom.gov.au/climate/averages/tables/cw_009225.shtml [Accessed 19 Aug. 2025].

Carrick Consulting (WA) Pty Ltd. (2025). *Plutonic Gold Belt Project – High Level Surface Assessment Min-West Region, Western Australia*. Unpublished.

Environmental Protection Authority (EPA), (2016). *Technical Guidance - Flora and Vegetation Surveys for Environmental Impact Assessment, EPA, Western Australia*. Available from: http://www.epa.wa.gov.au/policies- guidance/technical-guidance-flora-and-vegetation-surveys-environmental-impact-assessment.

MBS Environmental. (2019). *Marymia Plutonic Dome Gold Project Baseline Soils and Landform Assessment*. Prepared for Vango Mining Ltd.

Onshore Environmental. (2019). *Marymia Gold Project: Detailed Flora and Vegetation Survey*. Prepared for Vango Mining.

Rockwater Pty Ltd. (2019). *Plutonic Dome Gold Project - Hydrology and Surface Water Assessment*.

Rockwater. (2024). *Dewatering Assessment for the Trident Pit*. Prepared for Catalyst Metals Limited.

Vango Mining Ltd (Vango). (2020). *Mine Closure Plan; Marymia Gold Mine – Plutonic Dome*.

APPENDIX 1. VEGETATION AND FLORA ASSESSMENT (Onshore, 2019)

APPENDIX 2. FAUNA ASSESSMENT (Bamford, 2019)

APPENDIX 3. SUBTERRANEAN FAUNA DESKTOP ASSESSMENT (Bennelongia, 2019).

Marymia Gold Project

Detailed Flora and Vegetation Survey

Prepared for Vango Mining
July 2019

Document Status						
Rev No.	Authors	Reviewer/s	Date	Approved for Issue		
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1	J.Waters, J. Bull	D. Brearley	24/07/19	D. Brearley	G. Povey	30/07/19

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EXECUTIVE SUMMARY

Onshore Environmental Consultants Pty Ltd (Onshore Environmental) was commissioned by Vango Mining Limited (Vango) to undertake a two season detailed flora and vegetation survey covering nine areas within the Marymia Project tenements (hereafter referred to as the study area):

- K2 Prospect;
- Apex Prospect;
- Cinnamon Prospect;
- Trident Prospect;
- Mar-east Prospect;
- Mill Area Prospect;
- Wedgetail Prospect;
- Mar-west Prospect; and
- Tails Dam Area.

The study area is situated 760 km northeast of Perth, 180 km to the northeast of Meekatharra, and 200 km south of Newman. The first season field survey was conducted between the 16th and 20th of November 2018 under relatively poor seasonal conditions. A follow-up second season survey was conducted between the 5th and 10th May 2019, also under poor seasonal conditions. Field work was undertaken by two Principal Botanists, Dr Darren Brearley and Dr Jerome Bull and Senior Botanist Ms Jessica Waters.

A total of 116 quadrats were assessed within the study area, including: 10 quadrats at Apex, 11 quadrats at Cinnamon, 16 quadrats at K2, 7 quadrats at Mar-West, 4 quadrats at Mar-east, 6 quadrats at the Mill Area, 14 quatrats at the Tailings Dam, 15 quadrats at the Tailings Pipeline, 26 quadrats at Trident and 7 quadrats at Wedgetail.

A total of 209 plant taxa (including varieties and subspecies) from 35 families and 89 genera were recorded from the study area. Species representation was greatest among the Fabaceae, Poaceae, Scrophulariaceae, Chenopodiaceae and Malvaceae families. The most speciose genus was *Acacia* (30 taxa), followed by *Eremophila* (21 taxa), *Senna* (11 taxa), *Maireana* (8 taxa), *Sida*, *Hibiscus* and *Ptilotus* (7 taxa each).

There were no plant taxa gazetted as Threatened Flora pursuant to subsection (2) of section 23F of the *Wildlife Conservation Act 1950* (WC Act), or listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) recorded from the study area.

A total of nine Priority listed flora were recorded from the study area; *Eremophila* cf. *demissa* (Priority 1), *Goodenia virgata* (Priority 2), *Calytrix praecipua* (Priority 3); *Eremophila lanata* (Priority 3), *Hemigenia tysonii* (Priority 3), *Maireana prosthecochaeta* (Priority 3), *Sauropus* sp. Woolgorong (M. Officer s.n. 10/8/94) (Priority 3), *Sporobolus blakei* (Priority 3) and *Thryptomene* sp. Leinster (B.J. Lepschi & L.A. Craven 4362) (Priority 3). An additional Priority flora species, *Eucalyptus semota* (Priority 1) was recorded just outside the boundary of the study area. A single taxa recorded from the study area is considered a range extension; *Hibiscus brachychlaenus.*

Two introduced species were recorded from the study area; **Bidens bipinnata* (Beggar's Ticks) and **Portulaca pilosa.* Neither of these taxa are listed as Declared Pests under the *Biosecurity and Agriculture Management Act 2007* (BAM Act).

A total of 32 vegetation associations were recorded within the project area. Vegetation was classified into 15 broad floristic formations on the basis of dominant vegetation stratum. None of the vegetation associations are aligned with Commonwealth or State listed Threatened Ecological Communities (TECs) or Priority Ecological Communities (PECs).

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1.0 INTRODUCTION

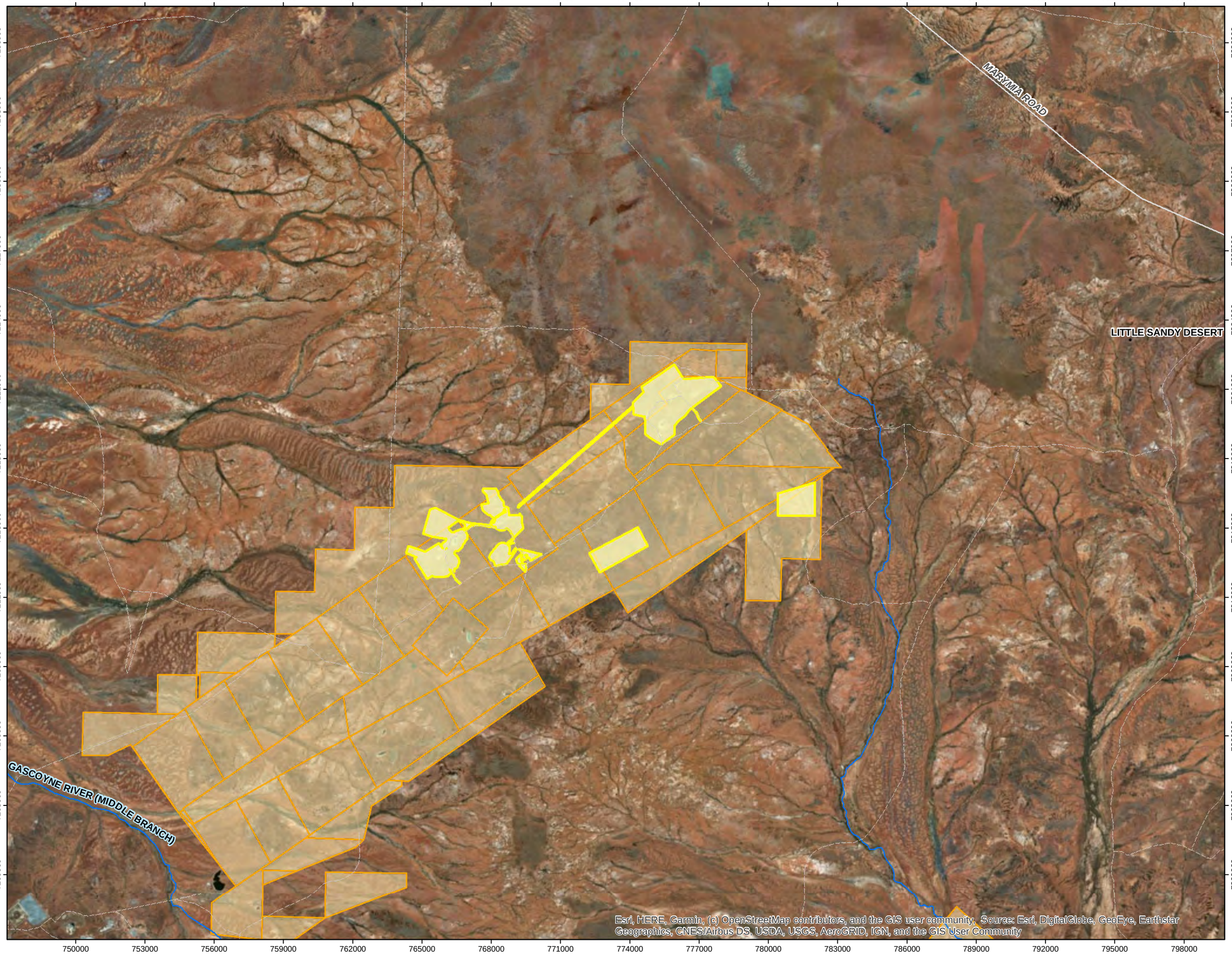
1.1 Preamble

Onshore Environmental was commissioned by Vango Mining Limited WAIO to undertake a detailed two season flora and vegetation survey within the Marymia project area, covering eight prospects and a proposed tails dam. The study area is located 760 km northeast of Perth, 180 km to the northeast of Meekatharra, and 200 km south of Newman. The Project is a brownfields site that was mined during the 1980s, 1990s and 2000s, with numerous open pits and other mine disturbance areas occurring within the Project tenure. The Project has been on care and maintenance for over ten years.

1.2 Previous Biological Surveys

There are at least four flora and vegetation surveys that have previously been completed in close proximity of the study area (within a 25 km radius):

- Marymia Hill Gold Project Notice of Intent: Biological Assessment Survey (Ecologia 1991);
- Outline for Biological and Environmental Components of a Notice of Intent – Apollo Deposit (Onshore Environmental Consultants 2002);
- Outline for Biological and Environmental Components of a Notice of Intent – Mar-east Deposit – Plutonic Gold Mine (Onshore Environmental Consultants 2003); and
- Outline for Biological and Environmental Components of a Notice of Intent – K2 Deposit – Plutonic Gold Mine (Onshore Environmental Consultants 2003).



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ONSHORE ENVIRONMENTAL

VANGO

Marymia

Survey Location

Legend

- Survey Areas
- Vango Tenure

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GRIFFIN SPATIAL & MAPPING

1.3 Climate

The climate of the Gascoyne is arid, with hot summers extending from October to April and mild winters from May to September. The climate is dry, and rainfall is variable and unreliable. Winter rainfall is dominant in the west and summer rainfall in the east.

Annual average rainfall for the nearest long term weather station at Three Rivers is 234 mm and occurs predominantly in summer (Bureau of Meteorology, 2019). Average maximum summer temperatures are typically between 37°C to 39°C, and winter maximum temperatures are between 21°C and 23°C. The prevailing wind direction for Three Rivers is east (Bureau of Meteorology 2019).

Rainfall at the Three Rivers station for 2018 was above average with a total of 288.4 mm recorded, compared to the average of 234 mm. However, the majority of this rainfall fell in the summer with over 100 mm recorded in February. Seasonal conditions at the time of the first season survey in November 2018 were poor. It is noted that rainfall is often sporadic throughout the area and that Three Rivers is located 60km west of the study, hence it may not accurately represent conditions at the project area.

Monthly rainfall totals for December 2018 to April 2019 were all below the long term average, with less than 50mm recorded across the 5 months between the two surveys. Hence, seasonal conditions at the time of the second season survey were very poor.

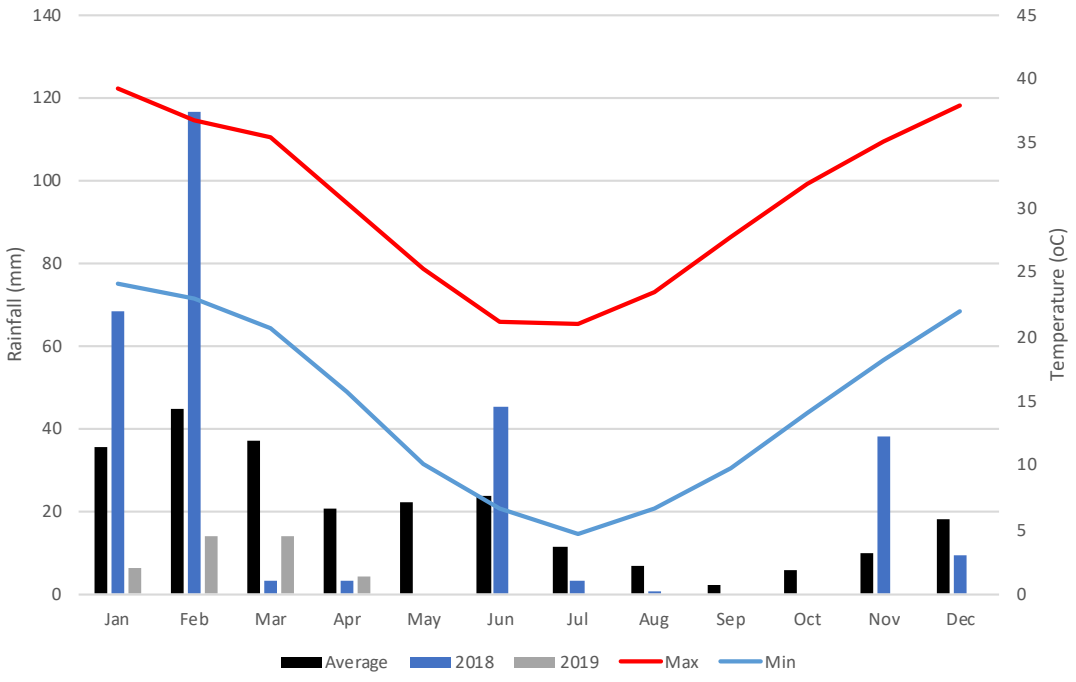

Figure 2 **Climatic data recorded from Three Springs, with long term monthly rainfall compared against monthly rainfall for 2018 and January-April 2019 (BoM 2019).**

1.4 Biogeographic Regions

The Interim Biogeographic Regionalisation for Australia (IBRA7) divides Australia into 89 bioregions and 419 subregions based on climate, geology, landform, native vegetation and species information (Department of the Environment and Energy [DoEE] 2018). The study area lies within the Gascoyne bioregion and the Augustus subregion (GAS3).

The Augustus subregion has an area 10,687,739 ha. It is described as low rugged ranges of Proterozoic sedimentary and granite ranges interspersed with broad flat valleys. The subregion includes the Narryera Complex and Bryah Basin of the Proterozoic Capricorn Orogen (on the northern margin of the Yilgarn Craton), as well as the Archaean Marymia and Sylvania Inliers. The main drainage in the subregion is to the Gascoyne River System, however the area also contains the headwaters of the Ashburton and Fortescue Rivers. Extensive areas of alluvial valley-fill deposits occur within this subregion. The vegetation on rises consists of Mulga woodland and *Triodia* on shallow stony loams. The hardpan plains of the subregion are dominated by Mulga parkland with shallow earthy loams (Desmond *et al.* 2001).

1.5 Existing Land Use

Land tenure in the Gascoyne consists mainly of native pasture grazing with areas of UCL and Crown Reserves, Aboriginal reserves and conservation lands. The Collier Range National Park is the nearest reserve, situated approximately 70 km to the north of the project area.

1.6 Soils and Landforms

Tille (2006) collated the most recent and detailed mapping of Western Australia's Rangelands and Arid interior into a hierarchy of soil-landscape mapping units. The study area falls within the Ashburton Province, an area that occupies approximately 188,375 km^2 (7.5% of Western Australia) and is located in the southern Pilbara/Northern Gascoyne. Soils and landforms of the Ashburton Province are described as "Hills and ranges (with stony plains and hardpan wash plains) on the sedimentary and granitic rocks of the Capricorn Orogen. Stony soils with Red loamy earths, Red shallow loams and Red-brown hardpan shallow loams (and some Red deep sands, Red/brown non-cracking clays and Red deep sandy duplexes) (Tille 2006). The Ashburton Province is divided into nine soil-landscape zones:

- Bulloo Plains and Hills Zone;
- South Bangemall Hills Zone;
- Frere Uplands Zone;
- Paroo Uplands Zone;
- Yaragner Hills and Plains Zone;
- Gascoyne Valley Zone;
- Stuart Plains and Hills Zone;
- Ashburton Valley Zone; and
- North Bangemall Hills Zone.

The study area lies within the Paroo Uplands Zone, which covers a total area of 21,175 km^2. Landforms within this zone include hills, hardpan wash plains and stony plains with some sandplains. Soils in the area are described as red-brown hardpan shallow loams

with red loamy earths and stony soils and some red shallow sands, red shallow loams, red sandy earths and red deep sands. The vegetation is predominantly Mulga shrublands with some spinifex, eucalypts and halophytic shrubs.

1.7 Geology

The Ashburton Provence lies on several sedimentary basins that separate the Yilgarn and Pilbara Cratons. The area consists of the sandstone, shales and conglomerate of the Ashburton Basins (Tille 2006).

The study area lies on the Peak Hill sheet of the Geological Survey of Western Australia. The following geological features occur in the area (Gee 1986):

- Qs: Reddish eolian sand;
- Qc: Colluvial gravel on scree slopes and sheet wash plains;
- Qa: Alluvial sand and silt in drainages;
- Tl: Tertiary laterite;
- Au: Chlorite-tremolite schist after ultramarfic volcanics;
- Ag: Biotite adamellite;
- Ab: Metamorphosed tholeiitic basalt; and
- As: Pelitic metasedimentry rocks, quartzite, banded iron-formation.

1.8 Regional Vegetation

The study area is located within the Ashburton Valley Botanical District, within the Gascoyne IBRA region, which is part of the Eremaean Province (Beard 1990).

The original vegetation mapping was undertaken by Beard (1975) and refined by Shepherd *et al.* (2002). There were three vegetation associations described from the study area (Figure 3). While the Pre-European extent for each vegetation association is close to 100 percent, less than 10 percent of each association occurs within formal or informal reserves (Table 1).

Table 1 Pre-European extent of vegetation associations occurring within the study area (Shepherd *et al*. 2002).

Vegetation Association	Description	Pre-Euro. Extent Remaining (ha)	Remaining area (ha) in IUCN Class I-IV Reserves	% remaining Other Reserves	% remaining DBCA Managed PL
Carnegie Salient - 18	Low woodland; mulga (*Acacia aneura*)	99.9	2.0	0.3	2.5
Gascoyne Ranges/ Carnegie Salient, 29	Sparse low woodland; mulga, discontinuous in scattered groups	100	0.3	0	2.4
Gascoyne Ranges -111	Hummock grasslands, shrub steppe; *Eucalyptus gamophylla* over hard spinifex	100	5.8	0.6	0

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7227000 7224000 7221000 7218000 7215000 7212000 7209000

ONSHORE ENVIRONMENTAL

VANGO

MARYMIA PROJECT

Beard (1975) vegetation complexes within the study area

Legend

- Study Area

Pre-European Vegetation (Beard 1975)

- CARNEGIE SALIENT, 18
- CARNEGIE SALIENT, 29
- GASCOYNE RANGES, 111
- GASCOYNE RANGES, 18
- GASCOYNE RANGES, 29

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GRIFFIN SPATIAL & MAPPING

1.9 Land Systems

The Department of Agriculture (now the Department of Agriculture and Food) has conducted a number of inventory and condition surveys across the rangelands of Western Australia, using an integrated survey method involving the land system approach to rangeland description evaluation. The primary objective of the surveys was to provide comprehensive descriptions and mapping of the biophysical resources of the region, as well as an evaluation on the condition of soils and vegetation. The mapping is based on patterns in topography, soils and vegetation.

A total of 51 land systems were defined in the Gascoyne catchment at a scale of 1: 250,000 (Wilcock and McKinnon 1974). There were 3 land systems represented within the study area (Table 2, Figure 4).

Table 2 Land systems occurring within the study area (descriptions from Wilcock and McKinnon 1974).

Land System	Description
Durlacher	Occasional sharp quartz ridges and strike residuals with stony plains and wide drainage sections.
Divide	Sandplains with minor dunes. Gently undulating terrain with predominantly internal drainage.
Thomas	Laterised breakaways and mesas which form a backdrop up to 50 ft high to lower plains and the low rounded rocky hills up to 100 ft high.

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7225000 7220000 7215000 7210000

RGEDIV
RGETHO
RGEDUR
RGETHR
RGEDUR
RGEFRE
RGEDUR
RGEFRE
RGETHO
RGETHR
RGEDUR

VANGO

MARYMIA PROJECT

Land systems occurring within the study area (descriptions from Wilcock and McKinnon 1974)

Legend

- Study Area

Land Systems

- RGEDIV, Divide Land System
- RGEDUR, Durlacher Land System
- RGEFRE, Frederick Land System
- RGETHO, Thomas Land System
- RGETHR, Three Rivers Land System
- No Data

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2.0 METHODOLOGY

2.1 Guidance and Legalisation

2.1.1 Guidance Documents

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

- Statement of Environmental Principles, Factors and Objectives (EPA 2018);
- Environmental Factor Guideline Flora and Vegetation (EPA 2016a); and
- Technical Guidance Flora and Vegetation Surveys for Environmental Impact Assessment (EPA 2016b).

2.1.2 Legalisation and Assessment of Conservation Significance

The conservation significance of flora and ecological communities are classified at an International, Commonwealth, State and Local level on the basis of various Acts and Agreements, including:

International Level:

- IUCN: The IUCN 'Red List' lists species at risk under nine categories (status codes) (Appendix 1).

Commonwealth Level:

- *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act): The DoEE lists Threatened flora and ecological communities, which are determined by the Threatened Species Scientific Committee according to criteria set out in the Act. The Act lists flora that are considered to be of conservation significance under one of six categories (Appendix 2).

State Level:

- *Biodiversity Conservation Act* 2016 (BC Act): At a State level, native flora species are protected under the BC Act. A number of species are assigned an additional level of conservation significance based on a limited number of known populations and the perceived threats to these locations.
- DBCA Priority list: DBCA produces a list of Priority species and ecological communities that have not been assigned statutory protection under the WC Act. Possibly threatened species that do not meet survey criteria, or are otherwise data deficient, are added under Priorities 1, 2 or 3. Species that are adequately known, are rare but not threatened, or meet criteria for near threatened, or that have been removed from the threatened species list for other taxonomic reasons, are placed in Priority 4. These species require regular monitoring (see Appendix 3). The list of PECs identifies those that need further investigation before nomination for TEC status at a State level.

Local Level:

- Species may be considered of local conservation significance because of their patterns of distribution and abundance. Although not formally protected by legislation, such species are acknowledged to be in decline as a result of threatening processes, primarily habitat loss through land clearing.

2.2 Desktop Assessment

2.2.1 Literature Review

A literature review of relevant surveys previously completed within or in close proximity to the study area was completed, comprising four flora and vegetation surveys.

2.2.2 Database Searches

Database searches included databases relating to significant flora, TECs and PECs previously collected or described within, or in close proximity to, the study area. For this report the search was extended beyond the project area to place species and community values into a local and regional context.

The following databases were searched:

- NatureMap: This database represents the most comprehensive source of information on the distribution of Western Australia's flora, comprising records from the Department of Biodiversity, Conservation and Attractions (DBCA) database, and the Western Australian Herbarium (WAH) Specimen Database (40 km radial search) (Department Biodiversity Conservation and Attractions [DBCA] 2019);
- DBCA's Threatened Flora Database was searched to confirm the NatureMap results (50 km radial search) (DBCA 2018a);
- DBCA's TEC, PEC and Environmentally Sensitive Areas (ESAs) database was searched to identify significant communities (50 km radial search, DBCA 2018b);
- EPBC Act Protected Matters database (50 km radial search, DoEE 2019); and
- International Union for Conservation of Nature (IUCN) database (IUCN 2019).

2.2.3 Assessment of Likelihood of Occurrence in the Study Area

A list of conservation significant flora species occurring within a 50 km radius of the study area was compiled during the literature review and database searches. The likelihood of each taxon occurring within the study area was assessed using a set of rankings and criteria (as described in Table 3). The criteria are based on the presence of suitable landform (inferred from aerial imagery with contours overlayed) and distance to known records.

Table 3 Ranking system used to assign the likelihood that a flora species could occur in the study area.

Rank	Criteria
Recorded	The species has been recorded in the study area.
Likely to occur	The species has previously been recorded from a landform/habitat which is present within the study area, and there are previous records within a 20 km radius of the study area.
Possible to occur	The species has previously been recorded from a landform/habitat which is present within the study area, and there are previous records within a 50 km radius of the study area.
Unlikely to occur	The landform/habitat from which the species has previously been recorded is absent within the study area, and/or there are no previous records within a 50 km radius of the study area.

2.3 Survey Methodology

2.3.1 Timing and Personnel

The first season flora and vegetation survey was completed by Principal Botanists Dr Darren Brearley and Dr Jerome Bull, between the 16th and 20th of November 2018, under relatively poor seasonal conditions. A follow-up second season survey was conducted between the 5th and 10th May 2019, also under poor seasonal conditions. Second season field work was completed by Dr Jerome Bull and Senior Botanist Ms Jessica Waters.

All botanists are familiar with the flora and vegetation of the Gascoyne, having undertaken numerous baseline surveys over the past 20 years. The original surveys of the Marymia area between 2001 and 2004 were completed by the Principal Botanists.

2.3.2 Sampling of Study Sites

The field survey involved systematic sampling using quadrats (referred to as study sites). Relevé vegetation descriptions were made to increase the accuracy of vegetation mapping and targeted searches were completed in habitats where it was anticipated that significant flora or weeds might occur.

A total of 116 study sites (50 m x 50 m) were assessed during the survey (Figure 5), including 10 quadrats at Apex, 11 quadrats at Cinnamon, 16 quadrats at K2, 7 quadrats at Mar-West, 4 quadrats at Mar-east, 6 quadrats at the Mill area, 14 at the Tailings Dam, 15 quadrats at the Tailings Pipeline, 26 quadrats at Trident and 7 quadrats at Wedgetail.

The study sites were assessed to provide a list of the total flora occurring within the study area and a description of the vegetation structure. Data collected covered a range of environmental parameters including:

- Landform and habitat;
- Aspect;
- Soil colour and soil type;
- Rock type;
- Slope (angle);
- Vegetation condition;
- Disturbance (caused by fire, clearing, grazing etc.);
- Age since fire;
- Broad floristic formation;
- Vegetation association description; and
- Height, number of plants and percentage ground cover provided by conservation

significant and introduced plant taxa.

Other parameters recorded for each study site were:

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

Vegetation condition for each of the study sites was determined using a recognised rating scale (based on Keighery 1994, see Appendix 4).

2.3.3 Targeted Surveys for Conservation Significant Species

Targeted searches were conducted for flora of conservation significance within the project areas. Ground truthing provided an opportunity to record opportunistic locations for Threatened and Priority listed flora and undertake closer examination of specific landforms where conservation significant flora may be expected to occur. Additionally, locations for conservation significant flora previously recorded within or in close proximity to the study area were revisited to confirm their presence and to identify their habitat preference.

2.3.4 Weed Survey and Mapping

Introduced weed species were recorded from the 116 study sites assessed within the study area. Opportunistic collections were also made while moving around the study area, with targeted weed searches completed in high moisture habitats of the drainage channels.

765000 767500 770000 772500 775000 777500 780000 782500

7225000 7222500 7220000 7217500 7215000 7212500 7210000

K2-13 K2-12 K2-11 K2-14 K2-15 K2-03 K2-04 K2-16 K2-06 K2-07 K2-09 K2-08 K2-05 K2-02 K2-10 K2-01

TP-04 TP-03 TP-02 TP-01 TP-14 TP-12 TP-10 TP-15 TP-09 TP-11 TP-13 TP-08 TP-07 TP-05 TP-06

MA-01 MA-02 MA-03 MA-04 MA-05 MA-06

TD-03 TD-04 TD-05 TD-13 TD-06 TD-14 TD-12 TD-10 TD-02 TD-01 TD-07 TD-08 TD-09 TD-11 TRI-01 TRI-02 TRI-24 TRI-26 TRI-25 TRI-03 TRI-23 TRI-04 TRI-12 TRI-11 TRI-10 TRI-09 TRI-07 TRI-08 TRI-13 TRI-06 TRI-05 TRI-15 TRI-17 MW-03 MW-02 MW-01 MW-05 MW-07 MW-06 MW-08 TRI-19 TRI-22 TRI-20 TRI-21 TRI-18 TRI-14 TRI-16

ME-01 ME-02 ME-04 ME-03 WE-04 WE-03 WE-05 WE-02 WE-07 WE-01 WE-06

CIN-07 CIN-03 CIN-08 CIN-06 CIN-09 CIN-05 CIN-11 CIN-10 CIN-04 CIN-01 CIN-02

APEX-06 APEX-07 APEX-10 APEX-05 APEX-08 APEX-02 APEX-09 APEX-04 APEX-03 APEX-01

VANGO

Marymia

Study Sites

Legend

- Survey Areas
- Sample Locations

N

0 500 1,000 1,500 2,000

Meters

1:60,000

Datum: GDA94

Projection: MGA Zone 50

Date:	11/06/2019
Status:	Final
Figure:	5
Sheet Size:	A3
Internal Reference:	Marymia_Apex_SS
Drawn by:	GSM
Requested by:	DB

2.3.5 Vegetation Association Mapping

The vegetation mapping utilised high-resolution aerial photography of the entire study area at a scale of 1:7,500 with definition of vegetation polygons based on contrasting shading patterns. Ground-truthing of the study area was completed during the survey with vegetation descriptions made within selected vegetation polygons to confirm dominant structural layers and associated plant taxa.

The location of the study sites and additional relevé plots were overlaid on the aerial photography, and associated flora and vegetation data was used to provide vegetation association descriptions for the individual polygons defined. Description of vegetation structure follows the height, life form and density classes of Specht (1970) as modified by Aplin (1979) (see Appendix 5). This is largely a structural classification suitable for broader scale mapping, but taking all ecologically significant strata into account.

2.3.6 Vouchering

Voucher specimens were taken for species that could not readily be identified in the field to verify identification. Taxonomy was completed by Dr Jerome Bull, with selected voucher specimens provided to the specialist botanists within the WA Herbarium for further study where required. Use was made of the Western Australian Herbarium (WAH) for confirmation of species identification.

2.3.7 Field Survey Constraints

The Environmental Protection Authority (EPA) Technical Guidance (EPA 2016b) list potential limitations that field surveys may encounter. Limitations associated with the flora and vegetation reconnaissance survey are addressed in Table 4. The major limitation for this survey was the extremely dry conditions experienced across the two surveys.

Table 4 Relevance of constraints, as identified by EPA to the flora and vegetation (EPA 2016b).

Constraint	Relevance
Availability of contextual information at a regional and local scale	There are at least four flora and vegetation surveys that have been previously completed within or in close proximity to the study area, providing an extensive local database.
Proportion of flora recorded and/or collected, any identification issues	The two-season flora and vegetation survey was undertaken under poor seasonal conditions. Hence, a large proportion of the ephemeral taxa occurring within the study area would not have been present at the time of the surveys. Additional survey effort in good seasonal conditions is recommended.
Survey timing, rainfall, season of survey	The survey was completed in November 2018 under poor seasonal conditions and a second season survey was completed in May 2019 after a summer of below average rainfall.
Disturbance that may have affected the results of survey such as fire, flood or clearing	Disturbances within the study area included previous historical mining and exploration activities and grazing of vegetation by domestic stock (cattle). None of the disturbances were a constraint to completing the survey.
Was the appropriate area fully surveyed (effort and extent)	A total of eleven field days over two trips were completed at the site. Quadrats at Cinnamon, Trident and K2 were assessed for a second time during the second field trip. Sites established at the remaining prospects were assessed for the first time at May 2019 and will require a second season survey. Surveying of the Triple P/Albatross, Southern Haul Road and Speckled Hen prospects were not completed during the second season field trip due to time constraints.
Access restrictions within the survey area	There were no access restrictions experienced during the survey with the study area accessible by vehicle and on foot; noting that vegetation mapping was facilitated by high-resolution aerial photography.
Competency/experience of the team carrying out the survey, including experience in the bioregion surveyed	The two Principal Botanist working on the survey have over 20 years' experience in the Gascoyne and Pilbara regions, and have completed numerous surveys in close proximity to the study area.

3.0 RESULTS

3.1 Literature Review

The flora and vegetation of the Murchison has been assessed at a broad scale by Beard (1975). In addition to the larger broad scale surveys, an increasing number of smaller intensive surveys have been completed in the area associated with resource development projects. These surveys have resulted in the collection of a significant amount of site-specific biological survey data, most of which has been undertaken for formal environmental impact assessment.

There are at least 4 flora and vegetation that have previously been completed in close proximity to or within the study area. These surveys are described in Appendix 6.

3.2 Database Searches

3.2.1 Flora Species

Threatened Flora listed under the EPBC Act

A search of the EPBC Act Protected Matters Database (DoEE 2019) identified no Threatened Flora or their habitat as occurring within a 40 km radius of the study area.

Threatened Flora listed under the IUCN Red List

A search of the International Union for Conservation of Nature (IUCN) database (IUCN 2019) determined that no Threatened Flora taxa were likely to occur within the study area.

Threatened Flora listed under the WC Act

The DBCA rare flora database search (DBCA 2018a) did not identify any plant taxon gazetted as Threatened Flora (T) pursuant to subsection (2) of Section 23F of the WC Act from a 50 km radius around the study area.

Priority Flora recognised by the DBCA

The DBCA rare flora database search (DBCA 2018a) identified 31 Priority flora taxa as potentially occurring within a 50 km radius of the study area. The NatureMap search (DBCA 2019) identified eight Priority flora as potentially occurring within a 20 km radius.

A total of 33 Priority flora taxa were identified during the desktop assessment. These taxa are detailed in Table 5.

Three of these Priority flora have previously been recorded from within the study area. Based on the known distributions and habitat preferences of Priority flora taxa, and comparison with the habitats identified and mapped for the study area, three taxa were determined as being “likely” to occur within the study area, six as “possible” to occur, and one determined as unknown. The remaining taxa were identified as “unlikely” to occur (Table 5).

Table 5 Conservation significant flora taxa identified during the desktop assessment.

Taxon	Cons. Code	Life Form	Habitat Preference	Suitable Habitat Present	Likelihood in the Study Area
Calytrix praecipua	P3	Perennial	Skeletal sandy soils over granite or laterite. Breakaways, outcrops.	Yes	Likely
Comesperma sabulosum	P3	Perennial	Red sand on dunes	No	Unlikely
Comesperma viscidulum	P4	Perennial	Dunes	No	Unlikely
Daviesia arthropoda	P3	Perennial	Dunes	No	Unlikely
Eremophila anomala	P1	Perennial	Basalt outcrop	No	Unlikely
Eremophila appressa	P1	Perennial	Ironstone gravel. Ridge slopes.	Yes	Possible
Eremophila arguta	P1	Perennial	Floodplain in rangeland with brown/red loam soil.	Yes	Possible
Eremophila demissa	P1	Perennial	Silcrete plains	Yes	Possible
Eremophila lanata	P3	Perennial	Stony red clayey sand.	Yes	Unlikely
Eucalyptus semota	P3	Perennial	Quartz outcrops	Yes	Recorded
Fimbristylis sieberiana	P3	Perennial	Mud, skeletal soil pockets. Pool edges, sandstone cliffs	No	Unlikely
Frankenia glomerata	P4	Perennial	White sand.	No	Unlikely
Gonocarpus pycnostachyus	P3	Annual	Sand or clay soils. Wet depressions, granite rocks.	No	Unlikely
Goodenia modesta	P3	Annual	Red loam, sand.	Yes	Possible
Hemigenia tysonii	P3	Perennial	Red sand, sandy clay or lateritic sandy soils on flats, sand dunes and hills	Yes	Likely
Hemigenia virescens	P3	Perennial	Hillside. Rangeland. Brown ironstone gravel.	Yes	Possible
Hibiscus sp. Carnarvon (S. van Leeuwen 5110)	P1	Perennial	Unknown	Unknown	Unknown
Maireana prosthecochaeta	P3	Perennial	Lateritic hills, slopes and saline areas	Yes	Recorded
Micromyrtus mucronulata	P3	Perennial	Hillslopes, brown loam dolerite, sandy soils.	Yes	Likely
Minuria sp. Little Sandy Desert (S. van Leeuwen 4919)	P1	Unknown	Flat around salt lake. Soil pink sand.	No	Unlikely
Ptilotus tetrandrus	P1	Perennial	Loamy sand.	Yes	Unlikely - Nearest record > 50 km
Samolus sp. Fortescue Marsh (A. Markey & R. Coppen FM 9702)	P1	Perennial	Margins of clay pans and salt lakes	No	Unlikely
Sauropus sp. Woolgorong (M. Officer s.n. 10/8/94)	P3	Perennial	Red sandy soils on plains	Yes	Recorded (just outside the study area)
Sida picklesiana	P3	Perennial	Variety of habitats including exposed rocky habitats such as BIF and granite breakaways, footslopes, stony plains and near creek lines	Yes	Possible

Stackhousia clementii	P3	Perennial	Skeletal soils. Sandstone hills.	Yes	Unlikely - Nearest record > 50 km
Stackhousia sp. Lake Mackay (P.K. Latz 12870) PN	P1	Perennial	Red dune near lake.	No	Unlikely
Tecticornia bibenda	P1	Perennial	Red-brown saline sand with some clay over calcrete and gypsum. Near the edges of gypsiferous playas and salt lakes on flat to gently undulating terrain.	No	Unlikely
Tecticornia mellarium	P1	Perennial	Along thin margin between salt lake and foredune. Pale yellow to white sand over clay.	No	Unlikely
Tecticornia sp. Christmas Creek (K.A. Shepherd & T. Colmer et al. KS 1063)	P1	Perennial	Saline flats. Marsh.	No	Unlikely
Tecticornia sp. Sunshine Lake (K.A. Shepherd et al. KS 867)	P1	Perennial	Flats near water line. Red-brown clayey sand.	No	Unlikely
Tecticornia willisii	P1	Perennial	Unknown	No	Unlikely
Thryptomene sp. Leinster (B.J. Lepschi & L.A. Craven 4362)	P3	Perennial	Sandy soils. Sandplains, stony ridges, breakaways	Yes	Unlikely - Nearest record > 50 km
Triodia birriliburu	P3	Perennial	Crest of red sand dune.	No	Unlikely

3.2.2 Ecological Communities

TECs listed under State and Federal Legislation

A search of the EPBC Act Protected Matters database (DoEE 2019) identified no Federal listed TECs previously recorded within, or adjacent to, the study area.

Search results from the DBCA ecological community database (DBCA 2018b) confirmed there was no State listed TECs known from within a 50 km of the study area.

PECs recognised by DBCA

A search of the State database (DBCA 2018b) identified three PECs located in close proximity (Table 6):

- Three Rivers Plutonic calcrete groundwater assemblage types on Gascoyne palaeodrainage on Three Rivers Station (Priority 1);
- Blech Land System (Priority 3iii); and
- Jingle Land System (Priority 3iii).

Table 6 PECs located in close proximity to the study area.

Name	Description	Distance to study area
Three Rivers Plutonic calcrete groundwater assemblage types on Gascoyne palaeodrainage on Three Rivers Station (Priority 1)	Supports a unique assemblages of invertebrates in the groundwater calcretes. Threatened by mining.	40 km west
Blech Land System (Priority 3iii)	Characterised by large sandy banks up to 1.6 km long and 1 km wide connected by several arcuate bands. Interbanks occur between sandy banks and may coalesce into discernible through drainage plains in some areas. Threatened by overgrazing and erosion.	30km south-west
Jingle Land System (Priority 3iii)	Floodplains with *Eucalypt* woodlands and variable shrublands marginal to rivers. Threatened by overgrazing and erosion.	40km north-west

3.3 Field Survey

3.3.1 Flora Species

A total of 209 plant taxa (including varieties and subspecies) from 35 families and 89 genera were recorded from the study area (Table 7, Appendix 7). Species representation was greatest among the Fabaceae (47 taxa), Poaceae (24 taxa), Scrophulariaceae (21 taxa), Chenopodiaceae and Malvaceae families (18 taxa). The most speciose genus was *Acacia* (30 taxa), followed by *Eremophila* (21 taxa), *Senna* (11 taxa), *Maireana* (8 taxa), *Sida*, *Hibiscus* and *Ptilotus* (7 taxa each) (Table 7).

Table 7 Statistics for total flora recorded from the study area.

Overview	**No. Taxa**
Families	35
Genera	89
Taxa (species, subspecies, varieties)	209
Native Taxa	207
Introduced Taxa	2
Threatened Flora	0
Priority Flora	9
Range Extension	1
Speciose Families	**No. Taxa**
Fabaceae	47
Poaceae	24
Scrophulariaceae	21
Chenopodiaceae	18
Malvaceae	17
Asteraceae	8
Myrtaceae	8
Speciose Genera	**No. Taxa**
Acacia (Fabaceae)	30
Eremophila (Scrophulariaceae)	21
Senna (Fabaceae)	11
Maireana (Chenopodiaceae)	8
Sida (Malvaceae)	7
Hibiscus (Malvaceae)	7
Ptilotus (Amaranthaceae)	7

Threatened Flora listed under the WC Act and EPBC Act

No plant taxon gazetted as Threatened Flora (T) pursuant to subsection (2) of section 23F of the WC Act or listed under the EPBC Act were recorded from the study area.

Priority Flora recognised by the DBCA

A total of nine conservation significant flora species were recorded within the study area during the current survey with an additional priority species occurring just outside the study area (Figure 6):

- *Eremophila* cf. *demissa* (Priority 1)*;*
- *Goodenia virgata* (Priority 2);
- *Calytrix praecipua* (Priority 3);
- *Eremophila lanata* (Priority 3);

- *Hemigenia tysonii* (Priority 3);
- *Maireana prosthecochaeta* (Priority 3);
- *Sauropus* sp. Woolgorong (M. Officer s.n. 10/8/94) (Priority 3);
- *Sporobolus blakei* (Priority 3);
- *Thryptomene* sp. Leinster (B.J. Lepschi & L.A. Craven 4362) (Priority 3); and
- *Eucalyptus semota* (Priority 1, recorded just outside the study area boundary).

GPS coordinates of each species are provided in Appendix 8. Descriptions of the conservation codes for Western Australian flora species are detailed in Appendix 3.

Summarised descriptions of each conservation significant flora species recorded from the Marymia Project Area are provided below.

***Eremophila* cf. *demissa* Chinnock (Family: Scrophulariaceae), Priority 1**

Eremophila cf. *demissa* is a small compact shrub growing to between 0.25-0.50 meters high with small grey to yellowish-grey, felty and narrowly ovate leaves, densely hairy sepals and mauve to blue tubular flowers to 1.5-2.5 cm long (Plate 1, Brown & Buirchell, 2011). It typically grows on silcrete plains in a small region northeast and east of Meekatharra in the Gascoyne and Murchison bioregions of central Western Australia (WAH 2019; Atlas of Living Australia 2019). It is a poorly collected taxon having only been recorded from a small geographical area of the state and has therefore been assigned Priority 1 status.

The taxon collected from the study area was identified as *Eremophila* cf. *demissa* as no flowers were recorded at the time of survey due to poor seasonal conditions. Further surveys during good seasonal conditions would be needed to confirm the identification of this species.

The closest documented populations of *Eremophila demissa* to the study area are located approximately 35km to the southwest near the decommissioned Plutonic Mine site. All of these populations are growing on broad stony plains and upland slopes that form the catchment divide of the headwaters of the Gascoyne River flowing westward and the various unnamed waterways flowing to the east and south.

Eremophila cf. *demissa* was recorded at 14 locations during the survey with more than 150 plants recorded. Percentage cover ranged from <1 to 10%. It was recorded from sandy/stony plains and drainage areas/floodplains.

***Goodenia virgata* Carolin (Family: Scrophulariaceae), Priority 2**

Goodenia virgata is an ascending to erect virgate (wand-shaped) perennial herb growing to 0.4 meters high with thin, glabrous, green leaves and delicate yellow flowers[1]. Due to its thin leaves and stems, it is often difficult to locate in the field and is typically a minor component of the vegetation. It has been found growing on red sandy loam soils, sometimes near saltpans. The majority of collections have been recorded from central Australia with scattered occurrences in the Gascoyne, Gibson Desert, Great Sandy Desert and Little Sandy Desert bioregions of central Western Australia (WAH 2019).

Goodenia virgata was only found within the Apex and Trident tenements. It was recorded as scattered plants from six locations. It was recorded from stony plains and hillslopes with mulga woodlands. Additional locations for *Goodenia* sp. indet at the Tailings Dam and along the Tailings Pipeline may also be this species, however seasonal conditions at the time of survey were too poor for these taxa to be identified to species level.

The populations recorded within the study area are a significant range extension for the taxon, being situated approximately 233 km northwest of the closest recorded location near Lorna Glen Homestead Airport in the Murchison bioregion.

[1] This species was not photographed in the field.

***Calytrix praecipua* Craven (Family: Myrtaceae), Priority 3**

Calytrix praecipua is an open twiggy shrub that typically grows to a height between 0.3 - 0.7 metres tall. It has short, thin, glabrous leaves in opposite pairs that are often densely clustered at the ends of branchlets. It produces pink-white star-shaped flowers between June and November (Plate 2, ALA 2019). *Calytrix praecipua* typically grows on skeletal sandy soils on hill crests and breakaways composed of laterite or granite (WAH 2019; Brown & Buirchell 2011). Most populations of *Calytrix praecipua* are found further south of the study area in the Murchison, Little Sandy Desert and Great Victoria Desert bioregions of central Western Australia. The Marymia populations form the northernmost geographic extent of the taxon.

Calytrix praecipua was found at 16 locations within the Trident and Wedgetail prospects and the Mill area. A total of 159 plants were recorded from stony plains and hillslopes with coverage ranging between <1 to 3%.

***Eremophila lanata* Chinnock (Family: Scrophulariaceae), Priority 3**

Eremophila lanata is a low compact to spreading shrub with small, oblong, shortly hairy and densely clustered leaves, densely hairy sepals and mauve or lilac tubular flowers up to 20 mm long (Plate 3). It grows between 0.1 to 0.3 metres in height and is found growing in red clayey sand soils on stony flats and rocky slopes underlain by quartz (WAH 2019; Brown & Buirchell 2011). The only documented populations of *E. lanata* are located approximately 180 km to the southwest of the study area near Meekatharra in the Gascoyne bioregion (WAH 2019). However, a number of populations have been documented in unpublished reports and via opportunistic observations as occurring within and adjacent to the wider study area (Brown & Buirchell 2011).

Eremophila lanata was found at 59 locations within the Trident and Mar-east Prospects and along the proposed tailings pipeline and tails dam areas. Approximately, 2700 plants were recorded from stony plains, hardpan plains, hillslopes and undulating low hills. Coverage ranged from <1% up to 10%.

***Hemigenia tysonii* F.Muell. (Family: Lamiaceae), Priority 3**

Hemigenia tysonii is a low, intricately-branching mint bush up to 0.5 metres high and 0.7 metres wide. The leaves are small, grey green in colour, opposite or whorled, scented and up to 11 mm long by 2 mm wide. The flowers are either white or purple/blue/pink with white spots on the inside surface (WAH 2018) (Plate 4). *Hemigenia tysonii* is primarily found growing in red sand, sandy clay or lateritic sandy soils on flats, sand dunes and hills in the Murchison, Carnarvon and Gascoyne bioregions. The main populations occur over 250 km southwest of the study area in the eastern Murchison and southern Carnarvon bioregions, however there is one historical record existing nearby, adjacent to the Apex tenement (DBCA 2018a).

Hemigenia tysonii was recorded at ten locations across the Apex prospect.

***Maireana prosthecochaeta* (F.Muell.) (Family: Chenopodiaceae), Priority 3**

Maireana prosthecochaeta is an open, densely-leaved glabrous shrub growing to 0.3-0.6 metres high. It has erect branches with narrow, glabrous, succulent and somewhat terete leaves and fruits that are black, glabrous with a prominent circular wing and 4-6 erect perianth processes (Plate 5). It is known to occur on lateritic hills, slopes and saline areas within the Gascoyne and northern Murchison bioregions of central Western Australia with an outlier collection in the central Kimberley (WAH 2019).

Maireana prosthecochaeta was collected from 22 locations on hill slopes and undulating low hills in the Wedgetail and Trident prospects. This species occurs as a scattered component of the understorey.

***Sauropus* sp. Woolgorong (M. Officer s.n. 10/8/94) (Family: Phyllanthaceae), Priority 3**

Sauropus sp. Woolgorong is a low, bright green shrub growing to 0.3-1 metres high with very small, cryptic, yellow flowers and green ovoid capsules. The leaves are glabrous, obovate and generally 10-15mm long and 2-5mm wide whilst the stems are somewhat 'zigzag' and rough in texture (Plate 6). Individuals sometimes appear leafless due to the somewhat caducous nature of the leaves during drier seasons. This taxon primarily inhabits red sandy soils on plains in the northern Murchison and central Yalgoo bioregions, with a northerly outlier in the central Gascoyne.

Sauropus sp. Woolgorong was found at 21 locations in the K2, Trident and Apex Prospects. Approximately 20 plants were recorded from breakaways and hillslopes.

Sporobolus blakei B.K.Simon (Family: Poaceae), Priority 3

Sporobolus blakei is a tufted perennial grass growing to 0.45-0.6 metres high. The inflorescence is elongated, compact and feathery and has very small green to purple flowers[2]. It primarily grows in red sandy clays and loams in creek lines and is widely distributed, though poorly collected, across the state in the Carnarvon, Central Kimberley, Gascoyne, Gibson Desert, Jarrah Forest and Murchison bioregions. Due to paucity of documented collections, the current location at Marymia represents a significant range infill/ extension, the closest recorded location being approximately 250km east southeast near Wongawol Airport on the Carnegie Rd in the eastern Gascoyne (WAH 2019).

Sporobolus blakei was restricted to one location within the study area scattered within a rocky creekline in the north-western sector of the Trident prospect. The number of plants was not recorded.

***Thryptomene* sp. Leinster (B.J. Lepschi & L.A. Craven 4362) (Family: Myrtaceae), Priority 3**

Thryptomene sp. Leinster is a shrub in the family Myrtaceae. It is an erect shrub with a messy habit, growing between 0.6-3 metres high. It has small, circular leaves which are densely clustered along the branches and small, pink to white flowers that are produced between July and November (Plate 7). *Thryptomene* sp. Leinster occurs in a band across the Murchison and Gascoyne bioregions from Leinster in the south to Meekatharra and Marymia in the north. The populations found in the study area are the most north-eastern extent of the currently known distribution of this taxon.

Thryptomene sp. Leinster primarily grows in orange to brown sandy loams on weathered ironstone and lateritic ridges, breakaways and stony slopes in the study area. These landforms appear to have a consistent plant assemblage and include species such as *Acacia subcontorta, Acacia incurvaneura* (bushy form), *Sida* cf. *ectogama, Ptilotus schwartzii, Eragrostis eriopoda* and the Priority 3 taxon *Calytrix praecipua. Thryptomene* sp. Leinster appears to be an indicator species for this vegetation community.

[2] This species was not photographed in the field

Thryptomene sp. Leinster was recorded at 42 locations during the survey with a total of 438 plants. It was recorded from minor drainage lines, rocky hillslopes and undulating low hills within the Trident, Wedgetail, Ibis and K2 prospects.

***Eucalyptus semota* C.J.Macpherson & Grayling (Family: Myrtaceae), Priority 1 (not within study area boundary)**

Eucalyptus semota, commonly known as Marymia Mallee, is a mallee or small tree growing to 2-9 m high. It has smooth pink to cream coloured bark with a stocking of rough, peeling bark below. It has thin, lanceolate, glossy green leaves with small white/cream/yellow flowers and small, cup-shaped gum nuts approximately 6 mm long (Plate 8) (Macpherson & Grayling, 1996). It typically grows on pallid zone clay soils below lateritic mesa caps and quartz outcrops in a small region between Meekatharra and Kumarina in the Gascoyne, Murchison and Little Sandy Desert bioregions of central Western Australia (WAH 2019; Atlas of Living Australia 2019). It is a poorly collected taxon, and most known populations are from the Marymia Hill area. It has therefore been assigned Priority 1 status by DBCA.

This species was recorded at three locations just outside the study area from minor rocky drainage lines. A total of 13 plants were observed ranging from 4-6 metres in height.

Range Extensions

One flora species with a significant range extension was recorded within the study area: *Hibiscus brachychlaenus.* This species is a perennial shrub reaching 1.8 meters in height. It produces blue, purple or pink flowers in March to April or August to November and grows on sandy or loamy soils on sandstone, sand plains or dunes.

Hibiscus brachychlaenus was recorded from one location within the study area at the K2 prospect. It was recorded from a sandplain with brown sandy loam and was a minor component of the vegetation.

Introduced Flora

Two introduced flora were recorded from the study area; **Bidens bipinnata* and **Portulaca pilosa* (Appendix 9, Figure 7).

**Bidens bipinnata* is an erect annual herb that grows up to 1m in height. This species is widespread in the northern parts of WA, from Shark Bay up to the Northern Territory Border. It has three pronged barbs on its seeds, so it is easily spread by livestock and other animals. It is common in moist habitats such as drainage lines, flood plains and gorges, and responds vigorously following rainfall.

Within the study area it was recorded from two locations in the Trident and Apex Prospects. It was recorded from a major drainage line and a floodplain with coverage between 1-3%.

**Portulaca pilosa* is a succulent, erect or prostrate annual herb reaching 0.2 meters high. Flowers are yellow or pink and are produced between January to July or November. It grows on sandy, loamy & clayey soils. It has predominantly been recorded throughout the Pilbara and Kimberley with a few scattered records extending into the Gascoyne.

Within the study area **Portulaca pilosa* was recorded from one location within the Apex prospect. Scattered plants were recorded from a medium drainage line.

Plate 1 ***Eremophila* cf. *demissa***

Plate 2 ***Calytrix praecipua***

Plate 3 ***Eremophila lanata***

Plate 4 ***Hemigenia tysonii***

Plate 5 ***Maireana prosthecochaeta***

Plate 6 ***Sauropus*** **sp. Woolgorong (M. Officer s.n. 10/8/94)**

Plate 7 *Thryptomene* sp. Leinster (B.J. Lepschi & L.A. Craven 4362)

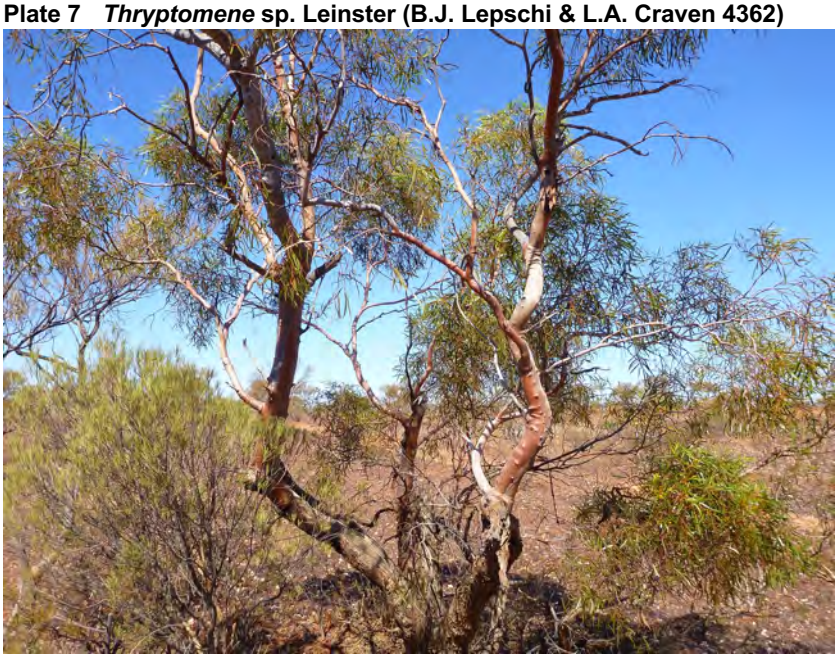

Plate 8 *Eucalyptus semota*

765000 767500 770000 772500 775000 777500 780000 782500

7225000 7222500 7220000 7217500 7215000 7212500 7210000

VANGO

Marymia

Significant Flora

Legend

- Survey Areas

Significant Flora

- Calytrix praecipua (C.p)
- Eremophila cf. demissa (E.d)
- Eremophila lanata (E.l)
- Goodenia virgata (G.v)
- Hemigenia tysonii (H.t)
- Hibiscus brachychlaenus (H.b)
- Maireana prosthecochaeta (M.p)
- Sauropus sp. Woolgorong (M. Officer s.n. 10/8/94)
- Sporobolus blakei (S.b)
- Thryptomene sp. Leinster (B.J. Lepschi & L.A. Craven 4362)

N

0 500 1,000 1,500 2,000

Meters

1:60,000

Datum: GDA94

Projection: MGA Zone 50

Date:	11/06/2019
Status:	Final
Figure:	6
Sheet Size:	A3
Internal Reference:	Marymia_Apex_SF
Drawn by:	GSM
Requested by:	DB

765000 767500 770000 772500 775000 777500 780000 782500

7225000 7222500 7220000 7217500 7215000 7212500 7210000

B.b

B.b

P.p

VANGO

Marymia

Introduced Flora

Legend

Survey

Introduced Flora

Bidens bipinnata

Portulaca pilosa

N

0 500 1,000 1,500 2,000

Meters

1:60,000

Datum: GDA94

Projection: MGA Zone 50

Date:	11/06/2019
Status:	Final
Figure:	7
Sheet Size:	A3
Internal Reference:	Marymia_Apex_IF
Drawn by:	GSM
Requested by:	DB

765000 767500 770000 772500 775000 777500 780000 782500

3.3.2 Vegetation

Vegetation Associations

A total of 32 vegetation associations were described and mapped within the study area (Figure 8). The vegetation associations have been classified into 15 broad floristic formations on the basis of the dominant vegetation stratum (Table 8).

Table 8 Vegetation types mapped within the study area.

Vegetation Association Code	Sites		Vegetation Association Description
Hill Crests			
HC AsuAi TslAsu SeEllPs	IB-01, K2-08, K2-17, MA-01, TRI-15, WE-04	*Acacia* High Open Shrubland	High Open Shrubland of *Acacia subcontorta* and *Acacia incurvaneura* over Open Shrubland of *Thryptomene* sp. Leinster (B.J. Lepschi & L.A. Craven 4362) and *Acacia subcontorta* over Low Open Shrubland of *Sida* cf. *ectogama*, *Eremophila latrobei* subsp. *latrobei* and *Ptilotus schwartzii* over Very Open Tussock Grassland of *Eriachne mucronata*, *Thyridolepis xerophila* and *Eragrostis eriopoda* on orange sandy loam on weathered ironstone ridges and hill crests
Hill Slopes			
HS Apt SglSs Ema	TRI-21, WE-01, WE-02, WE-05	*Acacia* Low Open Woodland	Low Open Woodland of *Acacia pteraneura* over Open Shrubland of *Senna glutinosa* subsp. x *luerssenii* and *Senna stricta* over Low Open Shrubland of *Eremophila margarethae* on brown sandy loam on hillslopes
HS AptAi EmPrPo Tb	ME-01, TP-15, TP-06	*Acacia* Low Open Woodland	Low Open Woodland (or Low Woodland) of *Acacia pteraneura* and *Acacia incurvaneura* over Low Shrubland of *Eremophila margarethae*, *Ptilotus rotundifolius* and *Ptilotus obovatus* and Scattered Hummock Grasses of *Triodia basedowii* on orange sandy clay loam on hillslopes
HS CdPr EfGbAf	TRI-20, (TRI-22 outside study area)	*Calytrix* Low Shrubland	Low Shrubland of *Calytrix* cf. *desolata* and *Ptilotus rotundifolius* with Open Shrubland of *Eremophila fraseri*, *Grevillea berryana* and *Acacia fuscaneura* (*Senna glutinosa* subsp. x *luerssenii*) on brown sandy loam on hillslopes
Minor Drainage Lines			
MI AptAcGb DpAc SeShSsp	MA-03, ME-02	*Acacia* Low Open Woodland	Low Woodland of *Acacia pteraneura*, *Acacia citrinoviridis* and *Grevillea berryana* (*Acacia pruinocarpa*) over High Open Shrubland of *Dodonaea pachyneura* and *Acacia craspedocarpa* (hybrid) over Low Open Shrubland of *Sida* cf. *ectogamma*, *Senna artemisioides* subsp. *helmsii* and *Scaevola spinescens* (with an Open Shrubland of *Senna glutinosa* subsp. *luerssenii*) on brown sandy loam on minor drainage lines
MI AcApt DpAtSsp Tb	MA-06	*Acacia* Low Open Woodland	Low Open Woodland of *Acacia citrinoviridis* (*Acacia pteraneura*) over Open Shrubland of *Dodonaea pachynerua*, *Acacia tetragonophylla* and *Scaevola spinescens* over Very Open Hummock Grassland of *Triodia basedowii* on orange silty loam on hillslopes and minor drainage lines
MI ArlApt As	APEX-10	*Acacia* Scattered Tall Shrubs	Scattered Tall Shrubs of *Acacia ramulosa* var. *linophylla* and *Acacia pteraneura* over Scattered Low Shrubs of *Acacia sibirica* on brown sandy loam on minor drainage lines (eroded channels)
Medium Drainage Lines			

ME AapAan EfEff Tt	MW-03, MW-08, TRI-02	*Acacia* Low Open Forest	Low Open Forest of *Acacia aptaneura* and *Acacia aneura* over Open Shrubland of *Eremophila fraseri* and *Eremophila forrestii* subsp. *forrestii* over Very Open Tussock Grassland of *Themeda triandra* on brown sandy clay loam on medium drainage lines
ME Ai Tl Se	APEX-05	*Acacia* Low Open Forest	Low Open Forest of *Acacia incurvaneura* over Open Tussock Grassland of *Tripogonella loliiformis* with Open Shrubland of *Sida* cf. *ectogama* (*Eremophila fraseri* and *Acacia tetragonophylla*) on brown loamy sand on medium drainage lines and floodplains
Major Drainage Lines			
MA AanAcAm PlArlAt Tt	TP-08	*Acacia* Low Closed Forest	Low Closed Forest of *Acacia aneura*, *Acacia citrinoviridis* and *Acacia macraneura* over High Open Shrubland of *Psydrax latifolia*, *Acacia ramulosa* var. *linophylla* and *Acacia tetragonophylla* over Very Open Tussock Grassland of *Themeda* sp. indet on brown loamy sandy on major drainage lines
MA AapAanAi TlEkCf At CsEal	APEX-06	*Acacia* Low Closed Forest	Low Closed Forest of *Acacia aptaneura*, *Acacia aneura* and *Acacia incurvaneura* over Open Tussock Grassland of *Tripogonella loliiformis*, *Eragrostis kennedyae* and *Chrysopogon fallax* with High Open Shrubland of *Acacia tetragonophylla* and Very Open Herbs of *Cheilanthes sieberi* and *Evolvulus alsinoides* on brown silty clay loam on major drainage lines
MA AmApt AcrAtAss CfTtEk	APEX-08, APEX-09	*Acacia* Low Open Forest	Low Open Forest of *Acacia macraneura* and *Acacia pteraneura* (*Eucalyptus victrix*) over High Open Shrubland of *Acacia craspedocarpa*, *Acacia tetragonophylla* and *Acacia sclerosperma* subsp. *sclerosperma* over Low Open Shrubland of *Senna artemisioides* subsp. *artemisioides*, *Eremophila margarethae* and *Ptilotus obovatus* (over Very Open Tussock Grassland of *Chrysopogon fallax*, *Themeda triandra* and *Eragrostis kennedyae*) on brown sand on major drainage lines
Floodplains			
FP Ai ArlPlGb EffSeEf TxEe Cs	CIN-03, CIN-07, CIN-11, K2-12, TRI-07, TRI-11	*Acacia* Low Open Forest	Low Open Forest (to Low Closed Forest) of *Acacia incurvaneura* (*Acacia pruinocarpa*, *Acacia ayersiana*, *Acacia aptaneura*, *Acacia aneura*) over High Shrubland of *Acacia ramulosa* var. *linophylla*, *Psydrax latifolia* and *Grevillea berryana* over Shrubland of *Eremophila forrestii* subsp. *forrestii*, *Sida* cf. *ectogama* and *Eremophila fraseri* over Very Open Tussock Grassland of *Thyridolepis xerophila* and *Eragrostis eriopoda* and Very Open Herbs of *Cheilanthes sieberi* on brown sandy clay loam on floodplains
Hardpan Plains			
HP Ai EffEsb Tb	TD-02	*Acacia* Low Woodland	Low Woodland of *Acacia incurvaneura* over Low Open Shrubland of *Eremophila forrestii* subsp. *forrestii* and *Eremophila spectabilis* over Very Open Hummock Grassland of *Triodia basedowii* on brown sandy clay loam on hardpan plains
HP AiGbApt AiAth EffPsEsb	MA-02, ME-03, ME-21, TD-03, TD-04, TD-06, TD-10	*Acacia* Low Open Woodland	Low Open Woodland of *Acacia incurvaneura*, *Grevillea berryana* and *Acacia pteraneura* over High Open Shrubland of *Acacia incurvaneura* and *Acacia thoma* and Low Open Shrubland of *Eremophila forrestii* subsp. *forrestii*, *Ptilotus schwartzii* and *Eremophila spectabilis* (over Very Open Tussock Grassland of *Eragrostis eriopoda*) on brown clay loam on hardpan plains
HP Tb AiAth EffElPs	TD-05, TD-07, TD-14	*Triodia* Hummock Grassland	Hummock Grassland of *Triodia basedowii* with High Open Shrubland of *Acacia incurvaneura* and *Acacia thoma* and Low Open Shrubland of *Eremophila forrestii* subsp. *forrestii*, *Eremophila lanata* and *Ptilotus schwartzii* (with Scattered Low Trees of *Acacia pruinocarpa* and *Grevillea berryana*) on orange sandy clay loam on hardpan plains
Stony Plains			

SP AptAiAp AsuAthAi SeElPs	IB-04, MA-05, TD-08, TD-09, TD-11, TRI-25,	*Acacia* Low Open Woodland	Low Open Woodland of *Acacia pteraneura*, *Acacia incurvaneura* and *Acacia pruinocarpa* over High Open Shrubland of *Acacia subcontorta*, *Acacia thoma* and *Acacia incurvaneura* over Low Open Shrubland of *Sida* cf. *ectogamma*, *Eremophila lanata* and *Ptilotus schwartzii* (with Scattered Tussock Grassland of *Eriachne mucronata* and *Eragrostis eriopoda*) on brown sandy clay loam on stony plans
SP Ai EffEcEll PsEd	APEX-07	*Acacia* High Open Shrubland	High Open Shrubland of *Acacia incurvaneura* (*Acacia pruinocarpa*, *Grevillea berryana*) over Open Shrubland of *Eremophila forrestii* subsp. *forrestii*, *Eremophila* cf. *citrina* and *Eremophila latrobei* subsp. *latrobei* over Low Open Shrubland of *Ptilotus schwartzii* and *Eremophila* cf. *demissa* (over Very Open Hummock Grassland of *Triodia basedowii*) on brown loamy sand on stony plains
SP Ai EfSgEff PsPoSl	APEX-02, K2-16, ME-04, MW-02, TP-13, TRI-01, TRI-03, TRI-06, TRI-09, TRI-16, TRI-17, TRI-18, WE-06, WE-07, K2-11 (i/g), K2-14 (i/g), TRI-08 (i/g), TRI-10 (i/g)	*Acacia* High Open Shrubland	High Open Shrubland of *Acacia incurvaneura* (*Acacia pteraneura, Acacia pruinocarpa*) over Open Shrubland of *Eremophila fraseri*, *Senna glaucifolia* and *Eremophila forrestii* subsp. *forrestii* (*Eremophila latrobei* subsp. *latrobei*) over Low Open Shrubland of *Ptilotus schwartzii*, *Ptilotus obovatus* and *Solanum lasiophyllum* on brown sandy loam on stony plains
SP AptAi AclSgl EmSsPo	IB-02, K2-15, K2-19, MA-04, MW-01, MW-06, TP-04, TRI-04, TRI-12, TRI-14, TRI-19	*Acacia* Low Closed Forest	High Open Shrubland of *Acacia pteraneura* and *Acacia incurvaneura* (*Acacia macraneura, Hakea preissii*) over Open Shrubland of *Acacia cuthbertsonii* subsp. *linearis* and *Senna glutinosa* subsp. x *luerssenii* over Low Open Shrubland of *Eremophila margarethae*, *Senna stricta* and *Ptilotus obovatus* on brown sandy loam on stony plains
SP AiGbPl EffEll EsEmPs	TP-10	*Acacia* Low Closed Forest	High Open Shrubland of *Acacia incurvaneura*, *Grevillea berryana* and *Psydrax latifolia* over Open Shrubland of *Eremophila forrestii* subsp. *forrestii* and *Eremophila latrobei* subsp. *latrobei* over Low Open Shrubland of *Eremophila spathulata*, *Eremophila margarethae* and *Ptilotus schwartzii* on orange sandy clay loam on stony plains
SP AiGb EsEmPs Apt	TP-02, TP-03, TP-10, TP-14	*Acacia* Low Closed Forest	High Open Shrubland of *Acacia incurvaneura* and *Grevillea berryana* over Low Open Shrubland of *Eremophila spathulata*, *Eremophila margarethae* and *Ptilotus schwartzii* (*Eremophila lanata*, *Ptilotus albidus*, *Solanum lasiophylum*) with Scattered Low Trees of *Acacia pteranaeura* on brown sandy clay loam on stony plains
SP ElPs EmEe GbAiApt	TD-01, TD-12, TRI-05, TRI-13, TRI-23	*Eremophila* Low Open Shrubland	Low Open Shrubland of *Eremophila lanata* and *Ptilotus schwartzii* over Very Open Tussock Grassland of *Eriachne mucronata* and *Eragrostis eriopoda* with Scattered Tall Shrubs of *Grevillea berryana*, *Acacia incurvaneura* and *Acacia pteraneura* on brown sandy loam on stony plains
SP SmFs Apt HpSm	APEX-01	*Senna* Low Open Shrubland	Low Open Shrubland of *Senna* sp. Meekatharra (E. Bailey 1-26), *Frankenia setosa* and *Sclerolaena* spp. with Scattered Tall Shrubs of *Acacia pteraneura* over Scattered Shrubs of *Hakea preissii* and *Senna* sp. Meekatharra (E. Bailey 1-26) on brown sandy loam on stony plains

SP EsEfPo	TRI-24, TRI-26	*Eremophila* Low Open Shrubland	Low Open Shrubland of *Eremophila spathulata*, *Eremophila fraseri* and *Ptilotus obovatus* on orange sandy clay loam on stony plains
SP EexPrEf AfAi	TP-09, TP-11, TP-12	*Eremophila* Low Open Shrubland	Low Open Shrubland of *Eremophila exilifolia*, *Ptilotus rotundifolius* and *Eremophila fraseri* with Scattered Low Trees of *Acacia fuscaneura* and *Acacia incurvaneura* on orange sandy loam on stony plains
Sandy/ Stony Plains			
SS AiApAa Ec Tb	APEX-04	*Acacia* Low Open Forest	Low Open Forest of *Acacia incurvaneura, Acacia pruinocarpa* and *Acacia ayersiana* over Shrubland of *Eremophila* cf. *citrina* (*Eremophila forrestii* subsp. *forrestii*) over Open Hummock Grassland of *Triodia basedowii* on brown sandy loam on sandy/stony plains
SS AanAa Arl EffArl Tb EeTx	CIN-01, CIN-06, CIN-09, CIN-10	*Acacia* Low Woodland	Low Woodland of *Acacia aneura* and *Acacia ayersiana* (*Acacia incurvaneura, Acacia pteraneura, Acacia pruinocarpa*) over High Open Shrubland of *Acacia ramulosa* var. *linophylla* over Open Shrubland of *Eremophila forrestii* subsp. *forrestii* and *Acacia ramulosa* var. *linophylla* over Very Open Hummock Grassland of *Triodia basedowii* over Very Open Tussock Grassland of *Eragrostis eriopoda* and *Thyridolepis xerophila* on red/orange silty loam on sandy/stony plains
SS EffEsEc Tb ApAaApt AiArl	CIN-02, K2-03, K2-06, K2-07, K2-10, K2-13	*Eremophila* Shrubland	Shrubland of *Eremophila forrestii* subsp. *forrestii*, *Eremophila spathulata* and *Eremophila* cf. *citrina* (*Eremophila latrobei* subsp. *latrobei*) over Open Hummock Grassland of *Triodia basedowii* with Low Open Woodland of *Acacia pruinocarpa*, *Acacia ayersiana* and *Acacia pteraneura* and High Open Shrubland of *Acacia incurvaneura* and *Acacia ramulosa* var. *linophylla* on brown loamy sand on sandy/stony plains
SS Tb AiAp Ar EcEs	APEX-03, K2-01, K2-02, K2-05, K2-09, MW-05, TP-18	*Triodia* Hummock Grassland	Hummock Grassland of *Triodia basedowii* with Low Open Woodland of *Acacia incurvaneura* and *Acacia pruinocarpa* (*Grevillea berryana*, *Acacia ayersiana*) and High Open Shrubland of *Acacia rhodophloia* (*Acacia ramulosa* var. *linophylla*, *Acacia thoma*) and Low Open Shrubland of *Eremophila* cf. *citrina* and *Eremophila spathulata* (*Eremophila latrobei* subsp. *latrobei*) on brown/orange sandy loam on sandy/stony plains and low rises
SS Tb AanAiAap EffEd	CIN-04, CIN-05, CIN-08	*Triodia* Hummock Grassland	Hummock Grassland of *Triodia basedowii* with Low Open Woodland of *Acacia aneura*, *Acacia incurvaneura* and *Acacia aptaneura* (*Acacia ayersiana*) and Scattered Low Shrubs of *Eremophila forrestii* subsp. *forrestii* and *Eremophila* cf. *demissa* on orange silty loam on sandy/stony plains
SS Tb ScSe AaAkEff	K2-04, K2-18, K2-20, K2-22	*Triodia* Hummock Grassland	Hummock Grassland of *Triodia basedowii* with Low Open Shrubland of *Sida cardiophylla* and *Seringia elliptica* with Scattered Shrubs of *Acacia ayersiana*, *Acacia kempeana* and *Eremophila forrestii* subsp. *forrestii* on brown loamy sand on sandy/stony plains

Ap, A. pruinocarpa; Apt, A. pteraneura; Aa, A. ayersiana; Aap, A. aptaneura; Aan, A. aneura; Ac, A. citrinoviridis; Acr, A. craspedocarpa (hybrid); As, A. subcontorta; Ass, A sclerosperma subsp*. sclerosperma;* Em*, E. mucronata;* Ema*, E. margarethae;* Ef*, E. fraseri;* Eff*, E. forrestii* subsp. *forrestii;* Es*, E. spathulata;* Esp*, E. spectabilis;* Ee*, E. eriopoda;* Eex*, Eremophila exilifolia;* Se*, Sida cf. ectogama;* Sel*, Seringia elliptica;* Ss*, Senna stricta;* Ssp*, Scaevola spinescens;* Sg*, S glaucifolia;* Sgl*, Senna glutinosa* subsp*. x luerssenii. (i/g)=intergrove site*

Vegetation Significance

None of the vegetation associations recorded within the study area are affiliated with any Federal or State listed TECs or PECs.

The weathered lateritic and ironstone communities in the study area are of conservation interest due to the propensity for these areas to contain Priority flora in the region. The vegetation is described as HC AsuAi TslAsu SeEllPs - High Open Shrubland of *Acacia subcontorta* and *Acacia incurvaneura* over Open Shrubland of *Thryptomene* sp. Leinster (B.J. Lepschi & L.A. Craven 4362) and *Acacia subcontorta* over Low Open Shrubland of *Sida* cf. *ectogama*, *Eremophila latrobei* subsp. *latrobei* and *Ptilotus schwartzii* (over Very Open Tussock Grassland of *Eriachne mucronata*, *Thyridolepis xerophila* and *Eragrostis eriopoda*) on orange sandy loam on weathered ironstone ridges and hill crests. Two Priority species occur consistently within this unit: *Thryptomene* sp. Leinster (B.J. Lepschi & L.A. Craven 4362) and *Calytrix praecipua. Eremophila lanata* also occurs sporadically within the unit.

This community appears to be poorly represented in the Marymia area, representing approximately 2% of the vegetation area that was assessed in the Project area.

Vegetation Condition

Vegetation condition within the study area ranged from Good to Very Good (Figure 9). Approximately 18 percent of the study area has previously been disturbed through historical mining and exploration activities. The remaining vegetation has also been impacted by mining and exploration activities with numerous tracks and drill pads present throughout the study area. The vegetation of the study area showed obvious signs of degradation by cattle grazing. Camels were also present within the study area. Weed species were a very minor disturbance within the study area with only two species recorded at low densities. Weed species may be more prevalent within the study area following higher rainfall seasons.

Legend

Survey Areas

Vegetation Types

Hill Crest

HC AsuAi TslAsu SeEllPs	High Open Shrubland of Acacia subcontorta and Acacia incurvaneura over Open Shrubland of Thryptomene sp. Leinster (B.J. Lepschi & L.A. Craven 4362) and Acacia subcontorta over Low Open Shrubland of Sida cf. ectogama, Eremophila latrobei subsp. latrobei and Ptilotus schwartzii over Very Open Tussock Grassland of Eriachne mucronata, Thyridolepis xerophila and Eragrostis eriopoda on orange sandy loam on weathered ironstone ridges

Hillslope

HS Apt SglSs Em	Low Open Woodland of Acacia pteraneura over Open Shrubland of Senna glutinosa subsp. x luerssenii and Senna stricta over Low Open Shrubland of Eremophila margarethae on brown sandy loam on hillslopes
HS CdPr EfGbAf	Low Shrubland of Calytrix cf. desolata and Ptilotus rotundifolius with Open Shrubland of Eremophila fraseri, Grevillea berryana and Acacia fuscaneura (Senna glutinosa subsp. x luerssenii) on brown sandy loam on hillslopes
HS AptAi EmPrPo	Low Open Woodland (or Low Woodland) of Acacia pteraneura and Acacia incurvaneura over Low Shrubland of Eremophila margarathe, Ptilotus rotundifolius and Ptilotus obovatus and Scattered Hummock Grasses of Triodia basedowii on orange sandy clay loam on hillslopes

Hardpan Plains

HP Tb AiAth	Hummock Grassland of Triodia basedowii with High Open Shrubland of Acacia incurvaneura and Acacia thoma and Low Open Shrubland of Eremophila forrestii subsp. forrestii, Eremophila lanata and Ptilotus schwartzii (Scattered Low Trees of Acacia pruinocarpa and Grevillea berryana) on orange sandy clay loam on hardpan plains
HP AiGbApt AiAth	Low Open Woodland of Acacia incurvaneura, Grevillea berryana and Acacia pteraneura over High Open Shrubland of Acacia incurvaneura and Acacia thoma and Low Open Shrubland of Eremophila forrestii subsp. forrestii, Ptilotus swartzii and Eremophila spectabilis (Very Open Tussock Grassland of Eragrostis eriopoda) on brown clay loam on hardpan plains
HP Ai EffEsb	Low Woodland of Acacia incurvaneura over Low Open Shrubland of Eremophila forrestii subsp. forrestii and Eremophila spectabilis subsp. brevis over Very Open Hummock Grassland of Triodia basedowii on brown sandy clay loam on hardpan plains

Sandy / Stony Plains

SS AanAa Arl EffArl Tb	Low Woodland of Acacia aneura and Acacia ayersiana (Acacia incurvaneura, Acacia pteraneura, Acacia pruinocarpa) over High Open Shrubland of Acacia ramulosa var. linophylla over Open Shrubland of Eremophila forrestii subsp. forrestii and Acacia ramulosa var. linophylla over Very Open Hummock Grassland of Triodia basedowii over Very Open Tussock Grassland of Eragrostis eriopoda and Thyridolepis xerophila on red/orange silty loam on sandy/stony plains
SS AiApAa Ec	Low Open Forest of Acacia incurvaneura, Acacia pruinocarpa and Acacia ayersiana over Shrubland of Eremophila cf. citrina (Eremophila forrestii subsp. forrestii) over Open Hummock Grassland of Triodia basedowii on brown sandy loam on sandy/stony plains
SS Tb AanAiAap	Hummock Grassland of Triodia basedowii with Low Open Woodland of Acacia aneura, Acacia incurvaneura and Acacia aptaneura (Acacia ayersiana) and Scattered Low Shrubs of Eremophila forrestii subsp. forrestii and Eremophila cf. demissa on orange silty loam on sandy/stony plains
SS Tb ScSe	Hummock Grassland of Triodia basedowii with Low Open Shrubs of Sida cardiophylla and Seringia elliptica with Scattered Shrubs of Acacia ayersiana, Acacia kempeana and Eremophila forrestii subsp. forrestii on brown loamy sand on sandy/stony plains
SS EffEsEc Tb ApAaApt	Shrubland of Eremophila forrestii subsp. forrestii, Eremophila spathulata and Eremophila cf. citrina (Eremophila latrobei subsp. latrobei) over Open Hummock Grassland of Triodia basedowii with Low Open Woodland of Acacia pruinocarpa, Acacia ayersiana and Acacia pteraneura and High Open Shrubland of Acacia incurvaneura and Acacia ramulosa var. linophylla on brown loamy sand on sandy/stony plains
SS Tb AiAp Ar	Humock Grassland of Triodia basedowii with Low Open Woodland of Acacia incurvaneura and Acacia pruinocarpa (Grevillea berryana, Acacia ayersiana) and High Open Shrubland of Acacia rhodophloia (Acacia ramulosa var. linophylla, Acacia thoma) and Low Open Shrubland of Eremophila cf. citrina and Eremophila spathulata (Eremophila latrobei subsp. latrobei) on brown/orange sandy loam on sandy/stony plains and low rises

Stony Plains

SP Ai EfSgEff PsPoSl	High Open Shrubland of Acacia incurvaneura (Acacia pteraneura, Acacia pruinocarpa) over Open Shrubland of Eremophila fraseri, Senna glaucifolia and Eremophila forrestii subsp. forrestii (Eremophila latrobei subsp. latrobei) over Low Open Shrubland of Ptilotus schwartzii, Ptilotus obovatus and Solanum lasiophyllum on brown sandy loam on stony plains
SP AiGbPl EffEll EsEmPs	High Open Shrubland of Acacia incurvaneura, Grevillea berryana and Psydrax latifolia over Open Shrubland of Eremophila forrestii subsp. forrestii and Eremophila latrobei subsp. latrobei over Low Open Shrubland of Eremophila spathulata, Eremophila margarathe and Ptilotus schwartzii on orange sandy clay loam on stony plains
SP EexPrEf AfAi	Low Open Shrubland of Eremophila exilifolia, Ptilotus rotundifolius and Eremophila fraseri with Scattered Low Trees of Acacia fuscaneura and Acacia incurvaneura on orange sandy loam on stony plains
SP Ai EffEcEll PsEd Tb	High Open Shrubland of Acacia incurvaneura (Acacia pruinocarpa, Grevillea berryana) over Open Shrubland of Eremophila forrestii subsp. forrestii, Eremophila cf. citrina and Eremophila latrobei subsp. latrobei over Low Open Shrubland Ptilotus schwartzii and Eremophila cf. demissa over Very Open Hummock Grassland of Triodia basedowii on brown loamy sand on stony plains
SP AptAiAp AsuAthAi	Low Open Woodland of Acacia pteraneura, Acacia incurvaneura and Acacia pruinocarpa over High Open Shrubland of Acacia subcontorta, Acacia thoma and Acacia incurvaneura over Low Open Shrubland of Sida cf. ectogamma, Eremophila lanata and Ptilotus schwartzii (Scattered Tussock Grassland of Eriachne mucronata and Eragrostis eriopoda) on brown sandy clay loam on stony plains
SP ElPs EmEe GbAiApt	Low Open Shrubland of Eremophila lanata and Ptilotus schwartzii over Very Open Tussock Grassland of Eriachne mucronata and Eragrosits eriopoda with Scattered Tall Shrubs of Grevillea berryana, Acacia incurvaneura and Acacia pteraneura on brown sandy loam on stony plains
SP AiGb EsEmPs	High Open Shrubland of Acacia incurvaneura and Grevillea berryana over Low Open Shrubland of Eremophila spathulata, Eremophila margarathe and Ptilotus schwartzii (Eremophila lanata, Ptilotus albidus, Solanum lasiophylum) with Scattered Low Trees of Acacia pteranaeura on brown sandy clay loam on stony plains
SP EsEfPo	Low Open Shrubland of Eremophila spathulata, Eremophila fraseri and Ptilotus obovatus on orange sandy clay loam on stony plains
SP AptAi AclSgl	High Open Shrubland of Acacia pteraneura and Acacia incurvaneura (Acacia macraneura, Hakea preissii) over Open Shrubland of Acacia cuthbertsonii subsp. linearis and Senna glutinosa subsp. x luerssenii over Low Open Shrubland of Eremophila margarethae, Senna stricta and Ptilotus obovatus on brown sandy loam on stony plains
SP SmFs Apt HpSm	Low Open Shrubland of Senna sp. Meekatharra (E. Bailey 1-26), Frankenia setosa and Sclerolaena ssp. with Scattered Tall Shrubs of Acacia pteraneura over Scattered Shrubs of Hakea preissii and Senna sp. Meekatharra (E. Bailey 1-26) on brown sandy loam on stony plains

Flood Plain

FP Ai ArlPlGb EffSeEf	Low Open Forest (to Low Closed Forest) of Acacia incurvaneura (Acacia pruinocarpa, Acacia ayersiana, Acacia aptaneura, Acacia aneura, Grevillea berryana) over High Shrubland of Acacia ramulosa var. linophylla, Psydrax latifolia and Grevillea berryana over Shrubland of Eremophila forrestii subsp. forrestii, Sida cf. ectogama and Eremophila fraseri over Very Open Tussock Grassland of Thyridolepis xerophila and Eragrostis eriopoda and Very Open Herbs of Cheilanthes austrotenuifolia on brown sandy clay loam on floodplains

Major Drainage Line

MA AapAanAi TlEkCf	Low Closed Forest of Acacia aptaneura, Acacia aneura and Acacia incurvaneura over Open Tussock Grassland of Tripogonella loliiformis, Eragrostis kennedyae and Chrysopogon fallax with High Open Shrubland of Acacia tetragonophylla and Very Open Herbs of Cheilanthes austrotenuifolia and Evolvulus alsinoides on brown silty clay loam on major drainage lines
MA AanAcAm PlArlAt Tt	Low Closed Forest of Acacia aneura, Acacia citrinoviridis and Acacia macraneura over High Open Shrubland of Psydrax latifolia, Acacia ramulosa var. linophylla and Acacia tetragonophylla over Very Open Tussock Grassland of Themeda triandra on brown loamy sandy on major drainage lines
MA AmApt AcrAtAss	Low Open Forest of Acacia macraneura and Acacia pteraneura (Eucalyptus victrix) over High Open Shrubland of Acacia craspedocarpa, Acacia tetragonophylla and Acacia sclerosperma subsp. sclerosperma over Low Open Shrubland of Senna artemisioides subsp. artemisioides, Eremophila margarethae and Ptilotus obovatus over Very Open Tussock Grassland of Chrysopogon fallax, Themeda triandra and Eragrostis kennedyae on brown sand on major drainage lines

Medium Drainage Line

ME AapAan EfEff	Low Open Forest of Acacia aptaneura and Acacia aneura over Open Shrubland of Eremophila fraseri and Eremophila forrestii subsp. forrestii over Very Open Tussock Grassland of Themeda triandra on brown sandy clay loam on medium drainage lines
ME Ai Tl	Low Open Forest of Acacia incurvaneura over Open Tussock Grassland of Tripogonella loliiformis with Open Shrubland of Sida cf. ectogama (Eremophila fraseri and Acacia tetragonophylla) on brown loamy sand on medium drainage lines and floodplains

Minor Drainage Line

MI ArlApt	Scattered Tall Shrubs of Acacia ramulosa var. linophylla and Acacia pteraneura over Scattered Low Shrubs of Acacia sibirica on brown sandy loam on minor drainage lines (eroded channels)
MI AptAcGb DpAc SeShSsp	Low Woodland of Acacia pteraneura, Acacia citrinoviridis and Grevillea berryana (Acacia pruinocarpa) over High Open Shrubland of Dodonaea pachyneura and Acacia crasepedocarpa (hybrid) over Low Open Shrubland of Sida cf. ectogama, Senna artemisioides subsp. helmsii and Scaevola spinescens (Open Shrubland of Senna glutinosa subsp. x luerssenii) on brown sandy loam on minor drainage lines
MI Ac DpAtSsp	Low Open Woodland of Acaica citrinoviridis (Acacia pteraneura) over Open Shrubland of Dodonaea pachyneura, Acacia tetragonophylla and Scaevola spinescens over Very Open Hummock Grassland of Triodia basedowii on orange silty loam on hillslopes and minor drainage lines

Other

Disturbed	
Mosaic of HP Tb AiAth EffElPs & SP ElPs EmEe GbAiApt	Mosaic of Hummock Grassland of Triodia basedowii with High Open Shrubland of Acacia incurvaneura and Acacia thoma and Low Open Shrubland of Eremophila forrestii subsp. forrestii, Eremophila lanata and Ptilotus schwartzii (Scattered Low Trees of Acacia pruinocarpa and Grevillea berryana) on orange sandy clay loam on hardpan plains & Low Open Shrubland of Eremophila lanata and Ptilotus schwartzii over Very Open Tussock Grassland of Eriachne mucronata and Eragrosits eriopoda with Scattered Tall Shrubs of Grevillea berryana, Acacia incurvaneura and Acacia pteraneura on brown sandy loam on stony plains

ONSHORE ENVIRONMENTAL

VANGO

Marymia

Vegetation Types Legend

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Status:	Final
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Internal Reference:	Marymia_Apex_VT
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Requested by:	DB

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SP Ai EfSgEff PsPoSl
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SP SmFs Apt HpSm
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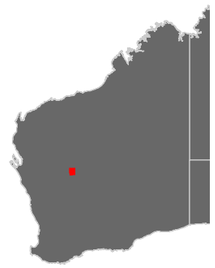
VANGO

Marymia

Apex Vegetation Types

Legend

Survey Areas



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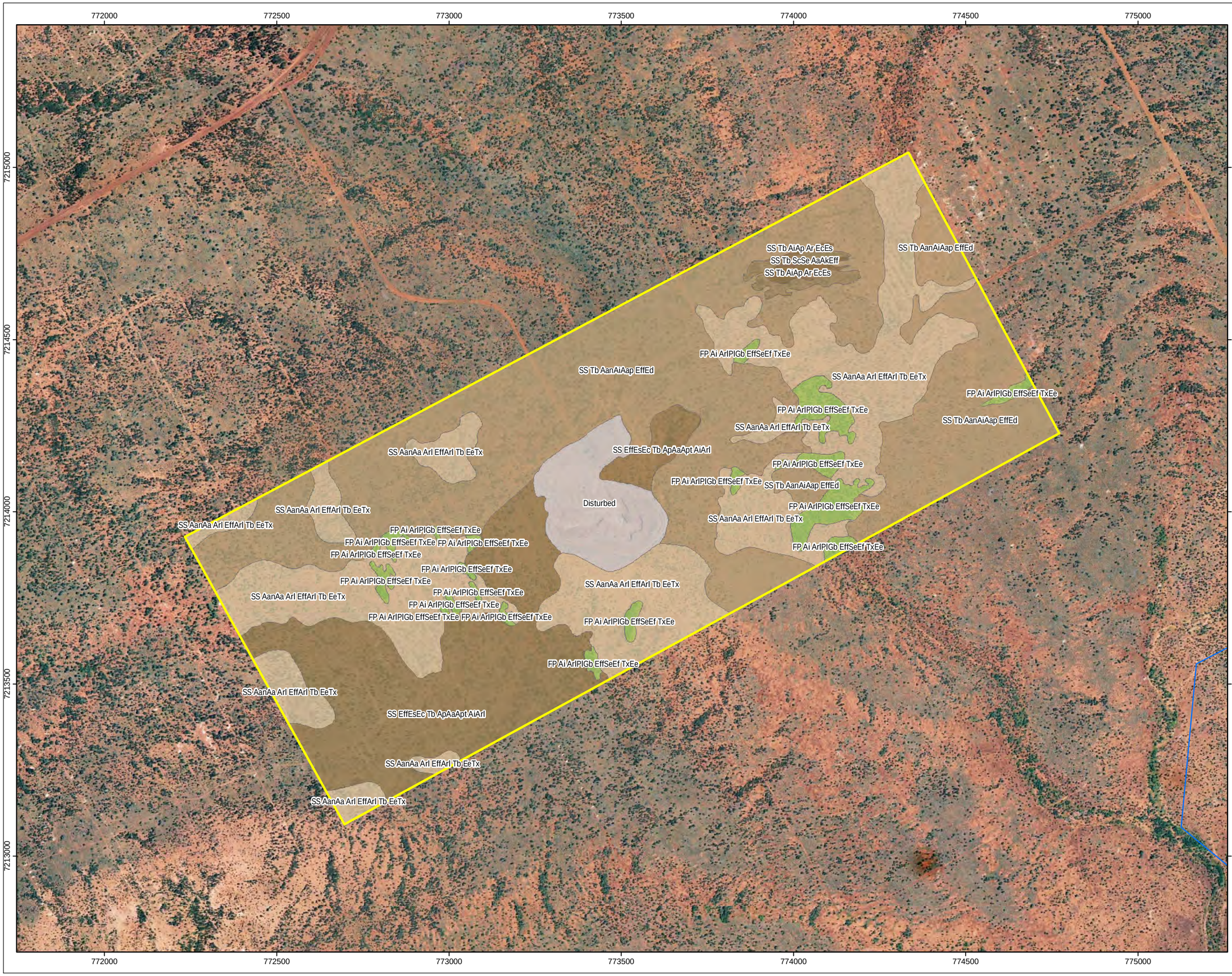

ONSHORE ENVIRONMENTAL

VANGO

Marymia

Cinnamon Vegetation Types

Legend

Survey Areas

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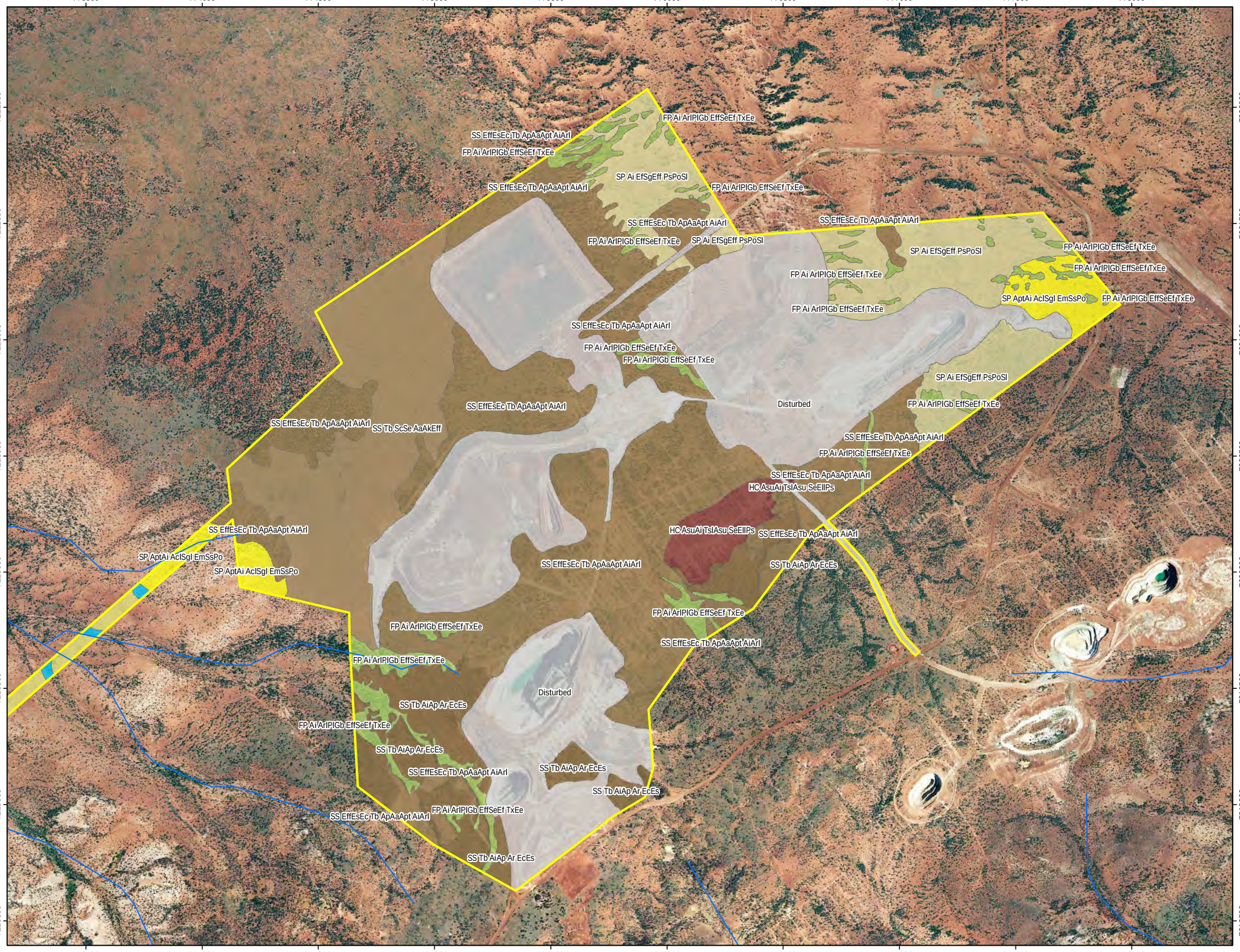

ONSHORE ENVIRONMENTAL

VANGO

Marymia

K2
Vegetation Types

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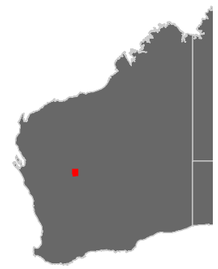
Survey Areas



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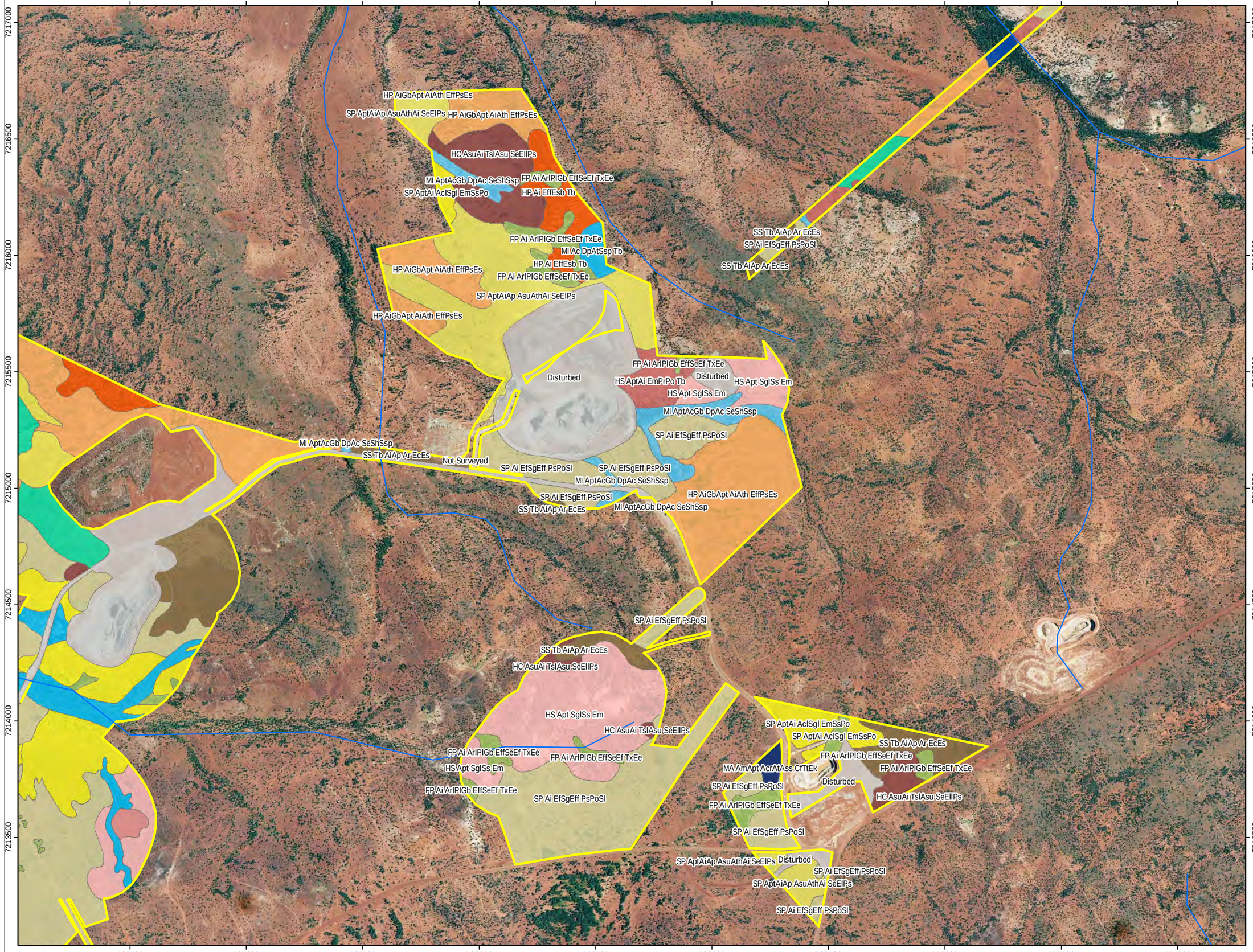


ONSHORE ENVIRONMENTAL

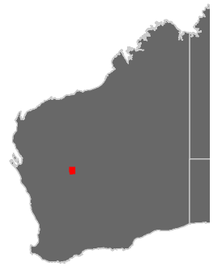
VANGO

Marymia

Wedgetail, Mareast & Ibis Area Vegetation Types

Legend

Survey Areas



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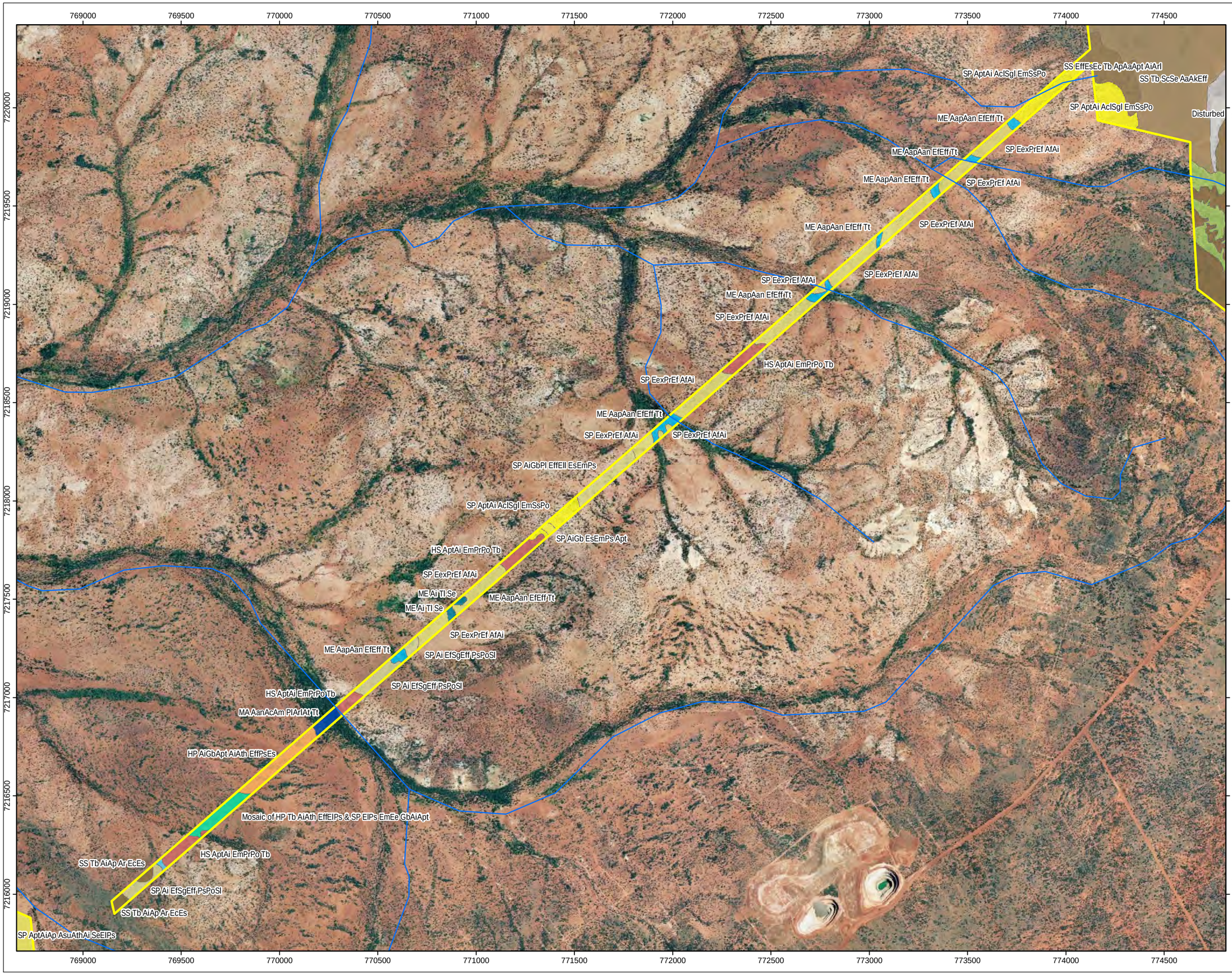

VANGO

Marymia

Access Road Vegetation Types

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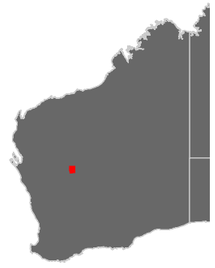
Survey Areas



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GRIFFIN SPATIAL & MAPPING

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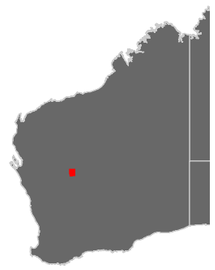
VANGO

Marymia

Trident Area Vegetation Types

Legend

Survey Areas



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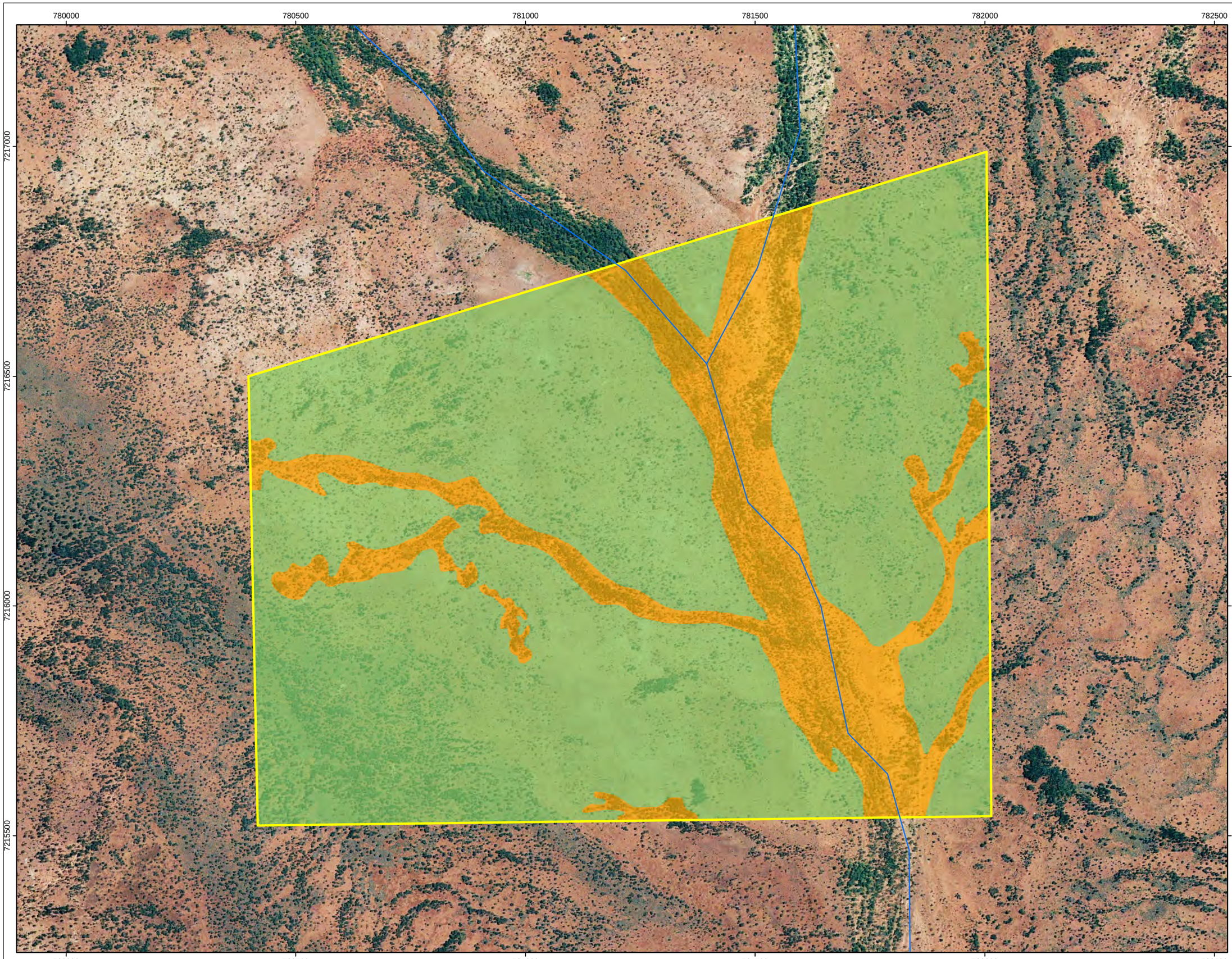


ONSHORE ENVIRONMENTAL

VANGO

Marymia

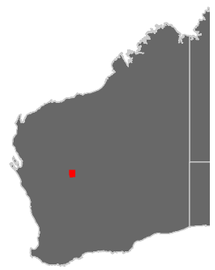
Apex Vegetation Condition

Legend

- Survey Areas

Vegetation Condition

- Disturbed
- Good
- Very Good



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GRIFFIN SPATIAL & MAPPING

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VANGO

Marymia

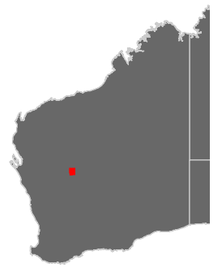
Cinnamon Vegetation Condition

Legend

- Survey Areas

Vegetation Condition

- Disturbed
- Good
- Very Good



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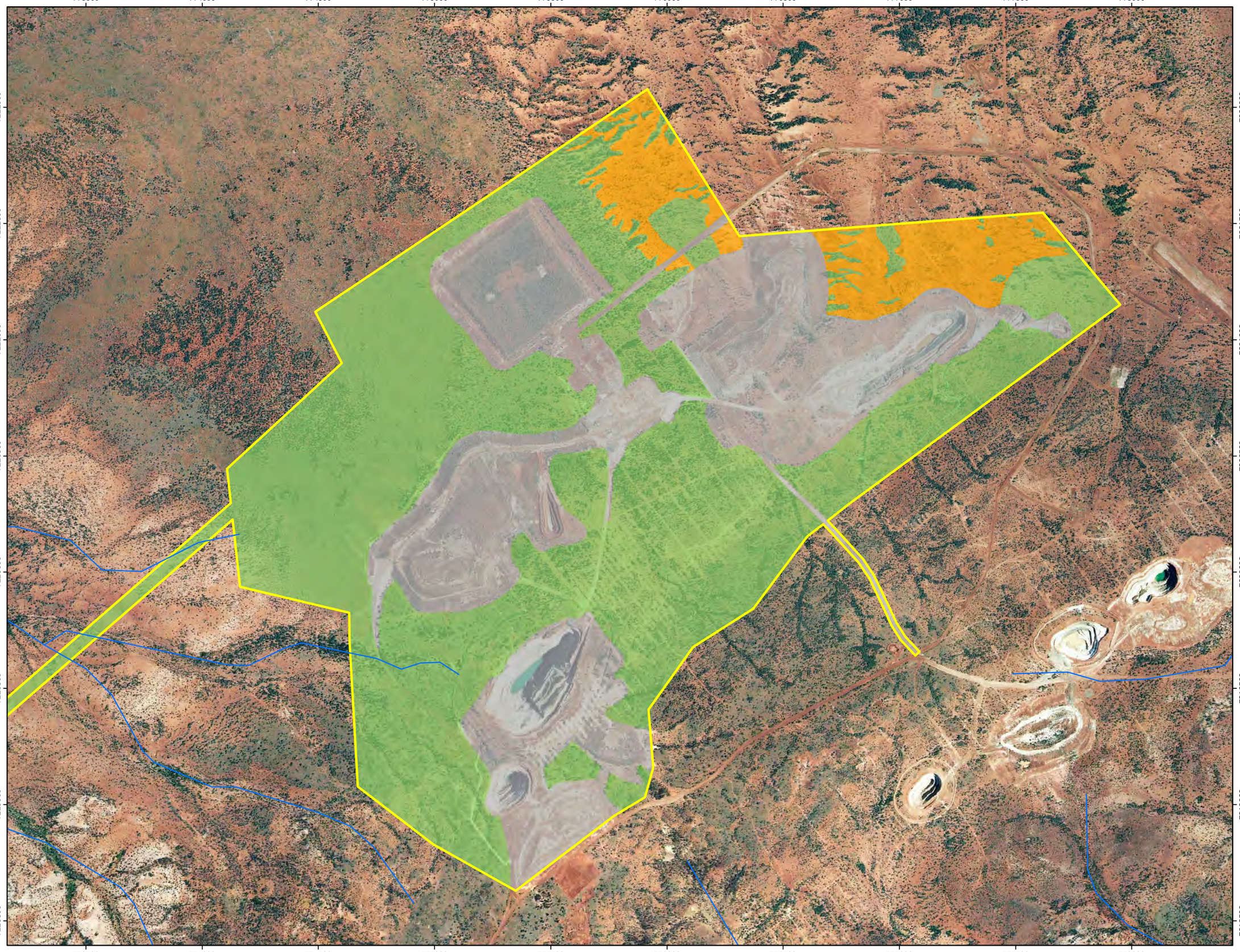


ONSHORE ENVIRONMENTAL

VANGO

Marymia

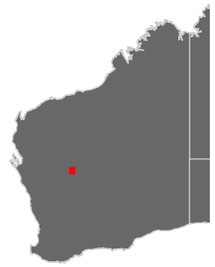
K2 Vegetation Condition

Legend

- Survey Areas

Vegetation Condition

- Disturbed
- Good
- Very Good



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GRIFFIN SPATIAL & MAPPING

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VANGO

Marymia

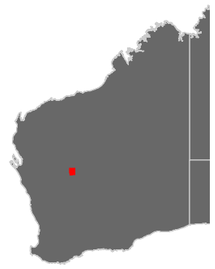
Wedgetail, Mareast & Ibis Area Vegetation Condition

Legend

- Survey Areas

Vegetation Condition

- Disturbed
- Good
- Very Good



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Projection: MGA Zone 50

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Status:	Final
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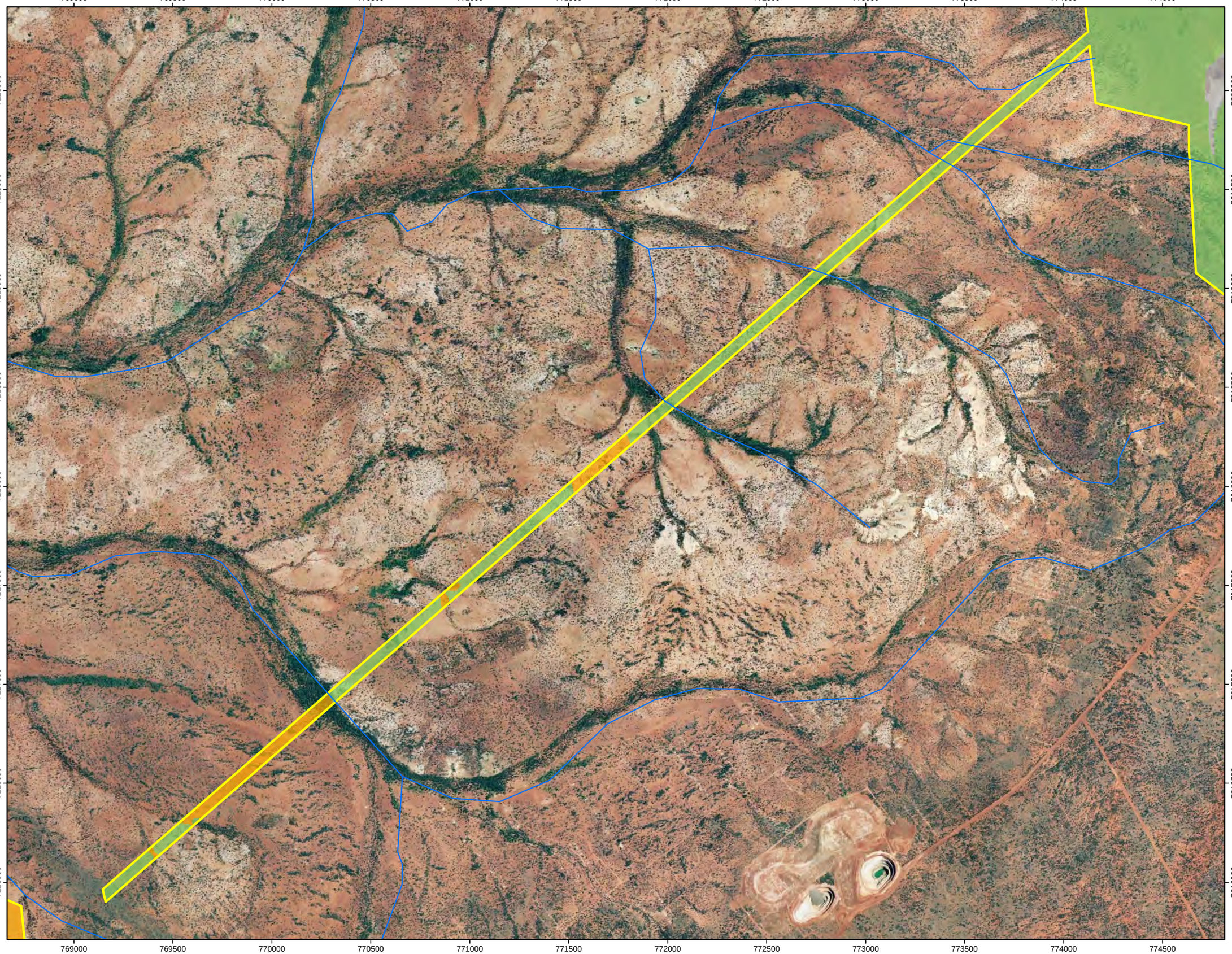
Requested by:	DB



VANGO

Marymia

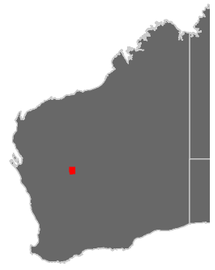
Access Road Vegetation Condition

Legend

- Survey Areas

Vegetation Condition

- Disturbed
- Good
- Very Good



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Datum: GDA94

Projection: MGA Zone 50

Date:	11/06/2019
Status:	Final
Figure:	9
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Drawn by:	GSM
Requested by:	DB

763500 764000 764500 765000 765500 766000 766500 767000 767500

7215500 7215000 7214500 7214000 7213500 7213000

VANGO

Marymia

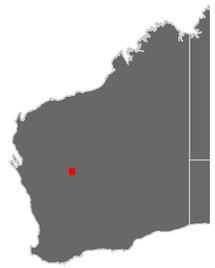
K2 Vegetation Condition

Legend

- Survey Areas

Vegetation Condition

- Disturbed
- Good
- Very Good



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Projection: MGA Zone 50

Date:	11/06/2019
Status:	Final
Figure:	9
Sheet Size:	A3
Internal Reference:	Marymia_K2_VC
Drawn by:	GSM
Requested by:	DB

GRIFFIN SPATIAL & MAPPING

Broad Floristic Formation	*Acacia* High Open Shrubland
Vegetation Association	HC AsuAi TslAsu SeEllPs - High Open Shrubland of *Acacia subcontorta* and *Acacia incurvaneura* over Open Shrubland of *Thryptomene* sp. Leinster (B.J. Lepschi & L.A. Craven 4362) and *Acacia subcontorta* over Low Open Shrubland of *Sida* cf. *ectogama*, *Eremophila latrobei* subsp. *latrobei* and *Ptilotus schwartzii* (over Very Open Tussock Grassland of *Eriachne mucronata*, *Thyridolepis xerophila* and *Eragrostis eriopoda*) on orange sandy loam on weathered ironstone ridges and hill crests

Area Mapped	30.74 ha
Quadrats Sampled	IB-01, K2-08, K2-17, MA-01, TRI-15, WE-04
Soils	Orange Sandy Loam
Land Form	Hill crest/ Upper Hill slopes of weathered ironstone ridges
Priority Ecological Community	No
Conservation Significant Flora	*Eremophila lanata* (P3) *Thryptomene* sp. Leinster (B.J. Lepschi & L.A. Craven 4362) (P3) *Calytrix praecipua* (P3)
Introduced Species	None recorded
Vegetation Condition	Very Good
Disturbances	Road/access track, cattle grazing
Average Fire Age	Old (6+ years)
Vegetation Structure & Floristics	
Shrubs >2 m	*Acacia subcontorta, Acacia incurvaneura, Acacia ramulosa var. linophylla, Acacia mulganeura, Grevillea berryana, Acacia pteraneura*
Shrubs 1-2 m	*Thryptomene* sp. Leinster (B.J. Lepschi & L.A. Craven 4362), *Acacia subcontorta*
Shrubs 0-1 m	*Sida* cf. *ectogama*, *Eremophila latrobei* subsp. *latrobei*, *Ptilotus schwartzii, Calytrix praecipua*
Tussock Grasses	*Eriachne mucronata*, *Thyridolepis xerophila*, *Eragrostis eriopoda*

Broad Floristic Formation	*Acacia* High Open Shrubland
Vegetation Association	SP Ai EffEcEll PsEd - High Open Shrubland of *Acacia incurvaneura* (*Acacia pruinocarpa*, *Grevillea berryana*) over Open Shrubland of *Eremophila forrestii* subsp. *forrestii*, *Eremophila* cf. *citrina* and *Eremophila latrobei* subsp. *latrobei* over Low Open Shrubland *Ptilotus schwartzii* and *Eremophila* cf. *demissa* on brown loamy sand on stony plains

Area Mapped	14.34 ha
Quadrats Sampled	APEX-07
Soils	Brown Loamy Sand
Land Form	Stony Plain
Priority Ecological Community	No
Conservation Significant Flora	*Eremophila* cf. *demissa* (P1) *Goodenia virgata* (P2) *Hemigenia tysonii* (P3)
Introduced Species	None recorded
Vegetation Condition	Very Good
Disturbances	Cattle Grazing
Average Fire Age	Old (6+ years)
Vegetation Structure & Floristics	
Shrubs >2 m	*Acacia incurvaneura, Acacia pruinocarpa*, *Grevillea berryana*
Shrubs 1-2 m	*Eremophila forrestii* subsp. *forrestii*, *Eremophila* cf. *citrina*, *Eremophila latrobei* subsp. *latrobei*
Shrubs 0-1 m	*Ptilotus schwartzii, Eremophila* cf. *demissa*
Hummock Grasses	*Triodia basedowii*

Broad Floristic Formation	*Acacia* High Open Shrubland
Vegetation Association	SP Ai EfSgEff PsPoSl - High Open Shrubland of *Acacia incurvaneura* (*Acacia pteraneura, Acacia pruinocarpa*) over Open Shrubland of *Eremophila fraseri*, *Senna glaucifolia* and *Eremophila forrestii* subsp. *forrestii* (*Eremophila latrobei* subsp. *latrobei*) over Low Open Shrubland of *Ptilotus schwartzii*, *Ptilotus obovatus* and *Solanum lasiophyllum* on brown sandy loam on stony plains

Area Mapped	311.18 ha
Quadrats Sampled	APEX-02, K2-16, ME-04, MW-02, TP-13, TRI-01, TRI-03, TRI-06, TRI-09, TRI-16, TRI-17, TRI-18, WE-06, WE-07, K2-11 (i/g), K2-14 (i/g), TRI-08 (i/g), TRI-10 (i/g)
Soils	Brown Sandy Loam
Land Form	Stony Plain (ironstone/quartz)
Priority Ecological Community	No
Conservation Significant Flora	*Goodenia virgata* (P2) *Eremophila lanata* (P3)
Introduced Species	None recorded
Vegetation Condition	Very Good
Disturbances	Cattle Grazing, Mining Exploration, Road/Access Track
Average Fire Age	Old (6+ years)
Vegetation Structure & Floristics	
Trees <10m	*Acacia pteraneura, Acacia pruinocarpa, Grevillea berryana, Acacia paraneura, Acacia aptaneura, Acacia ayersiana*
Shrubs >2 m	*Acacia incurvaneura, Acacia pteraneura, Acacia pruinocarpa, Acacia ramulosa* var. *linophylla, Acacia thoma, Psydrax latifolia, Acacia rhodophloia, Acacia aneura, Acacia cuthbertsonii* subsp. *linearis*
Shrubs 1-2 m	*Eremophila fraseri*, *Senna glaucifolia*, *Eremophila forrestii* subsp. *forrestii*, *Eremophila latrobei* subsp. *latrobei, Acacia thoma, Eremophila forrestii* subsp. *forrestii, Senna glutinosa* subsp. x *luerssenii, Senna artemisioides* subsp. *helmsii, Scaevola spinescens, Acacia tetragonophylla*
Shrubs 0-1 m	*Ptilotus schwartzii*, *Ptilotus obovatus*, *Solanum lasiophyllum, Senna glaucifolia, Senna artemisioides* subsp. *oligophylla, Eremophila margarathe, Ptilotus rotundifolius, Eremophila spathulata, Maireana georgei, Eremophila punctate, Sida* cf. *ectogama, Eremophila spectabilis, Senna* sp. Meekatharra (E. Bailey 1-26)
Hummock Grassland	*Triodia basedowii*
Tussock Grassland	*Eragrostis eriopoda, Eriachne mucronata*

Broad Floristic Formation	*Acacia* High Open Shrubland
Vegetation Association	SP ElPs EmEe GbAiApt - Low Open Shrubland of *Eremophila lanata* and *Ptilotus schwartzii* over Very Open Tussock Grassland of *Eriachne mucronata* and *Eragrostis eriopoda* with Scattered Tall Shrubs of *Grevillea berryana*, *Acacia incurvaneura* and *Acacia pteraneura* on brown sandy loam on stony plains

Area Mapped	38.82 ha
Quadrats Sampled	TD-01, TD-12, TRI-05, TRI-13, TRI-23
Soils	Brown Sandy Loam
Land Form	Stony Plain
Priority Ecological Community	No
Conservation Significant Flora	*Goodenia virgata* (P3) *Eremophila lanata* (P3) *Thryptomene* sp. Leinster (B.J. Lepschi & L.A. Craven 4362) (P3)
Introduced Species	None recorded
Vegetation Condition	Very Good
Disturbances	Cattle Grazing, Mining Exploration, Road/Access Track
Average Fire Age	Old (6+ years)
Vegetation Structure & Floristics	
Shrubs >2 m	*Grevillea berryana*, *Acacia incurvaneura*, *Acacia pteraneura, Acacia thoma, Acacia aptaneura, Acacia ramulosa* var. *linophylla*
Shrubs 0-1 m	*Eremophila lanata*, *Ptilotus schwartzii, Solanum lasiophyllum, Senna glaucifolia*
Tussock Grasses	*Eriachne mucronata, Eragrostis eriopoda, Amphipogon* sp. indet
Hummock Grasses	*Triodia basedowii*

Broad Floristic Formation	*Acacia* High Open Shrubland
Vegetation Association	SP AptAi AclSgl EmSsPo - High Open Shrubland of *Acacia pteraneura* and *Acacia incurvaneura* (*Acacia macraneura, Hakea preissii*) over Open Shrubland of *Acacia cuthbertsonii* subsp. *linearis* and *Senna glutinosa* subsp. x *luerssenii* over Low Open Shrubland of *Eremophila margarethae*, *Senna stricta* and *Ptilotus obovatus* on brown sandy loam on stony plains

Area Mapped	110.16 ha
Quadrats Sampled	IB-02, K2-15, K2-19, MA-04, MW-01, MW-06, TP-04, TRI-04, TRI-12, TRI-14, TRI-19
Soils	Brown Sandy Loam
Land Form	Stony plain
Priority Ecological Community	No
Conservation Significant Flora	*Eremophila lanata* (P3)
Introduced Species	None recorded
Vegetation Condition	Very Good
Disturbances	Cattle Grazing; Mining Exploration; Road/Access Track; Rubbish
Average Fire Age	Old (6+ years)
Vegetation Structure & Floristics	
Shrubs >2 m	*Acacia pteraneura, Acacia incurvaneura, Acacia macraneura, Hakea preissii*
Shrubs 1-2 m	*Acacia cuthbertsonii* subsp. *linearis, Senna glutinosa subsp. x luerssenii*
Shrubs 0-1 m	*Eremophila margarethae, Senna stricta, Ptilotus obovatus, Ptilotus albidus, Senna* sp. Meekatharra (E. Bailey 1-26), *Senna artemisioides* subsp. *helsmii*

Broad Floristic Formation	*Senna* Low Open Shrubland
Vegetation Association	SP SmFs Apt HpSm - Low Open Shrubland of *Senna* sp. Meekatharra (E. Bailey 1-26), *Frankenia setosa* and *Sclerolaena* spp. with Scattered Tall Shrubs of *Acacia pteraneura* over Scattered Shrubs of *Hakea preissii* and *Senna* sp. Meekatharra (E. Bailey 1-26) on brown sandy loam on stony plains

Area Mapped	13.73 ha
Quadrats Sampled	APEX-01
Soils	Brown Sandy Loam
Land Form	Stony plain
Priority Ecological Community	No
Conservation Significant Flora	None recorded
Introduced Species	None recorded
Vegetation Condition	Very Good
Disturbances	Cattle Grazing
Average Fire Age	Old (6+ years)
Vegetation Structure & Floristics	
Shrubs >2 m	*Acacia pteraneura*
Shrubs 1-2 m	*Hakea preissii*, *Senna* sp. Meekatharra (E. Bailey 1-26)
Shrubs 0-1 m	*Senna* sp. Meekatharra (E. Bailey 1-26), *Frankenia setosa*, *Sclerolaena* spp.

Broad Floristic Formation	*Acacia* Low Woodland
Vegetation Association	SS AanAa Arl EffArl Tb EeTx - Low Woodland of *Acacia aneura* and *Acacia ayersiana* (*Acacia incurvaneura, Acacia pteraneura, Acacia pruinocarpa*) over High Open Shrubland of *Acacia ramulosa* var. *linophylla* over Open Shrubland of *Eremophila forrestii* subsp. *forrestii* and *Acacia ramulosa* var. *linophylla* (over Very Open Hummock Grassland of *Triodia basedowii* over Very Open Tussock Grassland of *Eragrostis eriopoda* and *Thyridolepis xerophila*) on red/orange silty loam on sandy/stony plains

Area Mapped	66.64 ha
Quadrats Sampled	CIN-01, CIN-06, CIN-09, CIN-10
Soils	Orange Silty Loam
Land Form	Sandy/ Stony plain
Priority Ecological Community	No
Conservation Significant Flora	None recorded
Introduced Species	None recorded
Vegetation Condition	Very Good
Disturbances	Cattle Grazing; Mining Exploration
Average Fire Age	Old (6+ years)
Vegetation Structure & Floristics	
Trees <10 m	*Acacia aneura*, *Acacia ayersiana*, *Acacia incurvaneura, Acacia pteraneura, Acacia pruinocarpa*
Shrubs >2 m	*Acacia ramulosa* var. *linophylla*
Shrubs 1-2 m	*Eremophila forrestii* subsp. forrestii, *Acacia ramulosa* var. *linophylla*
Hummock Grasses	*Triodia basedowii*
Tussock Grasses	*Eragrostis eriopoda*, *Thyridolepis xerophila*

Broad Floristic Formation	*Acacia* Low Open Forest
Vegetation Association	SS AiApAa Ec Tb - Low Open Forest of *Acacia incurvaneura, Acacia pruinocarpa* and *Acacia ayersiana* over Shrubland of *Eremophila* cf. *citrina* (*Eremophila forrestii* subsp. *forrestii*) over Open Hummock Grassland of *Triodia basedowii* on brown sandy loam on sandy/stony plains

Area Mapped	8.21 ha
Quadrats Sampled	APEX-04
Soils	Brown Sandy Loam
Land Form	Sandy/ Stony plain
Priority Ecological Community	No
Conservation Significant Flora	None recorded
Introduced Species	None recorded
Vegetation Condition	Very Good
Disturbances	Cattle Grazing
Average Fire Age	Old (6+ years)
Vegetation Structure & Floristics	
Trees <10 m	*Acacia incurvaneura, Acacia pruinocarpa*, *Acacia ayersiana*
Shrubs 1-2 m	*Eremophila* cf. *citrina*, *Eremophila forrestii* subsp. *forrestii*
Hummock Grasses	*Triodia basedowii*

Broad Floristic Formation	*Acacia* Low Open Forest
Vegetation Association	SS EffEsEc Tb ApAaApt AiArl - Shrubland of *Eremophila forrestii* subsp. *forrestii*, *Eremophila spathulata* and *Eremophila* cf. *citrina* (*Eremophila latrobei* subsp. *latrobei*) over Open Hummock Grassland of *Triodia basedowii* with Low Open Woodland of *Acacia pruinocarpa*, *Acacia ayersiana* and *Acacia pteraneura* (and High Open Shrubland of *Acacia incurvaneura* and *Acacia ramulosa* var. *linophylla*) on brown loamy sand on sandy/ stony plains

Area Mapped	221.92 ha
Quadrats Sampled	CIN-02, K2-03, K2-06, K2-07, K2-10, K2-13
Soils	Orange Clay Loam, Sandy
Land Form	Sandy/ Stony plain
Priority Ecological Community	No
Conservation Significant Flora	*Hibiscus brachychlaenus* (Range extension)
Introduced Species	None recorded
Vegetation Condition	Very Good
Disturbances	Cattle Grazing; Mining Exploration; Road/Access Track; Rubbish; Old Mine nearby
Average Fire Age	Old (6+ years)
Vegetation Structure & Floristics	
Trees <10 m	*Acacia pruinocarpa*, *Acacia ayersiana*, *Acacia pteraneura, Acacia aneura, Acacia paraneura, Acacia incurvaneura, Grevillea berryana*
Shrubs >2 m	*Acacia ramulosa* var. *linophylla*, *Acacia incurvaneura, Hakea lorea* subsp. *lorea, Psydrax latifolia, Acacia thoma, Acacia subcontorta*
Shrubs 1-2 m	*Eremophila forrestii* subsp. forrestii, *Eremophila* cf. *citrina*, *Eremophila latrobei* subsp. *latrobei, Senna glaucifolia*
Shrubs <1m	*Sida* sp. Golden calyces glabrous (H.N. Foote 32)*, Seringia elliptica, Eremophila punctata*
Hummock Grasses	*Triodia basedowii*
Tussock Grasses	*Eragrostis eriopoda*

Broad Floristic Formation	*Acacia* Low Open Forest
Vegetation Association	SS Tb AanAiAap EffEd - Hummock Grassland of *Triodia basedowii* with Low Open Woodland of *Acacia aneura*, *Acacia incurvaneura* and *Acacia aptaneura* (*Acacia ayersiana*) and Scattered Low Shrubs of *Eremophila forrestii* subsp. *forrestii* and *Eremophila* cf. *demissa* on orange silty loam on sandy/ stony plains

Area Mapped	94.59 ha
Quadrats Sampled	CIN-04, CIN-05, CIN-08
Soils	Orange Silty Loam
Land Form	Sandy/ Stony plain
Priority Ecological Community	No
Conservation Significant Flora	*Eremophila* cf. *demissa* (P1)
Introduced Species	None recorded
Vegetation Condition	Very Good
Disturbances	Cattle Grazing
Average Fire Age	Old (6+ years)
Vegetation Structure & Floristics	
Trees <10 m	*Acacia aneura*, *Acacia incurvaneura, Acacia aptaneura*, *Acacia ayersiana*
Shrubs <1 m	*Eremophila forrestii* subsp. forrestii, *Eremophila* cf. *demissa, Eremophila granitica*
Hummock Grasses	*Triodia basedowii*

Broad Floristic Formation	Triodia Hummock Grassland
Vegetation Association	SS Tb AiAp Ar EcEs - Hummock Grassland of *Triodia basedowii* with Low Open Woodland of *Acacia incurvaneura* and *Acacia pruinocarpa* (*Grevillea berryana*, *Acacia ayersiana*) and High Open Shrubland of *Acacia rhodophloia* (*Acacia ramulosa* var. *linophylla*, *Acacia thoma*) and Low Open Shrubland of *Eremophila* cf. *citrina* and *Eremophila spathulata* (*Eremophila latrobei* subsp. *latrobei*) on brown/orange sandy loam on sandy/ stony plains and low rises

Area Mapped	72.86 ha
Quadrats Sampled	APEX-03, K2-01, K2-02, K2-05, K2-09, MW-05, TP-18
Soils	Brown Sandy Loam
Land Form	Sandy/ Stony plain
Priority Ecological Community	No
Conservation Significant Flora	*Sauropus* sp. Woolgorong (M. Officer s.n. 10/8/94) (P3)
Introduced Species	None recorded
Vegetation Condition	Very Good
Disturbances	Cattle Grazing; Mining Exploration; Road/ Access Track
Average Fire Age	Old (6+ years)
Vegetation Structure & Floristics	
Trees <10 m	*Acacia incurvaneura, Acacia pruinocarpa, Acacia ayersiana, Grevillea berryana, Acacia citrinoviridis*
Shrubs >2 m	*Acacia rhodophloia*, *Acacia ramulosa* var. *linophylla, Acacia thoma, Acacia subcontorta, Acacia mulganeura*
Shrubs <1 m	*Eremophila* cf. *citrina, Eremophila spathulata, Eremophila latrobei* subsp. *latrobei, Ptilotus obovatus, Ptilotus rotundifolius, Senna glaucifolia*
Hummock Grasses	*Triodia basedowii*

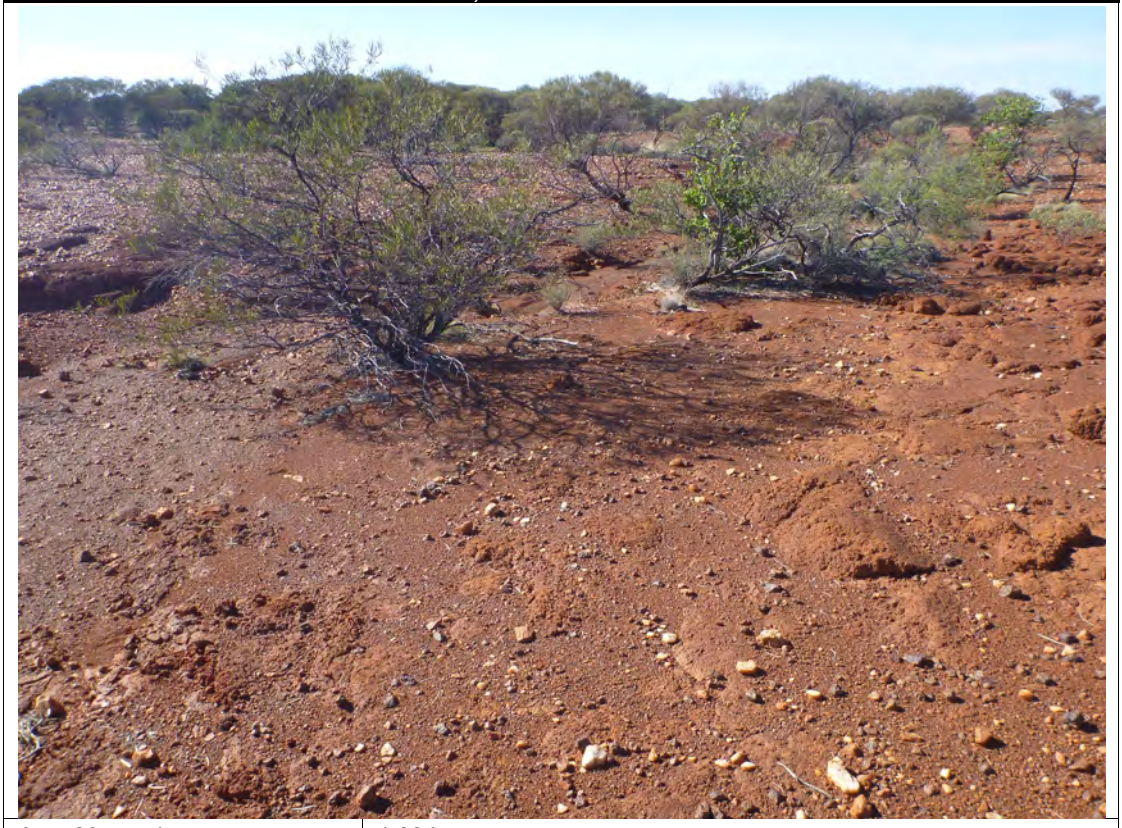
Broad Floristic Formation	*Triodia* Hummock Grassland
Vegetation Association	SS Tb ScSe AaAkEff - Hummock Grassland of *Triodia basedowii* with Low Open Shrubland of *Sida cardiophylla* and *Seringia elliptica* with Scattered Shrubs of *Acacia ayersiana*, *Acacia kempeana* and *Eremophila forrestii* subsp. *forrestii* on brown loamy sand on sandy/ stony plains

Area Mapped	72.97 ha
Quadrats Sampled	K2-04, K2-20, K2-18, K2-22
Soils	Brown Loamy Sand
Land Form	Sandplain
Priority Ecological Community	No
Conservation Significant Flora	None recorded
Introduced Species	None recorded
Vegetation Condition	Very Good
Disturbances	Cattle Grazing; Frequent Fire; Mining Exploration
Average Fire Age	Recent (0 to 2 yr)
Vegetation Structure & Floristics	
Shrubs 1-2 m	*Acacia ayersiana*, *Acacia kempeana*, *Eremophila forrestii* subsp. *forrestii*
Shrubs <1 m	*Sida cardiophylla, Seringia elliptica*
Hummock Grasses	*Triodia basedowii*

Broad Floristic Formation	*Acacia* Low Open Forest
Vegetation Association	FP Ai ArlPlGb EffSeEf TxEe - Low Open Forest (to Low Closed Forest) of *Acacia incurvaneura* (*Acacia pruinocarpa*, *Acacia ayersiana*, *Acacia aptaneura*, *Acacia aneura*) over High Shrubland of *Acacia ramulosa* var. *linophylla*, *Psydrax latifolia* and *Grevillea berryana* over Shrubland of *Eremophila forrestii* subsp. *forrestii*, *Sida* cf. *ectogama* and *Eremophila fraseri* (over Very Open Tussock Grassland of *Thyridolepis xerophila* and *Eragrostis eriopoda* and Very Open Herbs of *Cheilanthes sieberi*) on brown sandy clay loam on floodplains

Area Mapped	64.49 ha
Quadrats Sampled	CIN-03, CIN-07, CIN-11, K2-12, TRI-07, TRI-11, TD-13
Soils	Brown Sandy Clay Loam
Land Form	Drainage Area/ Floodplain, Stony Plain, Sandy/ Stony Plain
Priority Ecological Community	No
Conservation Significant Flora	None recorded
Introduced Species	**Bidens bipinnata*
Vegetation Condition	Very Good
Disturbances	Cattle Grazing
Average Fire Age	Old (6+ years)
Vegetation Structure & Floristics	
Trees <10 m	*Acacia incurvaneura, Acacia pruinocarpa*, *Acacia ayersiana*, *Acacia aptaneura*, *Acacia aneura, Acacia pteraneura, Acacia citrinoviridis*
Shrubs >2 m	*Acacia ramulosa* var. *linophylla*, *Psydrax latifolia*, *Grevillea berryana, Acacia minyura, Psydrax suaveolens, Acacia tetragonophylla*
Shrubs 1-2 m	*Eremophila forrestii* subsp. *forrestii*, *Sida ectogama*, *Eremophila fraseri, Ptilotus obovatus, Eremophila spectabilis, Enchylaena tomentosa, Eremophila latrobei* subsp. *latrobei, Abutilon cryptopetalum*
Shrubs <1m	*Sida fibulifera*
Hummock Grasses	*Triodia basedowii*
Tussock Grasses	*Thyridolepis xerophila, Eragrostis eriopoda, Eriachne helmsii, Paspalidium* sp. Indet, *Tripogonella loliiformis*
Herbs	*Cheilanthes austrotenuifolia*

Broad Floristic Formation	*Acacia* Scattered Tall Shrubs
Vegetation Association	MI ArlApt As - Scattered Tall Shrubs of *Acacia ramulosa* var. *linophylla* and *Acacia pteraneura* over Scattered Low Shrubs of *Acacia sibirica* on brown sandy loam on minor drainage lines (eroded channels)



Area Mapped	1.09 ha
Quadrats Sampled	APEX-10
Soils	Brown Sandy Loam
Land Form	Drainage Area/ Floodplain
Priority Ecological Community	No
Conservation Significant Flora	*Eremophila* cf. *demissa* (P1), *Sauropus* sp. Woolgorong (M.Officer s.n.10/8/94) (P3)
Introduced Species	None recorded
Vegetation Condition	None Discernible
Disturbances	Cattle Grazing
Average Fire Age	Old (6+ years)
Vegetation Structure & Floristics	
Shrubs >2 m	*Acacia ramulosa* var. *linophylla*, *Acacia pteraneura*
Shrubs <1 m	*Acacia sibirica*

Broad Floristic Formation	*Acacia* Low Open Forest
Vegetation Association	ME AapAan EfEff Tt - Low Open Forest of *Acacia aptaneura* and *Acacia aneura* over Open Shrubland of *Eremophila fraseri* and *Eremophila forrestii* subsp. *forrestii* over Very Open Tussock Grassland of *Themeda triandra* on brown sandy clay loam on medium drainage lines

Area Mapped	17.80 ha
Quadrats Sampled	TRI-02, MW-03, MW-08
Soils	Brown Sandy Clay Loam
Land Form	Medium Drainage Line
Priority Ecological Community	No
Conservation Significant Flora	*Sporobolus blakei* (P3)
Introduced Species	None recorded
Vegetation Condition	Very Good
Disturbances	Cattle Grazing
Average Fire Age	Old (6+ years)
Vegetation Structure & Floristics	
Trees <10 m	*Acacia aptaneura*, *Acacia aneura, Acacia incurvaneura, Acacia craspedocarpa, Acacia pteraneura, Acacia pruinocarpa,*
Shrubs <2m	*Acacia sibirica*
Shrubs 1-2 m	*Eremophila fraseri*, *Eremophila forrestii* subsp. *forrestii, Sida* cf. *ectogamma*
	Ptilotus obovatus, Indigofera monophyla
Tussock Grasses	*Themeda triandra*

Broad Floristic Formation	*Acacia* Low Open Forest
Vegetation Association	ME Ai TI Se - Low Open Forest of *Acacia incurvaneura* over Open Tussock Grassland of *Tripogonella loliiformis* with Open Shrubland of *Sida ectogama* (*Eremophila fraseri* and *Acacia tetragonophylla*) on brown loamy sand on medium drainage lines and floodplains

Area Mapped	8.12 ha
Quadrats Sampled	APEX-05
Soils	Brown Loamy Sand
Land Form	Drainage Area/ Floodplain
Priority Ecological Community	No
Conservation Significant Flora	None recorded
Introduced Species	None recorded
Vegetation Condition	Good
Disturbances	Cattle Grazing
Average Fire Age	Old (6+ years)
Vegetation Structure & Floristics	
Trees <10 m	*Acacia incurvaneura*
Shrubs 1-2 m	*Sida* cf. *ectogama*, *Eremophila fraseri*, *Acacia tetragonophylla*
Tussock Grasses	*Tripogonella loliiformis*

Broad Floristic Formation	*Acacia* Low Closed Forest
Vegetation Association	MA AapAanAi TlEkCf At - Low Closed Forest of *Acacia aptaneura*, *Acacia aneura* and *Acacia incurvaneura* over Open Tussock Grassland of *Tripogonella loliiformis*, *Eragrostis kennedyae* and *Chrysopogon fallax* with High Open Shrubland of *Acacia tetragonophylla* (and Very Open Herbs of *Cheilanthes sieberi* and *Evolvulus alsinoides*) on brown silty clay loam on major drainage lines

Area Mapped	15.55 ha
Quadrats Sampled	APEX-06
Soils	Brown Silty Clay Loam
Land Form	Major Drainage Line
Priority Ecological Community	No
Conservation Significant Flora	None recorded
Introduced Species	**Bidens bipinnata*
Vegetation Condition	Good
Disturbances	Cattle Grazing
Average Fire Age	Old (6+ years)
Vegetation Structure & Floristics	
Trees <10 m	*Acacia aptaneura*, *Acacia aneura*, *Acacia incurvaneura*
Shrubs >2 m	*Acacia tetragonophylla*
Tussock Grasses	*Tripogonella loliiformis*, *Eragrostis kennedyae*, *Chrysopogon fallax*
Herbs	*Cheilanthes sieberi, Evolvulus alsinoides*

Broad Floristic Formation	*Acacia* Low Open Forest
Vegetation Association	MA AmApt AcrAtAss CfTtEk - Low Open Forest of *Acacia macraneura* and *Acacia pteraneura* (*Eucalyptus victrix*) over High Open Shrubland of *Acacia craspedocarpa*, *Acacia tetragonophylla* and *Acacia sclerosperma* subsp. *sclerosperma* over Low Open Shrubland of *Senna artemisioides* subsp. *artemisioides*, *Eremophila margarethae* and *Ptilotus obovatus* over Very Open Tussock Grassland of *Chrysopogon fallax*, *Themeda triandra* and *Eragrostis kennedyae* on brown sand on major drainage lines

Area Mapped	19.92 ha
Quadrats Sampled	APEX-08, APEX-09
Soils	Brown Sand
Land Form	Major / Medium Drainage Line
Priority Ecological Community	No
Conservation Significant Flora	None recorded
Introduced Species	**Portulaca pilosa*
Vegetation Condition	Very Good to Degraded
Disturbances	Cattle Grazing; Erosion
Average Fire Age	Old (6+ years)
Vegetation Structure & Floristics	
Trees <10 m	*Acacia macraneura*, *Acacia pteraneura, Eucalyptus victrix*
Shrubs >2 m	*Acacia craspedocarpa*, *Acacia tetragonophylla*, *Acacia sclerosperma* subsp. *sclerosperma*
Shrubs <1 m	*Senna artemisioides* subsp. *artemisioides*, *Eremophila margarethae*, *Ptilotus obovatus*
Tussock Grasses	*Chrysopogon fallax*, *Themeda triandra*, *Eragrostis kennedyae*

Broad Floristic Formation	*Acacia* Low Open Woodland
Vegetation Association	HS Apt SglSs Em- Low Open Woodland of *Acacia pteraneura* over Open Shrubland of *Senna glutinosa* subsp. x *luerssenii* and *Senna stricta* over Low Open Shrubland of *Eremophila margarethae* on brown sandy loam on hillslopes

Area Mapped	44.23 ha
Quadrats Sampled	TRI-21, WE-01, WE-02, WE-05
Soils	Brown Sandy Loam
Land Form	Hill slopes
Priority Ecological Community	No
Conservation Significant Flora	*Maireana prosthecochaeta* (P3)
Introduced Species	None recorded
Vegetation Condition	Very Good
Disturbances	Cattle Grazing; Mining Exploration; Road/ Access Track
Average Fire Age	Old (6+ years)
Vegetation Structure & Floristics	
Trees <10 m	*Acacia pteraneura, Acacia pruinocarpa, Acacia fuscaneura, Eucalyptus gypsophila*
Shrubs <2m	*Hakea leucoptera* subsp. *sericipes*
Shrubs 1-2 m	*Senna glutinosa* subsp. *luerssenii, Senna stricta, Senna* sp. Meekatharra (E. Bailey 1-26), *Ptilotus albidus*
Shrubs <1 m	*Eremophila margarethae, Maireana prosthecochaeta*

Broad Floristic Formation	*Acacia* Low Open Woodland or Low Woodland
Vegetation Association	HS AptAi EmPrPo Tb - Low Open Woodland (or Low Woodland) of *Acacia pteraneura* and *Acacia incurvaneura* over Low Shrubland of *Eremophila margarethae*, *Ptilotus rotundifolius* and *Ptilotus obovatus* and Scattered Hummock Grasses of *Triodia basedowii* on orange sandy clay loam on hillslopes

Area Mapped	10.05 ha
Quadrats Sampled	ME-01, TP-15, TP-06
Soils	Orange Sandy Clay Loam
Land Form	Hill slopes
Priority Ecological Community	No
Conservation Significant Flora	None recorded
Introduced Species	None recorded
Vegetation Condition	Very Good
Disturbances	Cattle Grazing; Mining Exploration; Road/ Access Track
Average Fire Age	Old (6+ years)
Vegetation Structure & Floristics	
Trees <10 m	*Acacia pteraneura, Acacia incurvaneura*
Shrubs <2 m	*Acacia incurvaneura, Acacia ramulosa* var. *linophylla, Acacia craspeocarpa*
Shrubs <1 m	*Eremophila margarethae*, *Ptilotus rotundifolius, Ptilotus obovatus, Senna glutinosa* subsp. *x luerssenii*
Hummock Grasses	*Triodia basedowii*

Broad Floristic Formation	*Calytrix* Low Shrubland
Vegetation Association	HS CdPr EfGbAf – Low Shrubland of *Calytrix* cf. *desolata* and *Ptilotus rotundifolius* with Open Shrubland of *Eremophila fraseri*, *Grevillea* berryana and *Acacia fuscaneura* (*Senna glutinosa* subsp. *luerssenii*) on brown sandy loam on hillslopes

Area Mapped	1.54 ha
Quadrats Sampled	TRI-20, TRI-22 (outside study area)
Soils	Brown Sandy Loam
Land Form	Hill slopes
Priority Ecological Community	No
Conservation Significant Flora	None recorded
Introduced Species	None recorded
Vegetation Condition	Good
Disturbances	Cattle Grazing; Mining Exploration
Average Fire Age	Old (6+ years)
Vegetation Structure & Floristics	
Shrubs <2 m	*Acacia sibirica, Acacia fuscaneura*
Shrubs 1-2 m	*Eremophila fraseri*, *Grevillea berryana*, *Acacia fuscaneura*, *Senna glutinosa* subsp. x *luerssenii*
Shrubs <1 m	*Calytrix* cf. *desolata*, *Ptilotus rotundifolius*

Broad Floristic Formation	*Acacia* Low Woodland
Vegetation Association	MI AptAcGb DpAc SeShSsp - Low Woodland of *Acacia pteraneura*, *Acacia citrinoviridis* and *Grevillea berryana* (*Acacia pruinocarpa*) over High Open Shrubland of *Dodonaea pachyneura* and *Acacia craspedocarpa* (hybrid) over Low Open Shrubland of *Sida* cf. *ectogama*, *Senna artemisioides* subsp. *helmsii* and *Scaevola spinescens* (with an Open Shrubland of *Senna glutinosa* subsp. *luerssenii*) on brown sandy loam on minor drainage lines

Area Mapped	9.05 ha
Quadrats Sampled	MA-03, ME-02
Soils	Brown Sandy Loam
Land Form	Minor Drainage Line
Priority Ecological Community	No
Conservation Significant Flora	*Thryptomene* sp. Leinster (B.J. Lepschi & L.A. Craven 4362) (P3)
Introduced Species	None recorded
Vegetation Condition	Good
Disturbances	Cattle Grazing, mining Exploration, road/ access track
Average Fire Age	Old (6+ years)
Vegetation Structure & Floristics	
Trees <10 m	*Acacia pteraneura, Acacia citrinoviridis, Grevillea berryana, Acacia pruinocarpa*
Shrubs >2 m	*Dodonaea pachyneura, Acacia craspedocarpa* (hybrid)
Shrubs 1-2 m	*Senna glutinosa* subsp. x *luerssenii*
Shrubs <1 m	*Sida cf. ectogama, Senna artemisioides* subsp. *helmsii*, *Scaevola spinescens*

Broad Floristic Formation	*Acacia* Low Open Woodland
Vegetation Association	MI Ac DpAtSsp Tb - Low Open Woodland of *Acacia citrinoviridis* (*Acacia pteraneura*) over Open Shrubland of *Dodonaea pachyneura*, Acacia *tetragonophylla* and *Scaevola spinescens* over Very Open Hummock Grassland of *Triodia basedowii* on orange silty loam on hillslopes and minor drainage lines

Area Mapped	2.22 ha
Quadrats Sampled	MA-06
Soils	Orange Silty Loam
Land Form	Hill slopes and Minor Drainage Lines
Priority Ecological Community	No
Conservation Significant Flora	None recorded
Introduced Species	None recorded
Vegetation Condition	Very Good
Disturbances	Mining Exploration; Road/Access Track
Average Fire Age	Old (6+ years)
Vegetation Structure & Floristics	
Trees <10 m	*Acacia citrinoviridis*, *Acacia pteraneura*
Shrubs 1-2 m	*Dodonaea pachyneura*, *Acacia tetragonophylla*, *Scaevola spinescens*
Hummock Grasses	*Triodia basedowii*

Broad Floristic Formation	*Acacia* Low Closed Forest
Vegetation Association	MA AanAcAm PlArlAt Tt - Low Closed Forest of *Acacia aneura*, *Acacia citrinoviridis* and *Acacia macraneura* over High Open Shrubland of *Psydrax latifolia*, *Acacia ramulosa* var. *linophylla* and *Acacia tetragonophylla* over Very Open Tussock Grassland of *Themeda* sp. indet. on brown loamy sandy on major drainage lines

Area Mapped	0.91 ha
Quadrats Sampled	TP-08
Soils	Brown Loamy Sand
Land Form	Major / Medium Drainage Line
Priority Ecological Community	No
Conservation Significant Flora	None recorded
Introduced Species	None recorded
Vegetation Condition	Good
Disturbances	Cattle grazing
Average Fire Age	Old (6+ years)
Vegetation Structure & Floristics	
Trees <10 m	*Acacia aneura*, *Acacia citrinoviridis*, *Acacia macraneura*
Shrubs >2 m	*Psydrax latifolia*, *Acacia ramulosa* var. *linophylla*, *Acacia tetragonophylla*
Tussock Grasses	*Themeda triandra*

Broad Floristic Formation	*Acacia* Low Woodland
Vegetation Association	HP Ai EffEsb Tb – Low Woodland of *Acacia incurvaneura* over Low Open Shrubland of *Eremophila forrestii* subsp. *forrestii* and *Eremophila spectabilis* over Very Open Hummock Grassland of *Triodia basedowii* on brown sandy clay loam on hardpan plains

Area Mapped	11.09 ha
Quadrats Sampled	TD-02
Soils	Brown Sandy Clay Loam
Land Form	Hardpan Plain
Priority Ecological Community	No
Conservation Significant Flora	None recorded
Introduced Species	None recorded
Vegetation Condition	Good
Disturbances	Cattle Grazing
Average Fire Age	Old (6+ years)
Vegetation Structure & Floristics	
Trees <10 m	*Acacia incurvaneura*
Shrubs <1 m	*Eremophila forrestii* subsp. *forrestii*, *Eremophila spectabilis*
Hummock Grasses	*Triodia basedowii*

Broad Floristic Formation	*Acacia* Low Open Woodland
Vegetation Association	HP AiGbApt AiAth EffPsEsb - Low Open Woodland of *Acacia incurvaneura*, *Grevillea berryana* and *Acacia pteraneura* over High Open Shrubland of *Acacia incurvaneura* and *Acacia thoma* and Low Open Shrubland of *Eremophila forrestii* subsp. *forrestii*, *Ptilotus schwartzii* and *Eremophila spectabilis* (over Very Open Tussock Grassland of *Eragrostis eriopoda*) on brown clay loam on hardpan plains

Area Mapped	85.1 ha
Quadrats Sampled	MA-02, ME-03, ME-21, TD-03, TD-04, TD-06, TD-07, TD-10
Soils	Clay Loam
Land Form	Hardpan Plain
Priority Ecological Community	No
Conservation Significant Flora	*Eremophila lanata* (P3)
Introduced Species	None recorded
Vegetation Condition	Good
Disturbances	Cattle grazing
Average Fire Age	Old (6+ years)
Vegetation Structure & Floristics	
Trees <10 m	*Acacia incurvaneura*, *Grevillea berryana*, *Acacia pteraneura, Acacia ayersiana, Acacia pruinocarpa*
Shrubs >2 m	*Acacia incurvaneura*, *Acacia thoma, Psydrax latifolia, Acacia ramulosa* var. *linophylla, Acacia rhodophloia, Anthobolus leptomerioides*
Shrubs <1 m	*Eremophila forrestii* subsp. *forrestii*, *Ptilotus schwartzii*, *Eremophila spectabilis, Eremophila latrobei* subsp. *latrobei, Senna glaucifolia, Eremophila spectabilis* subsp. *brevis, Sida cf. ectogama, Ptilotus schwartzii*
Hummock Grasses	*Triodia basedowii*
Tussock Grasses	*Eragrostis eriopoda*

Broad Floristic Formation	*Triodia* Hummock Grassland
Vegetation Association	HP Tb AiAth EffElPs – Hummock Grassland of *Triodia basedowii* with High Open Shrubland of *Acacia incurvaneura* and *Acacia thoma* and Low Open Shrubland of *Eremophila forrestii* subsp. *forrestii*, *Eremophila lanata* and *Ptilotus schwartzii* (with Scattered Low Trees of *Acacia pruinocarpa* and *Grevillea berryana*) on orange sandy clay loam on hardpan plains

Area Mapped	3.53 ha
Quadrats Sampled	TD-05, TD-07, TD-14
Soils	Orange Sandy Clay Loam
Land Form	Hardpan Plain
Priority Ecological Community	No
Conservation Significant Flora	*Eremophila lanata* (P3)
Introduced Species	None recorded
Vegetation Condition	Very Good
Disturbances	Cattle grazing, road/ access track, mining exploration
Average Fire Age	Old (6+ years)
Vegetation Structure & Floristics	
Trees <10 m	*Acacia pruinocarpa*, *Grevillea berryana*
Shrubs >2 m	*Acacia incurvaneura*, *Acacia thoma*
Shrubs <1 m	*Eremophila forrestii* subsp. *forrestii*, *Eremophila lanata*, *Ptilotus schwartzii, Senna glaucifolia*
Hummock Grasses	*Triodia basedowii*

Broad Floristic Formation	*Acacia* Low Open Woodland
Vegetation Association	SP AptAiAp AsuAthAi SeElPs - Low Open Woodland of *Acacia pteraneura*, *Acacia incurvaneura* and *Acacia pruinocarpa* over High Open Shrubland of *Acacia subcontorta*, *Acacia thoma* and *Acacia incurvaneura* over Low Open Shrubland of *Sida* cf. *ectogama*, *Eremophila lanata* and *Ptilotus schwartzii* (with Scattered Tussock Grassland of *Eriachne mucronata* and *Eragrostis eriopoda* on brown sandy clay loam on stony plans

Area Mapped	56.77 ha
Quadrats Sampled	IB-04, MA-05, TD-08, TD-09, TD-11, TRI-25
Soils	Brown Sandy Clay Loam
Land Form	Stony Plains
Priority Ecological Community	No
Conservation Significant Flora	*Eremophila lanata* (P3)
Introduced Species	None recorded
Vegetation Condition	Good
Disturbances	Cattle grazing, mining exploration, road/access track
Average Fire Age	Old (6+ years)
Vegetation Structure & Floristics	
Trees <10 m	*Acacia pteraneura*, *Acacia incurvaneura*, *Acacia pruinocarpa, Grevillea berryana*
Shrubs >2 m	*Acacia subcontorta*, *Acacia thoma*, *Acacia incurvaneura*
Shrubs 1-2m	*Acacia cuthbertsonii* subsp. *linearis, Eremophila fraseri*
Shrubs <1 m	*Sida* cf. *ectogama*, *Eremophila lanata*, *Ptilotus schwartzii, Eremophila margarethae*
Tussock Grasses	*Eriachne mucronata*, *Eragrostis eriopoda*

Broad Floristic Formation	*Acacia* High Open Shrubland
Vegetation Association	SP AiGbPl EffEll EsEmPs - High Open Shrubland of *Acacia incurvaneura*, *Grevillea berryana* and *Psydrax latifolia* over Open Shrubland of *Eremophila forrestii* subsp. *forrestii* and *Eremophila latrobei* subsp. *latrobei* over Low Open Shrubland of *Eremophila spathulata*, *Eremophila margarethae* and *Ptilotus schwartzii* on orange sandy clay loam on stony plains

Area Mapped	2.17 ha
Quadrats Sampled	TP-10
Soils	Orange Sandy Clay Loam
Land Form	Stony Plain
Priority Ecological Community	No
Conservation Significant Flora	*Eremophila lanata* (P3)
Introduced Species	None recorded
Vegetation Condition	Good
Disturbances	Cattle grazing, road/ access track
Average Fire Age	Old (6+ years)
Vegetation Structure & Floristics	
Trees <10 m	*Acacia incurvaneura*, *Grevillea berryana*, *Psydrax latifolia*
Shrubs 1-2 m	*Eremophila forrestii* subsp. *forrestii*, *Eremophila latrobei* subsp. *latrobei*
Shrubs <1 m	*Eremophila spathulata*, *Eremophila margarethae*, *Ptilotus schwartzii*

Broad Floristic Formation	*Acacia* High Open Shrubland
Vegetation Association	SP AiGb EsEmPs Apt - High Open Shrubland of *Acacia incurvaneura* and *Grevillea berryana* over Low Open Shrubland of *Eremophila spathulata*, *Eremophila margarethae* and *Ptilotus schwartzii* (*Eremophila lanata*, *Ptilotus albidus*, *Solanum lasiophylum*) with Scattered Low Trees of *Acacia pteranaeura* on brown sandy clay loam on stony plains

Area Mapped	0.27 ha
Quadrats Sampled	TP-02, TP-03, TP-10, TP-14
Soils	Brown Sandy Clay Loam
Land Form	Stony Plains
Priority Ecological Community	No
Conservation Significant Flora	*Eremophila lanata* (P3)
Introduced Species	None recorded
Vegetation Condition	Very Good
Disturbances	Cattle grazing, mining exploration, road/access track
Average Fire Age	Old (6+ years)
Vegetation Structure & Floristics	
Trees <10 m	*Acacia pteranaeura*
Shrubs >2 m	*Acacia incurvaneura*, *Grevillea berryana*
Shrubs 1-2m	*Eremophila latrobei* subsp. *latrobei, Acacia thoma*
Shrubs <1 m	*Eremophila spathulata*, *Eremophila margarethae*, *Ptilotus schwartzii*, *Eremophila lanata*, *Ptilotus albidus*, *Solanum lasiophylum*
Hummock Grasses	*Triodia basedowii*

Broad Floristic Formation	*Eremophila* Low Open Shrubland
Vegetation Association	SP EsEfPo - Low Open Shrubland of *Eremophila spathulata*, *Eremophila fraseri* and *Ptilotus obovatus* on orange sandy clay loam on stony plains

Area Mapped	4.98 ha
Quadrats Sampled	TRI-24, TRI-26
Soils	Orange Sandy Clay Loam
Land Form	Stony Plain
Priority Ecological Community	No
Conservation Significant Flora	*Eremophila lanata* (P3)
Introduced Species	None recorded
Vegetation Condition	Good
Disturbances	Cattle grazing, mining exploration, Road/Access track
Average Fire Age	Old (6+ years)
Vegetation Structure & Floristics	
Trees <10 m	*Acacia pteraneura*
Shrubs <1 m	*Eremophila spathulata*, *Eremophila fraseri, Ptilotus obovatus, Ptilotus schwartzii*

Broad Floristic Formation	*Eremophila* Low Open Shrubland
Vegetation Association	SP EexPrEf AfAi - Low Open Shrubland of *Eremophila exilifolia*, *Ptilotus rotundifolius* and *Eremophila fraseri* with Scattered Low Trees of *Acacia fuscaneura* and *Acacia incurvaneura* on orange sandy loam on stony plains

Area Mapped	14.31ha
Quadrats Sampled	TP-09, TP-11, TP-12
Soils	Orange Sandy Loam
Land Form	Stony Plains
Priority Ecological Community	No
Conservation Significant Flora	None recorded
Introduced Species	None recorded
Vegetation Condition	Very Good
Disturbances	Cattle grazing, mining exploration
Average Fire Age	Old (6+ years)
Vegetation Structure & Floristics	
Trees <10 m	*Acacia fuscaneura*, *Acacia incurvaneura, Grevillea berryana*
Shrubs <1 m	*Eremophila exilifolia*, *Ptilotus rotundifolius*, *Eremophila fraseri, Solanum lasiophyllum, Senna artemisioides* subsp. *helmsii, Eremophila spathulata*
Tussock Grassland	*Eragrostis eriopoda, Eriachne mucronata*

4.0 SUMMARY

A two season detailed flora and vegetation survey covering prospects within the Marymia Project tenements was completed in November 2018 and May 2018.

A total of 209 plant taxa (including varieties and subspecies) from 35 families and 89 genera were recorded from the study area. Species representation was greatest among the Fabaceae, Poaceae, Scrophulariaceae, Chenopodiaceae and Malvaceae families. The most speciose genus was *Acacia* (30 taxa), followed by *Eremophila* (21 taxa), *Senna* (11 taxa), *Maireana* (8 taxa), *Sida* (7 taxa), *Hibiscus* (7 taxa) and *Ptilotus* (7 taxa).

There were no plant taxa gazetted as Threatened Flora pursuant to subsection (2) of section 23F of the *Wildlife Conservation Act 1950* (WC Act), or listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) recorded from the study area.

Nine priority listed flora were recorded from the study area; *Eremophila* cf. *demissa* (Priority 1), *Goodenia virgata* (Priority 2), *Calytrix praecipua* (Priority 3); *Eremophila lanata* (Priority 3), *Hemigenia tysonii* (Priority 3), *Maireana prosthecochaeta* (Priority 3), *Sauropus* sp. Woolgorong (M. Officer s.n. 10/8/94) (Priority 3), *Sporobolus blakei* (Priority 3) and *Thryptomene* sp. Leinster (B.J. Lepschi & L.A. Craven 4362) (Priority 3). Additionally, *Eucalyptus semota* (Priority 1) was recorded just outside the boundary of the study area. One taxa recorded from the study area is considered a range extension; *Hibiscus brachychlaenus.*

Two introduced species were recorded from the study area; **Bidens bipinnata* (Beggar's Ticks) and **Portulaca pilosa.* Neither of these taxa are listed as Declared Pests under the *Biosecurity and Agriculture Management Act 2007* (BAM Act).

A total of 32 vegetation associations were recorded within the project area. Vegetation was classified into 15 broad floristic formations on the basis of dominant vegetation stratum. None of the vegetation associations are aligned with Commonwealth or State listed Threatened Ecological Communities (TECs) or Priority Ecological Communities (PECs).

5.0 STUDY TEAM

The detailed flora and vegetation survey was planned, co-ordinated and executed by the following personnel:

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Mrs Kerry Keenan		Data Analyst
Mr Todd Griffin	BSc	GIS and Mapping Specialist

Licences

The field survey was conducted under the authorisation of the following licences issued by DBCA:

- Jerome Bull, Onshore Environmental Consultants 'Licence to take flora for scientific & other prescribed purposes' Licence No. SL012079; and

6.0 REFERENCES

Aplin, T.E.H. (1979) The Flora. Chapter 3 in O'Brien, B.J. (ed.) (1979). Environment and Science. University of Western Australia Press.

Atlas of Living Australia (2019) http://www.ala.org.au. Accessed 6 June 2019.

Beard, J.S. (1975) The vegetation survey of Western Australia. Plant Ecology. Volume 30, Issue 3, pp 179–187

Beard, J.S. (1990) Plant Life of Western Australia. Kangaroo Press Pty Ltd, Kenthurst, NSW, Australia.

Brown, A. and Buirchell, B. (2011) A field guide to the *Eremophilas* of Western Australia. Simon Nevill Publications, Hamilton Hill, W.A., Australia.

Bureau of Meteorology (2019) *Climate Data Online.* Available from: http://www.bom.gov.au/climate/data/

Department of Biodiversity, Conservation and Attractions (DBCA) (2018a) Threatened Flora Database Search, accessed 5 September 2018. Department of Biodiversity Conservation and Attractions, WA.

Department of Biodiversity, Conservation and Attractions (DBCA) (2018b) Threatened Communities Database Search, accessed 3 September 2018. Department of Biodiversity Conservation and Attractions, WA.

Department of Biodiversity, Conservation and Attractions (DBCA) (2019) NatureMap: Mapping Western Australia's biodiversity. https://naturemap.dpaw.wa.gov.au/

Department of the Environment and Energy (2019) Protected Matters Search Tool, accessed March 2018, http://www.environment.gov.au/epbc/pmst/

Department of the Environment and Energy (DoEE) (2018) Australia's bioregions (IBRA). Online at: http://www.environment.gov.au/land/nrs/science/ibra.

Desmond, A., Kendrick, P. and Chant, A. (2001) Gascoyne 3 (GAS3 – Augustus subregion) A Biodiversity Audit of Western Australia's 53 Biogeographical Subregions in 2002.

Environmental Protection Authority (2016a) Statement of Environmental Principles, Factors and Objectives, EPA, Perth.

Environmental Protection Authority (2016b) Technical Guidance Flora and Vegetation Surveys for Environmental Impact Assessment, EPA, Perth.

Environmental Protection Authority (2018) Environmental Factor Guideline Flora and Vegetation, EPA, Perth.

Gee R. D. (1986) 1:250 000 Geological Series Explanatory Notes: Peak Hill. Geological Survey of Western Australia

International Union for Conservation of Nature (IUCN) (2019) *Interactive Environmental Database Reporting Tool Search*, performed March 2018. www.iucn.org

Keighery, B. J. (1994) Bushland Plant Survey: A Guide to Plant Community Survey for the Community. Wildflower Society of WA (Inc.), Nedlands, Western Australia.

Macpherson, C.J. & Grayling, P.M. (1996) *Eucalyptus semota* (Myrtaceae), a new species from the Ashburton District of Western Australia. *Nuytsia* 10 (3): 437–441.

Onshore Environmental Consultants (2002) Outline for Biological and Environmental Components of a Notice of Intent – Apollo Deposit. Report to Barrick Mining Australia Pty Ltd.

Onshore Environmental Consultants (2003a) Outline for Biological and Environmental Components of a Notice of Intent – Mar-east Deposit – Plutonic Gold Mine. Report to Barrick Mining Australia Pty Ltd.

Onshore Environmental Consultants Pty Ltd (2003b) Outline for Biological and Environmental Components of a Notice of Intent, K2 Deposit - Plutonic Gold Mine (M52/183, M52/233, M52/234, M52/235, M52/269 & M52/1052 Leases). Report to Barrick Mining Australia Pty Ltd.

Shepherd, D., Beeston, G and Hopkins, A. (2002) Native Vegetation in Western Australia. Extent, Type and Status. *Resource Management Technical Report 249*. Department of Agriculture, South Perth.

Specht R.L. (1970) Vegetation. In The Australian Environment. 4th edn (Ed. G.W. Leeper). Melbourne.

Western Australian Herbarium (2019) *Florabase - Information on the Western Australian flora.* Department of Biodiversity Conservation and Attractions. Online: https://florabase.dpaw.wa.gov.au/search

Wilcock and McKinnon (1974) A report on the condition of the Gascoyne catchment.

APPENDIX 1

Status codes for species listed on the IUCN 'Red List'

Category	Description
Extinct (EX)	A taxon is Extinct when there is no reasonable doubt that the last individual has died. A taxon is presumed Extinct when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and life form.
Extinct in the Wild (EW)	A taxon is Extinct in the Wild when it is known only to survive in cultivation, in captivity or as a naturalized population (or populations) well outside the past range. A taxon is presumed Extinct in the Wild when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and life form.
Critically Endangered (CR)	A taxon is Critically Endangered when the best available evidence indicates that it meets any of the criteria A to E for Critically Endangered, and it is therefore considered to be facing an extremely high risk of extinction in the wild.
Endangered (EN)	A taxon is Endangered when the best available evidence indicates that it meets any of the criteria A to E for Endangered, and it is therefore considered to be facing a very high risk of extinction in the wild.
Vulnerable (VU)	A taxon is Vulnerable when the best available evidence indicates that it meets any of the criteria A to E for Vulnerable, and it is therefore considered to be facing a high risk of extinction in the wild.
Near Threatened (NT)	A taxon is Near Threatened when it has been evaluated against the criteria but does not qualify for Critically Endangered, Endangered or Vulnerable now, but is close to qualifying for or is likely to qualify for a threatened category in the near future.
Least Concern (LC)	A taxon is Least Concern when it has been evaluated against the criteria and does not qualify for Critically Endangered, Endangered, Vulnerable or Near Threatened. Widespread and abundant taxa are included in this category.
Data Deficient (DD)	A taxon is Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status. A taxon in this category may be well studied, and its biology well known, but appropriate data on abundance and/or distribution are lacking. Data Deficient is therefore not a category of threat. Listing of taxa in this category indicates that more information is required and acknowledges the possibility that future research will show that threatened classification is appropriate. It is important to make positive use of whatever data are available. In many cases great care should be exercised in choosing between DD and a threatened status. If the range of a taxon is suspected to be relatively circumscribed, and a considerable period of time has elapsed since the last record of the taxon, threatened status may well be justified.
Not Evaluated (NE)	A taxon is Not Evaluated when it has not yet been evaluated against the criteria.

APPENDIX 2

Conservation categories for species listed under the EPBC Act

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

APPENDIX 3

Conservation codes for Western Australian flora

Threatened Species

Published as Specially Protected under the *Wildlife Conservation Act 1950*, and listed under Schedules 1 to 4 of the *Wildlife Conservation (Specially Protected Fauna) Notice* for Threatened Fauna and *Wildlife Conservation (Rare Flora) Notice* for Threatened Flora (which may also be referred to as Declared Rare Flora).

Threatened fauna is that subset of 'Specially Protected Fauna' declared to be 'likely to become extinct' pursuant to section 14(4) of the *Wildlife Conservation Act*.

Threatened flora is flora that has been declared to be 'likely to become extinct or is rare, or otherwise in need of special protection', pursuant to section 23F(2) of the *Wildlife Conservation Act*.

The assessment of the conservation status of these species is based on their national extent and ranked according to their level of threat using IUCN Red List categories and criteria.

Priority One: 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.

Priority Two: Poorly-known species

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, e.g. national parks, conservation parks, nature reserves and other lands with secure tenure being managed for conservation. 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 threat from known threatening processes. Such species are in urgent need of further survey.

Priority Three: Poorly-known species

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. Species may be included if they are comparatively well known from several locations but do not meet adequacy of survey requirements and known threatening processes exist that could affect them. Such species are in need of further survey.

Priority Four: Rare, Near Threatened and other species in need of monitoring

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

(b) Near Threatened. Species that are considered to have been adequately surveyed and that are close to qualifying for Vulnerable, but are not listed as Conservation Dependent.

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

APPENDIX 4

Vegetation condition scale
(as developed by Keighery 1994)

Condition	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.

APPENDIX 5

Vegetation classifications for the Pilbara
(based on Specht 1970 as modified by Aplin 1979 and Trudgen 2002)

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

APPENDIX 6

Summary of background and results for previous flora and vegetation surveys

Project	Survey Timing	Season	Survey Type	Area (ha)	No. Sites	No. Taxa	Significant Flora	Introduced Flora
Surveys completed within, or partly within, the study area								
Marymia Hill Gold Proect Notice of Intent: Biological Assessment Survey (Ecologia 1991)	6-10 July 1991	Poor	Biological survey	-	12	84	Undescribed *Eucalyptus* sp.	None
Outline for Biological and Envionmental Components of a Notice of Intent – Apollo Deposit (Onshore Environmental Consultants 2002)	5-8 August 2002	-	Biological survey	-	-	68	*Micromyrtus mucronulata*[3] (P1), *Maireana prosthecochaeta* (P3), *Calytrix praecipua* (P3)	None
Outline for Biological and Envionmental Components of a Notice of Intent – Mareast Deposit – Plutonic Gold Mine (Onshore Environmental Consultants 2003a)	11 March 2003	-	Biological survey	-	-	60	*Maireana prosthecochaeta* (P3), *Calytrix praecipua* (P3)	**Solanum nigrum* (Blackberry Nightshade)
Outline for Biological and Envionmental Components of a Notice of Intent – K2 Deposit – Plutonic Gold Mine (Onshore Environmental Consultants 2003b)	14-15th March 2003	-	Flora and vegetation survey	12 km^2	-	93	*Eucalyptus semota* (P3), *Micromyrtus mucronulata*[4] (P1), *Maireana prosthecochaeta* (P3), *Calytrix praecipua* (P3)	None

[3] Previously known as *Micromyrtus racemosa* var. *mucronata*
[4] Previously known as *Micromyrtus racemosa* var. *mucronata*

APPENDIX 7

Species list recorded from the study area

Family	Genus	Species	Rank	Name
Acanthaceae	*Harnieria*	*kempeana*	subsp.	*muelleri*
Adiantaceae	*Cheilanthes*		cf.	*brownii*
Adiantaceae	*Cheilanthes*	*austrotenuifolia*		
Adiantaceae	*Cheilanthes*	*sieberi*	subsp.	*sieberi*
Adiantaceae	*Marsilea*	*exarata*		
Adiantaceae	*Marsilea*	*hirsuta*		
Amaranthaceae	*Ptilotus*		sp.	indet
Amaranthaceae	*Ptilotus*	*albidus*		
Amaranthaceae	*Ptilotus*	*exaltatus*		
Amaranthaceae	*Ptilotus*	*obovatus*		
Amaranthaceae	*Ptilotus*	*roei*		
Amaranthaceae	*Ptilotus*	*rotundifolius*		
Amaranthaceae	*Ptilotus*	*schwartzii*	var.	*schwartzii*
Apocynaceae	*Apocynaceae*		sp.	indet. (white hairy climber)
Apocynaceae	*Cynanchum*	*viminale*	subsp.	*australe*
Apocynaceae	*Marsdenia*	*australis*		
Apocynaceae	*Rhyncharrhena*	*linearis*		
Apocynaceae	*Vincetoxicum*	*lineare*		
Asteraceae	**Bidens*	*bipinnata*		
Asteraceae	*Calocephalus*	*beardii*		
Asteraceae	*Centipeda*		cf.	*thespedioides*
Asteraceae	*Chrysocephalum*		cf.	*puteale*
Asteraceae	*Chrysocephalum*		cf.	*pterochaetum*
Asteraceae	*Chthonocephalus*		sp.	indet
Asteraceae	*Olearia*	*stuartii*		
Asteraceae	*Streptoglossa*		sp.	indet
Boraginaceae	*Heliotropium*	*moorei*		
Brassicaceae	*Lepidium*	*phlebopetalum*		
Campanulaceae	*Wahlenbergia*	*tumidifructa*		
Chenopodiaceae	*Atriplex*	*semilunaris*		
Chenopodiaceae	*Enchylaena*	*tomentosa*		
Chenopodiaceae	*Maireana*		sp.	indet
Chenopodiaceae	*Maireana*	*georgei*		
Chenopodiaceae	*Maireana*	*glomerifolia*		
Chenopodiaceae	*Maireana*	*prosthecochaeta*		
Chenopodiaceae	*Maireana*	*thesioides*		
Chenopodiaceae	*Maireana*	*tomentosa*		
Chenopodiaceae	*Maireana*	*triptera*		
Chenopodiaceae	*Maireana*	*villosa*		
Chenopodiaceae	*Rhagodia*	*eremaea*		
Chenopodiaceae	*Salsola*	*australis*		
Chenopodiaceae	*Sclerolaena*		sp.	indet
Chenopodiaceae	*Sclerolaena*	*convexula*		
Chenopodiaceae	*Sclerolaena*	*cuneata*		
Chenopodiaceae	*Sclerolaena*	*diacantha*		
Chenopodiaceae	*Sclerolaena*	*eriacantha*		
Chenopodiaceae	*Sclerolaena*	*fusiformis*		
Convolvulaceae	*Convolvulus*		sp.	indet
Convolvulaceae	*Convolvulus*	*clementii*		
Convolvulaceae	*Duperreya*	*commixta*		
Convolvulaceae	*Evolvulus*	*alsinoides*	var.	*villosicalyx*
Convolvulaceae	*Ipomoea*	*calobra*		
Cyperaceae	*Cyperus*	*bifax*		
Cyperaceae	*Cyperus*	*cf. betchei*	subsp.	*commiscens*
Cyperaceae	*Fimbristylis*	*dichotoma*		
Euphorbiaceae	*Euphorbia*		sp.	indet
Euphorbiaceae	*Euphorbia*	*porcata*		
Euphorbiaceae	*Euphorbia*	*tannensis*	subsp.	*eremophila*
Fabaceae	*Acacia*		aff.	*sibirica* (thin robust yellow phyllodes)
Fabaceae	*Acacia*		cf.	*clelandii*
Fabaceae	*Acacia*		cf.	*macraneura*
Fabaceae	*Acacia*		cf.	*incurvaneura* x *mulganeura* (probable hybrid)
Fabaceae	*Acacia*		cf.	*quadrimarginea*
Fabaceae	*Acacia*	*aneura*		
Fabaceae	*Acacia*	*aptaneura*		
Fabaceae	*Acacia*	*ayersiana*		
Fabaceae	*Acacia*	*balsamea*		
Fabaceae	*Acacia*	*citrinoviridis*		
Fabaceae	*Acacia*	*crasepedocarpa*		
Fabaceae	*Acacia*	*cuthbertsonii*	subsp.	*linearis*
Fabaceae	*Acacia*	*fuscaneura*		

Fabaceae	*Acacia*	*incurvaneura*		
Fabaceae	*Acacia*	*kempeana*		
Fabaceae	*Acacia*	*macraneura*		
Fabaceae	*Acacia*	*minyura*		
Fabaceae	*Acacia*	*mulganeura*		
Fabaceae	*Acacia*	*pachyacra*		
Fabaceae	*Acacia*	*paraneura*		
Fabaceae	*Acacia*	*pruinocarpa*		
Fabaceae	*Acacia*	*pteraneura*		
Fabaceae	*Acacia*	*pyrifolia*		
Fabaceae	*Acacia*	*ramulosa*	var.	*linophylla*
Fabaceae	*Acacia*	*rhodophloia*		
Fabaceae	*Acacia*	*sclerosperma*	subsp.	*sclerosperma*
Fabaceae	*Acacia*	*sibirica*		
Fabaceae	*Acacia*	*subcontorta*		
Fabaceae	*Acacia*	*tetragonophylla*		
Fabaceae	*Acacia*	*thoma*		
Fabaceae	*Glycine*	*canescens*		
Fabaceae	*Indigofera*		sp.	indet
Fabaceae	*Indigofera*	*georgei*		
Fabaceae	*Indigofera*	*monophylla*		
Fabaceae	*Isotropis*		sp.	Arid zone (G. Byrne 2775)
Fabaceae	*Leptosema*	*chambersii*		
Fabaceae	*Mirbelia*	*rhagodioides*		
Fabaceae	*Senna*		sp.	Meekatharra (E. Bailey 1-26)
Fabaceae	*Senna*	*artemisioides*	subsp.	*helmsii*
Fabaceae	*Senna*	*artemisioides*	subsp.	*oligophylla x helmsii*
Fabaceae	*Senna*	*artemisioides*	subsp.	*petiolaris*
Fabaceae	*Senna*	*artemisioides*	subsp.	x *artemisioides*
Fabaceae	*Senna*	*artemisioides*	subsp.	x *sturtii*
Fabaceae	*Senna*	*artemisioides*	subsp.	*helmsii* x *glaucifolia* (hybrid)
Fabaceae	*Senna*	*glaucifolia*		
Fabaceae	*Senna*	*glutinosa*	subsp.	x *luerssenii*
Fabaceae	*Senna*	*stricta*		
Frankenia	*Frankenia*	*setosa*		
Goodenia	*Goodenia*		sp.	indet
Goodenia	*^Goodenia*	*virgata*		
Goodeniaceae	*Scaevola*	*parvifolia*	subsp.	indet
Goodeniaceae	*Scaevola*	*spinescens*		
Gyrostemonaceae	*Codonocarpus*	*cotinifolius*		
Lamiaceae	*Dicrastylis*	*brunnea*		
Lamiaceae	*^Hemigenia*	*tysonii*		
Lamiaceae	*Prostanthera*	*albiflora*		
Lamiaceae	*Teucrium*	*teucriiflorum*		
Loranthaceae	*Amyema*	*fitzgeraldii*		
Loranthaceae	*Lysiana*	*murrayi*		
Malvaceae	*Abutilon*		sp.	indet
Malvaceae	*Abutilon*	*cryptopetalum*		
Malvaceae	*Abutilon*	*otocarpum*		
Malvaceae	*Hibiscus*		sp.	indet
Malvaceae	*Hibiscus*	*brachychlaenus*		
Malvaceae	*Hibiscus*	*burtonii*		
Malvaceae	*Hibiscus*	*coatesii*		
Malvaceae	*Hibiscus*	*sturtii*	var.	*campylochlamys*
Malvaceae	*Hibiscus*	*sturtii*	var.	indet
Malvaceae	*Hibiscus*	*sturtii*	var.	*truncatus*
Malvaceae	*Senna*	*elliptica*		
Malvaceae	*Sida*		cf.	*ectogama*
Malvaceae	*Sida*		sp.	Golden calyces glabrous (H.N. Foote 32)
Malvaceae	*Sida*		sp.	indet
Malvaceae	*Sida*		sp.	L (A.M. Ashby 4202)
Malvaceae	*Sida*		sp.	dark green fruits (S. van Leeuwen 2260)
Malvaceae	*Sida*	*cardiophylla*		
Malvaceae	*Sida*	*fibulifera*		
Myrtaceae	*Calytrix*		cf.	*desolata*
Myrtaceae	*^Calytrix*	*praecipua*		
Myrtaceae	*Corymbia*	*deserticola*	subsp.	*deserticola*
Myrtaceae	*Corymbia*	*opaca*		
Myrtaceae	*Eucalyptus*	*gypsophila*		
Myrtaceae	*Eucalyptus*	*victrix*		
Myrtaceae	*^Thryptomene*		sp.	Leinster (B.J. Lepschi & L.A. Craven 4362)
Nyctaginaceae	*Boerhavia*	*repleta*		

Ophioglossaceae	*Ophioglossum*	*lusitanicum*		
Phyllanthaceae	^*Sauropus*		sp.	Woolgorong (M. Officer s.n. 10/8/94)
Poaceae	*Amphipogon*		sp.	indet
Poaceae	*Aristida*	*contorta*		
Poaceae	*Chrysopogon*	*fallax*		
Poaceae	*Digitaria*	*brownii*		
Poaceae	*Enteropogon*	*ramosus*		
Poaceae	*Eragrostis*	*eriopoda*		
Poaceae	*Eragrostis*	*kennedyae*		
Poaceae	*Eragrostis*	*xerophila*		
Poaceae	*Eriachne*	*helmsii*		
Poaceae	*Eriachne*	*mucronata*		
Poaceae	*Eriachne*	*pulchella*	subsp.	*pulchella*
Poaceae	*Monachather*	*paradoxus*		
Poaceae	*Panicum*	*effusum*		
Poaceae	*Paraneurachne*	*muelleri*		
Poaceae	*Paspalidium*		sp.	indet
Poaceae	*Poaceae*		sp.	indet
Poaceae	^*Sporobolus*	*blakei*		
Poaceae	*Themeda*		sp.	indet
Poaceae	*Themeda*	*triandra*		
Poaceae	*Thyridolepis*	*xerophila*		
Poaceae	*Triodia*		cf.	*pungens*
Poaceae	*Triodia*	*basedowii*		
Poaceae	*Triodia*	*wiseana*		
Poaceae	*Tripogonella*	*loliiformis*		
Portulacaceae	*Portulaca*		sp.	indet
Portulacaceae	**Portulaca*	*pilosa*		
Proteaceae	*Grevillea*	*berryana*		
Proteaceae	*Hakea*	*leucoptera*	subsp.	*sericipes*
Proteaceae	*Hakea*	*lorea*	subsp.	*lorea*
Proteaceae	*Hakea*	*preissii*		
Rubiaceae	*Psydrax*	*latifolia*		
Rubiaceae	*Psydrax*	*rigidula*		
Rubiaceae	*Psydrax*	*suaveolens*		
Santalaceae	*Anthobolus*	*leptomerioides*		
Santalaceae	*Santalum*	*lanceolatum*		
Santalaceae	*Santalum*	*spicatum*		
Sapindaceae	*Dodonaea*	*pachyneura*		
Sapindaceae	*Dodonaea*	*petiolaris*		
Scrophulariaceae	*Eremophila*		cf.	*citrina*
Scrophulariaceae	^*Eremophila*		cf.	*demissa*
Scrophulariaceae	*Eremophila*		cf.	*granitica*
Scrophulariaceae	*Eremophila*		cf.	*incisa*
Scrophulariaceae	*Eremophila*	*exilifola*		
Scrophulariaceae	*Eremophila*	*forrestii*	subsp.	*forrestii*
Scrophulariaceae	*Eremophila*	*fraseri*		
Scrophulariaceae	*Eremophila*	*georgei*		
Scrophulariaceae	*Eremophila*	*granitica*		
Scrophulariaceae	^*Eremophila*	*lanata*		
Scrophulariaceae	*Eremophila*	*latrobei*	subsp.	*latrobei*
Scrophulariaceae	*Eremophila*	*longifolia*		
Scrophulariaceae	*Eremophila*	*margarethae*		
Scrophulariaceae	*Eremophila*	*micrantha*		
Scrophulariaceae	*Eremophila*	*oppositifolia*	subsp.	*angustifolia*
Scrophulariaceae	*Eremophila*	*platycalyx*	subsp.	indet
Scrophulariaceae	*Eremophila*	*punctata*		
Scrophulariaceae	*Eremophila*	*spathulata*		
Scrophulariaceae	*Eremophila*	*spectabilis*	subsp.	*brevis*
Scrophulariaceae	*Eremophila*	*spinosa*		
Scrophulariaceae	*Eremophila*	*spuria*		
Solanaceae	*Solanum*	*centrale*		
Solanaceae	*Solanum*	*lasiophyllum*		
Tecticornia	*Tecticornia*	*disarticulata*		
Zygophyllaceae	*Tribulus*		cf.	*hirsutus*
Zygophyllaceae	*Tribulus*	*suberosus*		

APPENDIX 8

Locations for conservation significant flora species recorded from the study area

GENUS	SPECIES	INF_RANK	INF_NAME	EASTING	NORTHING
Calytrix	*praecipua*			768156	7216228
Calytrix	*praecipua*			768690	7213946
Calytrix	*praecipua*			768719	7213955
Calytrix	*praecipua*			768748	7213974
Calytrix	*praecipua*			768804	7213965
Calytrix	*praecipua*			768300	7214231
Calytrix	*praecipua*			768599	7215891
Calytrix	*praecipua*			768127	7216210
Calytrix	*praecipua*			768107	7216274
Calytrix	*praecipua*			768026	7216390
Calytrix	*praecipua*			767988	7216442
Calytrix	*praecipua*			767925	7216456
Calytrix	*praecipua*			768153	7216467
Calytrix	*praecipua*			767804	7216509
Calytrix	*praecipua*			768652	7215979
Calytrix	*praecipua*			765887	7213237
Calytrix	*praecipua*			768274	7214255
Eremophila	*lanata*			764524	7213897
Eremophila	*lanata*			764573	7213850
Eremophila	*lanata*			764620	7213905
Eremophila	*lanata*			769178	7214944
Eremophila	*lanata*			765801	7213217
Eremophila	*lanata*			772171	7218569
Eremophila	*lanata*			772294	7218665
Eremophila	*lanata*			772222	7218613
Eremophila	*lanata*			771662	7218148
Eremophila	*lanata*			771598	7218077
Eremophila	*lanata*			764554	7211013
Eremophila	*lanata*			764627	7211043
Eremophila	*lanata*			764587	7210951
Eremophila	*lanata*			764617	7210982
Eremophila	*lanata*			765518	7209860
Eremophila	*lanata*			765702	7213072
Eremophila	*lanata*			765753	7213128
Eremophila	*lanata*			765807	7213176
Eremophila	*lanata*			765989	7215538
Eremophila	*lanata*			765843	7215636
Eremophila	*lanata*			765675	7215734
Eremophila	*lanata*			765474	7215742
Eremophila	*lanata*			765399	7215634
Eremophila	*lanata*			765370	7215148
Eremophila	*lanata*			765370	7215148
Eremophila	*lanata*			765458	7215041
Eremophila	*lanata*			765341	7214868
Eremophila	*lanata*			765514	7214931
Eremophila	*lanata*			765753	7215006
Eremophila	*lanata*			766112	7214698
Eremophila	*lanata*			765713	7214905
Eremophila	*lanata*			765488	7214727
Eremophila	*lanata*			766321	7214672
Eremophila	*lanata*			769619	7216335
Eremophila	*lanata*			770503	7217135
Eremophila	*lanata*			769806	7216445
Eremophila	*lanata*			769665	7216365
Eremophila	*lanata*			771517	7218012
Eremophila	*lanata*			771729	7218185
Eremophila	*lanata*			771894	7218311
Eremophila	*lanata*			772155	7218536
Eremophila	*lanata*			766099	7215142
Eremophila	*lanata*			765970	7215640
Eremophila	*lanata*			765566	7215842
Eremophila	*lanata*			765449	7215726
Eremophila	*lanata*			765205	7215313
Eremophila	*lanata*			765404	7215166
Eremophila	*lanata*			765204	7214841

Eremophila	*lanata*			765581	7214767
Eremophila	*lanata*			765787	7215081
Eremophila	*lanata*			765937	7215382
Eremophila	*lanata*			771548	7218027
Eremophila	*lanata*			770498	7217133
Eremophila	*lanata*			772466	7218839
Eremophila	*lanata*			764897	7213824
Eremophila	*lanata*			765824	7213554
Eremophila	*lanata*			765693	7213240
Eremophila	*lanata*			765620	7213450
Eremophila	*lanata*			765930	7213324
Eremophila	*lanata*			765932	7213278
Eremophila	*lanata*			765843	7213267
Eremophila	*lanata*			764620	7213905
Eremophila	*lanata*			764360	7213965
Eremophila	*lanata*			764518	7214148
Eremophila		cf.	demissa	782786	7216669
Eremophila		cf.	demissa	781953	7216618
Eremophila		cf.	demissa	774039	7214090
Eremophila		cf.	demissa	773531	7214592
Eremophila		cf.	demissa	773282	7213579
Eremophila		cf.	demissa	774347	7214151
Eremophila		cf.	demissa	781787	7216665
Eremophila		cf.	demissa	774342	7214076
Eremophila		cf.	demissa	774425	7214103
Eremophila		cf.	demissa	774520	7214190
Eremophila		cf.	demissa	774498	7214342
Eremophila		cf.	demissa	766794	7209181
Eremophila		cf.	demissa	767995	7216530
Eremophila		cf.	demissa	768326	7216066
Eremophila		cf.	demissa	768356	7216194
Eucalyptus	*semota*			766702	7213377
Eucalyptus	*semota*			766733	7213424
Eucalyptus	*semota*			766721	7213416
Goodenia	*virgata*			780917	7215736
Goodenia	*virgata*			782786	7216669
Goodenia	*virgata*			765483	7214164
Goodenia	*virgata*			765102	7213218
Goodenia	*virgata*			765620	7213450
Goodenia	*virgata*			766146	7213516
Hemigenia	*tysonii*			781849	7216626
Hemigenia	*tysonii*			781999	7216642
Hemigenia	*tysonii*			781787	7216665
Hemigenia	*tysonii*			781812	7216580
Hemigenia	*tysonii*			781828	7216634
Hemigenia	*tysonii*			781830	7216760
Hemigenia	*tysonii*			781835	7216917
Hemigenia	*tysonii*			781775	7216929
Hemigenia	*tysonii*			781752	7216867
Hemigenia	*tysonii*			782786	7216669
Maireana	*prosthecochaeta*			765921	7213361
Maireana	*prosthecochaeta*			778174	7220129
Maireana	*prosthecochaeta*			778215	7220337
Maireana	*prosthecochaeta*			765909	7213346
Maireana	*prosthecochaeta*			765935	7213382
Maireana	*prosthecochaeta*			765958	7213411
Maireana	*prosthecochaeta*			765950	7213349
Maireana	*prosthecochaeta*			765942	7213351
Maireana	*prosthecochaeta*			765946	7213362
Maireana	*prosthecochaeta*			765948	7213412
Maireana	*prosthecochaeta*			778208	7220297
Maireana	*prosthecochaeta*			765961	7213384
Maireana	*prosthecochaeta*			766581	7213429
Maireana	*prosthecochaeta*			766599	7213409
Maireana	*prosthecochaeta*			766583	7213364
Maireana	*prosthecochaeta*			766662	7213380
Maireana	*prosthecochaeta*			768641	7213908
Maireana	*prosthecochaeta*			768391	7214243

Maireana	*prosthecochaeta*			767923	7213839
Maireana	*prosthecochaeta*			767967	7213785
Maireana	*prosthecochaeta*			768626	7213928
Maireana	*prosthecochaeta*			767962	7213864
Sauropus		sp.	Woolgorong (M. Officer s.n. 10/8/94)	781953	7216618
Sauropus		sp.	Woolgorong (M. Officer s.n. 10/8/94)	781787	7216665
Sauropus		sp.	Woolgorong (M. Officer s.n. 10/8/94)	774948	7219208
Sauropus		sp.	Woolgorong (M. Officer s.n. 10/8/94)	774877	7219147
Sauropus		sp.	Woolgorong (M. Officer s.n. 10/8/94)	774765	7219027
Sauropus		sp.	Woolgorong (M. Officer s.n. 10/8/94)	774938	7218899
Sauropus		sp.	Woolgorong (M. Officer s.n. 10/8/94)	775033	7219014
Sauropus		sp.	Woolgorong (M. Officer s.n. 10/8/94)	775018	7219074
Sauropus		sp.	Woolgorong (M. Officer s.n. 10/8/94)	775047	7219208
Sauropus		sp.	Woolgorong (M. Officer s.n. 10/8/94)	778208	7220295
Sauropus		sp.	Woolgorong (M. Officer s.n. 10/8/94)	778481	7220483
Sauropus		sp.	Woolgorong (M. Officer s.n. 10/8/94)	781961	7216629
Sauropus		sp.	Woolgorong (M. Officer s.n. 10/8/94)	765832	7213502
Sauropus		sp.	Woolgorong (M. Officer s.n. 10/8/94)	765870	7213403
Sauropus		sp.	Woolgorong (M. Officer s.n. 10/8/94)	781906	7216089
Sauropus		sp.	Woolgorong (M. Officer s.n. 10/8/94)	781639	7216355
Sauropus		sp.	Woolgorong (M. Officer s.n. 10/8/94)	781635	7216494
Sauropus		sp.	Woolgorong (M. Officer s.n. 10/8/94)	775047	7219338
Sauropus		sp.	Woolgorong (M. Officer s.n. 10/8/94)	774952	7219212
Sauropus		sp.	Woolgorong (M. Officer s.n. 10/8/94)	774813	7219137
Sauropus		sp.	Woolgorong (M. Officer s.n. 10/8/94)	774782	7219157
Sauropus		sp.	Woolgorong (M. Officer s.n. 10/8/94)	774787	7219226
Sauropus		sp.	Woolgorong (M. Officer s.n. 10/8/94)	774800	7219192
Sporobolus	*blakei*			765684	7214276
Thryptomene		sp.	Leinster (B.J. Lepschi & L.A. Craven 4362)	776137	7220146
Thryptomene		sp.	Leinster (B.J. Lepschi & L.A. Craven 4362)	768156	7216228
Thryptomene		sp.	Leinster (B.J. Lepschi & L.A. Craven 4362)	767854	7216394
Thryptomene		sp.	Leinster (B.J. Lepschi & L.A. Craven 4362)	774765	7219027
Thryptomene		sp.	Leinster (B.J. Lepschi & L.A. Craven 4362)	767092	7208527
Thryptomene		sp.	Leinster (B.J. Lepschi & L.A. Craven 4362)	774938	7218899
Thryptomene		sp.	Leinster (B.J. Lepschi & L.A. Craven 4362)	774976	7218858
Thryptomene		sp.	Leinster (B.J. Lepschi & L.A. Craven 4362)	775071	7218866
Thryptomene		sp.	Leinster (B.J. Lepschi & L.A. Craven 4362)	775018	7219074
Thryptomene		sp.	Leinster (B.J. Lepschi & L.A. Craven 4362)	774980	7219075
Thryptomene		sp.	Leinster (B.J. Lepschi & L.A. Craven 4362)	765829	7213146
Thryptomene		sp.	Leinster (B.J. Lepschi & L.A. Craven 4362)	769856	7213830
Thryptomene		sp.	Leinster (B.J. Lepschi & L.A. Craven 4362)	769870	7213752
Thryptomene		sp.	Leinster (B.J. Lepschi & L.A. Craven 4362)	769741	7213723
Thryptomene		sp.	Leinster (B.J. Lepschi & L.A. Craven 4362)	769737	7213789
Thryptomene		sp.	Leinster (B.J. Lepschi & L.A. Craven 4362)	768690	7213946
Thryptomene		sp.	Leinster (B.J. Lepschi & L.A. Craven 4362)	768719	7213955
Thryptomene		sp.	Leinster (B.J. Lepschi & L.A. Craven 4362)	768804	7213965
Thryptomene		sp.	Leinster (B.J. Lepschi & L.A. Craven 4362)	768803	7214018
Thryptomene		sp.	Leinster (B.J. Lepschi & L.A. Craven 4362)	766321	7214672
Thryptomene		sp.	Leinster (B.J. Lepschi & L.A. Craven 4362)	766140	7214278
Thryptomene		sp.	Leinster (B.J. Lepschi & L.A. Craven 4362)	768236	7216192
Thryptomene		sp.	Leinster (B.J. Lepschi & L.A. Craven 4362)	768175	7216186
Thryptomene		sp.	Leinster (B.J. Lepschi & L.A. Craven 4362)	768127	7216210
Thryptomene		sp.	Leinster (B.J. Lepschi & L.A. Craven 4362)	768107	7216274
Thryptomene		sp.	Leinster (B.J. Lepschi & L.A. Craven 4362)	768061	7216362
Thryptomene		sp.	Leinster (B.J. Lepschi & L.A. Craven 4362)	768026	7216390
Thryptomene		sp.	Leinster (B.J. Lepschi & L.A. Craven 4362)	767988	7216442
Thryptomene		sp.	Leinster (B.J. Lepschi & L.A. Craven 4362)	767925	7216456
Thryptomene		sp.	Leinster (B.J. Lepschi & L.A. Craven 4362)	768153	7216467
Thryptomene		sp.	Leinster (B.J. Lepschi & L.A. Craven 4362)	768067	7216558
Thryptomene		sp.	Leinster (B.J. Lepschi & L.A. Craven 4362)	767995	7216530
Thryptomene		sp.	Leinster (B.J. Lepschi & L.A. Craven 4362)	767804	7216509
Thryptomene		sp.	Leinster (B.J. Lepschi & L.A. Craven 4362)	768006	7216080
Thryptomene		sp.	Leinster (B.J. Lepschi & L.A. Craven 4362)	768438	7215898
Thryptomene		sp.	Leinster (B.J. Lepschi & L.A. Craven 4362)	767951	7216275
Thryptomene		sp.	Leinster (B.J. Lepschi & L.A. Craven 4362)	768006	7216177
Thryptomene		sp.	Leinster (B.J. Lepschi & L.A. Craven 4362)	769842	7213803
Thryptomene		sp.	Leinster (B.J. Lepschi & L.A. Craven 4362)	765824	7213554
Thryptomene		sp.	Leinster (B.J. Lepschi & L.A. Craven 4362)	765930	7213324

Thryptomene		sp.	Leinster (B.J. Lepschi & L.A. Craven 4362)	765932	7213278
Thryptomene		sp.	Leinster (B.J. Lepschi & L.A. Craven 4362)	765910	7213246
Thryptomene		sp.	Leinster (B.J. Lepschi & L.A. Craven 4362)	765880	7213303
Hibiscus	*brachychlaenus*		(Range extension)	775283	7220764

APPENDIX 9

Locations for introduced flora species recorded from the study area

GENUS	SPECIES	EASTING	NORTHING
Bidens	*bipinnata*	781363	7216564
Bidens	*bipinnata*	765440	7213141
Portulaca	*pilosa*	781779	7215833

Vango Mining Pty Ltd

Marymia Project Fauna Assessment of exploration areas

Banded Knob-tailed Gecko (Pilbara sub-species) (photo: M. Bamford)

Prepared for: Vango Mining Pty Ltd

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Executive Summary

Introduction

Vango Mining Pty Ltd (Vango) is conducting exploration in the Marymia Project area where mining has previously been conducted, most recently (up to about 2010) by Barrick Gold. As part of the process for seeking approval of future mining, Bamford Consulting Ecologists (BCE) was commissioned in 2018 and 2019 to provide information on the fauna values of a suite of exploration leases in the project area. The focus of these investigations was on significant species, and the provision of discussion on the interaction of the proposal with fauna values and functions.

Methods

Fauna studies have previously been conducted in the area by *ecologia environment* and BCE, including monitoring of the Brush-tailed Mulgara. Therefore the 2018/2019 studies involved a review of existing data and detailed site inspections comprising: 1) identifying Vegetation and Substrate Associations present; 2) targeted searches for conservation significant fauna including the Malleefowl and Brush-tailed Mulgara; 3) bird censussing; and 4) operation of autonomous recording units such as motion-sensitive cameras, audio recording units and bat detectors. In addition, general fauna lists were produced based upon opportunistic observations. The exploration areas K2, Cinnamon, Apex and Trident were visited in November 2018, while the exploration areas K2 (east), Mareast, Marwest, Wedgetail, Ibis, Trident, Triple P, Speckled Hen and the Pipeline Corridor were visited in August 2019.

BCE uses a 'values and impacts' assessment process with the following components:

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

Results - Key fauna values

Vegetation and Substrate Associations (VSAs) that provide habitat for fauna. The exploration areas are broadly similar in vegetation and substrates with representatives of each VSA throughout the project area. The vegetation can be summarised as being mostly open Acacia or Mulga shrubland

over sparse to dense vegetation with many areas of spinifex. These occur over red loam to sandy loam on the flat areas and gravelly loam and rocky soil on the higher ground, with some gravelly areas overlaid with quartz/ironstone cobbles or pebbles. Drainage lines with Acacia or Mulga thickets on clayey loams occur throughout the exploration areas in varying sizes. VSAs can only be broadly defined in the absence of detailed vegetation surveys, but six VSAs can be recognised and they occur across the exploration areas in varying extent:

1. Acacia shrubland on gravelly loam with quartz/ironstone cobbles on flats and slight rises. This is very extensive and variable, with some areas of acacia thickets, but other areas that are very open and the quartz forms a veneer over open ground.
2. Open Acacia on rocky/gravelly soil, on high ground, sometimes with Miniritchi and sometimes over Spinifex.
3. Mulga over shrubs and spinifex on loam to sandy loam flats.
4. Drainage line with Acacia/Mulga thickets on clayey loam. On some drainage lines the acacia are a tall Miniritchi.
5. Old mine pits, stockpiles with partial rehabilitation; areas of good rehabilitation are similar to VSA 1. Some of these old pits contain water.

Environments of most interest with respect to fauna are the drainage lines, Mulga thickets and the mulga over spinifex on sandy loam. This is because they support some significant species and are restricted in extent. The mine portal in K2, and possibly other shafts in other mine pits, may be locally important (fauna discussed below). The general landscape is very extensive in the region with only small areas of development (past and current mines) and some grazing impacts.

Fauna assemblage. The desktop study identified 259 vertebrate fauna species as potentially occurring in the survey area: 9 frogs, 66 reptiles, 148 birds, 26 native mammals and 10 introduced mammals. This does not include several locally extinct mammal species. Except for these extinct mammals the assemblage is intact, and it is only moderately rich because the landscape is fairly uniform and lacks features such as large hills and major rivers. The assemblage appears to include elements of both the Pilbara and Murchison. Over half of the expected species (58%) were recorded across the present and previous surveys. It is noted that the August 2019 survey recorded a markedly lower abundance of birds than the November 2018 survey which is likely due to the poor long-term rainfall across the region in 2019, resulting in dry conditions, low productivity and therefore low fauna activity.

Species of conservation significance. The project area potentially supports about 20 conservation significant fauna species. The most notable is the Brush-tailed Mulgara (listed as Priority 3), which is locally common in the general region and was the subject of a research and monitoring project in the past. It favours sandy to sandy loam soils, usually with spinifex, and may be temporarily displaced by fire. Such soils occur in patches throughout the project area and are more widespread to the south, although inactive burrows were recorded in Cinnamon and K2 and extensive suitable habitat in K2 was recently burnt. The Mulgara is also sensitive to Fox and Cat predation. A pair of Peregrine Falcons (listed as Schedule 3 under the WA Biodiversity Conservation Act 2016) was present in Flamingo Pit in August 2019. It is likely they were breeding on a ledge on the side of the pit.

Patterns of biodiversity. Across the exploration areas, Mulga over spinifex on sandy loam and Mulga thickets along drainage lines are likely to be richest in fauna, while gravelly and rocky soils with sparse

vegetation are likely to be lowest in fauna species richness. Mulga over spinifex on sandy loam is also where the Brush-tailed Mulgara can occur. This VSA is widespread in the north of K2, across much of Cinnamon, in the north of Triple P and along the southern Haul Road. Mulga thickets along drainage lines is well-developed in Apex but also occurs in patches across Trident, Cinnamon, K2, Triple P and Speckled Hen. Trident has the most extensive areas of gravelly soils and sparse shrublands.

Key ecological processes. The most important ecological processes affecting the fauna assemblage are fire, landscape connectivity related to Mulga thickets, impacts of feral predators and local hydrology.

Overall, the project area has a fauna species assemblage that has suffered some species loss. It is a moderately rich assemblage, and includes some species of conservation significance, although only the Brush-tailed Mulgara is of concern. The assemblage is sensitive to landscape connectivity, introduced species and fire, while the most important environments for fauna richness are Mulga over spinifex on sandy loam, and Mulga thickets along drainage lines or in slightly lower areas of the landscape. K2 has the widest range of environments and extensive habitat for the Brush-tailed Mulgara. Cinnamon also has extensive Mulgara habitat. Cinnnamon is also likely to be richest in bird species due to the extensive Mulga with understorey present. Apex has a major drainage line with associated tall Mulga thickets important for fauna. Trident has the most extensive areas of gravelly and rocky soils that are probably less rich in fauna, but even this is interspersed with Mulga thickets. The Triple P area is large with a complex array of VSAs and several moderately large water courses. It also has some Mulgara habitat and an apparently nesting pair of Peregrine Falcons (in Flamingo Pit).

Potential impacts upon fauna and recommendations

Potential impacts to fauna can come from a range of sources, but key concerns are:

- Mortality of Brush-tailed Mulgara during clearing;
- Loss of Peregrine Falcon nest in Flamingo Pit;
- Changes in abundance of feral predators;
- Altered fire regimes;
- Disturbance of birds from noise, dust and light, potentially leading to changes in the bird assemblage away from direct impact areas;
- Hydrological change, and in particular changes to surface hydrology which can affect Mulga;
- Impacts of feral species; and
- Altered fire regimes.

Recommendations to manage potential impacts include:

- Minimise clearing footprint and rehabilitate where possible;
- Pre-clearing surveys and displacement of Mulgara; this would be limited to activities in the Mulga and spinifex on sand VSA in parts of K2, Cinnamon and Triple P;
- Monitor the pair of Peregrine Falcons to see if they move to an alternative nesting site. Could consider constructing a ledge on the side of a pit that is not going to be disturbed to give the birds an alternative nesting site.
- Hydrological management in particular to ensure surface hydrology is not altered near Mulga areas;

- Feral fauna management and monitoring;
- Fire management measures; and
- Minimise noise, dust and light.

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1 Introduction

Vango Mining Pty Ltd (Vango) is conducting exploration in the Marymia Project area where mining has previously been conducted, most recently (up to about 2010) by Barrick Gold. As part of the process for seeking approval of future mining, Bamford Consulting Ecologists (BCE) was initially commissioned in 2018 to provide information on the fauna values of four exploration areas that form part of the Marymia Project: Trident, K2, Cinnamon and Apex (Figure 1-1). In 2019, BCE was requested to provide information on additional exploration areas in the project area: a smaller area of K2, the tailings pipeline corridor, Trident/Mareast, Wedgetail, Ibis, Marwest, Triple P and Speckled Hen (Figure 1-2). Fauna studies have previously been conducted in the general Marymia Project area by *ecologia environment* and BCE, including monitoring of the Brush-tailed Mulgara. Therefore, the 2018 to 2019 studies presented in this report involved a review of existing data and detailed site inspections of the exploration areas, including targeted searching for the Brush-tailed Mulgara. The aim of these investigations is to broadly outline the fauna assemblage and its values, particularly for significant species, and to provide discussion on the interaction of the proposal with these fauna values and functions.

1.1 General Approach to Fauna Impact Assessment

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

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

Descriptions and background information on these values and processes can be found in Appendices 1 to 4. In particular, Appendix 1 explains and defines the fauna values, including the recognition of three classes of species of conservation significance (CS): those listed under legislation (CS1), those listed as priority by the Department of Biodiversity, Conservation and Attractions (CS2), and those that

can be considered of local or other significance, but which have no formal listing (CS3). Appendix 2 describes threatening processes, while Appendix 3 outlines the legal definitions and classes of conservation significance, and Appendix 4 presents the threatening processes recognised under legislation. Based on this impact assessment process, the objectives of investigations are to: identify fauna values; review impacting processes with respect to these values and the proposed activity; and provide recommendations to mitigate these impacts.

1.2 Description of Project Area

The Marymia Project area lies on Marymia station about 150km north-east of Meekatharra and 150km north-west of Wiluna. It lies in the south of the Augustus Subregion of the Gascoyne Bioregion (Figure 1-3), identified as part of the Interim Biogeographic Regionalisation of Australia (IBRA) that has identified 26 bioregions in Western Australia which are further divided into subregions (DSEWPaC 2013, Environment Australia 2000). Bioregions are classified on the basis of climate, geology, landforms, vegetation and fauna (Thackway and Cresswell, 1995). IBRA Bioregions are affected by a range of different threatening processes and have varying levels of sensitivity to impact (EPA 2004).

The Augustus subregion is characterised by Mulga woodlands on hard pan and stony rises and *Triodia* hummock grasslands on sandy soils. The climate is arid with bimodal rainfall, and the dominant land use is grazing (based on native pastures), with small areas of mining, UCL and Crown Reserves (Desmond *et al*. 2001).

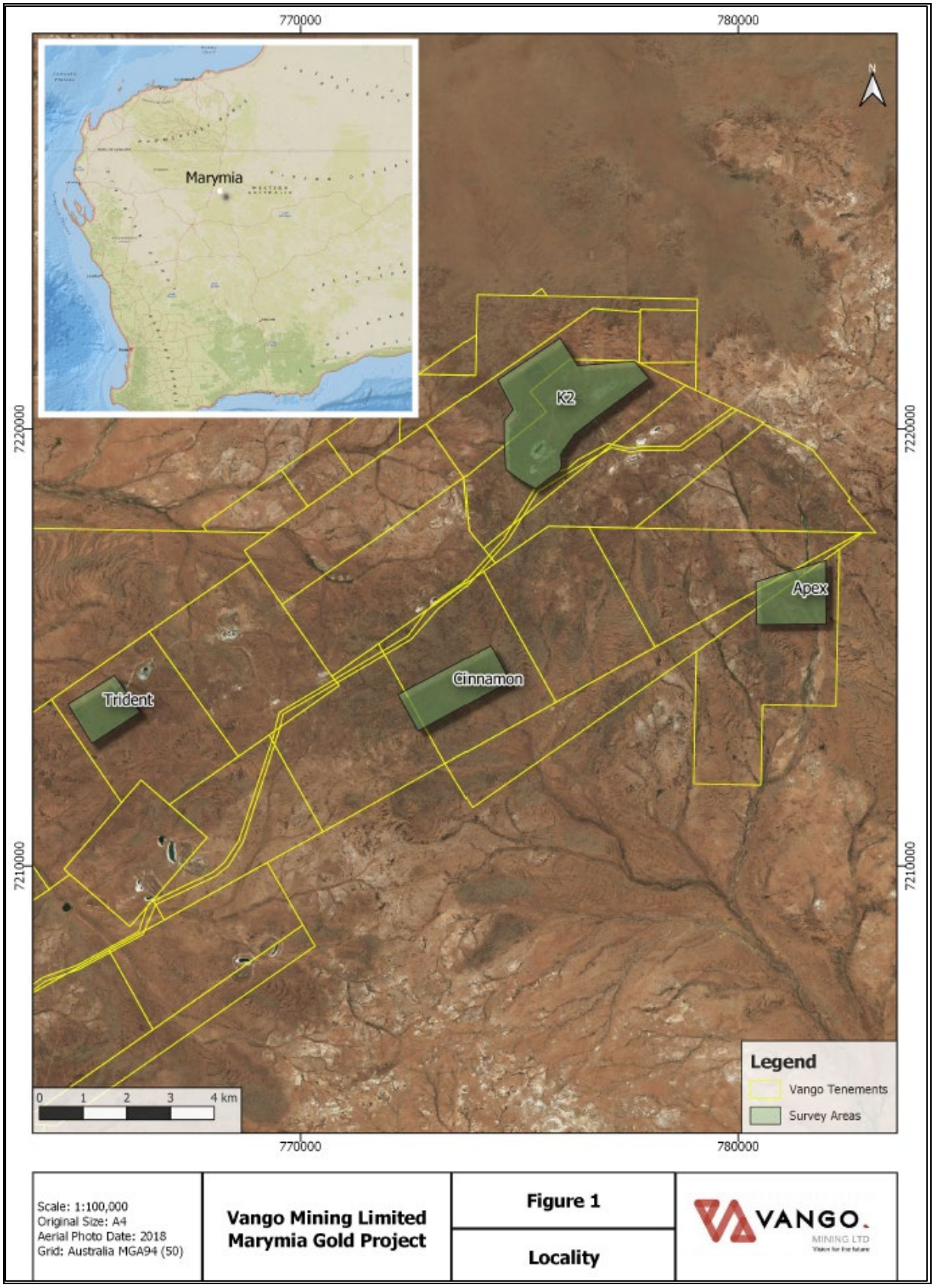


Figure 1-1. Location of Marymia Project area and 2018 exploration areas.

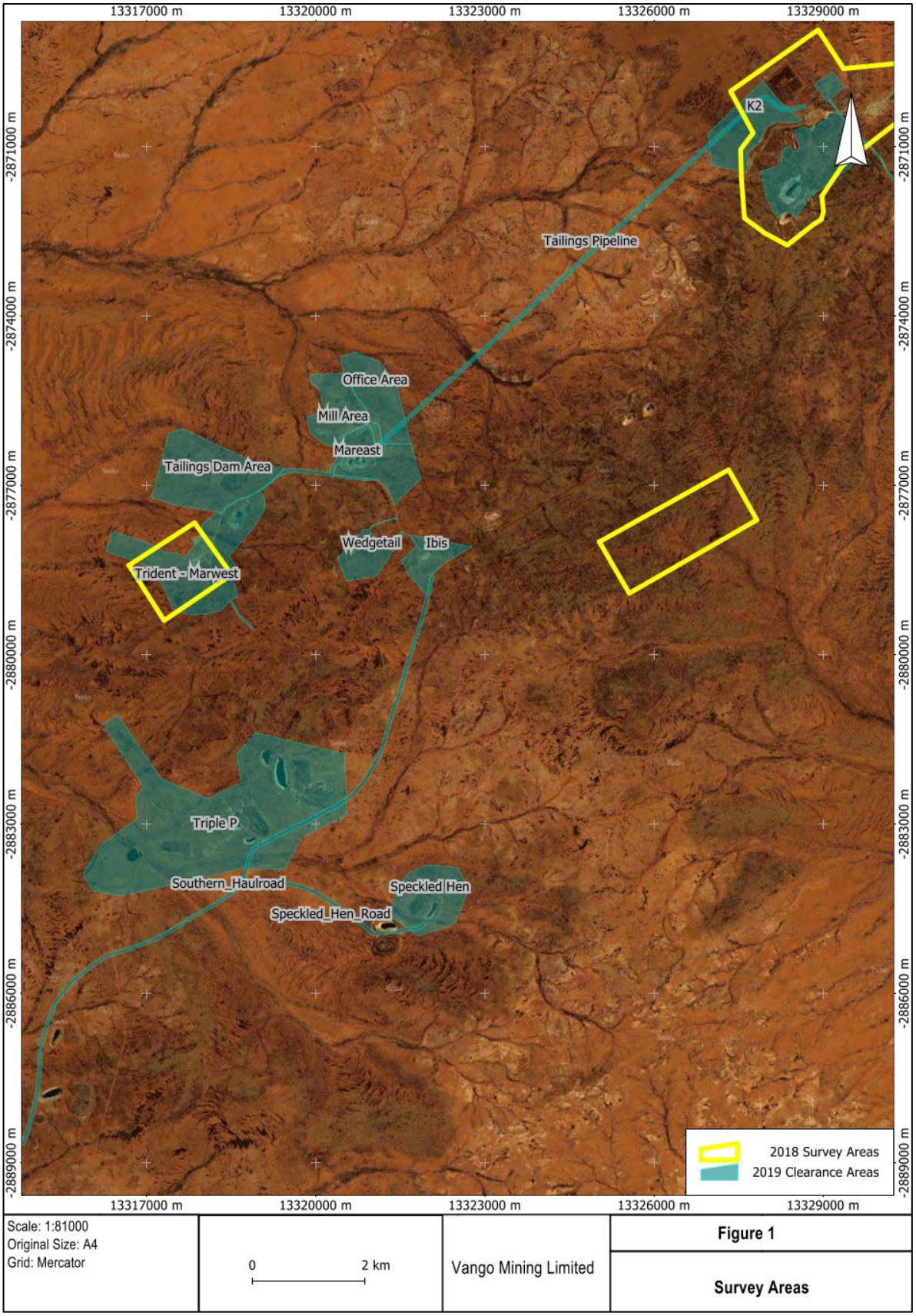
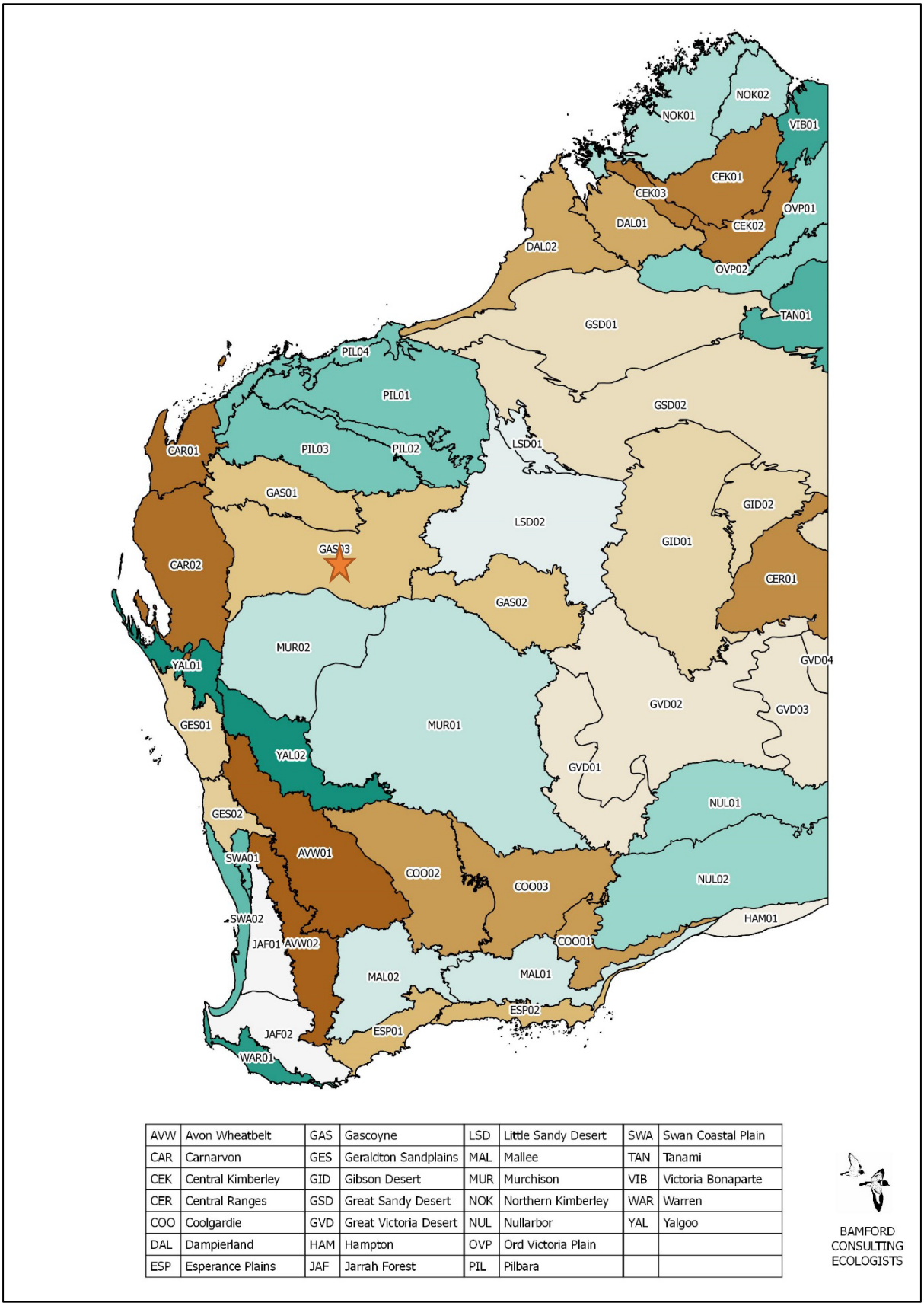


Figure 1-2. Locations of 2019 survey areas (blue boundaries); 2018 survey areas are indicated in yellow, see preceding figure for detail.



AVW	Avon Wheatbelt	GAS	Gascoyne	LSD	Little Sandy Desert	SWA	Swan Coastal Plain
CAR	Carnarvon	GES	Geraldton Sandplains	MAL	Mallee	TAN	Tanami
CEK	Central Kimberley	GID	Gibson Desert	MUR	Murchison	VIB	Victoria Bonaparte
CER	Central Ranges	GSD	Great Sandy Desert	NOK	Northern Kimberley	WAR	Warren
COO	Coolgardie	GVD	Great Victoria Desert	NUL	Nullarbor	YAL	Yalgoo
DAL	Dampierland	HAM	Hampton	OVP	Ord Victoria Plain		
ESP	Esperance Plains	JAF	Jarrah Forest	PIL	Pilbara		

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Figure 1-3. Bioregions across Western Australia, indicating the approximate location of the Marymia Project area (orange star).

2 Methods

2.1 Overview

The methods used for this assessment are based upon the general approach to fauna investigations for impact assessment as outlined in Section 1.1 and with reference to Appendices 1 to 4. Thus, the impact assessment process involves the identification of fauna values, review of impacting processes and, where possible, preparation of mitigation recommendations.

This approach to fauna impact assessment has been developed with reference to guidelines and recommendations set out by the Western Australian Environmental Protection Authority (EPA) on fauna surveys and environmental protection, and Commonwealth biodiversity legislation (EPA 2002; EPA 2004, EPA and Department of Environment and Conservation 2010). The EPA proposes two levels of investigation that differ in the approach to field investigations, Level 1 (this assessment) being a review of data and a site reconnaissance to place data into the perspective of the site, and Level 2 being a literature review and intensive field investigations (e.g. trapping and other intensive sampling). The level of assessment recommended by the EPA is determined by the size and location of the proposed disturbance, the sensitivity of the surrounding environment in which the disturbance is planned, and the availability of pre-existing data.

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

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

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

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

2.2 Desktop Assessment

2.2.1 Sources of information

Information on the fauna assemblage of the survey area was drawn from a wide range of sources (Table 2-1). These included state and federal government databases and results of regional studies. Databases accessed were the Atlas of Living Australia (ALA), the WA Department of Biodiversity, Conservation and Attractions (DBCA) NatureMap (incorporating the Western Australian Museum's FaunaBase and the DBCA Threatened and Priority Fauna Database), BirdLife Australia's Birdata (Atlas) Database, the EPBC Protected Matters Search Tool managed by the Department of Energy and the Environment (DEE). There were also some records from the Bamford Consulting Database from studies within c. 50km, but these will be captured in NatureMap. Information from the above sources was supplemented with species expected in the area based on general patterns of distribution. Sources of information used for these general patterns were:

- Frogs: Tyler *et al.* (2000) and Anstis (2013);
- Reptiles: Storr *et al.* (1983, 1990, 1999 and 2002) and Wilson and Swan (2013);
- Birds: Blakers *et al.* (1984); Johnstone and Storr (1998, 2004), Barrett *et al.* (2003) and Menkhorst *et al.* (2017);
- Mammals: Menkhorst & Knight (2004); Churchill (2008); and Van Dyck and Strahan (2008).

Table 2-1. Sources of information used for the desktop assessment.

Database / Survey	Comment	Area searched
NatureMap (DBCA, December 2018)	Records in the WAM and DPaW databases. Includes historical data and records on Threatened and Priority species in WA.	Project area – plus 40 km buffer
BirdLife Australia Atlas Database (BirdLife Australia, December 2018)	Records of bird observations in Australia, 1998-2018.	Species list for one degree cell containing project area
EPBC Protected Matters (DEE, December 2018)	Records on matters of national environmental significance protected under the EPBC Act.	Project area – plus 40 km buffer
ALA (December 2018)	Fauna records submitted to the Atlas of Living Australia	Project area – plus 40 km buffer

In addition to the databases, some fauna studies have previously been carried out as part of the Marymia Project (*ecologia* 1991, 2005; Mulgara surveys by Rodda and Bamford 2007, 2008; Zosky and Bamford 2009), and on the nearby (20km south-west) Doolgunna Station, owned by the DBCA (Bell *et al.* 2013, Ninox 2011, Turpin and Bamford 2016). The earlier studies on Marymia Station included general fauna observations and targeted research on the Brush-tailed Mulgara (referred to as *Dasycercus cristicauda* in earlier studies, but now identified as *D. blythi*). All previous studies conducted in Marymia were targeted Mulgara surveys, except for the 1991 *ecologia* survey which was a level 2 survey. Species recorded in the *ecologia* (1991) survey and in previous BCE surveys (2007 to 2009) are included in species totals in the results of this report.

2.2.2 Nomenclature and taxonomy

As per the recommendations of EPA (2004), the nomenclature and taxonomic order presented in this report are based on the Western Australian Museum's (WAM) Checklist of the Fauna of Western Australia 2016. The authorities used for each vertebrate group were: amphibians (Doughty *et al.* 2016a), reptiles (Doughty *et al*. 2016b), birds (Johnstone and Darnell 2016), and mammals (Travouillon 2016). In some cases, more widely-recognised names and naming conventions have been followed, particularly for birds where there are national and international naming conventions in place (e.g. the BirdLife Australia working list of names for Australian Birds). English names of species where available are used throughout the text; Latin species names are presented with corresponding English names in tables in the appendices.

2.2.3 Interpretation of species lists

Species lists generated from the review of sources of information are generous as they include records drawn from a large region and possibly from environments not represented in the survey area. Therefore, some species that were returned by one or more of the data searches have been excluded because their ecology, or the environment within the survey area, meant that it is highly unlikely that these species will be present. Such species can include, for example, seabirds that might occur as extremely rare vagrants at a terrestrial, inland site, but for which the site is of no importance. Species returned from databases but excluded from species lists are presented in Appendix 6. Databases can also include species that are locally or completely extinct; where a species would have occurred at the site but is now considered extinct at that site, it is listed separately (Appendix 6).

Species returned from the databases and not excluded on the basis of ecology, environment or extinction, are therefore considered potentially present or expected to be present in the survey area at least occasionally, whether or not they were recorded during field surveys, and whether or not the survey area is likely to be important for them. This list of expected species is therefore subject to interpretation by assigning each a predicted status in the survey area. The status categories used are:

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

These status categories make it possible to distinguish between vagrant species, which may be recorded at any time but for which the site is not important in a conservation sense, and species which use the site in other ways but for which the site is important at least occasionally. This is particularly

useful for birds that may naturally be migratory or nomadic, and for some mammals that can also be mobile or irruptive, and further recognises that even the most detailed field survey can fail to record species which will be present at times, or may have been previously confirmed as present. The status categories are assigned conservatively. For example, a lizard known from the general area is assumed to be a resident unless there is very good evidence that the site will not support it, and even then it may be classed as a vagrant rather than assumed to be absent if the site might support dispersing individuals.

2.3 Field Investigation Methodology

The field assessment incorporated a range of survey techniques so as to maximise developing an understanding of the exploration areas, their fauna and the potential impacts of exploration upon that fauna. Survey techniques utilised are outlined in the following sections.

2.3.1 Dates and Personnel

The initial four exploration areas (K2, Cinnamon, Trident and Apex) were visited from 6th to 10th November 2018. Personnel involved in the 2018 survey were: Dr Michael Bamford (B.Sc. Hons. Ph.D.), Mr Peter Smith (Assoc. Dip. Ag. (Farm Management)) and Mrs Sarah Smith (B.Sc.). The additional exploration areas (a smaller area of K2, the tailings pipeline corridor, Trident/Mareast, Wedgetail, Ibis, Marwest, Triple P and Speckled Hen) were visited from 6th to 9th August 2019. Personnel involved in the 2019 survey were: Dr Michael Bamford and Mrs Amanda Bamford (B.Sc. Hons.). This report was prepared by Dr Michael Bamford and Ms Natalia Huang (B.Sc. Hons.).

2.3.2 Vegetation and Substrate Associations

The Vegetation and Substrate Associations (VSAs) present in all areas were identified. These provide the habitat for fauna and inform the fauna assemblage expected in each area. Details on methodology are provided in Appendix 1.

2.3.3 Targeted searches for conservation significant fauna

Targeted searches for conservation significant fauna, including an assessment of their likelihood of occurrence, were conducted in November 2018 and August 2019. In November 2018, targeted searching was undertaken by the personnel spaced at 25-50m intervals and walking transects across each exploration area. In August 2019, exploration areas were examined by driving (an all-terrain vehicle) and walking through as much of the area as possible and considered necessary. Notes were made on the environment; searching was undertaken for Malleefowl mounds and Mulgara burrows; and general fauna observations were recorded. The tracks taken in each exploration area are given in Figures Figure 2-1 to Figure 2-5. Details on dates and locations of surveys are given in Table 2-2.

Table 2-2. Details of surveys at each exploration area.

Location	Date	Details
Trident	7th November 2018	Team of three walked around the lease area from about 08:00 to 12:30.
K2	7th and 8th November 2018	Team of three walked across much of the east of the area 14:45 to 16:30 (7/11/2018). Team of three walked across much of the area in north and west from 06:30 to 12:30 (8/11/2018).
Cinnamon	9th November 2018	Team of three walked across much of the area from 06:30 to 12:00.
Apex	9th November 2018	Team of three walked across much of the area from 14:00 to 17:30.
Pipeline corridor	7th August 2019	Team of two drove length of pipeline corridor using Can-Am as there was no access for a regular vehicle. Stopped regularly to look for evidence of fauna, including birds.
K2 (east)	7th August 2019	Team of two drove and walked through much of the area.
Mareast (west)	7th August 2019	Team of two drove and walked through much of the area.
Ibis	7th August 2019	Team of two drove and walked through much of the area.
Wedgetail	7th August 2019	Team of two drove and walked through much of the area.
Tailings Dam	8th August 2019	Team of two drove and walked through much of the area.
Marwest	8th August 2019	Team of two drove and walked through much of the area.
Trident	9th August 2019	Team of two drove and walked through much of the area.
Triple P	9th August 2019	Team of two drove and walked through much of the area.
Speckled Hen	9th August 2019	Team of two drove and walked through much of the area although not covered completely.

Figure 2-1. Walked transects in Trident (left) and Cinnamon (right) exploration areas (November 2018).

Figure 2-2. Walked transects in Apex (left) and K2 (right) exploration areas (November 2018).

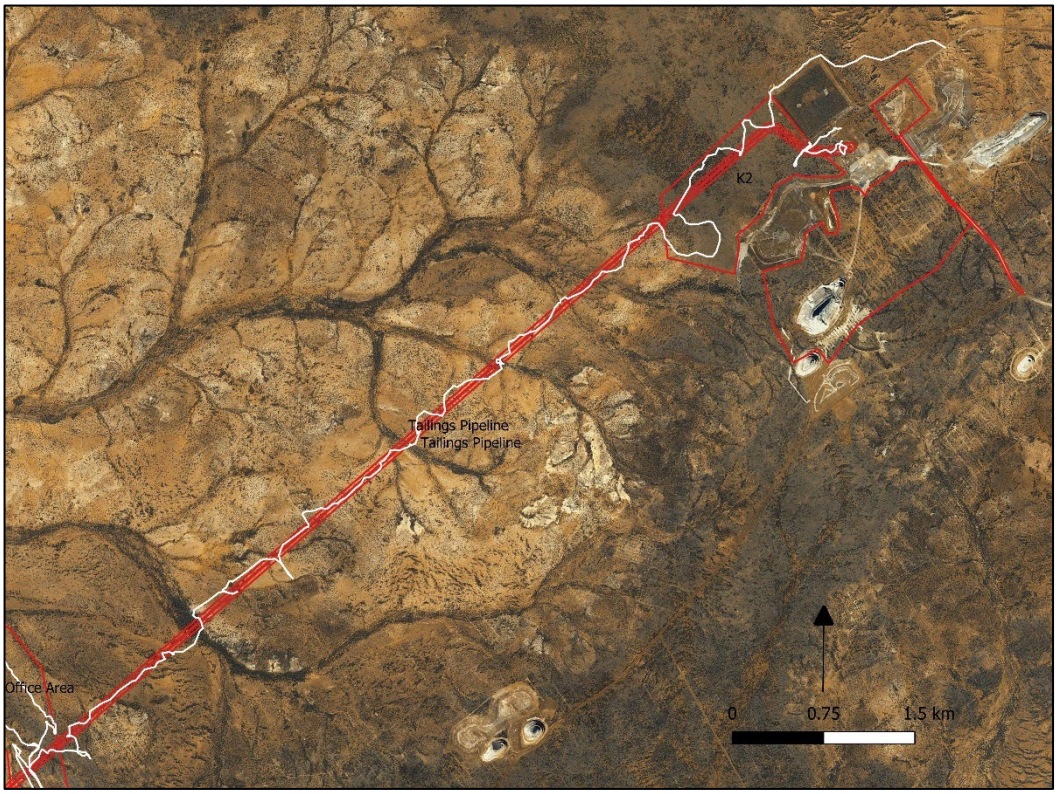

Figure 2-3. Driven or walked transects in K2 exploration area and along Pipeline Corridor (August 2019).

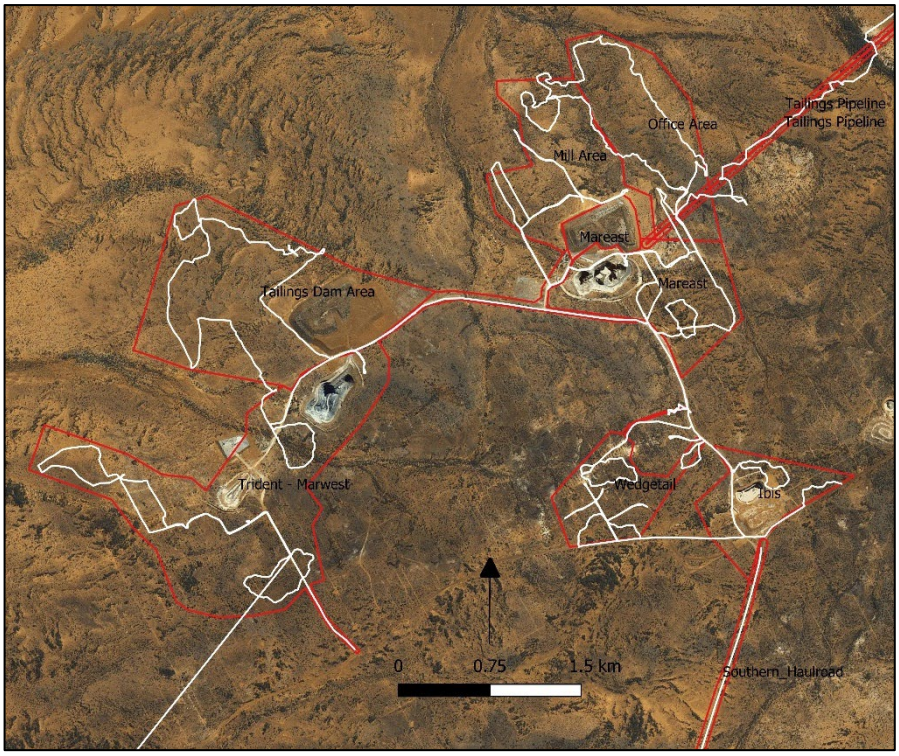

Figure 2-4. Driven and walked transects in Mareast, Trident, Marwest, Wedgetail and Ibis exploration areas (August 2019).

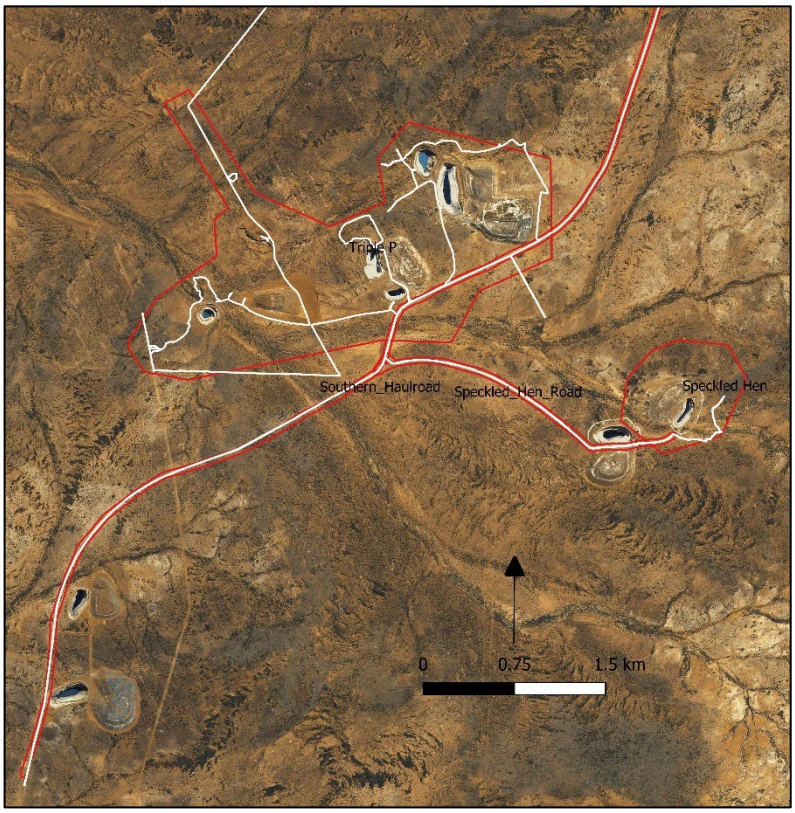

Figure 2-5. Driven and walked transects in Triple P and Speckled Hen exploration areas (August 2019).

2.3.4 Bird censussing

During all walks through the exploration areas in November 2018 and August 2019, birds were identified and counted, giving a measure of abundance of each species in each area.

2.3.5 Head-torching and Spotlighting

Head-torching was conducted in each exploration area in November 2018 by three personnel for at least half an hour. In addition, spotlighting was carried out when driving to and from the areas. Head-torching and spotlighting were not conducted in August 2019 as conditions were considered too cold for reptiles to be active.

2.3.6 Motion-sensitive cameras

A single motion-sensitive camera (baited with bait confined in a tube) was set in the Cinnamon exploration area at 25.16120°S, 119.71083°E on the night of 8th November 2018 (Figure 2-6). This was at a location that appeared to be frequented by a Fox. Cameras were not set in August 2019.

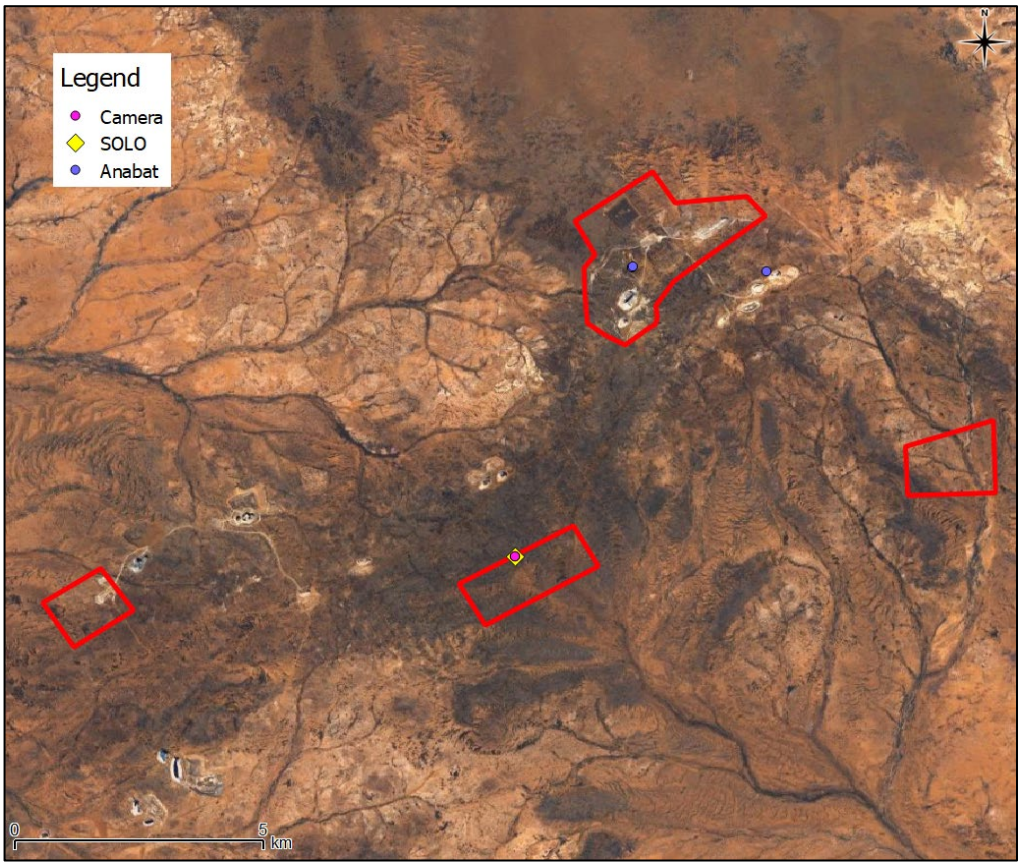

Figure 2-6. Locations of recording devices (November 2018 survey). Note: A bat detector ("Anabat") was also deployed in August 2019 at the same location within the K2 boundary (western purple dot).

2.3.7 Audio recording unit

An Autonomous Recording Unit (ARU), a SOLO, was set in the Cinnamon exploration area at 25.16120°S, 119.71083°E on the night of 8th November 2018 (Figure 2-6). This is a high definition audio recorder for acoustic monitoring of the environment. The audio recording unit was not set in August 2019.

2.3.8 Bat detectors

A bat detector (Anabat Swift, Titley) was deployed in a large mining portal in the K2 exploration area (Figure 2-7) for one night on 7th November 2018 and 8th August 2019. A detector was also deployed at the exploration camp (Figure 2-8) for one night on 8th November 2018. The locations of the bat detectors are shown in Figure 2-6. Details of the bat detector locations and dates are given in Table 2-3. These were the first bat survey work to be undertaken at the site.

Table 2-3. Details of bat detector deployment in November 2018 and August 2019 surveys.

Date	GPS coordinates	Description of location and features of interest
7th – 8th November 2018	25.10907°S, 119.73203°E	Detector set outside a large mining "portal" – vehicle entrance to underground system in K2 area. Portal was set in excavated hollow as shown in Figure 2-7.
8th – 9th November 2018	25.11009°S, 119.75627°E	Detector set near the camp in a sparsely vegetated area (Figure 2-8). Some small breakaways nearby and also some old open cut pits.
8th – 9th August 2019	25.10907°S, 119.73203°E	Detector set in excavated hollow outside mining portal as on 7th November 2018 and Figure 2-7.

The detectors were set to record from 30 minutes before sunset to 30 minutes after sunrise. Calls were assessed using Wildlife Acoustics Kaleidoscope software (v4.5.4) and compared against previously collected calls using the following characteristics:

Fmax (kHz): Average maximum frequency of call pulses within each call sequence;
Fpeak (kHz): Average frequency of peak energy within call pulses, within each call sequence;
Fmin (kHz): Average minimum frequency of call pulses within each call sequence;
Dur (ms): Average duration of call pulses.

Figure 2-7. Underground mine portal entrance outside which a bat detector was set on night of 7th November 2018 and 8th August 2019.

Figure 2-8. View of bat detector at exploration camp on night of 8th November 2018.

2.3.9 Opportunistic observations

At all times, opportunistic observations of fauna were recorded with all individuals identified to species level.

2.4 Survey Limitations

The EPA Guidance Statement 56 (EPA 2004, now EPA 2016) outlines a number of limitations that may arise during surveying. These survey limitations are discussed in the context of the BCE investigation of the survey area in Table 2-4. One issue was restrictions on movement due to Dingo activity in the area. As a result of very dry conditions and lack of food, Dingoes were travelling in packs and there was concern with being on-foot away from a vehicle.

Table 2-4. Survey limitations as outlined by EPA.

EPA Limitation	BCE Comment
Level of survey.	Level 1 (desktop study and site inspection). Survey intensity was deemed adequate due to the scale of the project and the amount of data available in the region.
Competency/experience of the consultant(s) carrying out the survey.	The ecologists have had extensive experience in conducting fauna surveys and have conducted several fauna studies within the immediate region.
Scope. (What faunal groups were sampled and were some sampling methods not able to be employed because of constraints?)	The survey focussed on vertebrate fauna and fauna values.
Proportion of fauna identified, recorded and/or collected.	All vertebrate fauna observed were identified.
Sources of information e.g. previously available information (whether historic or recent) as distinct from new data.	Abundant information from databases and previous studies.
The proportion of the task achieved and further work which might be needed.	The survey was completed and the report provides fauna values for the project area.
Timing/weather/season/cycle.	Timing is not of great importance for level 1 investigations.
Disturbances (e.g. fire, flood, accidental human intervention etc.) that affected results of survey.	None
Intensity. (In retrospect, was the intensity adequate?)	All major VSAs were visited and significant species habitat and traces were identified.

EPA Limitation	BCE Comment
Completeness (e.g. was relevant area fully surveyed).	Site was fully surveyed to the level appropriate for a level 1 assessment and for the proposed impact. Fauna database searches covered a 40 km radius beyond the survey area boundary. Detailed field investigations covered the VSAs present.
Resources (e.g. degree of expertise available in animal identification to taxon level).	Field personnel have extensive experience with fauna and habitat in the region.
Remoteness and/or access problems.	There were no serious remoteness/access problems encountered. In August 2019, walking long distances away from the vehicle was avoided due to concern with Dingoes present in packs in the area. The all-terrain vehicle (ATV) corrected for this to a great degree. Speckled Hen was not completely searched due to failing light on the last day and poor access (dense vegetation restricted access by the ATV).
Availability of contextual (e.g. biogeographic) information on the region.	Regional information was available and was consulted.

2.5 Presentation of Results for Impact Assessment

While some impacts are unavoidable during a development, of concern are long-term, deleterious impacts upon biodiversity. This is reflected in documents such as the Significant Impact Guidelines provided by DSEWPaC (2012) (see Appendix 4). Significant impacts may occur if:

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

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

The presentation of this assessment follows the general approach to impact assessment as given in Section 1.1), but modified to suit the characteristics of the site. Key components to the general approach to impact assessment are addressed as follows:

Fauna values

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

- Recognition of ecotypes or vegetation/substrate associations (VSAs);
- Assemblage characteristics (uniqueness, completeness and richness);
- Species of conservation significance;
- Patterns of biodiversity across the landscape; and
- Ecological processes upon which the fauna depend.

Impact assessment

This section reviews impacting processes (as described in detail in Appendix 2) with respect to the proposed development and examines the potential effect these impacts may have on the faunal biodiversity of the survey area. It thus expands upon Section 3) and discusses the contribution of the project to impacting processes, and the consequences of this with respect to biodiversity. A major component of impact assessment is consideration of threats to species of conservation significance as these are a major and sensitive element of biodiversity. Therefore, the impact assessment section includes the following:

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

The impact assessment concludes with recommendations for impact mitigation, based upon predicted impacts.

2.5.1 Criteria for impact assessment

Impact assessment criteria are based on the severity of impacts on the fauna assemblage and conservation significant fauna, and quantified on the basis of predicted population change (Table 2-5). Population change can be the result of direct habitat loss and/or impacts upon ecological processes.

The significance of population change is contextual. The EPA (2004) suggests that the availability of fauna habitats within a radius of 15 km can be used as a basis to predict low, moderate or high impacts. In this case, a high impact is where the impacted environment and its component fauna are rare (less than 5% of the landscape within a 15 km radius or within the Bioregion), whereas a low impact is where the environment is widespread (e.g. >10% of the local landscape). Under the Ramsar Convention, a wetland that regularly supports 1% of a population of a waterbird species is considered to be significant. These provide some guidance for impact assessment criteria. In the following criteria (Table 2-5), the significance of impacts is based upon percentage population decline within a 15 km

radius (effectively local impact) and upon the effect of the decline upon the conservation status of a recognised taxon (recognisably discrete genetic population, sub-species or species). Note that percentage declines can usually only be estimated on the basis of the distribution of a species derived from the extent of available habitat.

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

Table 2-5. Assessment criteria for impacts upon fauna.

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

3 Results: Fauna Values

3.1 Vegetation and Substrate Associations (VSAs)

The exploration areas are broadly similar in vegetation and substrates with representatives of each VSA throughout the project area. The vegetation can be summarised as being mostly open Acacia or Mulga shrubland over sparse to dense vegetation with many areas of spinifex. These occur over red loam to sandy loam on the flat areas and gravelly loam and rocky soil on the higher ground, with some gravelly areas overlain with quartz/ironstone cobbles or pebbles. Drainage lines with Acacia or Mulga thickets on clayey loams occur throughout the exploration areas in varying sizes. VSAs can only be broadly defined in the absence of detailed vegetation surveys, but key VSAs are listed in Table 3-1 and shown in Figures 3-1 to 3-9.

Table 3-1. Main VSAs across project area

VSA No.	VSA	Exploration areas with VSA
VSA 1	Acacia shrubland on gravelly loam with quartz/ironstone cobbles on flats and slight rises. This is very extensive and variable, with some areas of acacia thickets, but other areas that are very open and the quartz forms a veneer over open ground.	Trident, Mareast, Cinnamon, Triple P, Apex, K2, Marwest, Speckled Hen, Tailings Pipeline
VSA 2	Open Acacia on rocky/gravelly soil, on high ground, sometimes with Miniritchi and sometimes over Spinifex.	Tailings Pipeline, Mareast, East Ibis, Wedgetail, Speckled Hen
VSA 3	Mulga over shrubs and spinifex on loam to sandy loam flats.	Significant for Mulgara. Apex, north K2, east K2, pipeline, Triple P, Cinnamon
VSA 4	Drainage line with Acacia/Mulga thickets on clayey loam. On some drainage lines the acacia are a tall Miniritchi.	Trident, Apex, Tailings Pipeline, Ibis, Wedgetail, Mareast, Triple P, Marwest. Largest drainage lines are along the Tailings Pipeline and in Apex and Triple P.
VSA 5	Old mine pits, stockpiles with partial rehabilitation; areas of good rehabilitation are similar to VSA 1.	K2, Trident, Cinnamon, Ibis, Mareast, Triple P.

Detailed descriptions of the VSAs within each exploration area are given here:

K2. Several old mine workings, open-cuts and access to a portal at K2. Also large overburden stockpiles with some Acacia regeneration but a lot of bare ground and erosion channels. An old TSF to the north has impressively dense Acacia regrowth. In north, vegetation is Mulga over Spinifex on gravelly loam, over half burnt c. 3 years previously.
Notable for: Large areas of Mulga over Spinifex on gravelly loam.

Apex. Encompasses a major drainage system running north-south. Some small pools along drainage line were present in November 2018, with drainage system supporting a corridor of Acacia thickets

over dense patches of understorey on clayey loam. Some areas are clearly flooded to a shallow depth seasonally. Most of project area is Acacia open tall shrubland over sparse shrubs on quartz and ironstone cobbles/gravel veneer flats and slight rises.
Notable for: Large drainage line whereas most other areas have smaller drainage lines. No previous mining but some recent exploration so low levels of disturbance.

Cinnamon. Some mine workings but mostly undisturbed. More uniform than other areas, with tall Mulga over Spinifex on loam plain, slightly gravelly in north. Some areas of Mulga thicket with dense understorey.
Notable for: Large areas of Mulga over Spinifex on loam and low level of existing mine activity.

Trident/Marwest. Lower relief than in more easterly areas. Extensive low open Acacia woodland with sparse understorey on gravelly loam flats, some areas with quartz and ironstone cobbles/gravel veneer. In west and northwest, some minor drainage lines with dense and tall acacia over dense shrubs forming tall thickets. Similar thickets in slight depressions throughout. Moderately large drainage line in south supports dense belt of tall Acacia thicket over mixed understorey. Some areas of Spinifex and areas of open Acacia woodland on loam to clayey-loam flats. Shrub-steppe of low, sparse shrubs may be natural or the product of grazing. Old mine workings in east with a deep open pit, overburden stockpiles and generally disturbed ground. Active drilling in centre has resulted in a lot of loss of understorey but most taller shrubs retained.
Notable for: Large areas of Acacia woodland on gravelly loam and moderately large drainage line in south supporting Acacia thickets.

Pipeline Corridor. In east (K2 area), passes through open Mulga over Spinifex on loam plain, much of it burnt in 2016. Central section of corridor passes over a raised area dissected by several drainage lines. High ground supports Mulga and scattered shrubs on gravelly loam with a distinct veneer of quartz pebbles. A few small rocky hills are also present. Crosses several drainage lines, some large and supporting dense corridors of tall Mulga on loam soil. In west, near Mareast, high ground supports open woodland of Acacia, including Miniritchi, over Spinifex on rocky/gravelly soil.
Notable for: Diversity of vegetation over variety of soils on low and high ground, and major drainage lines.

Mareast. Part of area taken up with mine pit and overburden stockpile which is partly rehabilitated. Most of intact area supports Acacia open low woodland with little understorey on gravelly rises and plains. There are also some areas of Acacia thickets along drainage lines and slight depressions. In the east, there are areas of gravelly/rocky hills with Spinifex and Acacia. In the north, drainage lines have distinctive patches of a tall Miniritchi.
Notable for: Rocky hills with Acacia over Spinifex.

Wedgetail. Subject to exploration but no previous mining, so level of disturbance is low. Mostly Acacia low woodland on undulating rocky/gravelly hills. Small area (<1ha) of Mallee with little understorey also present. Dense thickets of Mulga in minor drainage lines between hills.
Notable for: Low level of disturbance, Acacia woodland on gravelly hills, and only area of Mallee in project area.

Ibis. Much of area taken up with old mine pit and overburden stockpiles which are partly rehabilitated. Intact areas mostly Acacia woodland on undulating rocky/gravelly hills with dense Mulga thickets in minor drainage lines. In far east, hills have Acacia over Spinifex on rocky/gravelly substrate.
Notable for: Acacia woodland on gravelly hills.

Haul road from Ibis to south of Exocet. Most notable feature is it passes through Mulgara conservation area. This has VSA of Mulga over Spinifex on loamy sand which seems to be more widespread in the south. Also passes through two major drainage lines.
Notable for: Mulgara conservation area of Mulga over Spinifex on loam.

Triple P. Relief of natural landscape low, but project area has several large pits and overburden stockpiles. Extensive areas in north and through centre of area of Mulga with shrubby understorey and occasional Spinifex on loam flats; this vegetation generally in good condition. Some of the Mulga over spinifex on loam is signposted as a conservation area (presumably for Mulgara). In far west, undulating gravelly hills supporting open Acacia low woodland over Spinifex. In south-east, areas of gravelly/rocky plain, including quartz veneer, supporting Acacia tall open shrubland. Several large drainage lines present. In north, these contain dense thickets of tall Mulga. In west, passing through Exocet pit, a drainage line with a distinctive woodland of tall Miniritchi is present.
Notable for: Large areas of Mulga over shrubby understorey on a range of soil types; several large drainage lines and belts of Miniritchi woodland.

Speckled Hen. Most of Speckled Hen is Mulga on loam; some of this is associated with drainage line or low-lying, sometimes damp areas. There is a Spinifex on a gravel rise in the east.
Notable for: Large areas of Mulga on loam.

Environments of most interest with respect to fauna are the drainage lines, Mulga thickets and the mulga over spinifex on sandy loam. This is because they support some significant species and are restricted in extent. The mine portal in K2, and possibly other shafts in other mine pits, may be locally important (fauna discussed below). The general landscape is very extensive in the region with only small areas of development (past and current mines) and some grazing impacts.

Figure 3-1. Example of VSA 1 – Acacia shrubland over gravelly loam (Trident).

Figure 3-2. Example of VSA 1 - Acacia tall shrubland on slight gravelly rise (Trident).

Figure 3-3. Example of VSA 1 – Acacia over dense shrubs on slightly gravelly loam (Apex).

Figure 3-4. Example of VSA 2 – Open Acacia over gravelly rise with Miniritchi over Spinifex (Tailings Pipeline Corridor).

Figure 3-5. Example of VSA 2 – Open Acacia shrubland and woodland over Spinifex on loam Cinnamon).

Figure 3-6. Example of VSA 3 - Mulga over Spinifex on loam to sandy loam (north of K2).

Figure 3-7. Example of VSA 4 - Drainage line with Acacia thickets (Apex, showing temporary pool).

Figure 3-8. Example of VSA 4 - Acacia along a drainage line, where the acacias are a tall Miniritchi and there is little understorey (Triple P).

Figure 3-9. Example of VSA 5. Flamingo Pit in Triple P. This was the location where a pair of Peregrine Falcons appeared to be nesting.

Figure 3-10. Example of moderately good rehabilitation on an old tailings storage facility in K2. This is effectively VSA 1.

3.2 Fauna assemblage

3.2.1 Overview of fauna assemblage

The desktop study identified 259 vertebrate fauna species as potentially occurring in the Marymia area: 9 frogs, 66 reptiles, 148 birds and 36 mammals. These species are listed in Appendix 5. Over half (150; 58%) of these species have been confirmed across multiple surveys, but many cannot be expected to be present all of the time. Species are considered recorded in the project area if they were recorded during the 2009 level 2 survey by *ecologia*, and during either of the BCE surveys conducted in the area, including the Mulgara surveys conducted between 2007 and 2009, and the present November 2018 and August 2019 surveys.

A further 10 species (1 bird and 9 mammals) are considered to be locally extinct, and 26 species retuned from databases have been excluded on the basis that they are not known to occur in the area (Appendix 6). An annotated species list for fauna recorded during the November 2018 and August 2019 surveys is presented in Appendix 7.

The composition of the vertebrate fauna is summarised in Table 3-2. Differences in the fauna assemblage between the exploration areas are likely to be subtle and cannot be investigated without massive sampling effort, but potential differences are discussed below.

Table 3-2. Composition of vertebrate fauna assemblage of the project area.
The number of non-native mammals is shown in parentheses. Locally extinct species are not included in totals.

Taxon	Expected Species	Recorded Species	Number of species in each status category				
			Resident	Migrant or regular visitor	Irregular visitor	Vagrant	Locally extinct
Frogs	9	3	9	-	-	-	-
Reptiles	66	29	65	1	-	-	-
Birds	148	91	60	40	37	11	1
Mammals	36 (10)	27 (10)	30 (6)	2 (1)	2 (2)	2	9
Total	259	150	164	43	39	13	10

The key features of the fauna assemblage expected in the survey area are:

- **Uniqueness:** The fauna assemblage is probably widespread across similar soils and vegetation in the region, and these soils and vegetation are widespread with localised disturbance from mining and extensive impacts from grazing. The assemblage appears to include at least some outlying populations of Pilbara sub-species, but extensive sampling would be required to document this.

- **Completeness:** The assemblage is likely to be substantially complete except for the mammal fauna, with at least nine species locally extinct. This is typical of a broad part of Australia.
- **Richness:** The assemblage is only moderately rich as the project area has a limited range of VSAs to provide habitat for fauna. For example, it lacks permanent water or very large river systems, and lacks major rocky landscapes.

As a fauna value, the most important features of the project area's assemblage are that it is substantially complete except for some mammals, and it contains elements of the Pilbara as well as the Murchison regions.

3.2.2 Frogs

The nine frog species are all considered to be residents and are likely to breed in seasonal freshwater pools such as along the major drainage lines such as in Apex and Triple P, but may also utilize temporary pools where-ever they occur. They may also breed in flooded mine pits if the water is fresh. Outside the breeding season, the frogs are likely to be widespread and not restricted to the margins of seasonal wetlands. The presence of only three frog species has been confirmed, probably because they can only be detected when active, with activity periods limited to rainy periods. All of the frog species are widespread and are not of conservation significance.

3.2.3 Reptiles

The 66 reptile species are all considered to be residents except for the Flat-shelled Tortoise which has been recorded but may only be present as a visitor along major drainage lines. However, it could possibly aestivate in the river bed when this system is dry. Studies have confirmed fewer than half the expected reptile assemblage which may reflect difficulty of detection of many species; for example the November 2018 site visit recorded two snake species that are almost certainly resident and common throughout the general area, but which had not previously been found and had not come up from the database search (but were considered to be expected based on known patterns of distribution). One of these, the Pygmy Python, was found when spotlighting at K2 and Cinnamon, and in both cases animals were using piles of rocks created by mining. One of the geckoes recorded, the Banded Knob-tailed Gecko (see cover photograph), was of interest as it represents the Pilbara sub-species (*Nephrurus wheeleri cinctus*) rather than the Murchison sub-species (*N. wheeleri wheeleri)*, whereas the latter would have been expected given the project area's location. The results of spotlighting and head-torching are included in the annotated species list in Appendix 7. There were no reptiles recorded in the August 2019 survey due to unsuitable conditions for observing this fauna group (temperatures being too low). All of the reptile species are widespread and are not of conservation significance.

3.2.4 Birds

The bird assemblage of 148 species includes a suite of about 20 wetland-dependent species that are only likely to occur as irregular visitors when suitable conditions (i.e. flooding of drainage lines and mine pits) occur within the survey area. Several of these waterbird species were present in August 2019, possibly because dry conditions over large areas were forcing birds to retreat to remnant water bodies such as flooded mine pits. Such water bodies are generally unproductive and thus do not support large numbers of waterbirds, and the numbers present were low (given in Appendix 7).

A high proportion (59%) of species are considered to be visitors, irregular visitors or vagrants; this is to be expected of a strongly seasonal environment with unpredictable rainfall. The majority (49 of 60 species) of bird species considered to be resident have been recorded, suggesting that this group of fauna has been well-covered in surveys. A smaller proportion (18 of 40) of species expected to be visitors have been confirmed.

Results of the bird census conducted in each exploration area in November 2018 and August 2019 are presented in Table 3-3. Comparisons between areas can only be made cautiously, as sampling effort was not strictly standardised and results have not been adjusted for sampling effort, but some trends are apparent. For example, there was higher bird activity in November 2018 surveys than in August 2019 surveys with the average number of species per site being ~17 in 2018 compared with ~5 in 2019. This can be attributed to the poor long-term rainfall across the region in 2018/2019 resulting in dry conditions, low productivity and therefore low fauna activity and abundance. The exception was at Triple P where bird activity was similar to November 2018 levels and much higher than in other sites in August 2019 (n=23 species compared with n=<5 in other sites, Table 3-3), but most of the birds were recorded around a pile of horse carcasses where they were foraging on invertebrates attracted to the carcasses. It is interesting to speculate that the survival of some sedentary insectivorous birds may be reliant on such a resource. In November 2018, the rehabilitation area in K2 had fewer bird species than other areas, was missing a suite of thornbills that are associated with medium to tall Mulga, and was also missing the otherwise widespread Spiny-cheeked Honeyeater. The Cinnamon and Apex exploration areas were notable for the abundance of the Red-capped and Hooded Robins, both of which were associated with dense, tall mulga that in Apex occurred along a major drainage line, but in Cinnamon similar vegetation was widespread on sandy loam soils. The majority of species recorded were classed as residents.

The bird assemblage includes 17 species of conservation significance, but most are expected only as irregular visitors or vagrants. These are discussed further below. One bird species is considered to be locally extinct.

Table 3-3. Raw data of bird surveys in each exploration area in November 2018 and August 2019 surveys.

Numbers are approximate number of each species counted in each area. K2 records from November 2018 are divided between rehabilitation area and native vegetation.

Species	November 2018 survey					August 2019 survey							
	Trident	K2 rehab	K2 native	Cinnamon	Apex	Pipeline corridor	K2 (west)	Ibis	Wedge-tail	Mareast	Marwest/ Trident	Triple P	Speckled Hen
Little Eagle	1												
Whistling Kite			1										
Nankeen Kestrel	1		1										
Peregrine Falcon												2	
Brown Falcon		1			1	1							
Common Bronzewing	1		2										
Crested Pigeon		2											
Diamond Dove			1										
Galah												2	
Australian Ringneck	2											1	
Red-backed Kingfisher	1												
Rainbow Bee-eater			2										
Western Quail-thrush	5				4	1						3	
Chestnut-rumped Thornbill	14		7	2	8			2	1	3	2	2	
Slaty-backed Thornbill	4		6	6					2				
Yellow-rumped Thornbill												2	
Inland Thornbill	2		2	2	4							2	
Southern Whiteface												2	
Redthroat				1	1							1	
Variegated Fairy-wren	3	3			7				3			3	
Splendid Fairy-wren	2			5	3								
Yellow-throated Miner	2			1	6								
Spiny-cheeked Honeyeater	2		8	8	5	1			2				
Singing Honeyeater	5	2	9	4	6					1			

Species	November 2018 survey					August 2019 survey							
	Trident	K2 rehab	K2 native	Cinnamon	Apex	Pipeline corridor	K2 (west)	Ibis	Wedge-tail	Mareast	Marwest/ Trident	Triple P	Speckled Hen
Mistletoebird					2								
Willie Wagtail	2	1	8	6	6			1	1			4	1
Red-capped Robin	1			2	2							2	
Hooded Robin				2	5	2				1		2	
Grey Shrike-thrush	1	2	6	3	3							1	
Rufous Whistler	5		6	8	4								
Crested Bellbird		1	3	2	3							1	
Grey-crowned Babbler	3			5	5							3	
White-browed Babbler		8	3	2	14								
Welcome Swallow												7	
White-backed Swallow		1											
Little Woodswallow	2		2					1				2	
Black-faced Woodswallow			2	3								30	12
Dusky Woodswallow												1	
Varied Sittella													6
White-winged Triller			1										
Magpie-lark												2	
Pied Butcherbird												1	
Grey Butcherbird			1	2									
Torresian Crow	3									1		1	1
Total Number of Species	**21**	**9**	**19**	**18**	**19**	**4**	**0**	**3**	**5**	**4**	**1**	**23**	**4**
Average in 2018/2019	**17**					**5**							

3.2.4.1 Audio Recording Unit

There were no significant findings recorded from the audio recording unit with only common bird species recorded.

3.2.5 Mammals

Most of the 37 mammal species are considered to be resident (n=31), with six of these being introduced species. The remaining six mammals are visitors, irregular visitors or vagrants, with three of these introduced. The two vagrant species are native and are probably locally extinct; one of these, the Bilby, is discussed below among significant species. The two irregular visitors are introduced, while the one native regular visitor is the White-striped Bat, which is a migrant in the region, visiting over winter but moving south over summer. Nine mammals are considered to be locally extinct (Appendix 6); these include several of conservation significance. The mammal assemblage includes four species of conservation significance that are discussed below. One of these, the Brush-tailed Mulgara (referred to as the Crest-tailed Mulgara in earlier studies), has been the subject of a major research project in the Marymia area.

3.2.5.1 Motion-sensitive cameras

There were no images recorded from motion-sensitive cameras.

3.2.5.2 Bat detectors

Six bat species were recorded on bat detectors in November 2018 and August 2019 surveys, and all are classed as residents in the project area (Table 3-4). Call charts from each species recorded on bat detectors are shown in Appendix 8. There were three bat species recorded at the K2 portal, with the same species recorded in November 2018 and August 2019 (Table 3-4). The large number of call sequences of *Taphozous georgianus* and *Vespadelus finlaysoni* recorded at the K2 portal contained social calls and feeding buzzes, suggesting these species were roosting in the portal. Similarly, a number of calls from *Saccolaimus flaviventris*, *V. finlaysoni* and *Scotorepens balstoni* in November 2018 contained social calls and feeding buzzes, suggesting these species were roosting in pits close to the exploration camp.

Of the nine bat species expected in the project area, seven have been recorded in previous and present surveys, and all except for one visitor are considered residents (Appendix 5). None is of conservation significance.

Table 3-4. Species recorded on bat detectors in November 2018 and August 2019. Relative abundance of calls indicated in parentheses.

Date/Location	Species					
	C. gouldii	***N. geoffroyi***	***S. balstoni***	***V. finlaysoni***	***S. flaviventris***	***T. georgianus***
7 Nov 2018 (K2 portal)	X (low)			X (high)		X (high)
8 Nov 2018 (camp)	X (low)	X (low)	X (moderate)	X (high)	X (high)	X (low)
8 Aug 2019 (K2 portal)	X (low)			X (high)		X (high)

3.2.6 Species of conservation significance

Of the 259 species of vertebrate fauna that are expected to occur in the survey area, 20 are considered to be of conservation significance (12 CS1, three CS2 and five CS3). The number of conservation significant species in each vertebrate class is given in Table 3-5 and the list of conservation significant species is given in Table 3-6. See Appendix 1 for descriptions of these CS (conservation significance) levels. The majority of conservation significant species are expected as irregular visitors or vagrants; only one bird is considered to be a Visitor, and one bird and three mammals are considered to be Resident. Significant species are discussed below, with the focus on species considered to be Visitors or Residents, but with some discussion on species of high (CS1) significance whatever their expected status.

Table 3-5. Number of conservation significant species in each vertebrate class.

See Appendix 1 for full explanation of Conservation Significance (CS) levels: CS1 = listed under WA State and/or Commonwealth legislation; CS2 = listed as Priority by DBCA; CS3 = considered locally significant.

CLASS	CONSERVATION SIGNIFICANCE			
	CS1	CS2	CS3	Total
Frogs	0	0	0	0
Reptiles	0	0	0	0
Birds	11	1	5	17
Mammals	1	2	0	3
Total	**12**	**3**	**5**	**20**

Table 3-6. Conservation significant fauna species expected to occur within the project area.

Species are listed in taxonomic order.
CS1, CS2, CS3 = (summary) levels of conservation significance. See Appendix 1 for full explanation.
EPBC Act listings: E = Endangered, V = Vulnerable, M = Migratory (see Appendix 3).
WA Biodiversity Conservation Act 2018 listings: S1 to S7 = Schedules 1 to 7 (see Appendix 3).
DBCA Priority species: P1 to P4 = Priority 1 to 4 (see Appendix 3).
LS = considered by BCE to be of local significance (see Appendix 3).

SPECIES	COMMON NAME	STATUS	EXPECTED OCCURRENCE
Leiopoa ocellata	Malleefowl	CS1 (V, S3)	Irregular visitor
Apus pacificus	Fork-tailed Swift	CS1 (M, S5)	Visitor
Ardea modesta	Eastern Great Egret	CS1 (M, S5)	Irregular visitor
Falco hypoleucos	Grey Falcon	CS1 (S3)	Vagrant
Falco peregrinus	Peregrine Falcon	CS1 (S7)	Resident
Calidris acuminata	Sharp-tailed Sandpiper	CS1 (M, S5)	Irregular Visitor
Calidris ruficollis	Red-necked Stint	CS1 (M, S5)	Irregular Visitor
Calidris melanotos	Pectoral Sandpiper	CS1 (M, S5)	Vagrant
Actitis hypoleucos	Common Sandpiper	CS1 (M, S5)	Irregular Visitor
Lophochroa leadbeateri	Major Mitchell's Cockatoo	CS3 (LS)	Vagrant
Neophema splendida	Scarlet-chested Parrot	CS3 (LS)	Vagrant

SPECIES	COMMON NAME	STATUS	EXPECTED OCCURRENCE
Polytelis alexandrae	Princess Parrot	CS1 (V, P4)	Vagrant
Pezoporus occidentalis	Night Parrot	CS1 (E, S1)	Vagrant
Ardeotis australis	Australian Bustard	CS3 (LS)	Resident
Burhinus grallarius	Bush Stone-curlew	CS3 (LS)	Irregular visitor
Amytornis striatus striatus	Inland Striated Grasswren	CS2 (P4)	Vagrant
Conopophila whitei	Grey Honeyeater	CS3 (LS)	Visitor
Hirundo rustica	Barn Swallow	CS1 (M, S5)	Visitor
Dasycercus blythi	Brush-tailed Mulgara	CS2 (P4)	Resident
Antechinomys laniger	Kultarr	CS3 (LS)	Resident
Sminthopsis longicaudata	Long-tailed Dunnart	CS2 (P4)	Resident
Macrotis lagotis	Greater Bilby	CS1 (V, S3)	Vagrant

3.2.6.1 Conservation Significance 1

Malleefowl

This species has been recorded to the south on Doolgunna (Turpin and Bamford 2015), but its distinctive mounds were not found in the exploration areas so it is very unlikely that it is a breeding resident. However, individual birds may visit the project area. They are likely to favour Mulga thickets and other dense vegetation that are found in all exploration areas.

Peregrine Falcon

A pair of Peregrine Falcons was present in Flamingo Pit in the Triple P area in August 2019. It is likely they were nesting on a ledge on the pit wall, although this could not be confirmed. Peregrine Falcon pairs are usually site-faithful, so these birds are likely to be long-term residents with a feeding range that encompasses several hundred square kilometres. The pair may have alternative nest sites in nearby mine pits; Marchant and Higgins (1993) report on studies that indicate most breeding territories have two or three alternative nesting sites.

Fork-tailed Swift and Barn Swallow

The Fork-tailed Swift is a non-breeding migrant to Australia and is more or less nomadic; therefore its occurrence at any one location is unpredictable. Being aerial, it is largely independent of terrestrial ecosystems. The Barn Swallow is also a non-breeding migrant that occurs regularly around some Pilbara towns in small numbers.

Significant waterbirds

Several migratory waterbird species may occur as irregular visitors or vagrants, including the Eastern Great Egret, sandpipers and stints. Other waterbird species could also occur very infrequently. These might occasionally visit natural wetlands along the drainage lines throughout the exploration areas, and could also visit flooded mine pits, although numbers would be very low.

Night Parrot

The Night Parrot is expected only as a vagrant, if at all. Its biology is poorly understood but there is some evidence that it favours the spinifex/samphire ecotone, such as the vegetation which occurs around the margins of salt lakes, but it is also known from rocky hills, particularly with spinifex. There are reports of the species around salt lake systems over 100km to the east of the project area.

Greater Bilby

There is a re-introduced population of the Greater Bilby over 100km to the east (Matawa/Lorna Glen Station) and as this is a mobile species there is a slight possibility of the occasional animal passing through the project area. In time, and given Fox control, the species could even colonise drainage lines in sandplain environments which exist throughout the exploration areas. However, the likelihood of such colonisation realistically is low.

3.2.6.2 Conservation Significance 2

Brush-tailed Mulgara

This species is locally common in suitable environments in the Marymia area and was subject to a long-term research project monitoring its numbers in the mid to late 2000s (*ecologia* 2005; Rodda and Bamford 2007, 2008; Zosky and Bamford 2009). At that time, the species was thought to be the Crest-tailed Mulgara *Dasycercus cristicauda*, which has a high level of conservation significance (CS1; listed under legislation). A subsequent taxonomic review determined the species to be the Brush-tailed Mulgara, which is of lower significance (CS2; listed as priority by DBCA). It occurs mainly in areas of spinifex on sandy to sandy-loam soils, with this environment best represented in the K2 and Cinnamon exploration areas, in part of Triple P and along the haul road to the south. Burrows were found in K2 and Cinnamon during the November 2018 survey (Figure 3-9; GPS coordinates given in Appendix 8). All burrows found were inactive, but this is typical of the species that can vary in abundance greatly from year to year. No burrows were found in the extensive sandplains in the north of K2, but this area had been fairly recently burnt which may have caused animals to emigrate. No burrows were found in the other exploration areas surveyed in August 2019, most of which had no suitable (sandy) substrate. Suitable habitat in Triple P and along the southern Haul Road have already been identified as significant for the species.

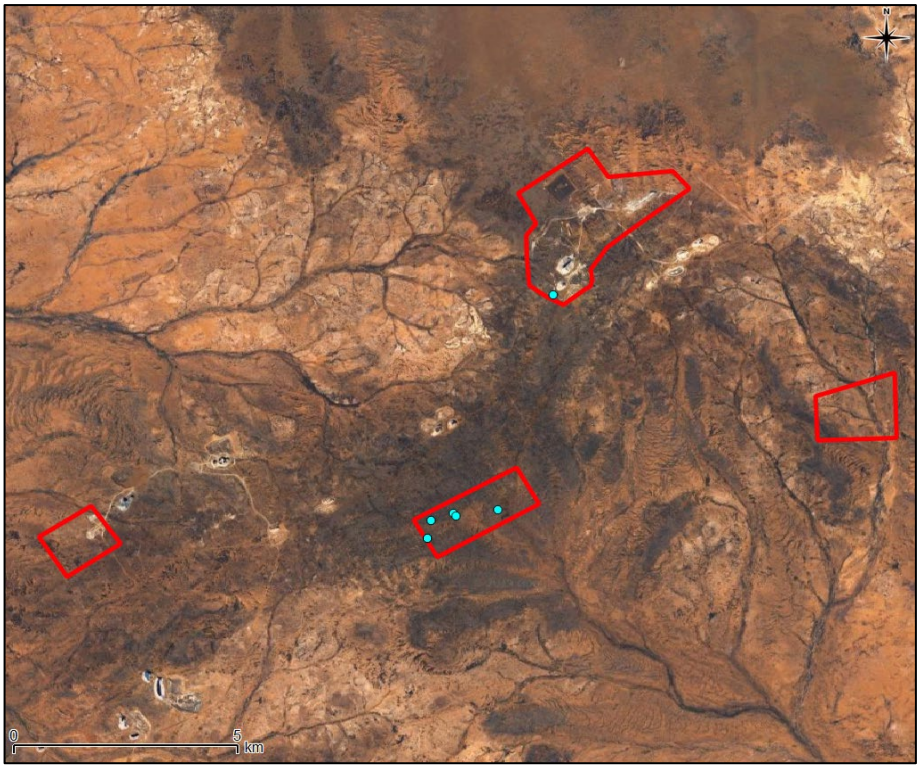

Figure 3-11. Locations of Brush-tailed Mulgara burrows found in November 2018.

Long-tailed Dunnart

This species is usually associated with rocky environments and was not included in the database search results, but it was recorded near Wiluna in 2015 (M. Bamford pers. obs.) on a low rocky hill, similar to the small rocky hills present near the Marymia camp and just east of the Apex exploration area. It is therefore considered likely to be resident in the region although it might only occasionally visit the actual exploration areas. However, rocky landscapes created by mining may provide habitat for it.

3.2.6.3 Conservation Significance 3

Australian Bustard

This large bird is moderately common in the region but is included as locally significant because it is vulnerable to feral predators and roadkill. In addition, it has declined across southern Australia and the project area is on the edge of where the species remains common.

Bush Stone-curlew

This ground-nesting bird has disappeared from southern Australia and remains in small numbers across the Murchison and Gascoyne. It remains common only in the Pilbara and further north. While not recorded in the project area, it may be present occasionally. It is often associated with dense thickets along drainage lines, such as found throughout the exploration areas.

Grey Honeyeater

This is an infrequently seen honeyeater that has been recorded in Doolgunna and therefore may be present as a visitor if not a resident. It favours tall, dense Mulga so could occur in any of the exploration areas, although this vegetation is most extensive in Cinnamon and Apex.

Kultarr

This small marsupial is rarely-recorded but appears to be widespread. It was detected in the general Marymia area by ecologia (1991). It is often associated with gravelly and rocky plains with sparse vegetation, so could occur in any of the exploration areas.

Short Range Endemic (SRE) invertebrates

No range-restricted invertebrates were returned from databases; though this is not to say there are no such species in the general area, but just that they have not been detected. The landscape of the study area is not conducive to the presence of SRE invertebrates, which are often associated with relictual landscape features and mesic refugia, whereas the study area supports an environment typical of the region. However, speciation in invertebrates is complex and where groups have been studied in detail, species with restricted ranges that are not linked to relictual landscape features have been found (M. Heath, pers. comm.). One trapdoor spider was collected during the November 2018 survey and was identified as a juvenile *Gaius* sp., and there were many burrows of adult *Gaius* in the area. Members of this genus are generally widespread although it is currently under review (V. Framinau, pers. comm.). There has been no past sampling of potential SRE invertebrates, and no sampling of subterranean invertebrates.

3.2.7 Patterns of biodiversity

Investigating patterns of biodiversity can be complex and are often beyond the scope even of level 2 investigations, but it is possible to draw some general conclusions based upon the patterns of soils and vegetation across the landscape. Of particular interest are environments likely to be rich in species or that support species of conservation significance. These include:

- Mulga over spinifex on sandy loam. Spinifex tends to support a rich assemblage of reptiles and this VSA is also favoured by the Brush-tailed Mulgara. Mulga in general is rich in birds. This VSA is widespread in the north of K2, across much of Cinnamon, in the north of Triple P and along the southern Haul Road.
- Mulga thickets along drainage lines. This is well-developed in Apex but also occurs in patches across Trident, Cinnamon, K2, Triple P and Speckled Hen. Mulga thickets often have a well-developed understorey of *Eremophila* spp. and there was a high richness and abundance of birds in this vegetation.

In general, gravelly and rocky soils with open shrublands and occasionally spinifex are likely to be lower in fauna richness.

3.2.8 Ecological processes

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

Fire. As is the case throughout most of Western Australia, the vegetation of the region is fire-adapted to some degree, but the flora and fauna assemblages can be altered by too-frequent fires; and even by fire exclusion. Some species are particularly sensitive to wildfires and altered fire regimes. Fire season may also be important in seed germination. It appeared that a recent extensive fire across the north of K2 had resulted in the disappearance of the Brush-tailed Mulgara; K2 had been one of the monitoring areas for earlier studies on the species.

Feral species and interactions with over-abundant native species. Feral species occur throughout Western Australia, with the Fox, Rabbit, Cat, Cattle (domestic?), Donkey, Horse (apparently feral) and Camel recorded during the 2018/2019 surveys. These species have an impact on native fauna species through competition and predation. Cats and Foxes may also benefit from the control of Dingo/wild Dogs by nearby pastoralists, thereby removing one of their main predators. On Lorna Glen (Matawa) Station where Foxes and Cats are controlled, the Brush-tailed Mulgara has become abundant (N. Hamilton, pers. comm.)

Connectivity and landscape permeability. The native vegetation is mostly continuous with only small areas of clearing relative to a large landscape. However, there is linear connectivity along drainage lines containing dense Mulga which act as natural corridors for fauna, particularly birds and possibly also some mammals, to move through the landscape.

Hydrology. Mulga thickets are often associated with very slight changes in topography and can be sensitive to hydrological change, including surface flows. The extensive areas of Mulga in all exploration areas mean that local patterns of hydrology are important in maintaining vegetation that provides habitat for fauna.

3.2.9 Summary of fauna values

The desktop study identified 259 vertebrate fauna species as potentially occurring in the survey area (Appendix 5): 9 frogs, 66 reptiles, 148 birds, 26 native mammals and 10 introduced mammals. This does not include several locally extinct mammal species. The assemblage includes 20 species of conservation significance that may occur in the survey area. Fauna values within the survey area can be summarised as follows:

Fauna assemblage. Some species loss has occurred, affecting particularly mammals, but the remainder of the vertebrate assemblage is more or less intact. The assemblage appears to include elements of both the Pilbara and Murchison and is only moderately rich, reflecting a fairly uniform landscape lacking in dramatic features such as large hills and major rivers.

Species of conservation significance. The project area potentially supports about 20 conservation significant fauna species, but very few are likely to be residents or regular visitors. The most notable is the Brush-tailed Mulgara, which is locally common in the general region and was the subject of a research and monitoring project in the past (mid to late 2000s). It favours sandy to sandy loam soils, usually with spinifex, and may be temporarily displaced by fire. It is also sensitive to Fox and Cat predation. Such soils occur in patches throughout the project area and are more widespread to the south, although inactive burrows were recorded in Cinnamon and K2 and extensive suitable habitat in K2 was recently burnt. Also of importance is the pair of Peregrine Falcons in Flamingo Pit (Triple P).

Patterns of biodiversity. Across the exploration areas, Mulga over spinifex on sandy loam and Mulga thickets along drainage lines are likely to be richest in fauna, while gravelly and rocky soils with sparse vegetation are likely to be lowest in fauna species richness. Mulga over spinifex on sandy loam is also where Brush-tailed Mulgara can occur. This VSA is widespread in the north of K2 and across much of Cinnamon, in the north of Triple P and along the southern Haul Road, while Mulga thickets along drainage lines are best developed in Apex but can found in all areas. Trident/MarEast/MarWest have the most extensive areas of gravelly soils and sparse shrublands.

Key ecological processes. The most important ecological processes affecting the fauna assemblage are fire, impacts of feral predators and local hydrology. Landscape connectivity related to the distribution of Mulga thickets may also be important for some species.

Overall, the project area has a fauna species assemblage that has suffered some species loss. It is a moderately rich assemblage, although it may not provide core habitat for many of the fauna species listed. The assemblage does include some species of conservation significance. The assemblage is sensitive to landscape connectivity, introduced species and fire, while the most important environments for fauna richness are Mulga over spinifex on sandy loam, and Mulga thickets along drainage lines or in slightly lower areas of the landscape. K2 has awide range of environments and extensive habitat for the Brush-tailed Mulgara, albeit currently of limited suitability for the species due to a recent fire. Cinnamon also has extensive Mulgara habitat and several records of currently inactive burrows. Cinnnamon is also likely to be richest in bird species due to the extensive Mulga with understorey present. Apex has a major drainage line with associated tall Mulga thickets important for fauna. Trident has the most extensive areas of gravelly and rocky soils that are probably less rich in fauna, but even this is interspersed with Mulga thickets. Triple P is notable for being large with a wide range of environments, and for the presence of a pair of Peregrine Falcons (probably breeding).

4 Impact Assessment

Impacting processes have to be considered in the context of fauna values and the nature of the proposed development, which in this case involves exploration, leading to some temporary clearing, and could ultimately lead to the development of open mine pits across a portion of the exploration areas. Predicted impacts are examined below; impacting processes are outlined in Appendix 2 and definitions of levels of impact significance are given in Table 3.

Habitat loss leading to population decline.

Exploration leads to some habitat loss that should be temporary, and impacts understorey vegetation in particular. Mining leads to permanent habitat loss and the creation of what are effectively novel environments (rehabilitated stockpiles and rockpiles). Population decline will be roughly proportional to habitat loss which is a very small part of the overall landscape. Impact generally Minor, but of concern are the Peregrine Falcons at Flamingo Pit (Triple P), which could lose their nesting site and with a possibility of mortality of chicks if development occurred when the nest was occupied.

Habitat loss leading to population fragmentation.

The natural landscape is largely continuous but fauna of linear VSAs (drainage lines, bands of Mulga) may be sensitive to fragmentation. This would only occur where mine pits or major infrastructure occurs across the VSA, and the fragmentation would be partial, such as reduced dispersal rather than a complete end to movement. This is because the landscape in general remains intact. Impact Minor to Moderate.

Degradation of habitat due to weed invasion.

The site appears relatively weed free. There is some potential for the development to increase the number of weed species within the study area; basic hygiene measures such as cleaning the underside of vehicles should reduce the chances of this occurring. Impact Minor.

Direct mortality of fauna during operations.

Some mortality is inevitable during clearing and operation, such as from vehicle movements and entrapment of fauna in drilling sumps, trenches and the like. Mortality can be managed and reduced (see recommendations below), and in a conservation sense mortality of small numbers of common animals at sites that represent a very small proportion of the total landscape is not significant. In Mulgara habitat, direct mortality during clearing should be avoided where possible. Impact Minor.

Species interactions.

There is potential for the project to aid Cats and Foxes to more easily move through the landscape, such as along exploration lines, and this poses an increased risk to species such as the Brush-tailed Mulgara. Cats and Foxes can also increase in abundance close to centres of human activity. The Mulgara population in the area probably fluctuates in size and distribution with annual conditions and the impact of fire, and therefore a change in predation pressure could lead to the disappearance of sub-populations. Impact Minor to Moderate.

Hydrological change.

Some of the most important vegetation for fauna, Mulga thickets, may be sensitive to subtle changes in surface hydrology. This can occur through alterations of surface flow and through sub-surface hydrological change around deep pits. At least some of these effects can be managed as outlined below. Impact Minor to Moderate.

Altered fire regimes.

Altered fire regimes are a risk in particular to species in spinifex on sandy loam such as the Brush-tailed Mulgara. There may be an increase in the chance of fire due to exploration and mining activity, not least because of the presence of increased numbers of personnel on the site. Impact Minor to Moderate.

Disturbance (dust, noise, light).

Impacts from dust, noise and light are difficult to predict but are likely to be localised around the development areas that are a small part of the overall landscape. However, there is some concern that fauna are affected at some distance from mining activity in remote locations. This has been documented for birds, where in one study larger predatory species increased in abundance, while small insectivores declined or disappeared (Read *et al.* 2017). Such an effect is presumably temporary (across the life of mine). Such an effect may already be occurring around the exploration camp, where Grey Butcherbirds have become resident, feeding mainly on insects attracted to lights. Impact considered to be Minor to Moderate.

Overall, impacts of greatest concern are related to effects of feral species, hydrological change, altered fire regimes and possibly disturbance affecting bird assemblages. Direct impact upon the Peregrine Falcons of Flamingo Pit may also be a concern. At least some impacts can be ameliorated as discussed in recommendations below.

5 Recommendations

Recommendations for the minimisation of impacts can be drawn from the review of impacting processes. Many of these recommendations are standard procedures for exploration and mining in these sorts of landscapes.

- Habitat loss leading to population decline. Habitat loss should be minimised by clearly delineating clearing boundaries during any activities. Driving 'off road' should be prohibited except when establishing exploration lines. Exploration areas should be rehabilitated immediately, and there should be a rehabilitation program for long-term or permanent stockpiles.
- Habitat loss leading to population fragmentation. Clearing areas should be minimised, particularly in areas of linear VSAs (e.g. drainage lines and lines of Mulga) that may be used as corridors for fauna movement. Options may exist where such vegetation types can be avoided during operations. In general, avoiding impacting drainage lines is recommended.
- Degradation of habitat due to weed invasion. Vehicle hygiene should be practised to minimise transport of weeds into uncontaminated areas.
- Direct and indirect mortality of fauna during exploration and operation. Standard procedures for installing egress points in drill sumps and trenches, and for capping drill-holes, should be followed. Personnel should be made aware of the roadkill risk to wildlife. In Mulgara habitat, pre-clearing surveys should take place to identify locations where animals are present. These should be avoided if possible, or options for displacing the animals before clearing be investigated. In the special case of the Peregrine Falcons at Flamingo Pit, the location of the nest needs to be established and it needs to be determined if the birds have alternative nests (possibly in other pits). If or when development of Flamingo Pit is proposed, the nest needs to be checked to ensure chicks are not present.
- Species interactions. Changes in the abundance of feral predators and the vulnerability of some species, in particular the Brush-tailed Mulgara, are the main concern. Drill lines should be rehabilitated as quickly as possible so as not to provide access into undisturbed vegetation by feral predators. Feral species should not be encouraged, either deliberately or inadvertently, through the provision of food and water.
- Hydrological change. Surface flow should not be altered, particularly in areas of Mulga. It may be necessary to investigate the impact of mine pits on local hydrology.
- Altered fire regimes. Some fire management may be required to ensure that areas are not impacted by too frequent fires.
- Disturbance. As a precaution, light, noise and dust should be minimised during exploration, construction and operation. Unnecessary lighting should be avoided. For example, 'bug zappers' kill insects indiscriminately and do little if anything to control nuisance or pest species.

6 References

Anstis, M. (2013). Tadpoles and Frogs of Australia. New Holland Publishers, Sydney.

Atlas of Living Australia (2018). Online database resource. http://ala.org.au/species-by-location. (accessed October 2018).

Bamford, M., Bancroft, W. and Sibbell, N. (2010). Twenty years and two transects; spatial and temporal variation in local patterns of biodiversity – frogs, reptiles and small mammals. Presentation at 2010 conference of the Ecological Society of Australia, Canberra.

Bamford, M.J. and Roberts, J.D. (2003). The impact of fire upon frogs and reptiles in south-west Western Australia.pp. 349-362 in: Fire in ecosystems of south-west Western Austrlaia. Eds. I. Abott and N. Burrows. Backhuys Publishers, Leiden.

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

Bell, D.T., Luyer, J.R. and Agar, P.K. (2013). Birds of the Doolgunna and Mooloogool Rangelands, northeast Gascoyne Region, Western Australia Amytornis Western Australian Journal of Ornithology, Volume 5 (2013) 1-13.

Birdlife Australia (2018). Birdata Database and Map Tool. http://birdata.birdlife.org.au/ (accessed October 2018).

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

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

Department of Sustainability, Environment, Water, Population and Communities (2013). IBRA Subregions Map. http://www.environment.gov.au/parks/nrs/science/bioregion-framework/ibra/maps.html (accessed September 2012).

Desmond, A. Cowan, M. and Chant, A. (2001). Murchison 2 (MUR2 – Eastern Murchison subregion). In "A Biodiversity Audit of Western Australia", Available from the Department of Environment and Conservation at: http://www.dec.wa.gov.au/pdf/science/bio_audit/ (accessed September 2013).

Clevenger, A. P. and Waltho, N. (2000). Factors influencing the effectiveness of wildlife underpasses in Banff National Park, Alberta, Canada. *Conservation Biology***14**: 1-11.

Dufty, A. C. (1989). Some population characteristics of *Perameles gunnii* in Victoria. *Wildlife Research* **18**: 355-365.

Ecologia (1991). Biological Assessment Survey Marymia Gold Project, Resolute Resources Ltd. Prepared by *ecologia* Environment, Perth.

Ecologia (2005). K2 development Mulgara *Dasycercus cristicauda* assessment. Plutonic Gold Mine, Barrick Gold Australia. Prepared by *ecologia* Environment, Perth.

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

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

Environmental Protection Authority and Department of Environment and Conservation (2010). Technical Guide - Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment.

Technical report for the Environmental Protection Authority and the Department of Environment and Conservation.

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

Fox, B. J. (1982). Fire and mammalian secondary succession in an Australian coastal heath. *Ecology* **63**: 1332-1341.

Gill, A. M., Groves, R. H. and Noble, I. R. (Eds). (1981). *Fire and the Australian Biota*. Australian Academy of Science, Canberra, Australian Capital Territory.

Harrington, R. (2002). The effects of artificial watering points on the distribution and abundance of avifauna in an arid and semi-arid mallee environment. PhD thesis. Department of Zoology, Univesity of Melbourne, Melbourne, Victoria.

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

How, R.A. and Dell, J. (1990). Vertebrate fauna of Bold Park, Perth. West. Aust. Nat. 18: 122-131.

Jackson, S. D. and Griffin, C. R. (2000). A Strategy for Mitigating Highway Impacts on Wildlife. In: Messmer, T. A. and West, B. (Eds), *Wildlife and Highways: Seeking Solutions to an Ecological and Socio – economic Dilemma,* pp. 143-159. The Wildlife Society,

Johnstone, R. E., and Darnell, J. C. (2016). 'Checklist of the Birds of Western Australia.' Available at http://museum.wa.gov.au/sites/default/files/Checklist-of-Birds-of-WA-August-2016.pdf.

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

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

Jones, M. E. (2000). Road upgrade, road mortality and remedial measures: impacts on a population of Eastern Quolls and Tasmanian Devils. *Wildlife Research***27**: 289-296.

Kofoed, P. (1998). A wizard with wavelengths. *Ecos***96**: 32-35.

Letnic, M., Dickman, C.R., Tischler, M.K., Tamayo, B. and Beh, C.L. (2004). The responses of small mammals and lizards to post-fire succession and rainfall in arid Australia. *Journal of arid environments* **59** (1): 85-114

Mace, G. and Stuart, S. (1994). Draft IUCN Red List Categories, Version 2.2. Species; Newsletter of the Species Survival Commission. IUCN - The World Conservation Union.**21-22**: 13-24.

Marchant, S. and Higgins, P.J. (1993). Handbook of Australian, New Zealand and Antarctic Birds. Volume 2: Raptors to Lapwings. Oxford University Press, Melbourne.

Menkhorst, P. and Knight, F. (2004). A Field Guide to the Mammals of Australia. Oxford University Press, Melbourne.

Menkhorst, P., Rogers, D., Clarke, R., Davies, J., Marsack, P. and Franklin, K. (2017). The Australian Bird Guide. CSIRO Publishing, Clayton South.

Ninox Wildlife Consulting (2011). A Level 1 Vertebrate Fauna Assessment of the Sandfire Resources NL Degrussa Copper-Gold Project, North of Meekatharra, Western Australia (Borefield and Airstrip). Unpublished Report Prepared for Sandfire Resources NL by Ninox Wildlife Consulting.

Rich, C. and Longcore, T. (Eds). (2006). *Ecological Consequences of Artificial Night Lighting*. Island Press, Washington D.C., USA.

Rodda, K. and Bamford, M. (2007). Field survey for Mulgara *Dasycercus cristicauda* at Plutonic Gold Mine, August 2007. Unpubl. report to Barrick Gold Australia by Bamford Consulting Ecologists, Kingsley.

Rodda, K. and Bamford, M. (2008). Field survey for Mulgara *Dasycercus cristicauda* at Plutonic Gold Mine, August 2008. Unpubl. report to Barrick Gold Australia by Bamford Consulting Ecologists, Kingsley.

Scheick, B. K. and Jones, M. D. (1999). Locating wildlife underpasses prior to expansion on Highway 64 in North Carolina. In: Evink, G. L., Garrett, P. and Ziegler, D. (Eds), *Proceedings of the Third International Conference on Wildlife Ecology and Transportation,* pp. 247-252. Florida Department of Transportation, Tallahassee, Florida, USA.

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

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

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

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

Thackway, R. and Cresswell, I.D. (1995). An Interim Biogeographic Regionalisation for Australia: A framework for establishing the national system of reserves, Version 4.0. Australian Nature Conservation Agency, Canberra.

Turpin, J. and Bamford, M. (2016). Sandfire Resources NL. Monty Project level 1 fauna assessment October 2015. Unpubl. report to MBS Environmental by Bamford Consulting Ecologists, Kingsley.

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

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

Wilson, S. and Swan, G. (2013). A Complete Guide to Reptiles of Australia. Fourth edition. New Holland Publishers (Australia), Sydney.

Zosky, K. and Bamford, M. (2009). Field survey for Mulgara *Dasycercus cristicauda* at Plutonic Gold Mine, August 2009. Unpubl. report to Barrick Gold Australia by Bamford Consulting Ecologists, Kingsley.

7 Appendices

7.1 Appendix 1. Explanation of fauna values.

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

Assemblage characteristics

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

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

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

Vegetation and Substrate Associations

Vegetation and Substrate Associations (VSAs) combine broad vegetation types, the soils or other substrate with which they are associated, and the landform. In the context of fauna assessment, VSAs are the environments that provide habitats for fauna. The term habitat is widely used in this context, but by definition an animal's habitat is the environment that it utilises (Calver *et al.* 2009), not the environment as a whole. Habitat is a function of the animal and its ecology, rather than being a function of the environment. For example, a species may occur in eucalypt canopy or in leaf-litter on sand, and that habitat may be found in only one or in several VSAs. VSAs are not the same as vegetation types since these may not incorporate soil and landform, and recognise floristics to a degree that VSAs do not. Vegetation types may also not recognise minor but often significant (for fauna) structural differences in the environment, which VSAs will recognise. VSAs also do not necessarily correspond with soil types, but may reflect some of these elements.

Because VSAs provide the habitat for fauna, they are important in determining assemblage characteristics. For the purposes of impact assessment, VSAs can also provide a surrogate for detailed information on the fauna assemblage. For example, rare, relictual or restricted VSAs should automatically be considered a significant fauna value. Impacts may be significant if the VSA is rare, a large proportion of the VSA is affected and/or the VSA supports significant fauna. The disturbance of even small amounts of habitat in a localised area can have significant impacts to fauna if rare or unusual habitats are disturbed.

Patterns of biodiversity across the landscape

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

Species of conservation significance

Species of conservation significance are of special importance in impact assessment. The conservation status of fauna species in Australia is assessed under Commonwealth and State Acts such as the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the Western Australian *Biodiversity Conservation Act 2016* (Biodiversity Conservation Act). In addition, the Western Australian Department of Biodiversity, Conservation and Attractions (DBCA) recognises priority levels, while local populations of some species may be significant even if the species as a whole has no formal recognition. Therefore, three broad levels of conservation significance can be recognised and are used for the purposes of this report and are outlined below. A full description of the conservation significance levels, schedules and priority levels mentioned below is provided in Appendix 3.

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

Species listed under the EPBC Act are assigned to categories recommended by the International Union for the Conservation of Nature and Natural Resources (IUCN) and reviewed by Mace and Stuart (1994), or are listed as migratory. Migratory species are recognised under international treaties such as the China Australia Migratory Bird Agreement (CAMBA), the Japan Australia Migratory Bird Agreement (JAMBA), the Republic of South Korea Australia Migratory Bird Agreement (ROKAMBA), and/or the Convention on the Conservation of Migratory Species of Wild Animals (CMS; also referred to as the Bonn Convention). The Biodiversity Conservation Act uses a series of Schedules to classify status, but also recognizes the IUCN categories and ranks species within the Schedules using the categories of Mace and Stuart (1994).

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

In Western Australia, the DBCA has produced a supplementary list of Priority Fauna, being species that are not considered threatened under the Biodiversity Conservation Act but for which the DBCA believes there is cause for concern. Some Priority species are also assigned to the Conservation Dependent category of the IUCN.

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

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

or that are sensitive to impacts such as habitat fragmentation, may also be classed as CS3, as may colonies of waterbirds. The Western Australian Department of Environmental Protection, now DBCA, used this sort of interpretation to identify significant bird species in the Perth metropolitan area as part of the Perth Bushplan (DEP 2000).

Invertebrate species considered to be short range endemics (SREs) also fall within the CS3 category, as they have no legislative or published recognition and their significance is based on interpretation of distribution information. Harvey (2002) notes that the majority of species that have been classified as short-range endemics have common life history characteristics such as poor powers of dispersal or confinement to discontinuous habitats. Several groups, therefore, have particularly high instances of short-range endemic species: Gastropoda (snails and slugs), Oligochaeta (earthworms), Onychophora (velvet worms), Araneae (mygalomorph spiders), Pseudoscorpionida (pseudoscorpions), Schizomida (schizomids), Diplopoda (millipedes), Phreatoicidea (phreatoicidean crustaceans), and Decapoda (freshwater crayfish). The poor understanding of the taxonomy of many of the short-range endemic species hinders their conservation (Harvey 2002).

Introduced species

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

Ecological processes upon which the fauna depend

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

7.2 Appendix 2. Explanation of threatening processes.

Potential impacts of proposed developments upon fauna values can be related to threatening processes. This is recognised in the literature (e.g. Gleeson and Gleeson 2012) and under the EPBC Act, in which threatening processes are listed. Processes that may impact fauna values are discussed below. Rather than being independent of one another, processes are complex and often interrelated. They are the mechanisms by which fauna can be affected by development. Impacts may be significant if large numbers of species or large proportions of populations are affected.

Loss of habitat affecting population survival

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

Loss of habitat leading to population fragmentation

Loss of habitat can affect population movements by limiting movement of individuals throughout the landscape as a result of fragmentation (Gleeson and Gleeson 2012, Soule *et al.* 2004). Obstructions associated with the development, such as roads, pipes and drainage channels, may also affect movement of small, terrestrial species. Fragmented populations may not be sustainable and may be sensitive to effects such as reduced gene flow.

Degradation of habitat due to weed invasion leading to population decline

Weed invasion, such as through introduction by human boots or vehicle tyres, can occur as a result of development and if this alters habitat quality, can lead to effects similar to habitat loss.

Increased mortality

Increased mortality can occur during project operations; for example, roadkill, animals striking infrastructure, and entrapment in trenches. Roadkill as a cause of population decline has been documented for several medium-sized mammals in eastern Australia (Dufty 1989, Jones 2000). Increased mortality due to roadkill is often more prevalent in habitats that have been fragmented (Scheick and Jones 1999, Clevenger and Waltho 2000, Jackson and Griffin 2000). Increased mortality of common species during development is unavoidable and may not be significant for a population. However, the cumulative impacts of increased mortality of conservation significant species or species that already occur at low densities may have a significant impact on the population.

Species interactions, including predation and competition

Changes in species interactions often occur with development. Introduced species, including the feral Cat, Red Fox and Rabbit, may have adverse impacts upon native species and development can alter their abundance. In particular, some mammal species are very sensitive to introduced predators and the decline of many mammals in Australia has been linked to predation by the Red Fox, and to a lesser extent, the feral Cat (Burbidge and McKenzie 1989). Introduced grazing species, such as the Rabbit, Goat, Camel and domestic livestock, can also degrade habitats and deplete vegetation that may be a food source for other species.

Changes in the abundance of some native species at the expense of others, due to the provision of fresh watering points, can also be a concern. Harrington (2002) found the presence of artificial fresh waterpoints in the semi-arid mallee rangelands to influence the abundance and distribution of certain bird species. Common, water-dependent birds were found to out-compete some less common, water-independent species. Over-abundant native herbivores, such as kangaroos, can also adversely affect less abundant native species through competition and displacement.

Hydroecology

Interruptions of hydroecological processes can have major effects because they underpin primary production in ecosystems and there are specific, generally rare habitats that are hydrology-dependent. Fauna may be impacted by potential changes to groundwater level and chemistry and altered flow regime. These changes may alter vegetation across large areas and may lead to habitat degradation or loss. Impacts upon fauna can be widespread and major. Changes to flow regime across the landscape may alter vegetation and may lead to habitat degradation or loss, affecting fauna. For example, Mulga has a shallow root system and relies on surface sheet flow during flood events. If surface sheet flow is impeded, Mulga can die (Kofoed 1998), which may impact on a range of fauna associated with this vegetation type.

Fire

The role of fire in the Australian environment and its importance to vertebrate fauna has been widely acknowledged (Gill et al. 1981, Fox 1982, Bamford and Roberts 2003). It is also one of the factors that has contributed to the decline and local extinction of some mammal and bird species (Burbidge and McKenzie 1989). Fire is a natural feature of the environment but frequent, extensive fires may adversely impact some fauna, particularly mammals and short-range endemic species. Changes in fire regime, whether to more frequent or less frequent fires, may be significant to some fauna. Impacts of severe fire may be devastating to species already occurring at low densities or to species requiring long unburnt habitats to survive. In terms of conservation management, it is not fire *per se* but the fire regime that is important, with evidence that infrequent, extensive and intense fires adversely affect biodiversity, whereas frequent fires that cover small areas and are variable in both season and intensity can enhance biodiversity. Fire management may be considered the responsibility of managers of large tracts of land, including managers of mining tenements.

Dust, light, noise and vibration

Impacts of dust, light, noise and vibration upon fauna are difficult to predict. Some studies have demonstrated the impact of artificial night lighting on fauna, with lighting affecting fauna behaviour more than noise (Rich and Longcore 2006). Effects can include impacts on predator-prey interactions, changes to mating and nesting behaviour, and increased competition and predation within and between invertebrates, frogs, birds and mammals. The death of very large numbers of insects has been observed around some remote mine sites and attracts other fauna, notably native and introduced predators (M. Bamford, pers. obs). The abundance of some insects can decline due to mortality around lights, although this has previously been recorded in fragmented landscapes where populations are already under stress (Rich and Longcore 2006). Artificial night lighting may also lead to disorientation of migratory birds. Aquatic habitats and open habitats such as grasslands and dunes may be vulnerable to light spill.

7.3 Appendix 3. Categories used in the assessment of conservation status.

IUCN categories (based on review by Mace and Stuart 1994) as used for the *Environment Protection and Biodiversity Conservation Act 1999* and the Western Australian *Biodiversity Conservation Act 2016*.

Extinct	Taxa not definitely located in the wild during the past 50 years.
Extinct in the Wild (Ex)	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 (E)	Taxa facing a very high risk of extinction in the wild in the near future.
Vulnerable (V)	Taxa facing a high risk of extinction in the wild in the medium-term future.
Near Threatened	Taxa that risk becoming Vulnerable in the wild.
Conservation Dependent	Taxa whose survival depends upon ongoing conservation measures. Without these measures, a conservation dependent taxon would be classed as Vulnerable or more severely threatened.
Data Deficient (Insufficiently Known)	Taxa suspected of being Rare, Vulnerable or Endangered, but whose true status cannot be determined without more information.
Least Concern	Taxa that are not Threatened.

Schedules used in the WA *Biodiversity Conservation Act 2016.*

Schedule 1 (S1)	Critically Endangered fauna
Schedule 2 (S2)	Endangered fauna
Schedule 3 (S3)	Vulnerable Migratory species listed under international treaties
Schedule 4 (S4)	Presumed extinct fauna
Schedule 5 (S5)	Migratory birds under international agreement
Schedule 6 (S6)	Conservation dependent fauna
Schedule 7 (S7)	Other specially protected fauna

WA Department of Biodiversity, Conservation and Attractions Priority species (species not listed under the *Biodiversity Conservation Act 2016*, but for which there is some concern).

Priority 1 (P1)	Taxa with few, poorly known populations on threatened lands.
Priority 2 (P2)	Taxa with few, poorly known populations on conservation lands; or taxa with several, poorly known populations not on conservation lands.
Priority 3 (P3)	Taxa with several, poorly known populations, some on conservation lands.

		Taxa in need of monitoring.
Priority (P4)	**4**	Taxa which are considered to have been adequately surveyed, or for which sufficient knowledge is available, and which are considered not currently threatened or in need of special protection, but could be if present circumstances change.
Priority (P5)	**5**	Taxa in need of monitoring. Taxa which are not considered threatened but are subject to a specific conservation program, the cessation of which would result in the species becoming threatened within five years (IUCN Conservation Dependent).

7.4 Appendix 4. Ecological and threatening processes identified under legislation and in the literature.

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

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

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

Threatening processes (EPBC Act)

Under the EPBC Act, a key threatening process is an ecological interaction that threatens or may threaten the survival, abundance or evolutionary development of a threatened species or ecological community. There are currently 20 key threatening processes listed by the federal Department of the Environment and Energy (DoEE 2018c):

- Competition and land degradation by rabbits.
- Competition and land degradation by unmanaged goats.
- Dieback caused by the root-rot fungus (*Phytophthora cinnamomi*).
- Incidental catch (bycatch) of Sea Turtle during coastal otter-trawling operations within Australian waters north of 28 degrees South.
- Incidental catch (or bycatch) of seabirds during oceanic longline fishing operations.
- Infection of amphibians with chytrid fungus resulting in chytridiomycosis.
- Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris.
- Invasion of northern Australia by Gamba Grass and other introduced grasses.
- Land clearance.
- Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants.
- Loss of biodiversity and ecosystem integrity following invasion by the Yellow Crazy Ant (*Anoplolepis gracilipes*) on Christmas Island, Indian Ocean.
- Loss of climatic habitat caused by anthropogenic emissions of greenhouse gases.
- Novel biota and their impact on biodiversity.
- Predation by European red fox.

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

General processes that threaten biodiversity across Australia (Department of Environment, Water, Heritage and the Arts 2009):

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

In addition to the above processes, DSEWPaC (2013) (now DoEE) has produced **Significant Impact Guidelines** that provide criteria for the assessment of the significance of impacts. These criteria provide a framework for the assessment of significant impacts. The criteria are:

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

7.5 Appendix 5. Vertebrate fauna assemblage of the study area.

Levels of Conservation Significance (Cons Signif) are discussed in the "Assessment of Conservation Significance" section. Expected status categories are outlined in Methods. Data sources include:

- Databases: Naturemap, Atlas of Living Australia, Birdata and EPBC Search Engine
- Dool: Species recorded on Doolgunna Station and nearby by Ninox (2011), Bell *et al* 2013 and/or Turpin and Bamford (2015).
- Ecol 1991: Species recorded in the level 2 survey of the Marymia project area by *ecologia* (1991).
- BCE 07-09: Species recorded by Bamford Consulting Ecologists in the Marymia Project area during targeted Mulgara surveys across 2007 to 2009.
- BCE 18-19: Species recorded during the current Bamford Consulting Ecologists survey (November 2018 and August 2019).
- Recorded species totals include species recorded in Ecol. 1991, BCE 07-09 and BCE 18-19.

FROGS

Species		Cons Signif	Data bases	Dool	Ecol 1991	BCE 07-09	BCE 18-19	Expected status
HYLIDAE (Tree frogs)								
Cyclorana maini	Main's Frog		X					Res
Cyclorana platycephala	Water-holding Frog		X					Res
Litoria rubella	Desert Tree Frog		X	X		X	X	Res
LIMNODYNASTIDAE (Burrowing frogs)								
Platyplectrum spenceri	Spencer's Frog		X			X		Res
Neobatrachus aquilonius	Northern Burrowing Frog		X					Res
Neobatrachus sudellae	Trilling Frog		X			X?		Res
Neobatrachus sutor	Shoemaker Frog							Res
Neobatrachus wilsmorei	Wilsmore's Frog							Res
Notaden nichollsi	Desert Spadefoot		X					Res
Total Species Expected: 9 **Total Species Recorded: 3**								

REPTILES

Species	Cons signif	Data bases	Dool	Ecol 1991	BCE 07-09	BCE 18-19	Expected status
CHELUIDAE (freshwater tortoise)							
Chelodina steindachneri Flat-shelled Tortoise			X		X		Vis
CARPHODACTYLIDAE (knob-tailed geckoes)							
Nephrurus wheeleri Banded Knob-tailed Gecko		X	X			X	Res
DIPLODACTYLIDAE (ground geckoes)							
Amalosia lesueurii Lesueur's Velvet Gecko		X	X				Res
Diplodactylus granariensis rex Goldfields Stone Gecko							Res
Diplodactylus pulcher Western Saddled Ground Gecko		X		X			Res
Lucasium stenodactylum Pale-snouted Ground Gecko			X				Res
Rhynchoedura ornata Beaked Gecko			X				Res
Strophurus elderi Jewelled Gecko							Res
Strophurus strophurus Western Ring-tailed Gecko							Res
Strophurus wellingtonae Western Shield Spiny-tailed Gecko		X	X		X		Res
GEKKONIDAE (geckoes)							
Gehyra purpurascens Purple Arid Dtella							Res
Gehyra variegata Variegated Dtella		X	X	X	X	X	Res
Heteronotia binoei Bynoe's Gecko		X		X	X	X	Res
PYGOPODIDAE (legless lizards)							
Delma butleri Unbanded Delma							Res
Delma nasuta Long-nosed Delma							Res
Delma haroldi		X					Res
Lialis burtonis Burton's Legless Lizard		X	X		X		Res
Pygopus nigriceps Hooded Scaly-Foot		X					Res

Species		Cons signif	Data bases	Dool	Ecol 1991	BCE 07-09	BCE 18-19	Expected status
AGAMIDAE (dragon lizards)								
Ctenophorus caudicinctus	Ring-tailed Dragon		X	X	X		X	Res
Ctenophorus isolepis	Military Dragon		X			X	X	Res
Ctenophorus nuchalis	Central Netted Dragon							Res
Ctenophorus reticulatus	Western Netted Dragon		X		X			Res
Ctenophorus scutulatus	Lozenge-marked Dragon			X			X	Res
Diporiphora (Caimanops) amphiboluroides	Mulga Dragon		X				X	Res
Gowidon longirostris	Long-nosed Dragon		X					Res
Moloch horridus	Thorny Devil		X					Res
Pogona minor	Western Bearded Dragon			X	X	X	X	Res
Tympanocryptis cephalus	Earless Pebble Dragon		X	X		X		Res
VARANIDAE (monitors or goannas)								
Varanus brevicauda	Short-tailed Monitor							Res
Varanus caudolineatus	Stripe-tailed Monitor			X				Res
Varanus eremius	Desert Pygmy Monitor							Res
Varanus giganteus	Perentie							Res
Varanus gouldii	Sand Goanna		X		X			Res
Varanus panoptes	Yellow-spotted Monitor		X	X	X	X	X	Res
Varanus tristis	Black-headed Monitor					X		Res
SCINCIDAE (skinks)								
Egernia depressa	Pygmy Spiny-tailed Skink		X	X	X	X		Res
Egernia formosa	Goldfields Crevice Skink							Res
Cryptoblepharus australis	Inland Snake-eyed Skink		X					Res
Cryptoblepharus plagiocephalus	Fence Skink				X			Res
Eremiascincus isolepsis	Northern Bar-lipped Skink		X					Res

Species	Cons signif	Data bases	Dool	Ecol 1991	BCE 07-09	BCE 18-19	Expected status
Eremiascincus richardsonii Broad-banded Sand-swimmer		X					Res
Menetia greyii Common Dwarf Skink		X		X	X		Res
Ctenotus dux		X					Res
Ctenotus grandis							Res
Ctenotus inornatus		X					Res
Ctenotus leonhardii Leonhardi's Ctenotus		X	X			X	Res
Ctenotus pantherinus Leopard Skink		X		X	X		Res
Ctenotus schomburgkii Barred Wedge-snout Ctenotus				X			Res
Ctenotus severus					X		
Lerista timida		X		X			Res
TIliqua multifasciata Desert Bluetongue				X			Res
TYPHLOPIDAE (blind snakes)							
Anilios bicolor Dark-spined Blind Snake							Res
Anilios hamatus Northern Hook-snouted Blind Snake							Res
Anilios waitii Beaked Blind Snake							Res
BOIDAE (pythons)							
Antaresia perthensis Pygmy Python						X	Res
Antaresia stimsoni Stimson's Python							Res
ELAPIDAE (front-fanged snakes)							
Acanthophis pyrrhus Desert Death Adder							Res
Brachyurophis approximans Northern Shovel-nosed Snake							Res
Demansia psammophis Yellow-faced Whip-Snake		X			X		Res
Parasuta monachus Monk Snake		X					Res
Pseudechis australis Mulga Snake		X		X	X		Res
Pseudonaja modesta Ringed Brown Snake		X					Res

Species		Cons signif	Data bases	Dool	Ecol 1991	BCE 07-09	BCE 18-19	Expected status
Pseudonaja mengdeni	Gwardar							Res
Simoselaps bertholdi	Jan's Banded Snake		X					Res
Furina ornata	Moon Snake						X	Res
Suta fasciata	Rosen's Snake							Res
Total Species Expected: 66 **Total Species Recorded: 29**								

BIRDS

Species		Cons signif	Data bases	Dool	Ecol 1991	BCE 07-09	BCE 18-19	Expected status
CASUARIIDAE (Cassowaries and emus)								
Dromaius novaehollandiae	Emu		X	X	X	X	X	Res
MEGAPODIIDAE (Megapodes)								
Leipoa ocellata	Malleefowl	CS1		X				IrrVis
PHASIANIDAE (Pheasants and allies)								
Coturnix ypsilophora	Brown Quail			X				IrrVis
ANATIDAE (swans and ducks)								
Cygnus atratus	Black Swan			X				IrrVis
Tadorna tadornoides	Australian Shelduck		X					IrrVis
Anas superciliosa	Pacific Black Duck		X	X		X		IrrVis
Anas rhynchotis	Australasian Shoveler		X					Vag
Anas gracilis	Grey Teal		X	X		X		IrrVis
Chenonetta jubata	Australian Wood Duck		X	X		X		IrrVis
Malacorhynchus membranaceus	Pink-eared Duck						X	IrrVis
PODICIPEDIDAE (grebes)								
Tachybaptus novaehollandiae	Australasian Grebe		X	X		X	X	IrrVis

Species		Cons signif	Data bases	Dool	Ecol 1991	BCE 07-09	BCE 18-19	Expected status
Poliocephalus poliocephalus	Hoary-headed Grebe		X	X				IrrVis
COLUMBIDAE (Pigeons and doves)								
Phaps chalcoptera	Common Bronzewing		X	X	X		X	Res
Geophaps plumifera	Spinifex Pigeon		X			X		Vis
Ocyphaps lophotes	Crested Pigeon		X	X	X	X	X	Res
Geopelia cuneata	Diamond Dove		X	X				Vis
PODARGIDAE (Australian frogmouths)								
Podargus strigoides	Tawny Frogmouth		X	X	X	X		Res
CAPRIMULGIDAE (Nightjars and allies)								
Eurostopodus argus	Spotted Nightjar		X	X		X	X	Vis
AEGOTHELIDAE (Owlet-nightjars)								
Aegotheles cristatus	Australian Owlet-nightjar		X	X			X	Res
APODIDAE (Typical swifts)								
Apus pacificus	Fork-tailed Swift	CS1						Vis
PHALACROCORACIDAE (cormorants)								
Microcarbo melanoleucos	Little Pied Cormorant		X	X				Vag
ARDEIDAE (herons and egrets)								
Egretta novaehollandiae	White-faced Heron		X	X				IrrVis
Ardea pacifica	White-necked Heron		X	X		X		IrrVis
Ardea modesta (alba)	Eastern Great Egret	CS1	X					IrrVis
Nycticorax caledonicus	Nankeen Night Heron		X					IrrVis
THRESKIORNITHIDAE (ibis and spoonbills)								
Threskiornis molucca	Australian White Ibis			X				IrrVis
Threskiornis spinicollis	Straw-necked Ibis		X			X		IrrVis
Platalea flavipes	Yellow-billed Spoonbill		X					IrrVis
ACCIPITRIDAE (Osprey, hawks and eagles)								

Species		Cons signif	Data bases	Dool	Ecol 1991	BCE 07-09	BCE 18-19	Expected status
Elanus axillaris	Black-shouldered Kite		X	X		X		Vis
Lophoictinia isura	Square-tailed Kite							IrrVis
Hamirostra melanosternon	Black-breasted Buzzard		X	X			X	Vis
Milvus migrans	Black Kite		X	X				Vis
Haliastur sphenurus	Whistling Kite		X	X		X	X	Res
Circus assimilis	Spotted Harrier							Vis
Accipiter fasciatus	Brown Goshawk		X	X				Res
Accipiter cirrhocephalus	Collared Sparrowhawk		X	X				Res
Aquila audax	Wedge-tailed Eagle		X	X	X	X	X	Res
Hieraaetus morphnoides	Little Eagle		X				X	Vis
FALCONIDAE (Falcons)								
Falco berigora	Brown Falcon		X	X	X	X	X	Res
Falco longipennis	Australian Hobby		X	X				Res
Falco hypoleucos	Grey Falcon	CS1	X					IrrVis
Falco peregrinus	Peregrine Falcon	CS1	X	X			X	Res
Falco cenchroides	Nankeen Kestrel		X	X		X	X	Res
RALLIDAE (Rails, gallinules and coots)								
Tribonyx ventralis	Black-tailed Native-hen		X					IrrVis
Fulica atra	Eurasian Coot		X	X			X	IrrVis
OTIDIDAE (bustards)								
Ardeotis australis	Australian Bustard	CS3	X	X		X	X	Res
BURHINIDAE (stone-curlews)								
Burhinus grallarius	Bush Stone-curlew	CS3	X					IrrVis
RECURVIROSTRIDAE (stilts and avocets)								
Himantopus himantopus	Black-winged Stilt		X					IrrVis
CHARADRIIDAE (Lapwings, plovers and dotterels)								

Species		Cons signif	Data bases	Dool	Ecol 1991	BCE 07-09	BCE 18-19	Expected status
Erythrogonys cinctus	Red-kneed Dotterel							IrrVis
Charadrius ruficapillus	Red-capped Plover		X					IrrVis
Elseyornis melanops	Black-fronted Dotterel		X	X		X		IrrVis
Charadrius australis	Inland Dotterel							IrrVis
Vanellus tricolor	Banded Lapwing			X				IrrVis
SCOLOPACIDAE (sandpipers)								
Actitis hypoleucos	Common Sandpiper	CS1	X					IrrVis
Calidris ruficollis	Red-necked Stint	CS1	X					IrrVis
Calidris acuminata	Sharp-tailed Sandpiper	CS1	X					IrrVis
Calidris melanotos	Pectoral Sandpiper	CS1	X					Vag
GLAREOLIDAE (pratincoles)								
Stiltia Isabella	Australian Pratincole		X					Vag
TURNICIDAE (Button-quails)								
Turnix velox	Little Button-quail		X	X		X		Vis
CACATUIDAE (Cockatoos)								
Nymphicus hollandicus	Cockatiel		X	X		X		Vis
Calyptorhynchus banksii	Red-tailed Black-Cockatoo		X					IrrVis
Eolophus roseicapilla	Galah		X	X		X		Vis
Cacatua sanguinea	Little Corella		X	X				IrrVis
Lophochroa leadbeateri	Major Mitchell's Cockatoo	CS3						Vag
PSITTACIDAE (Parrots)								
Barnardius zonarius	Australian Ringneck		X	X	X	X	X	Res
Psephotus varius	Mulga Parrot		X	X	X	X	X	Res
Melopsittacus undulatus	Budgerigar		X	X	X	X		Vis
Neosephotus bourkii	Bourke's Parrot		X	X				Res
Neophema elegans	Elegant Parrot			X				Vag

Species		Cons signif	Data bases	Dool	Ecol 1991	BCE 07-09	BCE 18-19	Expected status
Neophema splendida	Scarlet-chested Parrot	CS3						Vag
Polytelis alexandrae	Princess Parrot	CS1	X					Vag
Pezoporus occidentalis	Night Parrot	CS1	X					Vag
CUCULIDAE (Old world cuckoos)								
Cacomantis pallidus	Pallid Cuckoo		X	X				Vis
Chalcites osculans	Black-eared Cuckoo		X	X	X	X		Vis
Chalcites basalis	Horsfield's Bronze-Cuckoo		X	X	X	X		Vis
STRIGIDAE (Hawk owls)								
Ninox novaeseelandiae	Southern Boobook		X	X	X			Res
TYTONIDAE (Barn owls)								
Tyto alba	Eastern Barn Owl		X	X				Vis
ALCEDINIDAE (Kingfishers)								
Dacelo leachii	Blue-winged Kookaburra		X					IrrVis
Todiramphus pyrrhopygia	Red-backed Kingfisher		X	X		X	X	Res
Todiramphus sanctus	Sacred Kingfisher		X	X				Vis
MEROPIDAE (Bee-eaters)								
Merops ornatus	Rainbow Bee-eater		X				X	Vis
CLIMACTERIDAE (Australo-Papuan treecreepers)								
Climacteris affinis	White-browed Treecreeper		X	X	X			Vis
PTILONORHYNCHIDAE (Bowerbirds)								
Ptilonorhynchus guttatus	Western Bowerbird		X	X	X	X		Res
MALURIDAE (Fairy-, emu- and grasswrens)								
Malurus splendens	Splendid Fairy-wren		X	X		X	X	Res
Malurus lamberti	Variegated Fairy-wren		X	X		X	X	Res
Malurus leucopterus	White-winged Fairy-wren		X	X		X		Res
Amytornis striatus striatus	Inland Striated Grasswren	CS2	X					Vag

Species		Cons signif	Data bases	Dool	Ecol 1991	BCE 07-09	BCE 18-19	Expected status
ACANTHIZIDAE (Thornbills and allies)								
Pyrrholaemus brunneus	Redthroat		X	X		X	X	Res
Smicrornis brevirostris	Weebill		X	X	X			Res
Gerygone fusca	Western Gerygone		X	X		X		Res
Acanthiza apicalis	Inland Thornbill		X	X	X	X	X	Res
Acanthiza uropygialis	Chestnut-rumped Thornbill		X	X	X	X	X	Res
Acanthiza robustirostris	Slaty-backed Thornbill		X	X		X	X	Res
Acanthiza chrysorrhoa	Yellow-rumped Thornbill		X	X			X	Res
Aphelocephala nigricincta	Banded Whiteface		X	X				Res
Aphelocephala leucopsis	Southern Whiteface		X	X		X	X	Res
PARDALOTIDAE (Pardalotes, thornbills and allies)								
Pardalotus rubricatus	Red-browed Pardalote		X					Res
Pardalotus striatus	Striated Pardalote		X	X				Res
MELIPHAGIDAE (Honeyeaters)								
Certhionyx variegatus	Pied Honeyeater		X			X		Vis
Lichenostomus virescens	Singing Honeyeater		X	X	X	X	X	Res
Ptilotula plumula	Grey-fronted Honeyeater		X		X			Res
Ptilotula penicillata	White-plumed Honeyeater		X	X				Vis
Purnella albifrons	White-fronted Honeyeater		X	X		X		Vis
Manorina flavigula	Yellow-throated Miner		X	X		X	X	Res
Acanthagenys rufogularis	Spiny-cheeked Honeyeater		X	X		X	X	Res
Conopophila whitei	Grey Honeyeater	CS3		X				Vis
Epthianura tricolor	Crimson Chat		X	X		X		Vis
Epthianura aurifrons	Orange Chat		X					IrrVis
Certhionyx niger	Black Honeyeater		X			X		Vis
Lichmera indistincta	Brown Honeyeater		X	X		X		Res

Species	Cons signif	Data bases	Dool	Ecol 1991	BCE 07-09	BCE 18-19	Expected status
POMATOSTOMIDAE (Babblers)							
Pomatostomus temporalis Grey-crowned Babbler		X	X	X	X	X	Res
Pomatostomus superciliosus White-browed Babbler		X	X		X	X	Res
PSOPHODIDAE (Quail-thrushes and allies)							
Psophodes occidentalis Chiming Wedgebill		X					Vis
Cinclosoma castaneothorax Chestnut-breasted Quail-thrush		X	X		X	X	Res
NEOSITTIDAE (Sitellas)							
Daphoenositta chrysoptera Varied Sittella		X	X	X	X	X	Res
CAMPEPHAGIDAE (Cuckoo-shrikes and trillers)							
Coracina novaehollandiae Black-faced Cuckoo-shrike		X	X		X		Res
Coracina maxima Ground Cuckoo-shrike		X	X				Vis
Lalage tricolor White-winged Triller		X	X			X	Vis
PACHYCEPHALIDAE (Whistlers and allies)							
Oreoica gutturalis Crested Bellbird		X	X	X	X	X	Res
Pachycephala rufiventris Rufous Whistler		X	X	X	X	X	Res
Colluricincla harmonica Grey Shrike-thrush		X	X		X	X	Res
ARTAMIDAE (Woodswallows and allies)							
Artamus personatus Masked Woodswallow		X	X		X		Vis
Artamus cinereus Black-faced Woodswallow		X	X	X	X	X	Res
Artamus cyanopterus Dusky Woodswallow						X	Vag
Artamus minor Little Woodswallow		X	X		X	X	Res
Artamus superciliosus White-browed Woodswallow		X					IrrVis
Cracticus torquatus Grey Butcherbird		X	X	X	X	X	Res
Cracticus nigrogularis Pied Butcherbird		X	X		X	X	Res
Cracticus tibicen Australian Magpie		X	X				Res

Species		Cons signif	Data bases	Dool	Ecol 1991	BCE 07-09	BCE 18-19	Expected status
Strepera versicolor	Grey Currawong			X				IrrVis
RHIPIDURIDAE (Fantails)								
Rhipidura fuliginosa	Grey Fantail			X				Vis
Rhipidura f. albicauda	White-tailed Fantail							Vis
Rhipidura leucophrys	Willie Wagtail		X	X		X	X	Res
CORVIDAE (Crows and allies)								
Corvus bennetti	Little Crow		X	X		X		Res
Corvus orru	Torresian Crow		X	X		X	X	Res
MONARCHIDAE (Monarchs and allies)								
Grallina cyanoleuca	Magpie-lark		X	X		X	X	Res
PETROICIDAE (Robins)								
Microeca leucophaea	Jacky Winter			X				Vis
Petroica goodenovii	Red-capped Robin		X	X		X	X	Res
Melanodryas cucullata	Hooded Robin		X	X	X	X	X	Res
MEGALURIDAE (grassbirds)								
Cinclorhamphus mathewsi	Rufous Songlark		X	X				Vis
Cinclorhamphus cruralis	Brown Songlark			X				Vis
HIRUNDINIDAE (Swallows and martins)								
Cheramoeca leucosternum	White-backed Swallow		X			X	X	Vis
Hirundo neoxena	Welcome Swallow		X	X		X	X	Vis
Petrochelidon nigricans	Tree Martin		X	X		X		Vis
Petrochelidon ariel	Fairy Martin		X	X		X	X	Vis
DICAEIDAE (Flowerpeckers)								
Dicaeum hirundinaceum	Mistletoebird		X	X		X	X	Res
ESTRILDIDAE (Sparrows, weaverbirds and allies)								
Emblema pictum	Painted Finch		X					Vag

Species	Cons signif	Data bases	Dool	Ecol 1991	BCE 07-09	BCE 18-19	Expected status
Taeniopygia guttata Zebra Finch		X	X		X		Res
MOTACILLIDAE (Old world wagtails and pipits)							
Anthus novaeseelandiae Australasian Pipit		X	X	X	X		Res
Total Species Expected: 148 **Total species Recorded: 91**							

MAMMALS

Species	Cons signif	Data bases	Dool	Ecol 1991	BCE 07-09	BCE 18-19	Expected status
TACHYGLOSSIDAE (Echidnas)							
Tachyglossus aculeatus Echidna			X	X	X	X	Res
DASYURIDAE (Dasyurids)							
Dasycercus blythi Brush-tailed Mulgara	CS2	X			X	X	Res
Antechinomys laniger Kultarr	CS3	X		X			Res
Ningaui ridei Wongai Ningaui		X					Res
Pseudantechinus woolleyae Woolley's Pseudantechinus		X	X	X	X		Res
Sminthopsis crassicaudata Fat-tailed Dunnart							Res
Sminthopsis dolichura Little Long-tailed Dunnart							Res
Sminthopsis longicaudata Long-tailed Dunnart	CS2						Res
Sminthopsis macruora Stripe-faced Dunnart		X		X			Res
Sminthopsis youngsoni Lesser Hairy-footed Dunnart		X					Res
PERAMELIDAE (Bandicoots)							
Macrotis lagotis Greater Bilby	CS1	X					Vag
MACROPODIDAE (Kangaroos, wallabies)							
Macropus robustus Euro, Biggada			X	X	X	X	Res

Species	Cons signif	Data bases	Dool	Ecol 1991	BCE 07-09	BCE 18-19	Expected status
Macropus rufus Red Kangaroo, Marlu			X		X	X	Res
MURIDAE (Rats and mice)							
Mus musculus House Mouse	INT			X			Res
Notomys alexis Spinifex Hopping-Mouse			X	X	X	X	Res
Pseudomys desertor Desert Mouse		X			X		Res
Pseudomys hermannsburgensis Sandy Inland Mouse		X		X			Res
Zyzomys argurus Common Rock-rat		X					Vag
EMBALLONURIDAE (Sheathtail bats)							
Saccolaimus flaviventris Yellow-bellied Sheathtail-Bat						X	Res
Taphozous georgianus Sheathtail-Bat						X	Res
VESPERTILIONIDAE (Vespertillionid bats)							
Chalinolobus gouldii Gould's Wattled Bat						X	Res
Nyctophilus geoffroyi Lesser Long-eared Bat						X	Res
Scotorepens balstoni Inland Broad-nosed Bat						X	Res
Vespadelus baverstocki Inland Forest Bat							Res
Vespadelus finlaysoni Finlayson's Cave Bat		X				X	Res
MOLOSSIDAE (Freetail bats)							
Ozimops planiceps Inland Freetail-bat							Res
Austronomous saustralis White-striped Freetail-bat					X		Vis
LEPORIDAE (Rabbits and hares)							
Oryctolagus cuniculus Rabbit	INT		X		X	X	Res
CANIDAE (Dogs and foxes)							
Canis lupus Dog/Dingo	INT	X	X	X	X	X	Res
Vulpes vulpes Red Fox	INT					X	Res

Species		Cons signif	Data bases	Dool	Ecol 1991	BCE 07-09	BCE 18-19	Expected status
FELIDAE (Cats)								
Felis catus	Cat	INT		X	X	X	X	Res
BOVIDAE (Horned ruminants)								
Bos taurus	Cattle	INT		X		X	X	Res
Capra hircus	Goat	INT						Vis
EQUIDAE (horses)								
Equus asinus	Donkey	INT					X	IrrVis
Equus caballus	Horse	INT					X	Res
CAMELIDAE (camels)								
Camelus dromedarius	Camel	INT		X	X	X	X	IrrVis
Total Species Expected: 36 **Total Species Recorded: 28 (10 introduced)**								

7.6 Appendix 6.

6a. Species considered extinct in the Marymia region

English Name	Latin Name
Thick-billed Grasswren	*Amytornis textilis*
Chuditch	*Dasyurus geoffroii*
Boodie	*Bettongia lesueur*
Rufous Hare-Wallaby	*Lagorchestes hirsutus*
Ghost Bat	*Macroderma gigas*
Golden Bandicoot	*Isoodon auratus*
Pig-footed Bandicoot	*Chaeropus ecaudatus*
Lesser Stick-nest Rat	*Leporillus apicalis*
Pebble-mound Moue	*Pseudomys chapmani*
Pilbara Leaf-nosed Bat	*Rhinonicteris aurantia*

Note that this list is probably incomplete and the past status of some of these species in the area is uncertain. With the exception of the Lesser Stick-nest Rat and the Pig-footed Bandicoot, all species are extant elsewhere. Old Boodie mounds were recorded in the Cinnamon area.

6b. Species retuned from databases but for which the project are is outside the known range; the birds in this list could all occur as extremely rare vagrants.

Latin Name	English Name
Litoria adelaidensis	Slender Tree Frog
Litoria ewingii	Brown Tree Frog
Heleioporus albopunctatus	Western Spotted Frog
Heleioporus psammophilus	Sand Frog
Crinia georgiana	Tschudi's Froglet
Pseudophryne bibronii	Brown Toadlet
Neobatrachus kunapalari	Kunapalari Frog
Pseudophryne occidentalis	Western Toadlet
Liopholis whitii	White's Skink
Tiliqua nigrolutea	Blotched Blue-Tongue
Tiliqua rugosa rugosa	Bobtail
Hemiergis peronii	Lowlands Earless Skink
Notechis scutatus scutatus	Tiger Snake
Ctenotus labillardieri	Red-legged Ctenotus
Amphibolurus muricatus	Jacky Lizard
Charadrius veredus	Oriental Plover
Geopelia placida	Peaceful Dove
Motacilla flava	Yellow Wagtail
Motacilla cinerea	Grey Wagtail
Circus approximans	Swamp Harrier
Platalea regia	Royal Spoonbill
Anhinga novaehollandiae	Australian Darter
Pelecanus conspicillatus	Australian Pelican
Phalacrocorax sulcirostris	Little Black Cormorant
Phalacrocorax carbo	Great Cormorant
Dasycercus cristicauda	Crest-tailed Mulgara

7.7 Appendix 7. Annotated species list from November 2018 and August 2019 surveys.

Frogs and Reptiles

Litoria rubella. Nov. 2018. One active at night at Cinnamon and reported in ablutions at old camp. Also several at night in puddle at Apex.

Gehyra variagata. Nov. 2018. One found around camp (form with reticulum forming lines down dorsum). Also one at night at Apex.

Heteronotia binoei. Nov. 18. One on road at night.

Nephrurus wheeleri cinctus. Nov. 18. Several on road at night including gravid female.

Ctenotus leonhardi. Nov. 18. One seen in Apex.

Caimanops amphioluroides. Nov. 18. Large female found at night perched in acacia at about 1.5m in Apex.

Ctenophorus caudicinctus. Nov. 18. Several seen in Trident and Apex areas.

Ctenopohorus isolepis. Nov. 18. Several seen in gravelly loam flats of K2. Include males in breeding colour. Also on gravelly loam flat in west of apex and in Cinnamon.

Ctenophorus scutullatus. Nov. 18. Several seen in Cinnamon area and one near Apex.

Pogona minor. Nov. 18. One along track in K2.

Varanus panoptes. Nov. 18. Two males filmed fighting. Foraging holes and burrows throughout.

Antaresia perthensis. Nov. 18. Adult of 500mm found at night in K2, and one at night at Cinnamon.

Furina ornata. Nov. 18. One active at night at Cinnamon.

Birds

1. Emu. Nov 18. Tracks in north of K2 and east of Cinnamon. Aug. 19. Dead bird in fence at Triple P.
2. Australasian Grebe. Aug 19.
3. Pink-eared Duck. Aug 19: B Zone pit: 1.
4. Black-breasted Buzzard. Nov. 18. One flew over K2 area (8/11).
5. Whistling Kite. Nov. 18. One over K2 and one near camp.
6. Little Eagle. Nov. 18. One over Trident.
7. Wedge-tailed Eagle. Nov. 18. Adult and juvenile near Apex and old nest.
8. Nankeen Kestrel. Nov. 18. Single birds seen in open cuts at Trident and K1.
9. Peregrine Falcon. Aug. 19. Pair in Flamingo Pit in Triple P area.
10. Brown Falcon. Nov. 18. A pair around K2 and one seen in apex. Aug. 19. One on drive in south of the loader tyre and one along pipeline corridor.
11. Common Bronzewing. Nov. 18. Few in Trident and K2. Bird on nest in K2.
12. Crested Pigeon. Nov. 18. Small flocks along drive in from highway.
13. Diamond Dove. Nov. 18. One seen in K2.
14. Eurasian Coot. Aug. 19. Six in flooded Mareast pit. Exocet Pit: 1. Flamingo pit: 7. B Zone Pit: 4. PPP pit: 28.
15. Australian Ringneck. Nov. 18. Seen in Trident. Aug. 19. One in Triple P area.

16. Australian Bustard. Nov. 18. One drinking from puddle on edge of Apex.
17. Spotted Nightjar. Nov. 18. Several foraging in evenings around camp and along roads. Heard occasionally. Aug 19. Two flushed at far eastern end of corridor.
18. Owlet-nightjar. Nov. 18. One flew from K2 portal.
19. Red-backed Kingfisher. Nov. 18. One in Trident.
20. Rainbow Bee-eater. Nov. 18. Few in north of K2.
21. Variegated Fairy-wren. Nov. 18. Parties in Trident, Apex and in K2. Coloured males present. Aug 19. Party in Wedgetail and party in rehab at Triple p..
22. Splendid Fairy-wren. Nov. 18. Parties in Trident, Apex and in Cinnamon. Coloured males present.
23. Chestnut-rumped Thornbill. Nov. 18. Parties in Trident, Apex, Cinnamon and K2. Aug 19. Single bird in Wedgetail. Few in Mareast and Marwest/Trident. Several amongst other small birds in rehab at Triple p.
24. Slaty-backed Thornbill. Nov. 18. Parties in Trident, K2 and Cinnamon. May be the more abundant thornbill but difficult to be sure. Aug 19. Two in mulga thicket in Wedgetail.
25. Inland Thornbill. Nov. 18. Few in Trident, Apex, Cinnamon and K2. Aug 19. Several amongst other small birds in rehab at Triple P.
26. Yellow-rumped Thornbill. Aug 19. Two in Triple P area.
27. Southern Whiteface. Aug 19. Teo near dead horse in Triple p.
28. Redthroat. Nov. 18. One in Apex, calling and seen; also in Cinnamon. Inland Thornbills copying Redthroat throughout suggesting they hear the species regularly. Aug 19. One heard near group of small birds in rehab at Triple p.
29. Spiny-cheeked Honeyeater. Nov. 18. Heard Trident and K2. Seen and heard in Cinnamon and Apex. Aug. 19. Few seen in Corridor and Wedgetail.
30. Yellow-throated Miner. Nov. 18. Heard in Trident and seen and heard in Apex and Cinnamon.
31. Singing Honeyeater. Nov. 18. Small numbers in all areas. Aug. 19. One in Mareast.
32. Mistletoebird. Nov. 18. Pair in Apex.
33. Willie Wagtail. Nov. 18. Pairs seen occasionally throughout. Aug. 19. Occasional single birds seen.
34. Red-capped Robin. Nov. 18. Seen in Trident, Apex, Cinnamon and K2. Aug 19. Pair in north of Triple p along drainage line.
35. Hooded Robin. Nov. 18. Pair in Cinnamon and family party in Apex. Aug. 19. Pair along corridor. Female in Mareast and pair flew across main road near K2 turnoff. Pair near dead horse in triple p.
36. Rufous Whistler. Nov. 18. Small numbers throughout.
37. Grey Shrike-thrush. Nov. 18. Few throughout. Aug 19. One near dead horses at Triple p.
38. Crested Bellbird. Nov. 18. Few throughout. Aug. 19. Unconfirmed sighting in Mareast. One near dead horses at Triple p.
39. Varied Sittella. Aug 19. Party of about 6 along road to Speckled Hen.
40. Grey-crowned Babbler. Nov. 18. Parties in Trident, Apex and Cinnamon. Aug 19. Three near dead horses in Triple P.
41. White-browed Babbler. Nov. 18. Several parties in rehab at K2. Also seen in native acacia shrubland nearby, and in Apex and Cinnamon.
42. Western Quail-thrush. Nov. 18. Parties in Trident and Apex. Aug. 19. Single bird along corridor. Male and two females on K2 ROM (8/08). Three birds near dead horse in Triple P.
43. White-winged Triller. Nov. 18. Single bird (female) see near K1 pit in K2.

44. Welcome Swallow. Aug 19. Seen around pits in Triple P, and seven birds around dead horses.
45. White-backed Swallow. Nov. 18. Few around most pits and breeding burrows present.
46. Fairy Martin. Nov. 18. Nests in K2 portal.
47. Little Woodswallow. Nov. 18. Few around pits. Aug. 19. Single bird in Ibis pit.
48. Black-faced Woodswallow. Nov. 18. Group of three in west of K2 and group of three in Cinnamon. Up to 10 near camp.
49. Dusky Woodswallow. Aug 19. One near dead horse in triple P. Seen from about 15m and white edges to primaries clearly seen. This represents an extension to the known range of the species but was probably a vagrant individual.
50. Magpielark. Aug 19. Several in triple p area, including two feeding around dead horses.
51. Pied Butcherbird. Aug 19. One near dead horse in triple P.
52. Grey Butcherbird. Nov. 18. One seen in K2 and one at camp. Aug. 19. Several birds around camp, where they regularly forage on insects under lights.
53. Torresian Crow. Nov. 18. Three birds seen in Trident and group of about 6 in Cinnamon. Aug. 19. Single bird in Mareast.

Mammals

Echidna. Nov. 18. Fairly recent diggings in rehab at K2.
Dasycercus blythi. Nov. 18. Group of disused burrows in west of K2. Few old burrows in Cinnamon.
Boodie. Nov. 18. Old warrens in Cinnamon.
Red Kangaroo. Nov. 18. Seen occasionally. Aug 19. One seen in north of Triple p.
Euro. Nov. 18. Few seen in K2. Aug. 19. Occasional tracks.
Notomys alexis. Nov. 18. Burrow system in sandy loam soils in west and north of K2 and in Cinnamon.
Taphozous georgianus. One seen before dawn along Marymia road on 9/11 and recorded on bat detectors.
Nyctophilus geoffroyii. Recorded on bat detectors.
Scotorepens bsalstoni. Recorded on bat detectors.
Vespadelus finlaysoni. Recorded on bat detectors.
Saccolaimus flaviventris. Recorded on bat detectors.
Rabbit. Nov. 18. Tracks, scats and burrows in Trident and K2. Aug. 19. Fresh tracks in MarEast.
Feral Horse. Nov. 18. Group of three in K2 and lots of tracks and scats in Apex (where one seen) and Cinnamon. Aug. 19. Group of four at Wedgetail.
Donkey. Aug. 19. Fresh tracks at Marwest.
Cattle. Nov. 18. Evidence throughout. Aug. 19. Evidence throughout.
Dingo. Nov. 18. Tracks in K2. Aug. 19. Fresh tracks around car at Mareast. Old tracks on edge of Marwest it.
Cat. Nov. 18. Tracks in K2.
Fox. Nov. 18. One reported by staff.
Camel. Aug. 19. Fresh tracks at Marwest.

7.8 Appendix 8. Call charts of bat species recorded on bat detectors.

Sample calls for each of the bats recorded are provided in Figures 1 to 6 with grey-scale full spectrum data and zero crossing overlay. All calls are time expanded and time between calls has been compressed.

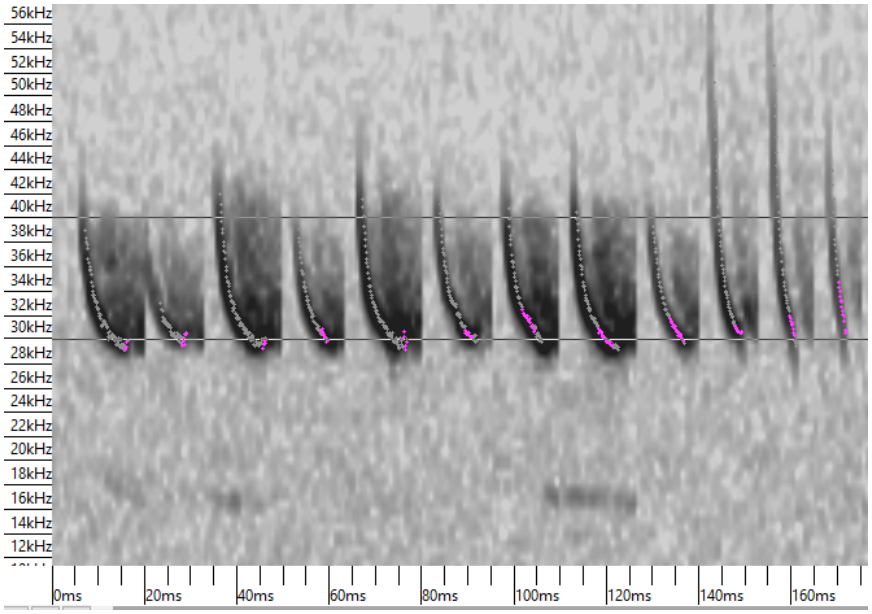

Figure 1: Sonogram of *C. gouldii* showing characteristic alternation in frequency in first nine calls.

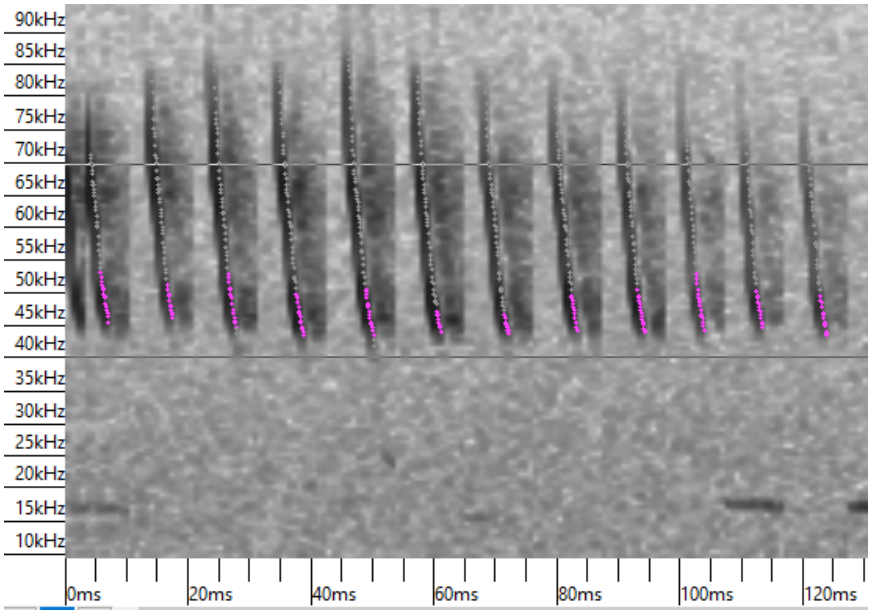

Figure 2: Sonogram of suspected *N. geoffroyi* showing relatively straight and near-vertical call structure.

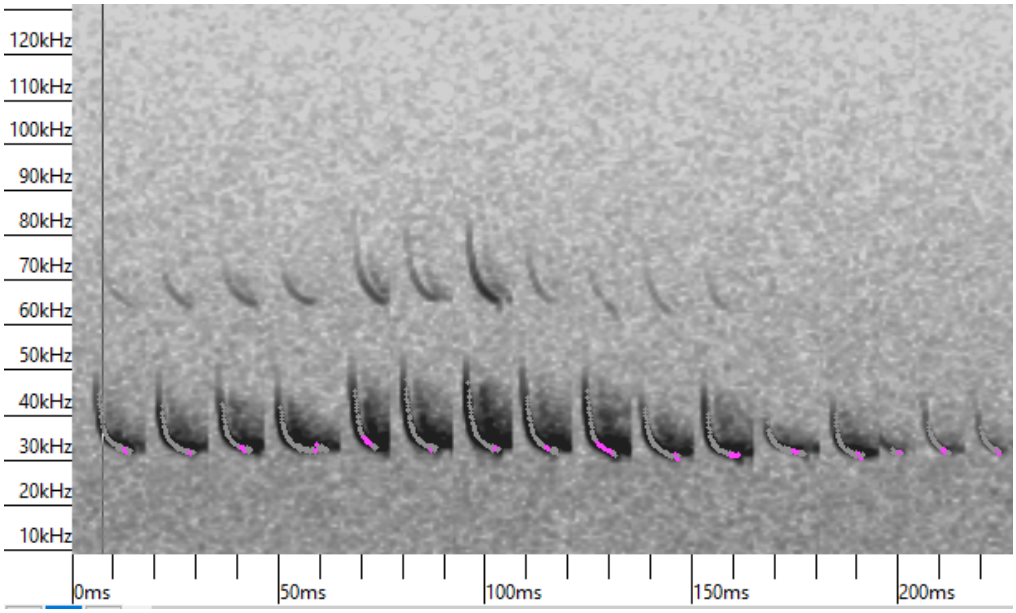

Figure 3: Sonogram of *S. balstoni* echolocation sequence.

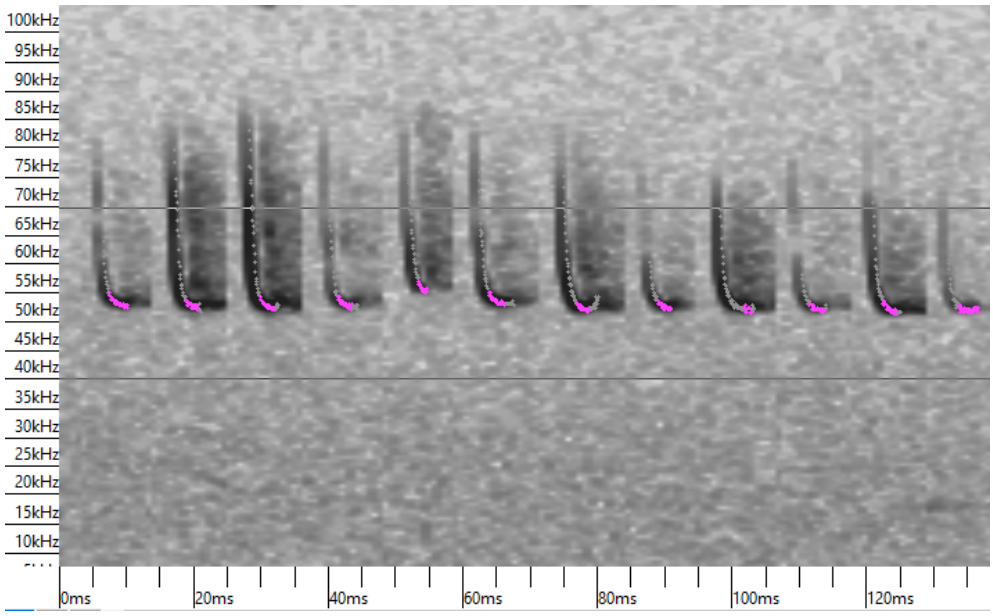

Figure 4: Sonogram of *V. finlaysoni*.

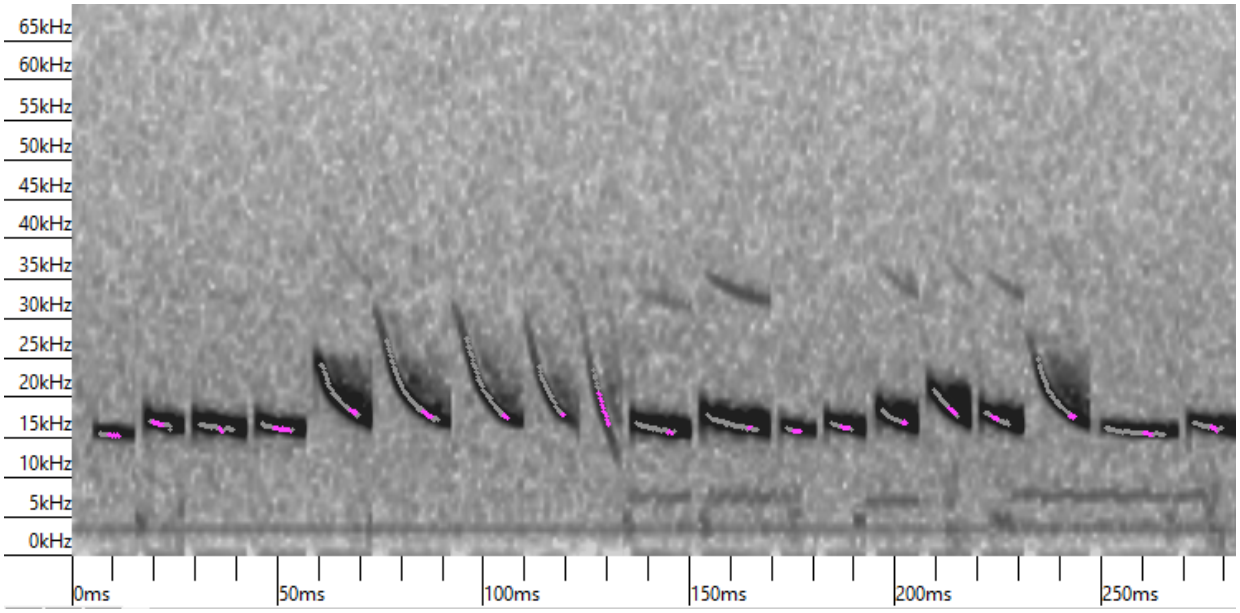

Figure 5: Sonogram of suspected *S. flaviventris* showing characteristic flat calls.

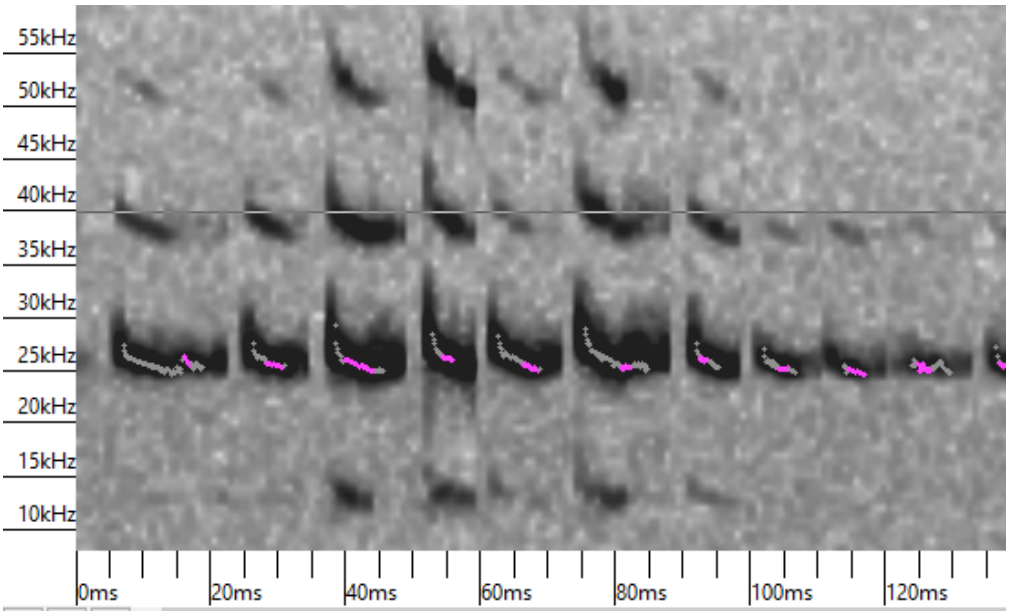

Figure 6: Sonogram of *T. georgianus* with characteristic weaker harmonic at circa 13 kHz.

7.9 Appendix 9. GPS coordinates of inactive Mulgara burrows and Boodie warrens recorded in November 2018 (none were recorded in August 2019).

Record of Interest	Easting	Northing
Boodie warren	772545	7213893
Boodie warren	772812.1	7213930
Boodie warren	780598.4	7215862
Mulgara burrow	772574.8	7213901
Mulgara burrow	773042.5	7214052
Mulgara burrow	773083.1	7214005
Mulgara burrow	775153.3	7218859
Mulgara burrow	773927.8	7214115
Mulgara burrow	772507.4	7213511
Mulgara burrow	772585.6	7213899

Bennelongia Environmental Consultants

Marymia Gold Project: Desktop Assessment of Subterranean Fauna Values

Prepared for:

Vango Mining Limited

June 2019

Draft Report

Short-Range Endemics | Subterranean Fauna

Waterbirds | Wetlands

Marymia Gold Project: Desktop Assessment of Subterranean Fauna Values

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EXECUTIVE SUMMARY

Vango Mining Limited (Vango) propose to develop the Marymia Gold Project in the eastern Gascoyne region of Western Australia (WA). This report presents an assessment of the potential values of the Project in the context of subterranean fauna based on a desktop review of available habitat information and records of subterranean fauna species in the vicinity.

Four rich and unique stygal communities in calcrete aquifers occur in the region surrounding the Project and are listed as PECs (Priority 1). The Project occurs within the outer extent of the buffer zone of the Three Rivers Plutonic PEC, whose core habitat comprises a large calcrete deposit and possibly connected alluvium and colluvium. Alluvial and colluvial deposits of the palaeovalley in which the inferred core habitat occurs extend to within 2 km of the Project at Trident.

The Project is hosted by the Plutonic Well greenstone belt that comprises metamorphosed ultramafic, mafic and sedimentary rocks, including BIF, with dolerite dykes intruding both granitoid and greenstone. The extent of weathering and the development of underground spaces, suitable for habitation by subterranean fauna, in the greenstone belt is unknown. Extensive aquifers in calcrete, alluvium and colluvium occur along the Gascoyne River and its headwater tributaries, to the west of the Project, as well as within the Lake Gregory drainage system to the south. These units extend to within close proximity to Vango tenements and the Project In the greenstone belt, groundwater occurs at 50–60 m below ground level, is generally brackish (around 1,500 µS cm^{-1}) and alkaline (7.9-9.1 pH).

At least 45 species of stygofauna have been recorded within an approximately 100 km radius of the Project, though it is highly unlikely that the full suite of species present has been recorded. Most records are from bores sampling calcrete, alluvium or colluvium in and adjacent to palaeovalleys. The known and inferred geographic ranges of the recorded species are highly variable and in the case of 23 species (beetles, syncarids, amphipods, some copepods and a seed shrimp) are small or very small. In many cases, these species have each been recorded from only a small number of bores and are confined to individual, isolated calcrete aquifers.

No targeted sampling for troglofauna has been undertaken in the vicinity of the Project resulting in the absence of troglofauna records in the search area.

The most prospective habitats for stygofauna in the broad vicinity of the Project are aquifers in calcrete, including a number of PECs, as well as alluvial and colluvial deposits associated with drainages, valleys and plains that in places may share some connectivity with calcretes. The nearest large body of mapped calcrete is some 17 km north of the Project. Alluvial and colluvial aquifers occur within close proximity to the Project.

Based on preliminary information, pending reporting on local hydrogeology, the prospectivity for stygofauna of the BIF and granite geologies of the greenstone belt on which the Project is situated is considered low, primarily due to the great depths to water.

Based on documented communities in similar geologies, it is considered likely that a low to moderate diversity of troglofauna species may exist in the alluvial and colluvial deposits adjacent to the Project. Banded ironstone is recognised as a prime habitat for troglofauna and, depending on the degree to which subterranean spaces have developed through weathering, the BIF and granite geologies within the Project area may offer prospective habitat to troglofauna.

The potential for impacts leading to habitat removal and extinction will depend on the design and layout of the Project, extent of activities (groundwater drawdown and pit excavation) and the range of species present.

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1. INTRODUCTION

Vango Mining Limited (Vango) propose to develop the Marymia Gold Project, approximately 200 km south of Newman and 70 km northeast of Kumarina, in the eastern Gascoyne region of Western Australia (WA). The Project comprises four Survey Areas – Trident, K2, Apex and Cinnamon – that are together referred to as the Project. The location and layout of the Project and neighbouring Vango tenements are shown in Figure 1.

This report presents an assessment of the potential values of the Project in the context of subterranean fauna based on a desktop review of available habitat information and records of subterranean fauna species (stygofauna and troglofauna in the vicinity. While impacts stemming from mine pit excavations, dewatering requirements and water supply have not yet been determined, general commentary is provided about the potential effects of the development of the Project on subterranean fauna species and communities. The specific aims of the review and assessment are:

1. Review available geological and hydrogeological information to assess the prospectivity of habitats in the vicinity of the Project for subterranean fauna;
2. Compile and evaluate records of subterranean fauna within the vicinity of the Project, assess ranges of recorded species and incorporate these results into the appraisal of prospectivity;
3. Identify key potential impacts of the Project on subterranean species and communities.

2. SUBTERRANEAN FAUNA FRAMEWORK

The term 'subterranean fauna' refers collectively to stygofauna, which occupy underground aquatic habitats; and troglofauna, which inhabit air-filled spaces above the water table. Hallmark adaptations of most subterranean species include reduced or absent eyes and reduced pigmentation due to lack of light. Other morphological and physiological adaptations reflecting the habitats occupied by subterranean species include loss of wings, increased lifespan, decreased metabolism and a shift towards K-selection breeding strategy (Gibert and Deharveng 2002). Species inhabiting large underground spaces such as caves tend to have elongate bodies and sensory structures, while species in smaller spaces outside caves, such as vughs and interstices may be more compact in form.

Except for a few species of fish, all subterranean fauna species in WA are invertebrates. Stygofauna species are considered to be ecologically important for the maintenance of groundwater quality through purification and nutrient cycling (Boulton *et al.* 2008).

While some subterranean species are obligate inhabitants of groundwater (stygobites) or deep subterranean spaces above the water table (troglobites), others use these habitats only for a proportion of their life cycle (stygophiles and troglophiles). Species with some surface occurrence usually have larger distributions than obligate subterranean species as a result of greater dispersal opportunities.

Although inconspicuous, subterranean fauna contribute markedly to the overall biodiversity of Australia. The Yilgarn, Pilbara and neighbouring regions of WA are recognised as hotspots of subterranean faunal biodiversity, with an estimated 4,000 or more subterranean species likely to occur (Guzik *et al.* 2010), the majority of which remain undescribed. Nearly all subterranean species satisfy Harvey's (2002) criteria for short-range endemism (SRE), namely a total range of less than 10,000 km^2, occurrence in discontinuous or fragmented habitats, slow growth and low fecundity. Given that species with small ranges are more vulnerable to extinction following habitat degradation than wider ranging species (Ponder and Colgan 2002), it follows that subterranean species are highly susceptible to anthropogenic threats such as groundwater abstraction or excavation.

In WA the Environmental Protection Authority (EPA) requires consideration of subterranean fauna as part of environmental impact assessment (EPA 2016a, b).

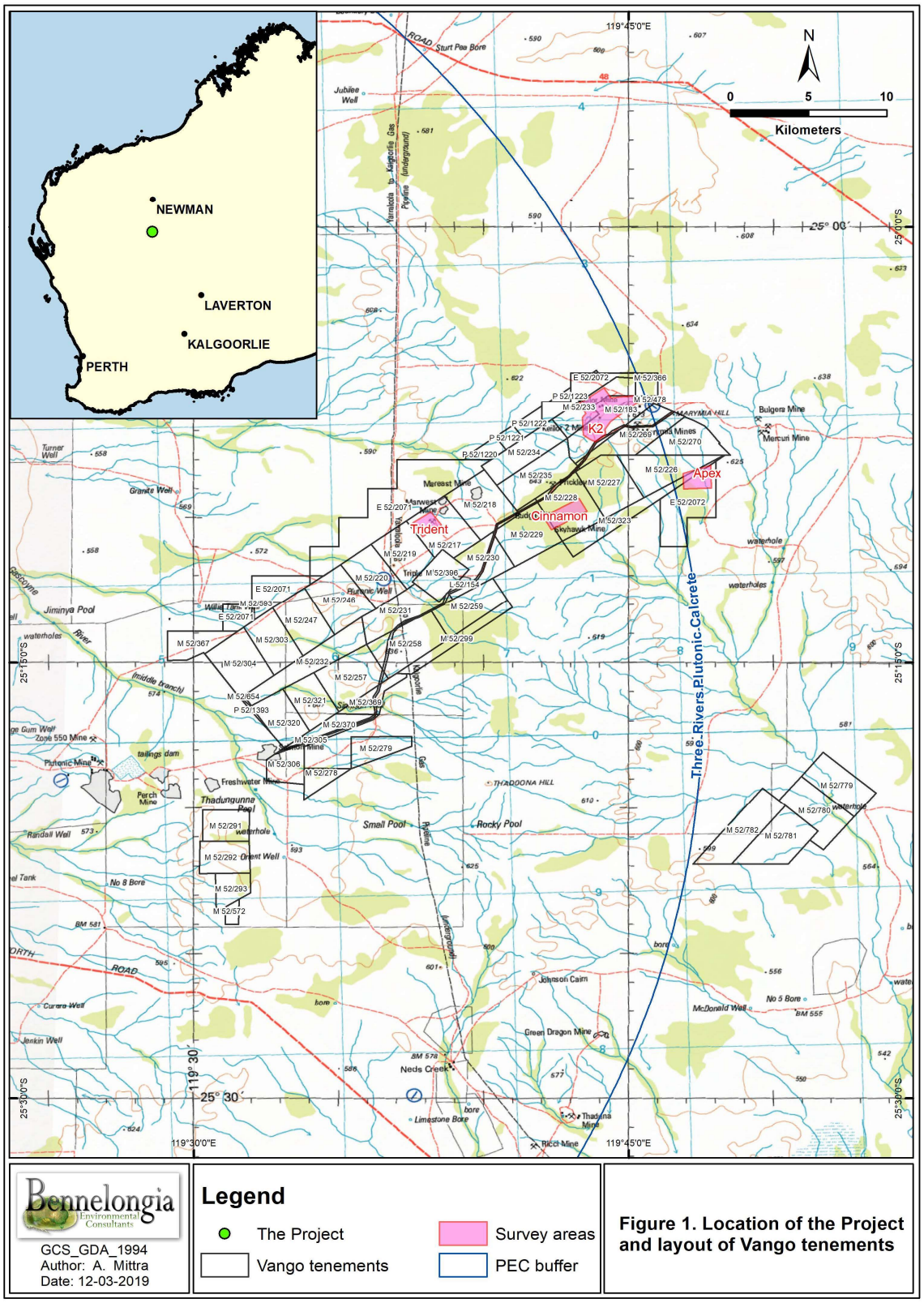

Figure 1. Location of the Project and layout of Vango tenements.

3. HABITAT OVERVIEW

Troglofauna occupy subterranean spaces, such as alluvial interstices, voids and fissures, while stygofauna inhabit water held by such structures. Additionally, stygofauna sometimes occur in the alluvium of hyporheic zones – the confluence of groundwater and surface-water habitats – as well as in groundwater-fed springs. Geology and hydrogeology are significant drivers of the distributions of subterranean species and communities (Eberhard *et al.* 2005; Hose *et al.* 2015).

Highly transmissive geologies tend to support richer and more abundant assemblages of subterranean fauna. For example, clastic alluvial media may host rich assemblages in the interstitial spaces between constituent sand and gravel. Coarse sediments tend to host the richest assemblages while silty or clay-rich substrates are generally not considered prospective (Korbel and Hose 2015).

Physical and chemical weathering of consolidated media can also provide inhabitable spaces such as underground vughs and caves. In arid and semi-arid WA, chemical deposition of carbonate-rich material in palaeochannels has led to the formation of calcrete aquifers offering habitat similar to classic karst formations. These calcretes are well documented as hosting very rich stygofaunal communities.

Geological, topographical and hydrological features can allow dispersal between subterranean populations. For instance, vertical shifts in the water table may act to unite previously isolated aquifers, thus allowing gene flow between stygal populations in separate aquifers (Finston *et al.* 2007). By the same token, subterranean geology and surface features such as drainages, tributary boundaries and dykes may barricade dispersal causing vicariance between populations and subsequent speciation over fine geographic scales. Many subterranean species are confined to single, isolated geological structures or aquifers (e.g. Eberhard *et al.* 2016; Harvey and Leng 2008).

3.1. Listed Ecological Communities

An ecological community comprising a naturally-occurring biological assemblage in a particular habitat type may be listed by the Department of Biodiversity, Conservation and Attractions (DBCA) as a Threatened Ecological Community (TEC) if it presumed to be totally destroyed, critically endangered, endangered or vulnerable. A community that is threatened but does not meet these criteria, is rare but not threatened, is near threatened, has recently been removed from the TEC list, or is conservation-dependent are listed by the DBCA as a Priority Ecological Community (PEC) under Priorities 1–5.

Four rich and unique stygal communities in calcrete aquifers occur in the region surrounding the Project and are listed as PECs (Priority 1). These are, 'Three Rivers calcrete groundwater assemblage types on Gascoyne palaeodrainage on Three Rivers Station', Three Rivers Plutonic calcrete groundwater assemblage type on Gascoyne palaeodrainage on Three Rivers Station', 'Doolgunna calcrete groundwater assemblage type on Gascoyne palaeodrainage on Doolgunna Station', and 'Cunyu SBF and Cunyu Sweetwater calcrete groundwater assemblage types on Nabberu palaeodrainage on Cunyu Station' (Figure 2).

The Project occurs within the outer extent of the buffer zone of the Three Rivers Plutonic PEC (Figure 2). The core habitat of this PEC, in which the majority of constituent stygofauna species are likely to occur, comprises a large calcrete deposit and possibly connected alluvium and colluvium. Alluvial and colluvial deposits of the palaeovalley in which the inferred core habitat occurs extend to within 2 km of the Project at Trident (Figure 2).

3.2. Geology

The Project is located on the Peak Hill 1:250,000 geological map sheet whose geology is detailed by Subramanya *et al.* (1995). Adjacent map sheets provide geological information for the surrounding regions: Collier to the north (Coker and Faulkner 1999), Bullen to the northeast (Williams 1995) and Nabberu to the east (Morris *et al.* 1997).

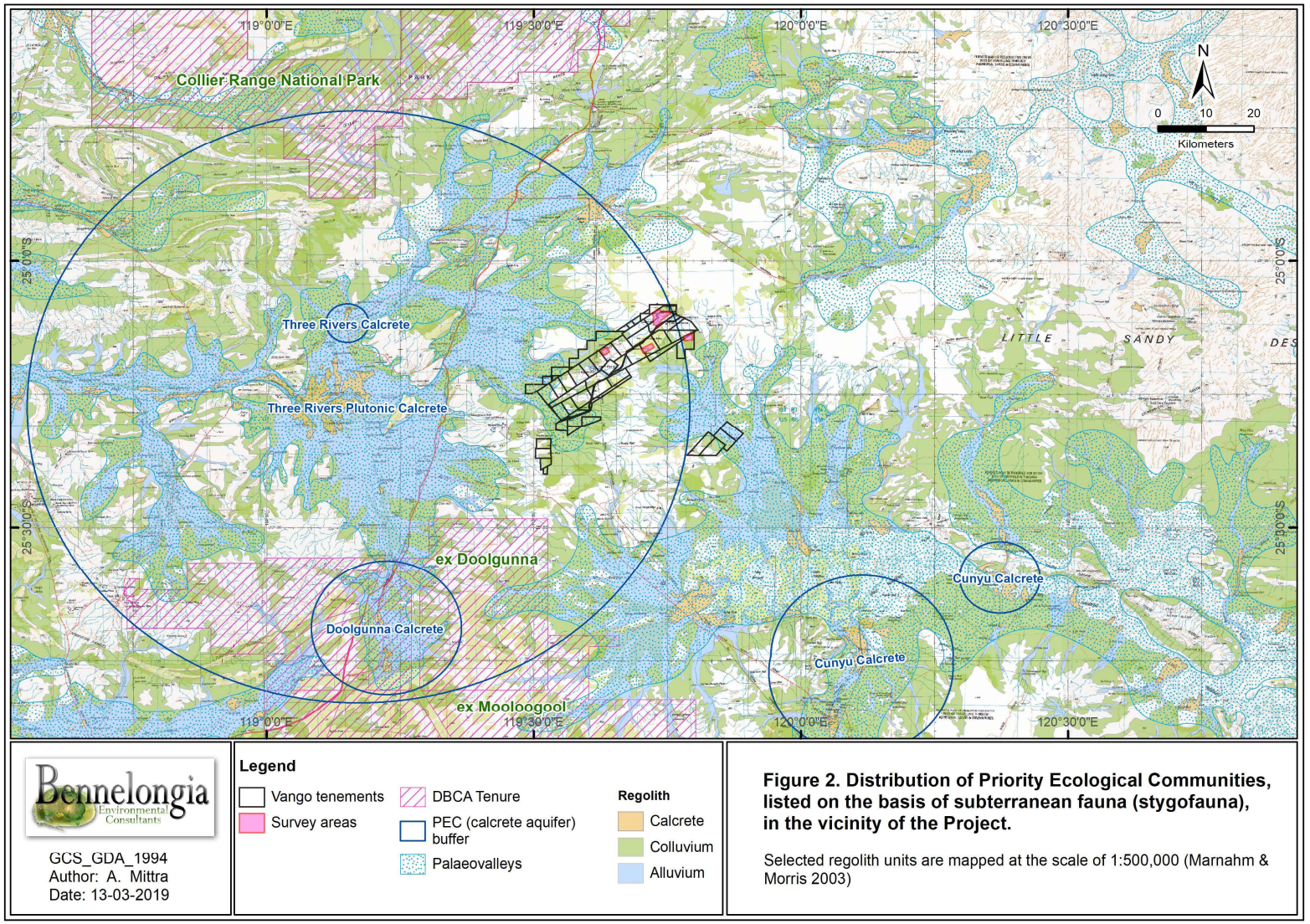

Figure 2. Distribution of Priority Ecological Communities, listed on the basis of subterranean fauna (stygofauna), in the vicinity of the Project.

On a regional scale, major landform and regolith features in the vicinity of the Project are sandstone and banded ironstone formation (BIF) hills and ridges and low granite and greenstone hills interspersed with sandplains, alluvial and colluvial plains and salt lakes (Subramanya *et al.* 1995).

Locally (Figure 3), the Project is hosted by the northeasterly trending Plutonic Well greenstone belt whose geological sequence comprises metamorphosed ultramafic, mafic and sedimentary rocks, including BIF, with dolerite dykes intruding both granitoid and greenstone. The extent of weathering and the development of underground spaces, suitable for habitation by subterranean fauna, in the greenstone belt is unknown.

The greenstone belt is bordered by alluvial and colluvial valley fill to the northwest, west, southwest and southeast (Figure 3).

3.3. Hydrogeology

Major drainages of the Peak Hill district within the broad vicinity of the Project are the Gascoyne River to the west, Murchison River to the southwest and the internal drainage of Lake Gregory to the south-southeast. Shallow aquifers along the rivers and in alluvial and colluvial valley fill and calcretes are accessed by pastoral bores and wells and generally contain fresh to brackish water, though probably tending saline within the Lake Gregory drainage system (Subramanya *et al.* 1995).

Extensive aquifers in calcrete, alluvium and colluvium occur along the Gascoyne River and its headwater tributaries, to the west of the Project, as well as within the Lake Gregory drainage system to the south. These units extend to within close proximity to Vango tenements and the Project (Figure 2).

Preliminary information (Vango 2017) suggests that within the greenstone belt hosting the Project, groundwater occurs at 50–60 m below ground level, is generally brackish (around 1,500 µS cm^{-1}) and alkaline (7.9-9.1 pH). While chemically these conditions are suitable for stygofauna, depths to water are likely to be a limiting factor on the occurrence and richness of a stygofauna community at the Project. Stygofauna are generally sparse where depth to water is greater than around 30 m (Halse *et al.* 2014). Detailed reporting on local hydrogeology is currently unavailable.

4. PREVIOUS RECORDS OF SUBTERRANEAN FAUNA

To further inform an appraisal of the prospectivity of the Project area, records of both stygofauna and troglofauna were compiled from a search area of Western Australian Museum (WAM) and Bennelongia databases within a radius of 100 km from the Project centroid. Species data were investigated spatially and cross-referenced with records outside the search area to determine the distribution of each species. Higher order identifications were not regarded as distinct species unless they belonged to taxa that had otherwise not been recorded.

4.1. Stygofauna

At least 45 species of stygofauna have been recorded in the search area (Table 1) including flatworms (Turbellaria), annelids (predominantly oligochaetes), rotifers (Rotifera), nematodes, (Nematoda), diving beetles (Dytiscidae), amphipods (Amphipoda), isopods (Isopoda), syncarids (Syncarida), copepods (predominantly cyclopoids but also at least one harpacticoid species) and seed shrimp (Ostracoda).

While a relatively high proportion of the recorded species (28 of the total 45 species, or 62%) have been formally described, the remaining taxa have been identified to morphospecies, higher-order groups or belong to species-complexes that are known or likely to be polyphyletic. Moreover, considering the relatively low intensity of historic survey within the search area, it is highly unlikely that the full suite of species present has been recorded.

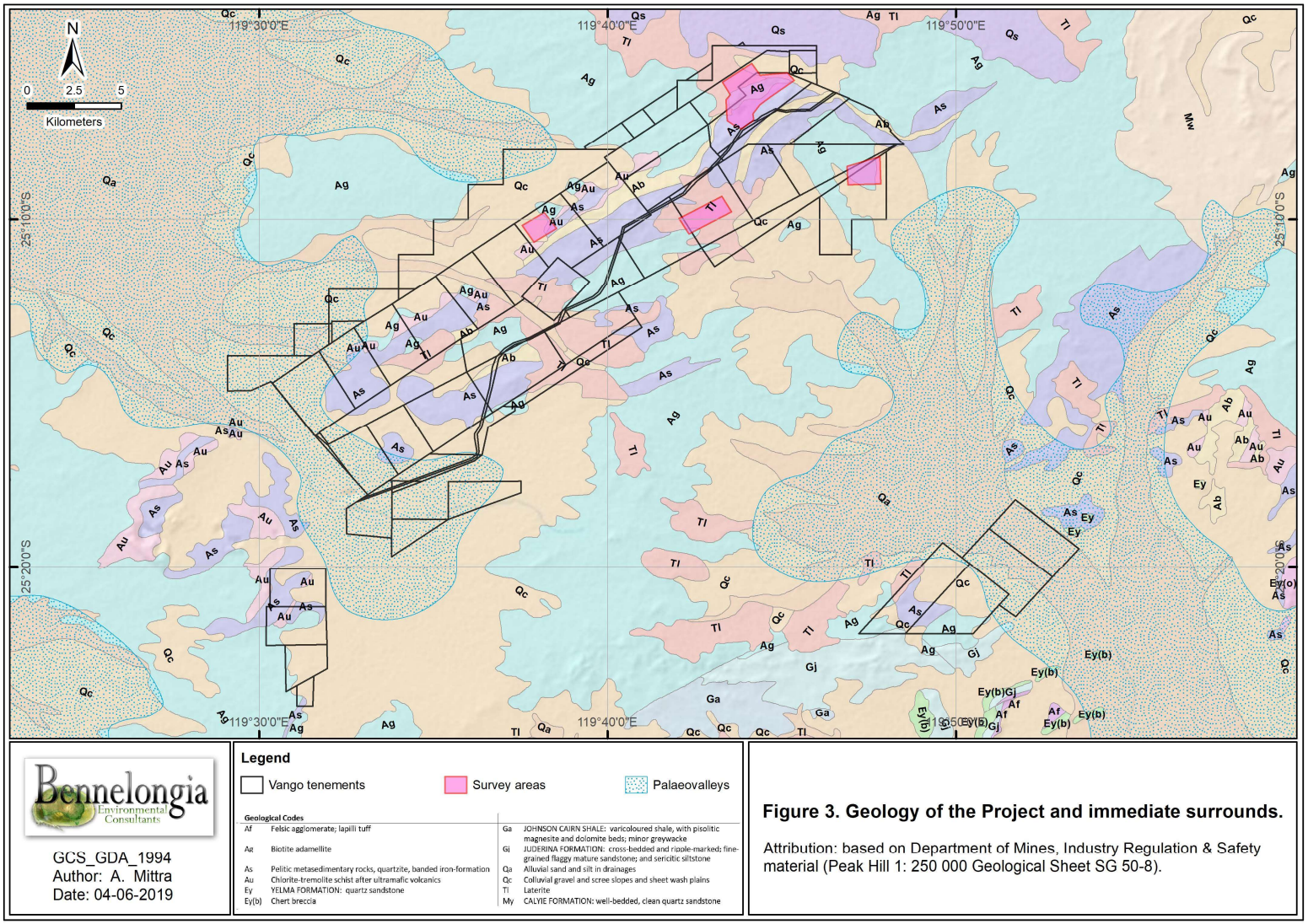

Figure 3. Geology of the Project and immediate surrounds.

Attribution: based on Department of Mines, Industry Regulation & Safety material (Peak Hill 1: 250 000 Geological Sheet SG 50-8).

Figure 3. Geology of the Project and immediate surrounds.

The known and inferred geographic ranges of the recorded species are highly variable. Eleven species have documented, widespread distributions within northern-WA, across the state or country, or in some cases beyond. The five rotifer species are considered likely to have at least moderately widespread distributions based patterns for the group (Fontaneto *et al.* 2008), although there is an insufficient systematic framework with which to assess the ranges of stygal rotifers, and cryptic diversity may be significant (Fontaneto *et al.* 2009). Stygal rotifers and nematodes are generally not assessed as part of environmental impact assessments (EIA) for subterranean fauna.

Twenty-three species, including all diving beetles, syncarids and amphipods, as well as some copepods and a seed shrimp are known or highly likely to have small or very small geographic ranges. In many cases, these species have each been recorded from only a small number of bores and are confined to individual, isolated calcrete aquifers (Cho *et al.* 2006; Hong and Cho 2009; King *et al.* 2012; Watts and Humphreys 2009). The likelihood of these species occurring at the Project is considered low, although similar or related species may occur.

The remaining six species (marked with asterisks in Table 1) are higher-order identifications whose ranges cannot be determined due to insufficient taxonomic information.

4.1.1. Spatial Distribution of Records

The majority of records of stygofauna in the search area appear to have come from bores sampling aquifers in calcrete, alluvium and colluvium in palaeovalleys (Figure 4). While these geologies appear to occur close to, but not within the Project, stygofauna have also been recorded from bores outside mapped palaeochannel deposits (Figure 4), suggesting that prospective habitats occur adjacent to mapped palaeochannels.

Based on desktop review and apart from samples that yielded stygofauna, which are as close as 32.2 km from Survey Areas, there have been no other samples taken targeting stygofauna within 46 km of the Survey Areas.

4.2. Troglofauna

No targeted sampling for troglofauna has been undertaken in the vicinity of the Project resulting in the absence of troglofauna records in the search area.

5. APPRAISAL OF PROSPECTIVITY

Based on the findings of desktop review, the prospectivity of the Project and immediate surrounds for subterranean fauna is outlined below.

5.1. Stygofauna

Despite only a moderate amount of sampling having been undertaken in the search area (Figure 4), the substantial number of species recorded (Table 1) shows very prospective habitats for subterranean aquatic species occur within the vicinity of the Project.

The most prospective habitats are aquifers in calcrete, including a number of PECs, as well as alluvial and colluvial deposits associated with drainages, valleys and plains that in places may share some connectivity with calcretes. Rich communities have been documented in calcretes (Bennelongia 2015, 2017b, 2018b; Halse 2018; Humphreys 2001; Hyde *et al.* 2018) as well as in alluvial and colluvial aquifers (Bennelongia 2018a, b; Stantec 2017a) across arid and semi-arid WA.

The nearest large body of mapped calcrete is some 17 km north of the Project (K2; Figure 2), although there is some suggestion that the occurrence of calcrete may be more extensive throughout palaeovalleys than coarse regolith mapping shows (Subramanya *et al.* 1995).

Table 1. Records of stygofauna in the vicinity of the Project identified through desktop review.
Higher order identifications that possibly belong to other recorded species are denoted with asterisks (*) and have not been counted as distinct species.

Higher Classification	Lowest Identification	No. of Sites	Closest Record to Survey Area	Comments on Distribution
Platyhelminthes				
Turbellaria	Turbellaria sp.	1	32.2 km NW (Trident)	Very little known about the systematics and ecology of stygal flatworms. Range unknown.
Annelida				
Aphanoneura				
Aeolosomatidae	*Aeolosoma* sp. 1 (PSS)	1	35.5 km NW (Trident)	Widespread morphospecies that may contain multiple species.
Clitellata				
Haplotaxida				
Naididae	*Dero* (*Aulophorus*) *furcatus*	1	51.4 km SW (Trident)	Widespread across WA.
Phreodrilidae	Phreodrilidae sp. AP DVC s.l.	2	85.6 km SW (Trident)	Both these morphospecies are widespread across northern and central WA but each in fact comprises multiple species.
	Phreodrilidae sp. AP SVC s.l.	1	32.5 km NW (Trident)	
Rotifera				
Bdelloidea	Bdelloidea sp. 2:2	2	57.1 km SW (Trident)	Very little known about the systematics and ecology of stygal rotifers.
	Bdelloidea sp. 2:3	1	67.1 km SW (Trident)	
Monogononta				
Ploima				
Brachionidae	*Brachionus urceolaris* s.l.	1	86 km SW (Trident)	
Lecanidae	*Lecane ludwigi* form *ichthyoura*	4	86 km SW (Trident)	
Nematoda	Nematoda spp.	3	51.3 km SW (Trident)	
Arthropoda				
Insecta				
Coleoptera				
Dytiscidae	*Limbodessus bivalveus*	1	76.4 km SE (Apex)	All species of stygal dytiscid (diving beetle) are range-restricted. Each of these species occurs in a single calcrete aquifer.
	Limbodessus cunyuensis	1	75.9 km SE (Apex)	
	Limbodessus jundeeensis	1	88.0 km SE (Apex)	
	Limbodessus macrotarsus	1	76.6 km SE (Apex)	
	Limbodessus silus	1	75.9 km SE (Apex)	
	Limbodessus sweetwatersensis	1	75.9 km SE (Apex)	
	Neobidessodes gutteridgei	1	47.1 km W (Trident)	
	Paroster plutonicensis	1	46.2 km W (Trident)	
Malacostraca				
Amphipoda				
Chiltoniidae	*Scutachiltonia axfordi*	1	76.5 km SE (Apex)	Endemic to the Sturt Meadows Calcrete.
Paramelitidae	Paramelitidae `AMP039`	1	60.3 km NE (Apex)	Range unknown but each species known only from one location.
	Paramelitidae `AMP040`	1	39.9 km N (K2)	
Isopoda				
Paraplatyarthridae	*Paraplatyarthrus cunyuensis*	2	75.2 km SE (Apex)	Endemic to the Cunynu Calcrete
Syncarida				
Parabathynellidae	*Billibathynella ilgarariensis*	1	72.3 km N (K2)	Precise ranges for each species unknown, but each species is known from only a few clustered localities and is highly likely to have a small or very small range.
	Billibathynella wolframnoodti	1	55.5 km S (Cinnamon)	
	Brevisomabathynella cunyuensis	1	76.5 km SE (Apex)	
	Brevisomabathynella leijsi	1	76.6 km SE (Apex)	
	Brevisomabathynella magna	1	77.1 km SE (Apex)	

Higher Classification	Lowest Identification	No. of Sites	Closest Record to Survey Area	Comments on Distribution
	Notobathynella sp. B03	1	67.0 km SW (Trident)	
	Parabathynellidae `BAP018`	1	53.6 km NE (Apex)	
	Parabathynellidae `BAP019`	1	39.5 km N (K2)	
	Bathynellacea `sp. indet.`*	1	-	Higher order identification.
Maxillopoda				
Cyclopoida				
Cyclopidae	`Nr. *Fierscyclops*` `sp. B01`	2	59.5 km NE (Apex)	Species known only from three bores, range unknown.
	Diacyclops scanloni	1	86.4 km N (K2)	Widespread in the Pilbara.
	Diacyclops sobeprolatus	1	35.4 km NW (Trident)	Widespread in the Pilbara.
	Dussartcyclops `sp. B13`	2	39.9 km N (K2)	Species known only from four bores, range unknown.
	Fierscyclops (*Fiercyclops*) *fiersi*	2	53.6 km NE (Apex)	Widespread throughout the Yilgarn, few records in the Pilbara.
	Pilbaracyclops frustratio	2	32.3 km NW (Trident)	Widespread (northern Yilgarn and Eastern Pilbara).
	Mesocyclops brooksi	6	43.4 km NE (Apex)	Widespread with records from across WA and Queensland.
	Microcyclops varicans	1	86.3 km N (K2)	Widespread across Australia.
	Paracyclops chiltoni	2	85.5 km SW (Trident)	Widespread with records across Australia and beyond.
	Thermocyclops decipiens	2	43.4 km NE (Apex)	Widespread across northern Australia.
	Cyclopoida `sp. indet.`*	1	-	Higher order identification.
Harpacticoida				
Canthocamptidae	Canthocamptidae sp.*	2	-	Higher order identification.
	Elaphoidella sp.	1	32.7 km NW (Trident)	Not identified to species.
	Harpacticoida sp.*	2	-	Higher order identification.
Ostracoda				
Podocopida				
Candonidae	*Candonopsis* `sp. indet.`	1	39.9 km N (K2)	Higher order identification.
Cyprididae	Cyprididae `sp. BOS1090`	1	60.3 km NE (Apex)	Known only from one bore, range unknown.
Popocopida				
Cyprididae	*Cypretta seurati*	2	35.4 km NW (Trident)	Cosmopolitan.
	Cypridopsis vidua	1	86.4 km N (K2)	Cosmopolitan.
	Ostracoda sp. unident.*	2	-	Higher order identification.

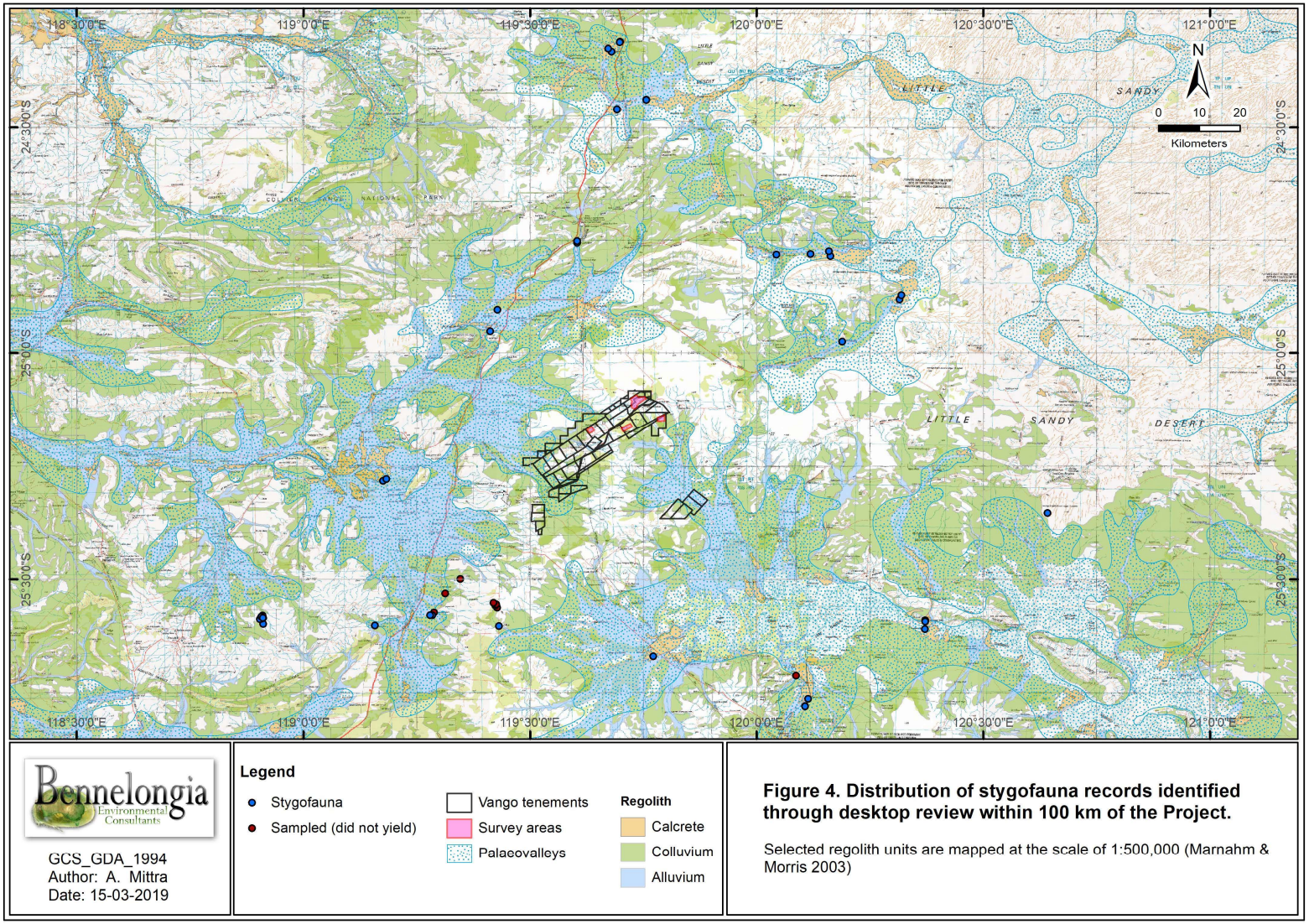

Figure 4. Distribution of stygofauna records identified through desktop review within 100 km of the Project.

The alluvial and colluvial aquifers are also considered highly prospective for stygofauna, particularly within, but also adjacent to mapped palaeovalleys and these habitats occur within close proximity to the Project (Figure 2).

Based on preliminary information, pending reporting on local hydrogeology, the prospectivity for stygofauna of the BIF and granite geologies of the greenstone belt on which the Project is situated is considered low. The main limiting factor on the occurrence of stygofauna in the greenstone belt is depth to water, although it is possible that a reduced community occurs. Stygal communities in fractured rock, including BIF and granite have tended not to be rich (Bennelongia 2009, 2016c, 2018b; Stantec 2017b).

5.2. Troglofauna

The lack of sampling and resultant absence of species records in the search area means that the appraisal of prospectivity for troglofauna is based solely on habitat information. In general, survey for troglofauna in WA outside the Pilbara has been limited compared to stygofauna. Nevertheless, moderately speciose troglofaunal communities have been documented elsewhere in the Yilgarn and Midwest.

Notably, a rich troglofaunal community was documented in calcrete above the water table around Yeelirrie (45 species, Bennelongia 2015), while 20 species of troglofauna were recorded in calcretes around Lake Way (Outback Ecology 2012). It is reasonable to expect that troglofaunal communities of at least moderate richness occur in large calcretes in the region surrounding the Project.

Survey in alluvial, colluvial and granitoid geologies within and adjacent to mapped palaeovalleys at Gifford Creek recorded at least 13 species (Bennelongia 2018b). It is considered likely that a low to moderate diversity of troglofauna species may exist in the alluvial and colluvial deposits adjacent to the Project, though depending on depths to water, the volume of available habitat and consequently the number of constituent species may be limited. It is expected that species occupying alluvial and colluvial geologies will have moderately extensive ranges due to the extent and likely connectivity of these habitats.

BIF is recognised as a prime habitat for troglofauna and, although most surveys to date in WA have occurred in the Pilbara (e.g. Bennelongia 2016b, 2017a; Biota 2006), sampling at Bungalbin in the Yilgarn recorded at least 17 species (Bennelongia 2016a). Depending on the degree to which subterranean spaces have developed through weathering, the BIF and granite geologies within the Project area may offer prospective habitat to troglofauna.

6. POTENTIAL IMPACTS

The potential impacts of mining and related operations on subterranean fauna can be broadly divided into primary impacts, namely the impacts causing possible extinction or threat to the persistence of local populations through direct removal of habitat, and secondary impacts that alter or degrade habitat rather than remove it, thereby reducing population densities.

Secondary impacts include pollutants, altered water chemistry, mine blasting and changes to energy and nutrient pathways. Assessing the threat of potential secondary impacts generally requires detailed physicochemical information on the environmental changes expected to occur.

The specific potential impacts on subterranean fauna species of the Project will depend on:

- Layout, depth and spatial extent of mine pits;
- Requirement for mine pit dewatering;
- Requirement for and location of water supply borefields; and
- Maximum spatial and vertical extents of groundwater drawdown.

6.1. Stygofauna

The most common factor causing the removal of habitat for stygofauna is drawdown of the watertable, either from mine pit dewatering (if required), or groundwater production in supply borefields. The threat to an individual species will depend on the relationship between its distribution and the spatial and vertical magnitude of drawdown.

If a species occurs outside the spatial extent of drawdown influence, its persistence will not be threatened, although local populations within the drawdown area may face extinction. The threat of extinction for a species restricted to the area of drawdown influence is greater, although persistence may still be possible if the habitat of the species extends below the depth of drawdown. For example, if a species occupies habitat between depths of 10 m and 20 m and the water table stands at 15 m following drawdown, half of the habitat of the species will remain intact (ignoring secondary impacts).

Determining the specific habitat of a species is difficult and usually relies on detailed geological information from collection bores, such as lithological logs, in combination with knowledge of screened depths allowing the ingress of stygofauna into the bore from the surrounding aquifer. It is usually not possible to determine a specific collection depth for stygofauna, unless bore casing at a collection site is screened within a single lithology. As a result, it is much simpler to demonstrate persistence by collecting a species outside the area of drawdown influence.

6.2. Troglofauna

The main factor causing the removal of habitat for troglofauna is the excavation of mine pits. As for stygofauna, the level of threat to a troglofauna species depends on its distribution relative to the spatial and vertical extent of excavations.

Sampling for troglofauna is undertaken in uncased drill holes and determining the depth at which troglofauna species have been collected can be somewhat easier than for stygofauna, depending on the collection method. Assuming that lithological logs are available, collection via trapping more or less allows the habitat of a species to be defined because trap depth is recorded (although migration by individual animals towards the trap cannot be accounted for). Collection via scraping does not allow for precise determination of collection depths, other than the fact that troglofauna are collected somewhere between surface and the water table.

7. CONCLUSIONS

The following conclusions are drawn based on the desktop review:

- Large bodies of calcrete outside the immediate vicinity of the Project are highly prospective for stygofauna and are also prospective for troglofauna.

- Aquifers in alluvium, colluvium and calcrete (if present) adjacent to the Project (including within Vango tenements) are prospective for stygofauna.

- The same geologies are prospective for troglofauna but are likely to harbour relatively few species that are expected to be moderately widespread.

- Geological units within the greenstone belt that hosts the Project are considered moderately prospective for troglofauna, although there is currently limited habitat information in this area regarding the development of subterranean spaces.

- The greenstone belt has a low prospectivity for stygofauna, mainly due to depth to water, though information is currently limited.

- The potential for impacts leading to habitat removal and extinction will depend on the design and layout of the Project, extent of impacts (groundwater drawdown and pit excavation) and the ranges of species present.

8. REFERENCES

Bennelongia (2009) Yilgarn Iron Ore Project: Carina deposit, subterranean fauna assessment. Report 2009/69, Bennelongia Pty Ltd, Jolimont, WA, 30 pp.

Bennelongia (2015) Yeelirrie Subterranean Fauna Assessment. Report 2015/236, Bennelongia Pty Ltd, Jolimont, WA, 33 pp.

Bennelongia (2016a) J5 and Bungalbin East Project: Additional Troglofauna Investigation. Report 2016/287, Bennelongia Pty Ltd, Jolimont, WA, 33 pp.

Bennelongia (2016b) Mining Area C – Southern Flank: Troglofauna Assessment. Report 2016/275, Bennelongia Pty Ltd, Jolimont, WA, 46 pp.

Bennelongia (2016c) Pilgangoora Project: subterranean fauna desktop and Level 1 assessment. Reort 272, Bennelongia Pty Ltd, Jolimont, 34 pp.

Bennelongia (2017a) Addendum based on updated habitat assessment. Mining Area C and Southern Flank Environmental Impact Assessment. Bennelongia Pty Ltd, Jolimont, WA, 6 pp.

Bennelongia (2017b) Mt Morgans Gold Project: Subterranean Fauna Assessment. Report 2016/273, Bennelongia Pty Ltd, Jolimont, WA, 60 pp.

Bennelongia (2018a) Christmas Creek Iron Ore Mine Distribution of Potentially Restricted Subterranean Fauna Species (MS 1033). 313, Bennelongia Environmental Consultants, Jolimont, WA, 49 pp.

Bennelongia (2018b) Yangibana Rare Earths Project: Subterranean Fauna Assessment. 293, Bennelongia Pty Ltd, Jolimont, WA, 38 pp.

Biota (2006) Mesa A and Robe Valley Mesas Troglobitic Fauna Survey - Subterranean Fauna Assessment. Biota Environmental Sciences, Leederville, WA, 80 pp.

Boulton, A.J., Fenwick, G.D., Hancock, P.J., and Harvey, M.S. (2008) Biodiversity, functional roles and ecosystem services of groundwater invertebrates. *Invertebrate Systematics* **22**, 103-116.

Cho, J.-L., Park, J.-G., and Reddy, Y.R. (2006) Brevisomabathynella gen. nov. with two new species from Western Australia (Bathynellacea, Syncarida): the first definite evidence of predation in Parabathynellidae. *Zootaxa* **1247**, 25-42.

Coker, J., and Faulkner, J.A. (1999) Geochemical Mapping of the Collier 1:250 000 Map Sheet. Geological Survey of Western Australia, Perth, WA, 69 pp.

Eberhard, S.M., Halse, S.A., and Humphreys, W.F. (2005) Stygofauna in the Pilbara, north-west Western Australia: a review. *Journal of the Royal Society of Western Australia* **88**, 167-176.

Eberhard, S.M., Watts, C.H.S., Callan, S.K., and Leijs, R. (2016) Three new subterranean diving beetles (Coleoptera: Dytiscidae) from the Yeelirrie groundwater calcretes, Western Australia, and their distribution between several calcrete deposits including a potential mine site. *Records of the Western Australian Museum* **31**, 27-40.

EPA (2016a) Environmental Factor Guideline - Subterranean Fauna. Environmental Protection Authority, Perth, WA, 5 pp.

EPA (2016b) Technical Guidance - Subterranean fauna survey. Environmental Protection Authority, Perth, WA, 24 pp.

Finston, T.L., Johnson, M.S., Humphreys, W.F., Eberhard, S.M., and Halse, S.A. (2007) Cryptic speciation in two widespread subterranean amphipod genera reflects historical drainage patterns in an ancient landscape. *Molecular Ecology* **16**, 355-365.

Fontaneto, D., Barraclough, T.G., Chen, K., Ricci, C., and Herniou, E.A. (2008) Molecular evidence for broad-scale distributions in bdelloid rotifers: everything is not everywhere but most things are very widespread. *Molecular Ecology* **17**, 3136-3146.

Fontaneto, D., Kaya, M., Herniou, E.A., and Barraclough, T.G. (2009) Extreme levels of hidden diversity in microscopic animals (Rotifera) revealed by DNA taxonomy. *Molecular Phylogenetics and Evolution* **53**, 182-189.

Gibert, J., and Deharveng, L. (2002) Subterranean ecosystems: a truncated functional biodiversity. *BioScience* **52**, 473-481.

Guzik, M.T., Austin, A.D., Cooper, S.J.B., *et al.* (2010) Is the Australian subterranean fauna uniquely diverse? *Invertebrate Systematics* **24**, 407-418.

Halse, S.A., 2018. Research in calcrete and other deep subterranean habitats outside caves. In: OT Moldovan, L Kovac and S Halse (Eds.), Cave ecology. Springer nature, Cham, Switzerland, pp. 415-434.

Halse, S.A., Scanlon, M.D., Cocking, J.S., Barron, H.J., Richardson, J.B., and Eberhard, S.M. (2014) Pilbara stygofauna: deep groundwater of an arid landscape contains globally significant radiation of biodiversity. *Records of the Western Australian Museum* **Supplement 78**, 443-483.

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

Harvey, M.S., and Leng, M.C. (2008) The first troglomorphic pseudoscorpion of the family Olpiidae (Pseudoscorpiones), with remarks on the composition of the family. *Records of the Western Australian Museum* **24**, 387-394.

Hong, S.J., and Cho, J.-L. (2009) Three new species of Billibathynella from Western Australia (Crustacea, Syncarida, Parabathynellidae). *Journal of Natural History* **43**, 2365-2390.

Hose, G.C., Sreekanth, J., Barron, O., and Pollino, C. (2015) Stygofauna in Australian Groundwater Systems: Extent of knowledge. CSIRO, Australia, 71 pp.

Humphreys, W.F. (2001) Groundwater calcrete aquifers in the Australian arid zone: the context of an unfolding plethora of stygal biodiversity. *Records of the Western Australian Museum* **Supplement 64**, 63-83.

Hyde, J., Cooper, S.J.B., Humphreys, W.F., Austin, A.D., and Munguia, P. (2018) Diversity patterns of subterranean invertebrate fauna in calcretes of the Yilgarn Region, Western Australia. *Marine and Freshwater Research* **69**, 114-121.

King, R.A., Bradford, T., Austin, A.D., Humphreys, W.F., and Cooper, S.J.B. (2012) Divergent Molecular Lineages and Not-So-Cryptic Species: The First Descriptions of Stygobitic Chiltoniid Amphipods (Talitroidea: Chiltoniidae) from Western Australia. *Journal of Crustacean Biology* **32**, 465-488.

Korbel, K.L., and Hose, G.C. (2015) Habitat, water quality, seasonality, or site? Identifying environmental correlates of the distribution of groundwater biota. *Freshwater Science* **34**, 329-343.

Morris, P.A., Sanders, A.J., and Faulkner, J.A. (1997) Geochemical Mapping of the Nabberu 1:250 000 Sheet. Geological Survey of Western Australia, Perth, WA, 107 pp.

Outback Ecology (2012) Toro Energy Ltd Wiluna Uranium Project subterranean fauna assessment. Outback Ecology Services, Jolimont, WA, 95 pp.

Ponder, W.F., and Colgan, D.J. (2002) What makes a narrow-range taxon? Insights from Australian freshwater snails. *Invertebrate Systematics* **16**, 571-582.

Stantec (2017a) Ethel Gorge Stygofauna Monitoring Program: 2017. Stantec, Jolimont, 57 pp.

Stantec (2017b) Mount Keith Satellite Operations: Stygofauna Assessment. Stantec Australia Pty Ltd, Jolimont, WA, 94 pp.

Subramanya, A.G., Faulkner, J.A., Sanders, A.J., and Gozzard, J.R. (1995) Geochemical Mapping of the Peak Hill 1:250 000 Sheet. Geological Survey of Western Australia, Perth, WA, 100 pp.

Vango (2017) Mine closure plan. Marymia Gold Mine - Plutonic Dome. Vango Mining Ltd, Sydney, NSW, 177 pp.

Watts, C.H.S., and Humphreys, W.F. (2009) Fourteen new Dytiscidae (Coleoptera) of the genera *Limbodessus* Guignot, *Paroster* Sharp, and *Exocelina* Broun from underground waters in Australia. *Transactions of the Royal Society of South Australia* **133**, 62-107.

Williams, I.R. (1995) Bullen, Western Australia (2nd Edition): 1:250 000 Geological Series Explanatory Notes. Geological Survey of Western Australia, Perth, WA, 30 pp.