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Department of Mines, Industry Regulation and Safety
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To Whom It May Concern

Application for a Native Vegetation Clearing Permit for the Paradigm Gold Mine – M16/548

Evolution Mining (Mungari) Pty Ltd (Evolution), a wholly owned subsidiary of Evolution Mining Limited, proposes to restart mining operations at the Paradigm Gold Mine (Paradigm) as part of the existing Mungari Gold Operations (MGO).

This letter has been prepared to support an application for a Purpose Native Vegetation Clearing Permit (NVCP), pursuant to Section 51E of the *Environmental Protection Act 1986* (EP Act).

The total proposed Disturbance Envelope comprises land within Mining Tenement M16/548, held by Evolution. This application seeks to allow an area of up to 300 hectares (ha) to be cleared within the Disturbance Envelope. This clearing is required to develop the proposed Paradigm Gold Mine which will feed ore to the Mungari Processing Plant (Mungari Mill).

An application to clear the Carbine/Paradigm project was submitted on 10 August 2018 by Northern Star Resources and subsequently granted on 27 September 2018 (CPS8165/1). Due to Evolution Mining acquiring this project in August 2021 and clearing permits not being transferrable between the entities – this application is therefore being resubmitted using the same background information that was assessed as part of the application process in 2018 by Northern Star Resources, as it is still considered current.

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1.0 Location

The Project area is located in the Goldfields region of Western Australia, approximately 60 km to the north-west of the City of Kalgoorlie-Boulder, and approximately 17 km to the south-west of Ora Banda (**Figure 1-1**)**.** Mined ore will be transported to the MGO for processing.

The registered tenement holder for the Mining Lease (M16/548) associated with this Project is **Kundana Gold Pty Ltd**, a wholly owned subsidiary of Evolution Mining (**Table 1-1**).

Table 1-1: Tenement holders of the Project Area

Tenement	Holder	Expiry Date	Area (ha)
M16/548	Kundana Gold Pty Ltd	31/07/2038	1,896.5

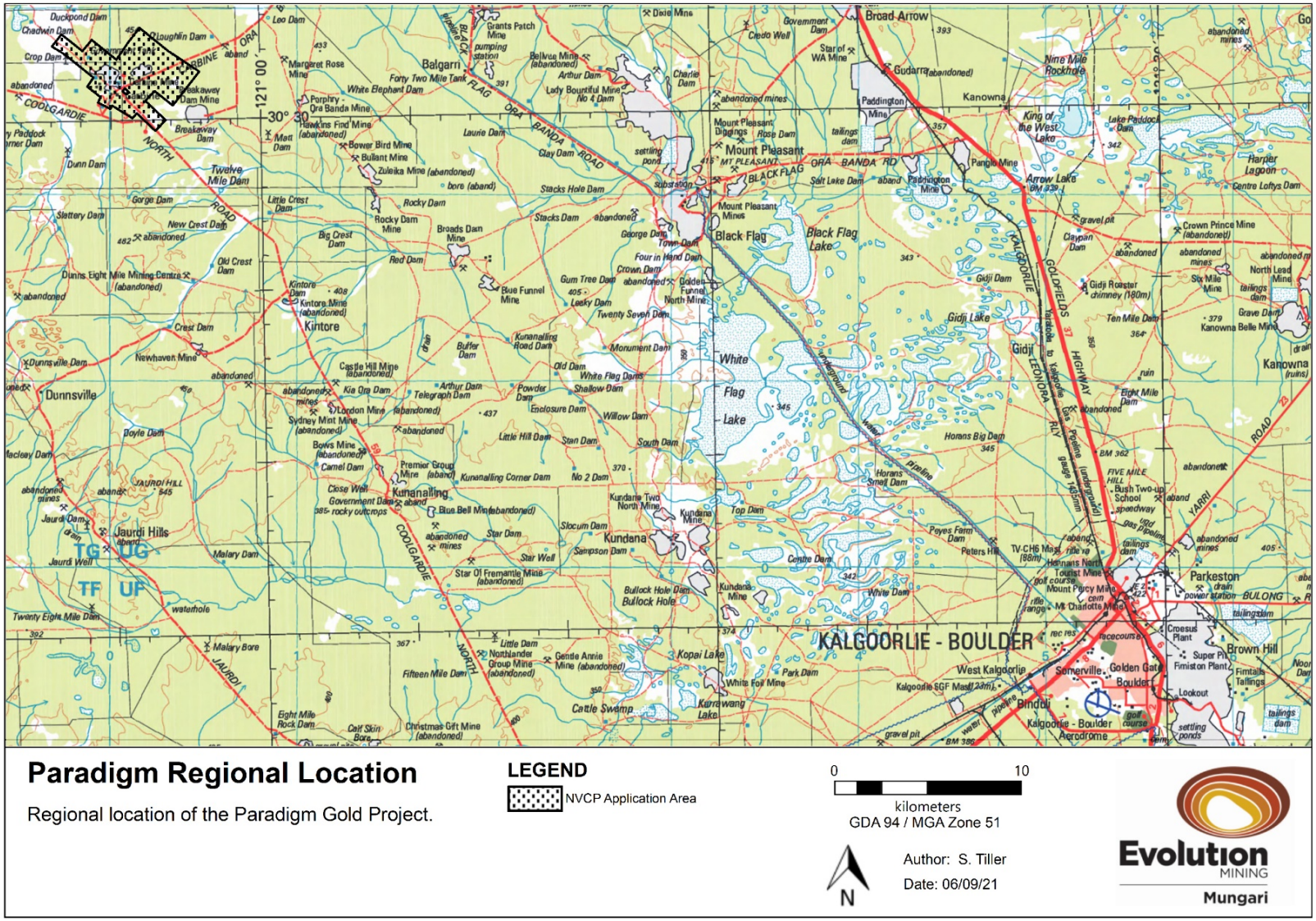


Figure 1-1: Regional Location Map of the Project

2.0 Project Description

Evolution Mining (Evolution) proposes to develop the Paradigm Gold Mine Project. The Paradigm deposit has been previously mined from 2002 to 2007 through the development of an open cut pit and associated underground workings. The Paradigm Gold Mine Project involves development of a new open cut pit to the north of the existing pit and potential for further underground workings. Excavated mine waste rock from the open cut pit and underground mine will be disposed of within a new Waste Rock Landform (WRL) to the east of the mine pit, and ore produced will be transported via road trains to Evolution Mining's Mungari Processing Plant.

The **Paradigm Mining Proposal (Reg ID 77054)** was approved by the Department of Mines, Industry regulation and Safety (DMIRS) in April 2019. The current mining proposal provides for an indicative 136 ha of disturbance, within the disturbance envelope.

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

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

As there is potential for this project to expand in the future, it is requested that up to **300 ha** of clearing is provided on the clearing permit to allow the flexibility to expand the project footprint without the requirement for seeking amendment if changes to design remain within the proposed disturbance envelope. The disturbance layout and indicative design is shown in **Figure 2-1.**

Figure 2-1: Map of Disturbance Envelope

3.0 Existing Environment

The Paradigm Gold Mine Project Area is located approximately 60km north-west of Kalgoorlie-Boulder in the Goldfields region of Western Australia (**Figure 1-1**). This region is located within the Murchison Province of the Interim Biogeographic Regionalisation for Australia (IBRA) scheme, which covers approximately 304,875km^2 and includes the mid-west and northern Goldfields.

The Project area is situated on the Mt Burges Pastoral Lease (N050354). Active stakeholder engagement has been undertaken with the Pastoral Manager informing him of the proposed mining related activities in the area. Due to the level of historic activity in the area, this Project is expected to have a negligible impact on pastoral activities.

The closest Reserves are Rowles Lagoon located approximately 8km north-west of the Project area, and a water reserve located approximately 6km north-east of the Project. A parcel of land surrounding Phantom pit area is Unallocated Crown Land.

3.1 Climate

The climate for the Kalgoorlie Region (Kalgoorlie Airport – Station No. 012038) is classified as semi-arid with hot dry summers and moderately cool winters. Annual rainfall varies from around 200mm to 300mm, with an average of approximately 270 mm/year. Rainfall is distributed fairly evenly throughout the year with an average monthly rainfall of approximately 23mm, whilst pan evaporation is greatest in the summer months and lowest during winter.

Pan evaporation greatly exceeds rainfall with an average annual pan evaporation of around 2,600 mm. Although the average pan evaporation exceeds rainfall for the majority of the year intense rainfall events associated with cyclonic activity results in monthly rainfalls often exceeding pan evaporation.

3.1 Geology

The Project survey area is located in the central part of the Archaean Norseman-Wiluna greenstone belt in Western Australia. It is located in the northern section of the 250km long, regionally significant Zuleika Shear which contains a number of significant gold mines along its length. The belt is characterised by thick sequences of ultramafic, mafic, and felsic volcanics, as well as various intrusive and sedimentary rocks. Generally, the mafic and ultramafic units occur at the base of the sequence, with the felsic volcanic to volcaniclastic rocks overlying these. Mineralisation in the area is interpreted to be a splay from the main Zuleika Shear.

The main mineralisation targeted by the proposed development of the deposit occurs in a north trending array of stacked quartz veins and quartz-sulphide stock work. This stockwork and veining is held within a sequence of intermediate volcaniclastic sediments, which has seen extensive weathering in the upper 50m.

3.1 Soils

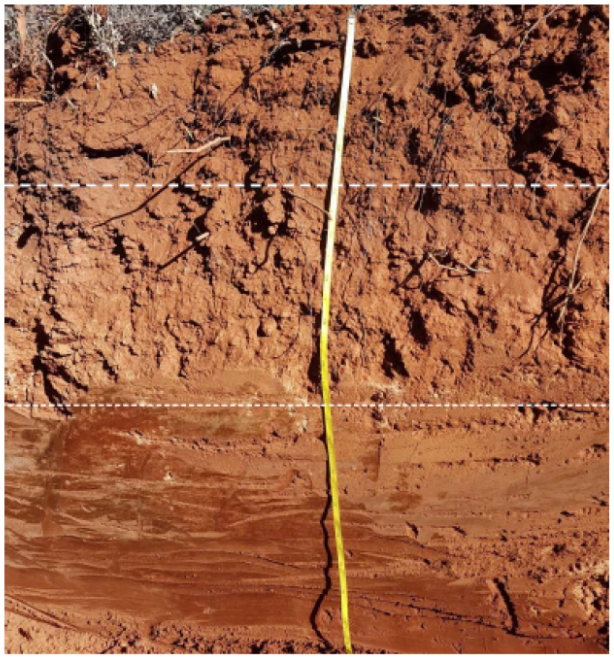
The survey area lies within the Kalgoorlie Province, which is further divided into seven soil-landscape zones. The Project area is located within the Kambalda Zone (265).

The Kambalda Zone is characterised by flat to undulating plains (with hills, ranges and some salt lakes and stony plains) on greenstone and granitic rocks of the Yilgarn Craton. Soils are calcareous loamy earths and red loamy earths with salt lakes soils and some red brown hardpan shallow loams and red sandy duplexes. Vegetation includes red mallee blackbutt salmon gum-gimlet woodlands with mulga and halophytic shrublands (and some spinifex grasslands). This zone is located in the south-eastern Goldfields between Menzies, Norseman and the Fraser Range.

A soil characterisation study was undertaken by Soil Water Consultants (SWC) in July 2018 to identify and characterise the range of surface soils across the proposed disturbance areas, and to assess their suitability for use in constructing the outer surfaces of the WRD in rehabilitation activities.

Based on the depositional history of the study area and the morphological characteristics of the soil profiles exposed by trench excavation, just one distinct Soil Mapping Unit (SMU) was defined – *Reddish Brown Duplex*. The soils encountered within the 7 separate investigation locations were generally uniform across the study disturbance area, consisting of varying depths of a reddish-brown sandy loam (between 80cm and 140cm) over stiff brown to red sandy clay. Assessed profiles generally only varied with the thickness of the lower sandy loam layer which contained calcareous nodules. This layer generally appeared at the base of the sandy loam directly overlying the more impermeable underlying stiff clays but varied in thickness from approximately 1m down to being almost absent in one trench location (Trench 5). However, in general the profiles encountered can be said to be uniform across the study area.

A characteristic soil profile through the red brown loam into the clay showing the duplex nature of the profile is presented in **Figure 3-1**, along with summary statistics on key physical, chemical and hydraulic properties.



Depth (cm)	Unit	Description
0		
	Upper loam	Reddish brown loamy sand with minor sub-rounded to rounded pisolithic gravels (<10 percent); horizon has a friable earthy fabric and is weakly coherent with abundant fine roots and common large lateral roots (1-2 cm diameter)
40		
	Lower loam	Reddish brown sandy loam to clay loam with common calcareous mottling; weakly structured with an earthy fabric. Abundant fine roots throughout. Boundary to underlying hard clay.
80-100		
	Clay	Reddish brown stiff sandy clay to clay. Massive structure with isolated fine to medium roots evident throughout. Minor mottling

Physical properties

Depth (cm)	Structure	Particle size distribution (< 2mm)				Gravel %	Field	Ksat	Structural stability	
		Sand (%)	Silt (%)	Clay (%)	Texture	(> 2mm)	Moisture (%)	(m/day)	Macro (slaking)	Micro (dispersive)
0-40	Granular	77.7	11.9	10.4	Loamy sand	24.9	5.6	0.33	good	good
40-100	Granular	68.7	11.2	20.1	Sandy loam – clay loam	14.2	7.6	0.09	moderate	moderate
100+	Massive	57.6	8.8	33.6	Sandy clay - clay	3.2	13.5	0.01	moderate	moderate

Chemical Properties

Depth (cm)	Nutrients (mg/kg)					Organic C (%)	Exchangeable Cation (meq/100g)					ESP (%)
	NO_3 - N	NH_4 - N	Colwell P	Colwell K	Ext. S		Ca	K	Mg	Na	CEC	
0-40	7	<1	4	300	5	0.58	11.5	2.96	0.73	0.51	15.75	3.0
40-100	58	<1	<2	214	128	0.16	11.2	2.7	2.8	2.8	19.6	13.9
100+	98	<1	<2	257	282	0.11	6.97	0.4	5.67	1.69	14.73	11.5

Figure 3-1: Characteristic soil profile (SWC, 2018)

3.1 Hydrology

3.1.1 Surface Water

According to the Geoscience Australia database (2001) there are no drainage lines or inland waters within the Project area. Much of the drainage within the Murchison Province is ephemeral, with >80% of the surface drainage flowing to the west into the Murchison, Wooramel and Greenough River Catchments, and subsequently to the Indian Ocean. The remainder of the drainage flows to inland salt-lake systems. Generally, the major drainage systems have broad flood plains.

The Paradigm deposit is located near the top of a catchment divide between the Black Flag palaeodrainage to the east, and an internal drainage system to the west that includes Carnage Lake, Clear Lake and Rowles Lagoon. It lies on generally flat, gently sloping ground (gradient approximately 1-in-100). There are no drainage lines in the local area that could concentrate runoff. Even in a major runoff event, surface water flows would be of limited depth and velocity.

A hydrology and surface water assessment of the Project was carried out by Rockwater Hydrogeological and Environmental Consultants (Rockwater) in August 2018. The aim of the study was to identify catchment areas, assess the potential impact of flood flows on the surface infrastructure and pit, and determine bunding and drainage requirements.

3.1.2 Groundwater

Groundwater quality and quantity is variable within the Province. The local groundwater in the Project area is naturally saline to hypersaline with high TDS concentrations (up to 90,000 mg/L). Based on drilling assessments and previous studies, groundwater levels are at a depth of approximately 40m. Due to the depth of the water table and groundwater quality there are no known groundwater dependent ecosystems in the area, and no beneficial users of the groundwater other than for use in pastoral and mining related activities.

3.2 Flora and Vegetation

3.2.1 Vegetation Associations

The Department of Agriculture and Food Western Australia (DAFWA) GIS file (2011) indicates that the survey area is located within Pre-European Beard vegetation associations Kunanalling 468 and 555. The extent of these vegetation associations, as specified in the 2015 Statewide Vegetation Statistics (DPaW, 2015) is provided in **Table 3-1** both vegetation associations retain approximately >98% of the original vegetation extent. Clearing within these vegetation associations are not likely to lead to land degradation issues such as salinity, water logging or acidic soils.

Table 3-1: Pre-European Vegetation Associations

Vegetation association	Pre-European extent remaining (%)	% of Current extent within DBCA managed lands	Vegetation Description (Beard, 1990)
Kunanalling 468	98.30	53.70	Medium woodland; salmon gum & goldfields blackbutt
Kunanalling 555	98.83	50.36	Hummock grassland, mallee steppe; red mallee over spinifex *Triodia scariosa*

3.2.2 Vegetation Types

Twelve broad vegetation types were identified within the survey area which were represented by a total 23 Families, 43 Genera and 94 Taxa, including sub-species and variants. These vegetation types were identified within four landform types and comprised of four major vegetation groups according to the NVIS, Major Vegetation Group (MVG) definition. These vegetation types are defined in **Table 3-2** below and shown spatially in **Figure 3-2**. The vegetation units present do not represent threatened ecological communities (TEC) or priority ecological communities (PEC) listed by the Department of Biodiversity, Conservation and Attractions (DBCA) (Botanica 2018).

Table 3-2: Summary of Vegetation Types present

Landform	NVIS Veg Group	Code	Vegetation Type	Area (ha)	Area (%)
Clay-Loam Plain	Casuarina Forests & Woodlands	CLP-CFW1	Low open forest of *Casuarina pauper* over mid open shrubland of *Acacia hemiteles* and low open shrubland of *Olearia muelleri/ Scaevola spinescens* on clay-loam plain	65	3.4
		CLP-CFW2	Low open woodland of *Casuarina pauper* over mid chenopod shrubland of *Maireana sedifolia/ M. pyramidata* and low open forbland of *Sclerolaena diacantha* on clayloam plain	66	3.5
	Eucalypt Woodland	CLP-EW1	Mid woodland of *Eucalyptus salubris* over mid shrubland of *Eremophila scoparia* and low open shrubland of *Olearia muelleri/* low open forbland of *Sclerolaena diacantha* on clay-loam plain	341	17.9
		CLP-EW2	Mid woodland of *Eucalyptus clelandiorum/ E. transcontinentalis* over mid open shrubland of *Acacia hemiteles/ Eremophila caperata* and low open shrubland of *Eremophila parvifolia/ Olearia muelleri* on clay-loam plain	305	16
		CLP-EW3	Mid woodland of *Eucalyptus salmonophloia* over mid open shrubland of *Acacia hemiteles/ Eremophila scoparia* and low open shrubland of *Ptilotus obovatus* on clay loam plain	528	27.7
		CLP-EW4	Low open forest of *Eucalyptus ravida* over mid sparse shrubland of *Eremophila scoparia* and low chenopod shrubland of *Maireana oppositifolia/* low shrubland of *Ptilotus obovatus* on clay-loam plain	103	5.4
		CLP-EW5	Mid open woodland of *Eucalyptus salmonophloia* over mid sparse shrubland of *Eremophila interstans* subsp. *virgata* and low chenopod shrubland of *Maireana sedifolia/ Atriplex nummularia* subsp. *spathulata* on clay-loam plain	34	1.8
	Eucalypt Woodlands/ Mallee Woodlands & Shrublands	CLP-EW/MWS1	Low woodland of *Eucalyptus clelandiorum*/ Open mallee woodland of *E. griffithsii/ E. oleosa* over mid open shrubland of *Eremophila caperata* and low open shrubland of *Scaevola spinescens/ Senna artemisioides* subsp. *filifolia* on clay-loam plain	102	5.4
Closed Depression	Chenopod Shrublands, Samphire Shrublands and Forblands	CD-CSSSF1	Isolated *Eucalyptus clelandiorum/ E. celastroides* over mid sparse shrubland of *Melaleuca lateriflora* and samphire shrubland of *Tecticornia disarticulata/T. halocnemoides* in closed depression	3	0.2
Hillslope	Eucalypt Woodlands	HS-EW1	Mid woodland *Eucalyptus clelandiorum/E. oleosa* over mid open shrubland of *Eremophila caperata* and low sparse shrubland of *Cratystylis conocephala/ Eremophila pustulata* on hillslope	114	6
		HS-EW2	Mid open woodland of *Eucalyptus salubris/E. clelandiorum* over mid sparse shrubland of *Eremophila* sp. Mt Jackson (G.J. Keighery 4372) and low sparse shrubland of *Cratystylis subspinescens* on hillslope	34	1.8
Open Depression	Eucalypt Woodlands	OD-EW1	Mid woodland of *Eucalyptus salmonophloia* over mid open shrubland of *Acacia hemiteles/ Eremophila scoparia* and low open shrubland of *Ptilotus obovatus* in open depression	20	1.1
N/A	N/A	CV	Mining Disturbance	189	9.9
TOTAL				**1903**	**100**

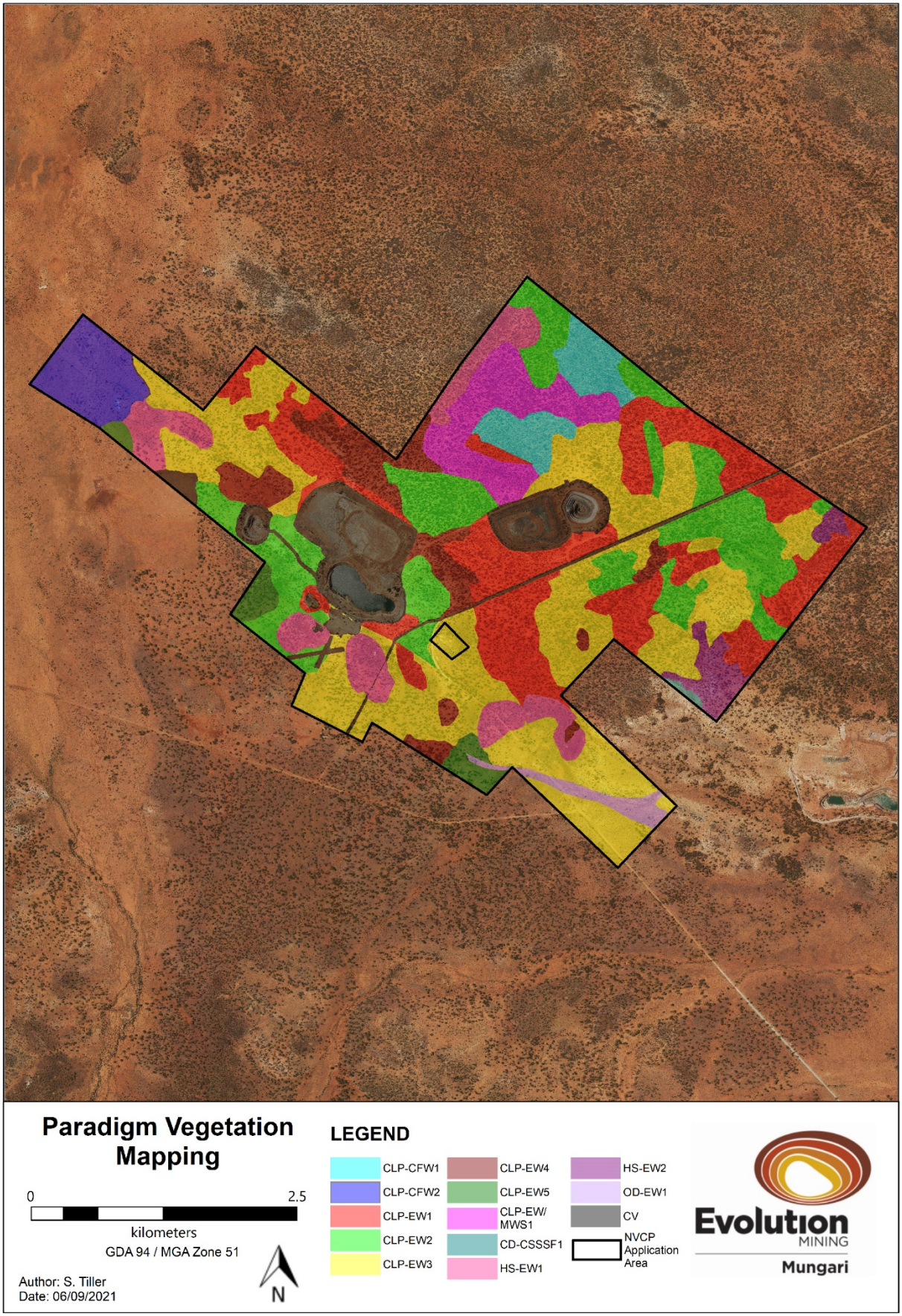


Figure 3-2: Map of Vegetation Types

3.2.3 Vegetation Condition

Based on the vegetation condition rating scale adapted from Keighery, 1994 and Trudgen, 1988, ten of the twelve vegetation types were rated as 'good' (**Table 3-3**). The remaining two groups were rated as 'very good'. Approximately 189 ha of the survey area (9.9%) was completely degraded from previous mining activities.

Table 3-3: Vegetation condition classifications

Vegetation condition	% of Study Area	Description
Pristine	0	Pristine or nearly so, no obvious signs of damage caused by human activities since European settlement.
Excellent	0	Vegetation structure intact, disturbance affecting individual species. Damage to trees caused by fire, the presence of non-aggressive wees and occasional vehicle tracks.
Very Good	3.6	Vegetation structure altered, obvious signs of disturbance. Disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback, logging and grazing.
Good	86.5	Vegetation structure significantly altered by obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate it. Disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds, partial clearing, dieback and grazing.
Degraded	0	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management. Disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds at high density, partial clearing, dieback and grazing.
Completely Degraded	9.9	The structure of the vegetation is no longer intact, and the area is completely or almost completely without native species. These areas are often described as 'parkland cleared' with the flora comprising weed or crop species with isolated native trees or shrubs.

(Keighery, BJ (1994) Bushland Plant Survey)

3.2.4 Conservation Significant Flora

No Threatened or other significant flora taxa were recorded in the Project Area during the Botanica survey (Botanica, 2018).

No Threatened or Priority Ecological Communities or otherwise significant vegetation were identified within the Project Area (Botanica, 2018).

3.2.5 Introduced Flora and Weeds

Four introduced taxa were identified within the survey area:

- *Carthamus lanatus* (Saffron Thistle)
- *Dittrichia graveolens* (Stinkwort)
- *Salvia verbenaca* (Wild Sage)
- *Cucumis myriocarpus* (Prickly Paddy Melon)

According to the Department of Primary Industries and Regional Development (DPIRD) none of these taxa are listed as a Declared Plant under the *Biosecurity and Agriculture Management* (BAM) *Act 2007.*

3.3 Fauna

3.3.1 Fauna Habitat

Seven broad scale terrestrial fauna habitats are present in the Project Area based on vegetation and associated landforms identified during the flora and vegetation assessment (**Figure 3-3**). All habitat types are commonly recorded in the region and are not restricted to the study area.

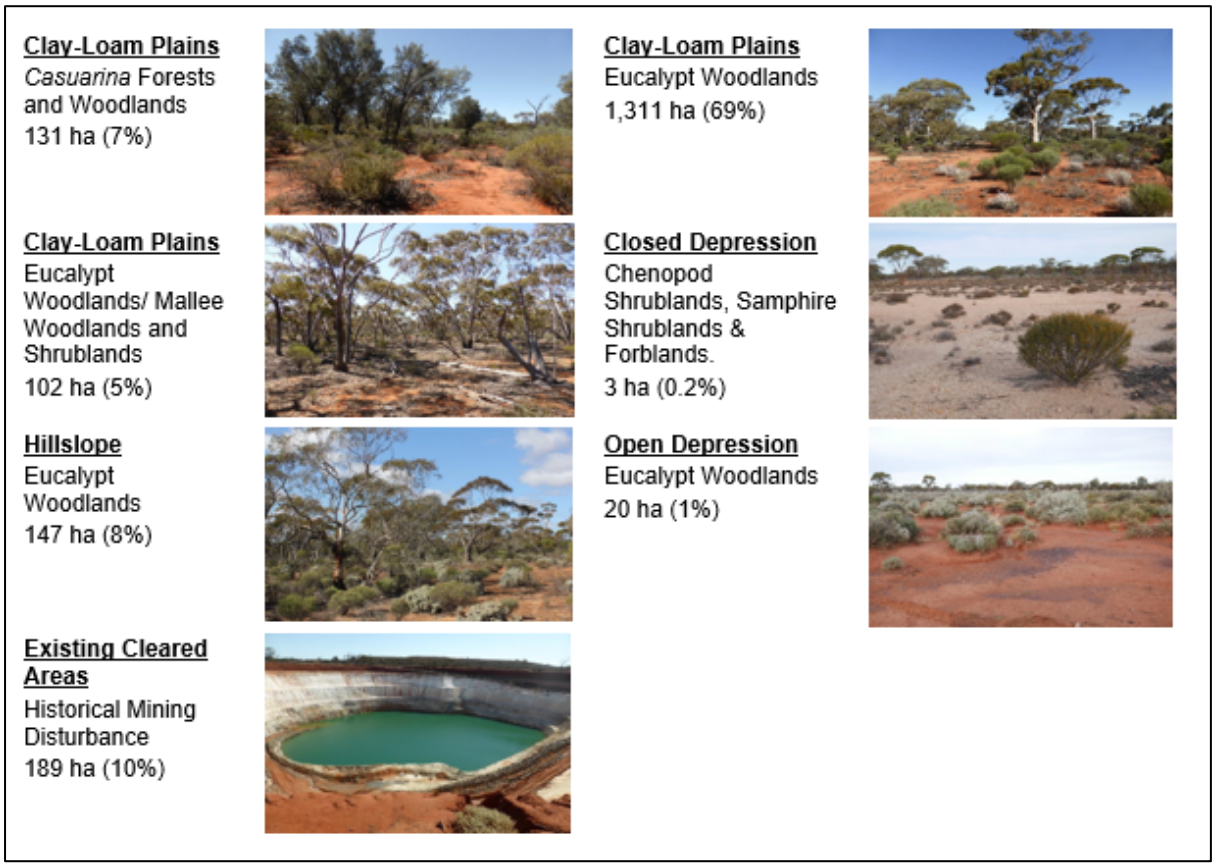


Figure 3-3: Summary of Fauna Habitats

3.3.2 Conservation Significant Fauna

No fauna of conservation significance was identified within the Project Area. The current status of some species on site and/or in the general area is difficult to determine, however, based on the habitats present and, in some cases, direct observations or recent nearby records, the following species of conservation significance can be regarded as possibly utilising the survey area for some purpose at times, these being:

- Peregrine Falcon (*Falco peregrinus*) – OS (BC Act);
- Central Long-eared Bat (*Nyctophilus major tor*) – P4 (DBCA Act); and
- Malleefowl (*Leipoa ocellata*) - Vulnerable (EPBC Act and BC Act).

A targeted survey for Malleefowl activity within the proposed clearing footprint was undertaken in September 2020. No evidence of Malleefowl activity (i.e. active or inactive mounds, tracks, feathers) was identified within the target survey area. No critical habitat for Malleefowl was identified within the target survey area (Botanica, 2020).

The habitat observed within the target survey area and the greater Permit Area is considered marginal and lacking sufficient cover to support breeding or critical habitat for Malleefowl. The vegetation was relatively sparse and has been impacted by historical mining/exploration activities and grazing (Botanica, 2020).

3.4 Heritage

The surrounding land is registered to the Native Title Claimants, the *Maduwongga* people (WC2017/001), the *Marlinyu Ghoorlie* people (WC2017/007) and the *Jardu Mar* People (WC2021/001) under the *Native Title Act 1993* (National Native Title Tribunal, 2019). An archaeological and ethnographic survey was undertaken in April 2018, by R. & E. O'Connor Pty. Ltd.

Field surveys with the Aboriginal representatives established that there are no sacred, ritual or ceremonial Aboriginal sites within the Project area; nor are there any known burial sites or known former camping places within them. One site of significance was identified however this is well beyond the proposed disturbance footprint and will not be affected by the Project.

A search on the Department of Planning, Lands and Heritage (DPLH) database - Aboriginal Heritage Inquiry System (AHIS) in August 2021 revealed that there are no registered Aboriginal sites or Other Heritage Places within tenement M16/548.

4.0 Land Clearing Process

Clearing will be undertaken progressively using the following equipment and methodology.

4.1 Equipment

The equipment required to support and undertake clearing at the Project will include:

- Dozer;
- Loader;
- Excavator;
- Water Cart; and
- Service Vehicles.

4.2 Proposed Clearing Methodology

Prior to clearing, the disturbance footprint will be demarcated using high visibility tape or equivalent where suitable to ensure operators undertake clearing within the Development Envelope. Clearing will be undertaken using dozer or loader to remove vegetation, topsoil and overburden. Any salvaged vegetation and topsoil will be stockpiled for rehabilitation purposes. A spotter will be present at all times to ensure all clearing and disturbance is undertaken within the proposed clearing boundaries.

5.0 Assessment against the Ten Clearing Principles

An assessment of the proposed clearing activities within the Development Envelope against the ten clearing principles outlined in Schedule 5 of the EP Act is provided in **Table 5-1** below. This assessment was undertaken utilising the information provided in the supporting studies and Evolution's understanding of the area being applied for.

This assessment demonstrates that the proposed total clearing is not in variance with any of the ten clearing principles and, where required, management measures will be established to mitigate any potential unacceptable detrimental environmental harm.

Table 5-1: Assessment against the Ten Clearing Principles

Clearing Principle	Assessment of Proposed Activities Against Clearing Principles	Outcome
1. Native vegetation should not be cleared if it comprises a high level of biological diversity.	The Eastern Goldfields subregion is rich and diverse in its flora, however, most species (excluding Priority Flora species) are wide ranging and usually occur in at least one, and often several, adjoining subregions (Cowan, 2001). The Carbine-Paradigm EGS is not considered to comprise a high level or biological diversity as the vegetation is similar to the surrounding regions. None of the vegetation types identified during the 2018 survey were considered to have high local or regional significance (Botanica 2018).	**Not** at variance with the clearing principle.
2. Native vegetation should not be cleared if it comprises the whole or a part of, or is necessary for the maintenance of, a significant habitat for fauna indigenous to Western Australia.	No significant fauna was observed during the 2018 survey (Botanica 2018). Based on the habitats present, the following species of conservation significance can be regarded as possibly utilising the survey area for some purpose at times, these being: • Peregrine Falcon (*Falco peregrinus*) – OS (BC Act); • Central Long-eared Bat (*Nyctophilus major tor*) – P4 (DBCA Act); and • Malleefowl (*Leipoa ocellata*) – Vulnerable (EPBC Act and BC Act). Most fauna species occurring in the region tend to be wide ranging, with the exception of *Leipoa ocellata* (Malleefowl). Malleefowl are known to inhabit the Goldfields region, therefore, Evolution will commit to undertaking a targeted malleefowl survey in areas known to support malleefowl inhabitance prior to significant clearing occurring in the Carbine-Paradigm EGS to reduce impacts to the species and their breeding habitat. A targeted survey for Malleefowl activity within the proposed clearing footprint was undertaken in September 2020. No evidence of Malleefowl activity (i.e. active or inactive mounds, tracks, feathers) was identified within the target survey area. No critical habitat for Malleefowl was identified within the target survey area (Botanica, 2020). Strategies to reduce negative impact to this species include; monitoring active nests, removing inactive nests in high-risk areas (such as those located within the project's footprint or within 50m of an active haul road), reporting all malleefowl sightings to DBCA, erecting signage warning of malleefowl in the area and sharing information on malleefowl to all employees via information posters and toolbox topic talks.	**Not** at variance with the clearing principle.
3. Native vegetation should not be cleared if it includes or is necessary for the continued existence of rare flora.	No DRF/Threatened Flora species, pursuant to subsection (2) of section 23F of the *Wildlife Conservation Act 1950*, the *Environmental Protection and Biodiversity Conservation Act 1999* (*EPBC Act)* and as listed by DBCA have been identified in the areas proposed to be disturbed.	**Not** at variance with the clearing principle.
4. Native vegetation should not be cleared if it comprises the whole or a part of or is necessary for the maintenance of a threatened ecological community.	There are no known Threatened Ecological Communities (TECs) or Priority Ecological Communities (PECs) located within a 30 km radius of the project area. No Threatened or Priority Ecological Communities or otherwise significant vegetation were identified within the study area during the 2018 survey (Botanica 2018).	**Not** at variance with the clearing principle.
5. Native vegetation should not be cleared if it is significant as a remnant of native vegetation in	The area applied to be cleared is located within the Coolgardie bioregion (DSEWPaC, 2012). Dwarf shrublands of samphires persist on salt lakes, surrounded by diverse *Eucalyptus* woodlands, which also occur on ranges and in valleys.	**Not** at variance with the

Clearing Principle	Assessment of Proposed Activities Against Clearing Principles	Outcome
an area that has been extensively cleared	Two Pre-European vegetation associations have been identified as occurring within the survey area; Kunanalling 468 and Kunanalling 555. According to the DBCA both associations are considered to be of Least Concern from a conservation perspective. It is not considered the proposed disturbance area represents a significant portion of remnant vegetation, especially as the entire area to be disturbed lies over an active pastoral lease which supports the grazing of cattle and other pastoral activities.	clearing principle.
6. 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 watercourses or wetlands within the application area. The nearest watercourse or wetland is Rowles Lagoon Nature Reserve and Clear and Muddy Lakes Nature Reserve located approximately 2.5km to the north-west of the project area. There are no drainage lines in the local area that could concentrate runoff. Even in a major runoff event, surface water flows would be of limited depth and velocity (Rockwater 2018).	**Not** at variance with the clearing principle.
7. Native vegetation should not be cleared if the clearing of the vegetation is likely to cause appreciable land degradation.	Potential land degradation as a result of the proposed clearing may be minimised by the implementation of a staged clearing condition. All clearing will be under an approved Clearing Permit and clearing will be conducted with a staged approach, to avoid unnecessary or over-clearing. Areas to be cleared will be pegged out by the Survey Department and overseen by the Environment Department and Open Pit Supervisors to ensure clearing is appropriately managed as per relevant approvals.	**Not** at variance with the clearing principle.
8. 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.	The nearest conservation area is Rowles Lagoon Nature Reserve and Clear and Muddy Lakes Nature Reserve located approximately 2.5km to the north-west of the project area. Vegetation clearing and project operation will not impact the environmental value of these areas.	**Not** at variance with the clearing principle.
9. 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.	There are no drainage lines in the local area that could concentrate runoff. Even in a major runoff event, surface water flows would be of limited depth and velocity (Rockwater 2018). The climate of the region is semi-arid, with a low average rainfall of approximately 264mm per year. Drainage lines in the area are dry for most of the year, only flowing briefly immediately following significant rainfall. The groundwater of the region is hypersaline which is unsuitable for humans and or animal consumption and is noted at a depth of greater than 20m below ground level.	**Not** at variance with the clearing principle.
10. Native vegetation should not be cleared if clearing the vegetation is likely to cause, or exacerbate, the incidence or intensity of flooding.	The climate of the region is semi-arid, with a low average rainfall of approximately 264mm per year. Drainage lines in the area are dry for most of the year, only flowing briefly immediately following significant rainfall. The project will not exacerbate or intensify incidences of flooding. Culverts will be installed under haul roads where necessary to ensure surface flows are allowed to follow their natural pathway and surface water management features such as drains, sumps and sediment traps may be included to direct water back to natural surface water flow systems and prevent flooding.	**Not** at variance with the clearing principle.

6.0 Environmental Management

6.1 Environmental Approvals

The area has been previously disturbed by historical mining that occurred from 2002 to 2007. **Table 6-1** outlines all environmental approvals (existing and planned) for the Paradigm Project.

Table 6-1: Environmental Approvals, Licenses and Documentation

Document Title	Document ID	Date Approved
Paradigm Mining Proposal	Reg ID: 77054	26/04/2019
Groundwater License	GWL 104053(8)	09/10/2017
Works Approval	-	Application if needed

6.2 Threatened or Priority Flora and Fauna

In the instance where the proposed works unexpectedly intercept Threatened or Priority flora or fauna, Evolution will cease work and seek independent management advice.

6.3 Weed Species

Four introduced taxa were identified within the survey area. According to the Department of Primary Industries and Regional Development (DPIRD) none of these taxa are listed as a Declared Plant under the *Biosecurity and Agriculture Management* (BAM) *Act 2007.* To avoid the introduction and spread of weeds, the following management techniques will be implemented:

- Visual inspection of all vehicles and machinery prior to access to the site. In the event where any seeds or weeds are identified, they will be removed, contained and disposed of in an appropriate manner;
- Ensure no weed-affected soils or other material is brought into the area; and
- Restrict the movement of machines and other vehicles to the limits of the areas being cleared.

6.4 Feral and Pest Animals

Feral and pest animals such as stray cattle, wild dogs, cats, rabbits and mice are known to occur within Evolution's tenement package. Risks during operations include the advertent or inadvertent feeding of feral or pest populations, contributing to the humanisation of feral animals which increases risk of feral cats or groups of wild dogs approaching work sites, interactions with vehicles and destruction of habitat or native fauna or flora populations.

Strategies for minimisation include but are not restricted to:

- Training/toolbox topics to educate employees on the detrimental impact of feral animal populations and how to avoid encouraging humanisation; and
- How to identify and report sightings or feral or pest populations to the Environment Department for potential eradication strategies.

6.5 Fire

Due to Evolution's operations being located largely within surrounding bushland, bushfire presents a threat to all operations.

Strategies for minimisation include but are not restricted to:

- Ensuring all vehicles travel only on formed roads;
- Hot work activities take place within workshops or sufficiently cleared areas;
- Magazines, fuel bays and other high-risk storage areas are kept free of vegetation or other flammable matter; and
- Work programs consider the time of year/weather conditions (e.g. large-scale clearing is not undertaken during extreme heat or on a Total Fire Ban day).

6.6 Surface Water

Local catchment areas are minor, and therefore will not require any specific management. Surface water management will be undertaken with consideration the Paradigm Surface Water Management Plan (Rockwater, 2018) which involves directing any localised sheet flow around mine infrastructure.

6.7 Emissions

The construction and operation at the project will result in the emission of greenhouse gases from a wide range of activities including:

- Clearing of vegetation;
- Use of diesel fuel for mining and transport operations; and
- Power generation.

The effect of the particulates released from the combustion of fuel is expected to be negligible given the location of the area and the low population density.

6.8 Dust

Due to exposure of the ground surface as a result of the proposed works, there is a potential for fugitive dust to be generated on site. In order to ensure dust from the project areas do not cause a breach of the relevant environmental legislation, Evolution have a number of management strategies and control measures in place. These include:

- Clearing conducted only under suitable climatic conditions;
- Clearing will be minimised, and protective vegetation that provides a wind barrier will not be cleared unless necessary;
- Blasting will be conducted only under suitable climatic conditions;
- Vehicle traffic will be confined to established roads and tracks as much as possible;
- Dust will be suppressed by water carts using hypersaline water sourced from the nearest open pit;
- Ensure water suppression is occurring within pits during open cut operations; and
- Inductions and training of employees and operators on site will identify the potential impact of dust generation on the nearby community.

6.9 Hydrocarbons

Due to the utilisation of heavy machinery and vehicles during the proposed works, there is a potential for minor hydrocarbon spills to occur at the Project. Hydrocarbon storage, handling, disposal, and spillage response will be managed in accordance with Evolution's existing hydrocarbon management procedures. Hydrocarbon spill kits will be available to manage any spills from machinery. Any contaminated material/rags etc. will be removed from site in a suitable container and disposed of appropriately.

7.0 References

Botanica (2020), Targeted Malleefowl Assessment – CPS8165/1. September 2020.

Botanica Consulting (2018), *Reconnaissance Flora and Fauna Survey – Carbine-Paradigm*. Prepared for Northern Star Resources Ltd. June 2018.

R. &E. O'Connor (2018), *Aboriginal Heritage Survey of M16/548 and Paradigm Pit Extension Project.* Prepared for Northern Star Resources Ltd. April 2018.

Rockwater (2018), *Paradigm North Project – Hydrology and Surface Water Assessment*. Report for Northern Star Resources. September 2018.

Soilwater Consultants (2018), *Paradigm Gold Deposit – Soil Characterisation Study.* Prepared for Northern Star Resources Ltd. August 2018.

Annex I:

Proof of Tenement Holdings

Government of Western Australia
Department of Mines, Industry Regulation and Safety

eMiTS MINERAL TITLES ONLINE

MINING TENEMENT SUMMARY REPORT

MINING LEASE 16/548

Status: Live

TENEMENT SUMMARY

Area: 1,896.50000 HA
Mark Out : 19/09/2016 14:30:00
Received : 21/09/2016 11:30:00
Term Granted : 21 Years
Death Reason :
Death Date :
Commence : 01/08/2017

CURRENT HOLDER DETAILS

Name and Address
KUNDANA GOLD PTY LIMITED
MCMAHON MINING TITLE SERVICES PTY LTD, C/- MCMAHON MINING TITLE SERVICES PTY LTD, PO BOX 592, MAYLANDS, WA, 6931, xxxx@mmts.net.au, xxxxxxxxxxx997

DESCRIPTION

Locality: Carbine
Datum: Datum is situated GDA Zone 51 301579.646 metres East 6628947.452 metres North
Boundary: Thence to 303138.968 metres East 6627691.345 metres North Thence to 304771.521 metres East 6626602.543 metres North Thence to 304090.017 metres East 6625722.648 metres North Thence to 303358.074 metres East 6624785.134 metres North Thence to 302395.700 metres East 6625555.556 metres North Thence to 301897.062 metres East 6625029.824 metres North Thence to 302984.976 metres East 6623997.459 metres North Thence to 302433.396 metres East 6623417.475 metres North Thence to 301441.050 metres East 6624359.973 metres North Thence to 301202.529 metres East 6624097.400 metres North Thence to 300125.866 metres East 6624774.449 metres North Thence to 300035.591 metres East 6624594.384 metres North Thence to 299367.846 metres East 6624933.072 metres North Thence to 299496.542 metres East 6625237.265 metres North Thence to 298795.144 metres East 6625790.053 metres North Thence to 299119.966 metres East 6626278.152 metres North Thence to 298088.708 metres East 6627110.509 metres North Thence to 297563.683 metres East 6627534.274 metres North Thence to 296909.618 metres East 6627942.256 metres North Thence to 297410.539 metres East 6628594.221 metres North Thence to 298539.634 metres East 6627699.908 metres North Thence to 299031.682 metres East 6628295.663 metres North Thence to 300350.323 metres East 6627239.073 metres North Thence to 300948.690 metres East 6628119.476 metres North Thence to

301579.646 metres East 6628947.452 thence back to datum

Area :	Type	Dealing No	Start Date	Area
	Surveyed		12/07/2018	1,896.50000 HA
	Granted		01/08/2017	1,904.00000 HA
	Applied For		19/09/2016	1,904.00000 HA

SHIRE DETAILS

Shire	Shire No	Start	End	Area
COOLGARDIE SHIRE	1960	21/09/2016		1,896.50000 HA

Appendix A:

Soilwater Soil Characterisation Study

SOILWATER CONSULTANTS

PARADIGM GOLD DEPOSIT - SOIL CHARACTERISATION STUDY	
Prepared for:	NORTHERN STAR RESOURCES LTD
Date of Issue:	20/08/2018
Project No.:	NST-005-1-06

Distribution:

Electronic Copy – Yvonne Hynes, Northern Star Resources Ltd

A Member of the SOILWATER GROUP

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DOCUMENT STATUS RECORD

Project Title:	PARADIGM GOLD DEPOSIT - SOIL CHARACTERISATION STUDY
Project No.:	NST-005-1-06
Client:	NORTHERN STAR RESOURCES LTD

Revision History

Revision Code[1]	Date Revised	Revision Comments	Signatures		
			Originator	Reviewer	Approved
A	03/07/18	Internal review	SC	ASP	ASP
B	05/07/18	Draft for client review	SC	YH	SC
C	20/08/18	Final report	SC		

Revision Code[1]

A - Report issued for internal review

B - Draft report issued for client review

C - Final report issued to client

LIMITATIONS

The sole purpose of this report and the associated services performed by Soil Water Consultants (SWC) was to undertake a soil characterisation assessment at Northern Star Resources (Northern Star) Paradigm Gold Deposit. This work was conducted in accordance with the Scope of Work presented to Northern Star ('the Client'). SWC performed the services in a manner consistent with the normal level of care and expertise exercised by members of the earth sciences profession. Subject to the Scope of Work, the soil characterisation was confined to the Paradigm Gold Deposit site. No extrapolation of the results and recommendations reported in this study should be made to areas external to this project area. In preparing this study, SWC has relied on relevant published reports and guidelines, and information provided by the Client. All information is presumed accurate and SWC has not attempted to verify the accuracy or completeness of such information. While normal assessments of data reliability have been made, SWC assumes no responsibility or liability for errors in this information. All conclusions and recommendations are the professional opinions of SWC personnel. SWC is not engaged in reporting for the purpose of advertising, sales, promoting or endorsement of any client interests. No warranties, expressed or implied, are made with respect to the data reported or to the findings, observations and conclusions expressed in this report. All data, findings, observations and conclusions are based solely upon site conditions at the time of the investigation and information provided by the Client. This report has been prepared on behalf of and for the exclusive use of the Client, its representatives and advisors. SWC accepts no liability or responsibility for the use of this report by any third party.

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1 INTRODUCTION

Northern Star Resources Limited (Northern Star) is proposing to expand the existing Paradigm Gold Deposit, located approximately 80 km north-west of Kalgoorlie in the Goldfields region of Western Australia. The Paradigm Deposit has been previously mined, with a mine pit and associated WRL produced. The current proposal is for a secondary pit and adjacent WRL to be developed, with ore produced transported to Kundana for processing.

The purpose of the overall project is to identify and characterise the range of surface soils across the proposed disturbance areas, and to assess their suitability for use in constructing the outer surfaces of the WRL in rehabilitation activities.

1.1 ROLE OF SOILWATER CONSULTANTS

Soilwater Consultants (SWC) will provide the following scope of work:

- Task 1: A desktop assessment of available information related to soils and landforms within the area of the proposed Paradigm mining operation.
- Task 2: A field survey to confirm landform units (potential soil mapping units) and soil characterisation to assist in their management during mining and rehabilitation operations.
- Task 3: Undertake soil analysis for a range of physical and chemical parameters.
- Task 4: Erosion testing under laboratory conditions and modelling.

The outcomes from the scope of works by SWC will be a report detailing:

- Outcomes from the desktop study;
- Summary of results from the field study and associated laboratory analyses;
- Erosion modelling using soil materials from proposed disturbance areas; and
- Assessment of the soils for use in WRL construction and rehabilitation.

2 SITE DESCRIPTION

The Paradigm Gold Deposit is located approximately 80 km north-west of Kalgoorlie in the Goldfields region of Western Australia (Figure 2.1). This region is located within the Murchinson Province of the interim biogeographic regionalisation for Australia (IBRA) scheme, which covers approximately 304,875 km^2 and includes the mid-west and northern Goldfields (Tille, 2006).

2.1 CLIMATE

The climate for the Kalgoorlie Region (Kalgoorlie Airport – Station No. 012038; 18 km southwest of the KB Deposit) is classified as semi-arid with hot dry summers and moderately cool winters. Annual rainfall varies from around 150 mm up to 450 mm, with an average of approximately 270 mm/year (Figure 2.2). Rainfall is distributed fairly evenly throughout the year with an average monthly rainfall of approximately 23 mm, whilst pan evaporation is greatest in the summer months and lowest during winter.

Pan evaporation greatly exceeds rainfall with an average annual pan evaporation of around 2,600 mm. Although the average pan evaporation exceeds rainfall for the majority of the year intense rainfall events associated with cyclonic activity results in monthly rainfalls often exceeding pan evaporation. Pan evaporation data was unavailable for this climate station post 2006.

2.2 SITE LAYOUT

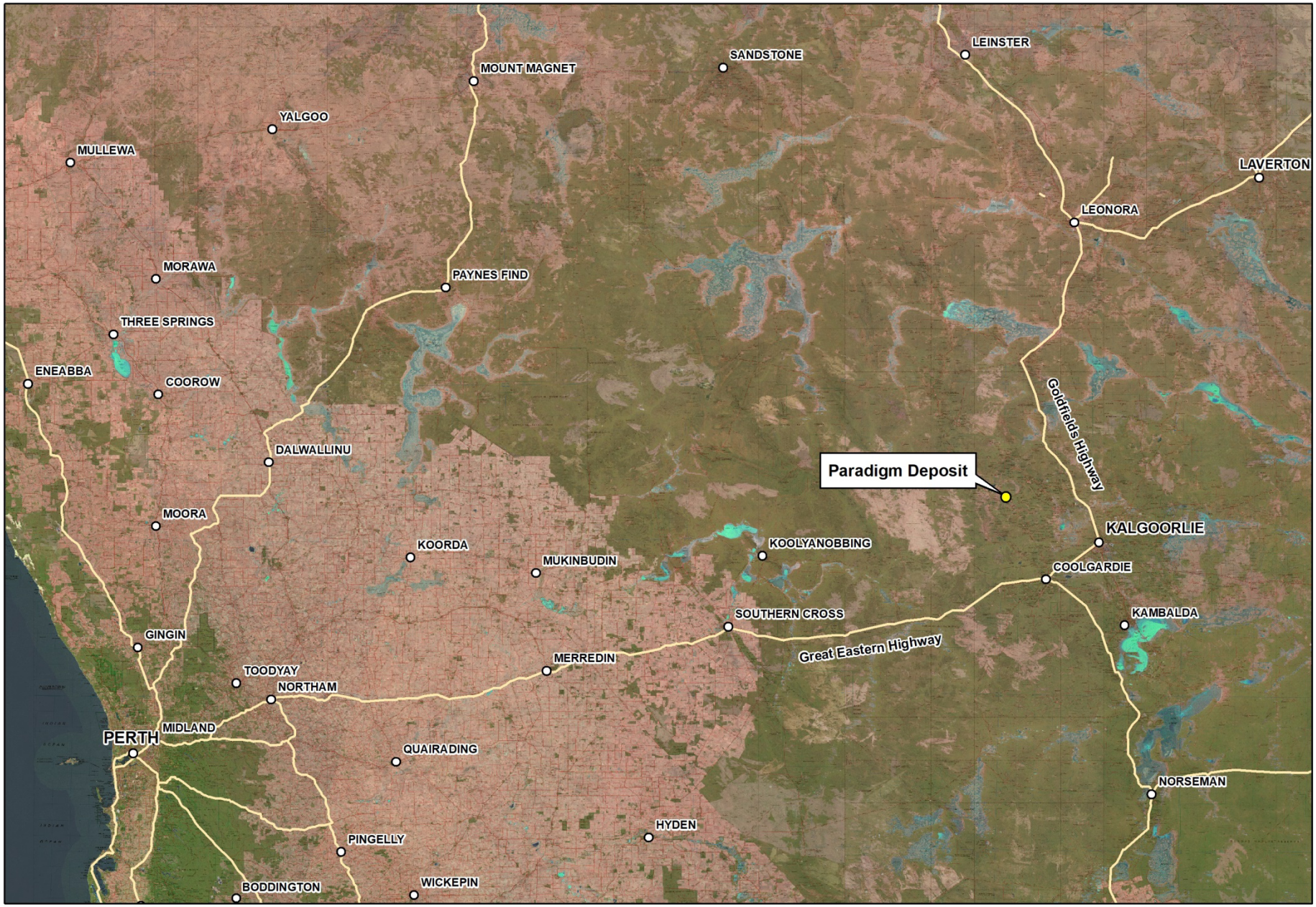
The proposed location of the mine pit and associated waste dump is presented in Figure 2.3. These locations were used to target soil sampling locations (see Section 3). The primary targets were identified as those areas that will be disturbed during the mining process, these being the indicative mine pit location and waste rock dump. The total area of disturbance associated with the mine pit and waste rock dump footprints is 48 ha.

2.3 GEOLOGY

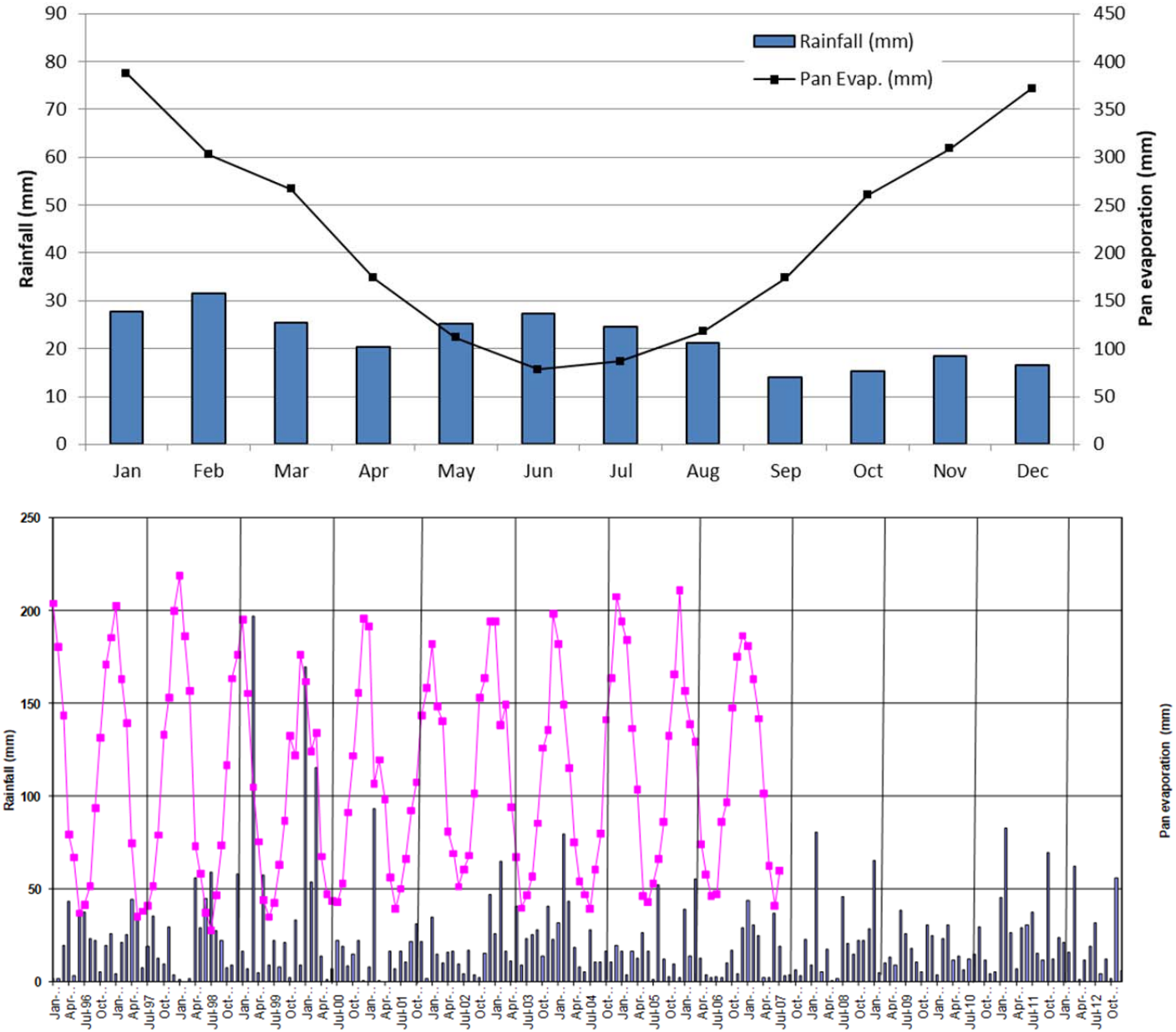
2.3.1 REGIONAL GEOLOGY AND LANDFORMS

A detailed description of the regional geology of the Murchinson Province has been documented by Laws (1994) and Tille (2006). The Murchinson Province is the westernmost of three granite-greenstone terraces in the Archaen Yilgarn Craton. The underlying rocks are predominantly Archaean even-grained porphyritic granitic rocks. These are intruded by quartz veins and dolerite dykes (Tille, 2006). Areas of gneiss are associated with Archaean greenstone belts contain a mixture of metamorphosed mafic to ultra-mafic volcanic rocks (including basalt, amphibolite, dolerite and gabbro), felsic volcanic rocks, and metasedimentary rocks (including cherts and banded iron formations). This Archaean bedrock has been extensively weathered and laterised, and have been overlain by Tertiary and Quaternary alluvial, colluvial and aeolian deposits (Laws, 1994).

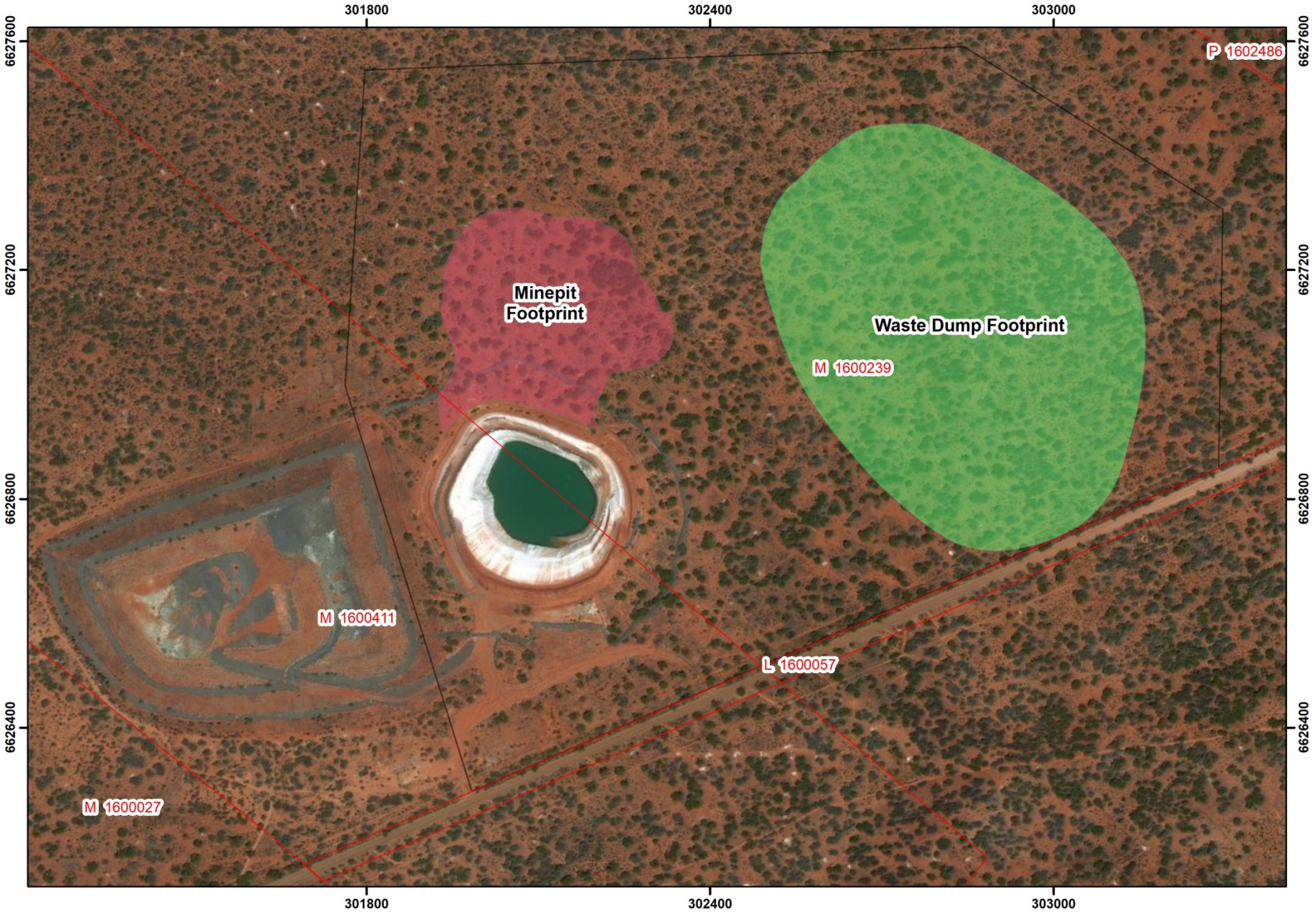
The Murchinson Province is comprised of an extensive plateau of low relief. Laterite or silicrete mesas often occur at the top of the landscape, and tend to be surrounded by gently undulating wash plains and sandplains (Tille, 2006). These wash plains consist of gently inclined alluvial surfaces with an almost continuous underlying cemented red-brown hardpan. Other areas contain quartz-strewn plains and plains with stony and gravelly mantles associated with low rises containing outcrops of granite, gneiss and schists.



NORTHERN STAR RESOURCES LTD	Figure 2.1: Regional location of the Paradigm Gold Deposit study area	soilwater GROUP
PARADIGM GOLD DEPOSIT - SOIL CHARACTERISATION STUDY		



NORTHERN STAR RESOURCES LTD	Figure 2.2: Climate data	soilwater GROUP
PARADIGM GOLD DEPOSIT - SOIL CHARACTERISATION STUDY		



NORTHERN STAR RESOURCES LTD	Figure 2.3: Proposed locations of mine pit and waste dump at the Paradigm Gold Deposit	soilwater GROUP
PARADIGM GOLD DEPOSIT - SOIL CHARACTERISATION STUDY		

PN: NST-005-1-06 Prepared by: SC Date: 07/03/18 Reviewed by: ASP Date: 07/04/18 Revision: 1

2.4 HYDROLOGY AND HYDROGEOLOGY

The report by Laws (1994) describes the surface water drainage and hydrogeology of the Murchinson Province. Much of the drainage is ephemeral, with >80% of the surface drainage flowing to the west into the Murchinson, Wooramel and Greenough River Catchments, and subsequently to the Indian Ocean. The remainder of the drainage flows to inland salt lake systems. Generally, the major drainage systems have broad flood plains (Laws, 1994).

Groundwater quality and quantity is variable within the Province, and is used for pastoral and mining activities. Better quality groundwater is often sourced from colluvium, valley-fill alluvium, and calcrete and calcrete alluvium (Laws, 1994). The wash plains, often underlain by a hardpan, that flank the main drainage lines, provide a source of shallow, good quality groundwater of varying salinity.

2.5 REGIONAL SOILS

2.5.1 REGIONAL SOILS AND ASSOCIATED WESTERN AUSTRALIA SOIL GROUPS

The Murchison Province (Mapping Unit 27; Purdie *et al.*, 2004) is described as *extensive plains with residuals of laterite or Precambrian igneous rocks. Drainage lines have extensive saline or calcrete deposits. Soils with red-brown hardpan (duripan) are common*. The dominant geology comprises granitic rocks and greenstone of the Yilgarn Craton, and soils are red loamy and sandy earths, red shallow loams and red deep sands. The dominant vegetation is spinifex grasslands with wanyu scrub, eucalypt woodlands, and halophytic shrublands.

The Paradigm Gold Deposit is located in the Kambalda Zone (Map Unit 265) which is described as comprising *Flat to undulating plains, hills and ranges on greenstone and granitic rocks of the Yilgarn Craton with Calcareous loamy earths, Red loamy earths, Salt lakes soils and some Red-brown hardpan shallow loams and Red sandy duplexes.* The vegetation comprises Red mallee-blackbutt-salmon gum-gimlet woodlands with mulga and halophytic shrublands (and some spinifex grasslands and salt lakes).

The project area is located entirely within one sub-units of the Kambalda Zone, the Atlas Land System.

The corresponding Soil Supergroups which occur within the Kambalda Zone and their associated Soil Groups based on the Western Australia classification for this soil mapping unit is presented in Table 2.1 (Schoknecht and Pathan, 2013).

Table 2.1: Relationship between regional soil mapping unit and Western Australia Soil Groups.

Mapping Unit	Mapping Unit Name	Soil Super Group Description	Dominant WA Soil Group	WA Soil Group Description
265Mx43	Atlas Land System	Loamy earths supergroup	540 (65%)	Loamy surface soils grading to clay loam or clay
		Shallow loams supergroup	520 (20%)	Red shallow loam
		Sandy earths supergroup	460 (10%)	Sandy surface soils grading to clay loam or clay
		Cracking clays supergroup	600 (5%)	Surface clay which cracks strongly when dried

2.6 VEGETATION

Vegetation within the Murchinson Province is described as woodlands with spinifex grasslands (and some wanyu scrub, eucalypt woodlands and halophytic shrublands). A more comprehensive description of the vegetation found in the Murchinson Province is provided by Beard (1990) and Tille (2004). Generally, mulga (*Acacia aneura*) shrublands and woodlands (*A. pruinocarpa*, *A. tetragonophylla*, *A. linophylla*, *A. ramulosa*, *A. acuminata*, *A. grasbyi*), Senna *spp*. and Eremophila *spp*. dominate the hardpan wash plains, while the sandplains in the east support grasslands of hard spinifex (*Triodia basedowii*). These grasslands occur with an open tree and shrub steppe of mulga, marble gum (*Eucalyptus gongylocarpa*), mallees (*E. kingsmillii*, *E. trichopoda*, *E. brachycorys* and *E. youngiana*), bowgada (*A. ramulosa*) and spinifex wattle (*A. coolgardiensis*). The stony plains support shrublands of mulga, gidgee (*A. pruinocarpa*), granite wattle (*Acacia quadrimarginea*), and Eremophila *spp*. The valley floors support shrublands of samphire (Halosarcia *spp*.), saltbush (Atriplex *spp*.), sage (*Cratystylis subspinescens*) and Frankenia *spp*. surrounding salt lakes. Floodplains along the Murchison and its tributaries have shrublands of bluebush (Maireana *spp*.), saltbush and Frankenia *spp*., as well as mulga, prickly wattle and Acacia distans.

The Kambalda Zone (265) supports Red mallee-blackbutt-salmon gum-gimlet woodlands with mulga and halophytic shrublands (and some spinifex grasslands and salt lakes). (Tille, 2004).

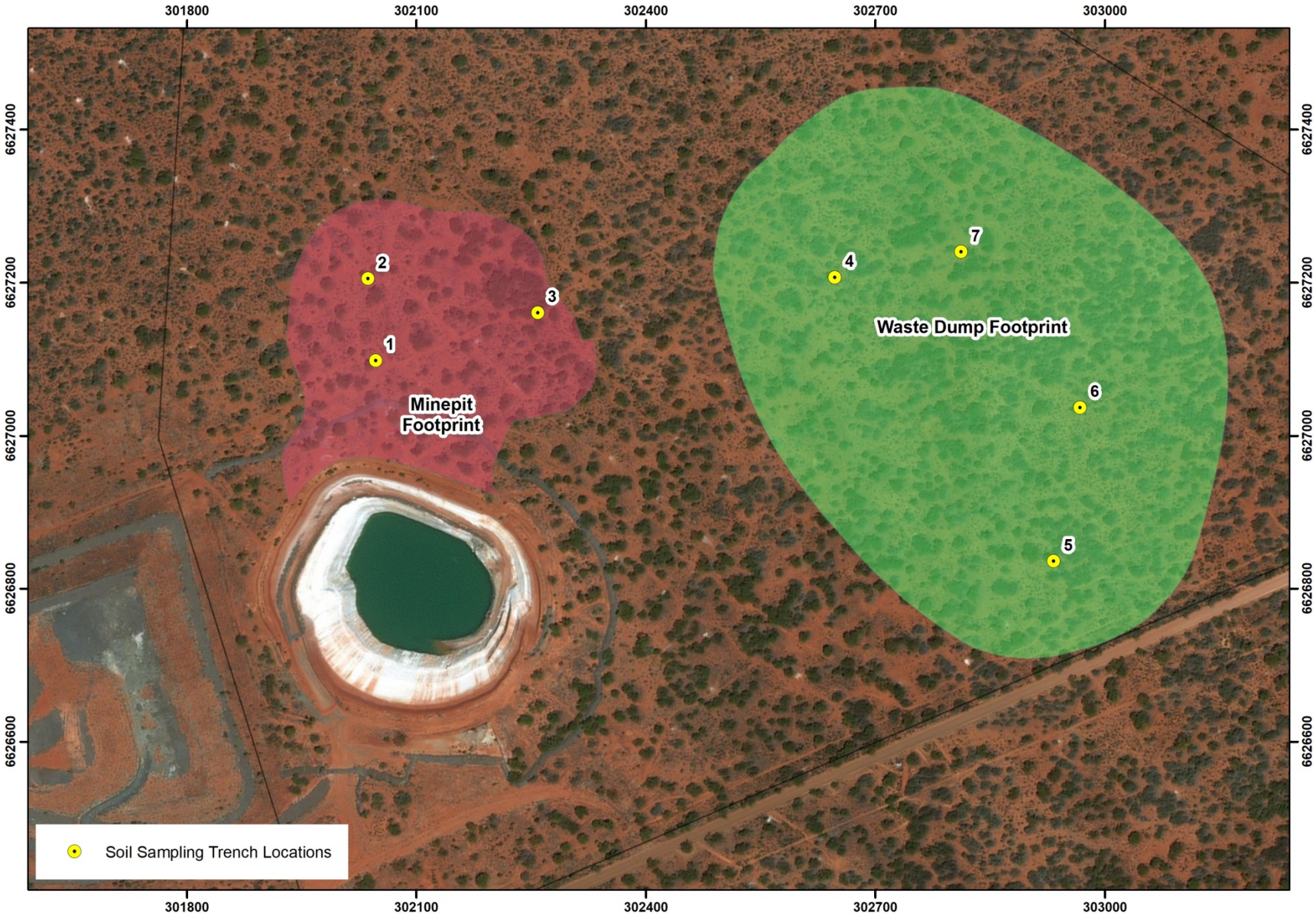
3 STUDY METHODOLOGY

3.1 SELECTION OF SAMPLING LOCATIONS

Soil sampling locations within the Paradigm Gold Mine study area were selected based on the expected disturbance areas, and sought to provide information on the potential ranges of landscape geomorphology and pedogenic processes. Targeting of the expected disturbance areas was prioritised as soil removed from these areas will constitute a valuable resource during future mine management, mine closure and rehabilitation activities. The location of each sampling point within the study area is provided in Figure 3.1 and Table 3.1.

Table 3.1: Location and depth of excavation for each sampling location.

Trench ID	Coordinates (GDA 94, Zone 51)		Depth of Trench (cm)	Sample Location
	Easting	Northing		
01	302,047	6,627,098	180	Mine pit footprint
02	302,037	6,627,205	170	Mine pit footprint
03	302,259	6,627,161	170	Mine pit footprint
04	302,647	6,627,207	170	Waste dump footprint
05	302,933	6,626,836	200	Waste dump footprint
06	302,968	6,627,037	180	Waste dump footprint
07	302,812	6,627,240	170	Waste dump footprint



NORTHERN STAR RESOURCES LTD	Figure 3.1: SWC of soil sampling locations within the Paradigm Gold Mine area.	soilwater GROUP
PARADIGM GOLD DEPOSIT - SOIL CHARACTERISATION STUDY		

3.2 SOIL SAMPLING

Sampling trenches (01 to 07) were dug using a mechanical excavator (backhoe) to a maximum depth of 2 m.

The sampling protocol at each location involved:

- Recording surface features such as topography, vegetation and soil surface condition using field recording sheets and a digital camera.
- Describing the soil profile morphology in terms of colour, texture, structure and horizonation / layering. All field information was recorded using recording sheets and by digital camera. Field texture analysis was performed to estimate soil type (McDonald and Isbell, 2009) and subsequent identification of soil management units (SMUs).
- Discrete samples were collected down the exposed soil profile for subsequent laboratory analyses.
- Estimated root density was recorded using the semi-quantitative method of McDonald and Isbell (2009) (Table 3.2).

A total of 79 soil samples from 7 locations were collected from within the study area.

Table 3.2: Semi-quantitative assessment of plant roots used in this investigation.

Rating	Number of roots per 0.01 m2 (10 cm × 10 cm)	
	Very fine - fine roots (< 2 mm diameter)	Medium - coarse roots (> 2 mm diameter)
0 No roots	0	0
1 FSWC roots	1 - 10	1 - 2
2 Common roots	10 - 25	2 - 5
3 Many roots	25 - 200	> 5
4 Abundant roots	> 200	> 5

3.3 EROSION SAMPLING

Approximately 300 kg of soil was collected as a bulk composite from several trench locations for erosion testing. Samples were collected from locations from the major areas of disturbance and/or were exhibiting contrasting visual and physical characteristics.

3.4 LABORATORY ANALYSES

3.4.1 PHYSICAL AND CHEMICAL ANALYSES

The physical and chemical properties of the soil materials were assessed at Soilwater Analysis and CSBP Laboratories in Perth. All samples collected in the field were analysed for pH, EC, field (gravimetric) and moisture content to initially screen samples for more detailed analyses and to establish key properties that may distinguish important soil characteristics (e.g. salinity limitations, texture, surface charge chemistry etc.). The remaining properties (Table 3.3) were assessed on a select number of samples that will reflect the physical and chemical properties of soil materials within each of the major soil mapping units. The analytical methods for measuring the soil physical and chemical properties are detailed in McKenzie *et al.* (2002) and Rayment and Lyons (2010). The specific method used for each analysis is:

- pH and electrical conductivity (EC) measured on a 1:5 soil to water suspension (Method 4A1);
- Gravel content (>2.36 mm sieve);
- Field gravimetric water content;
- Inorganic nitrogen (ammonium and nitrate, (2M KCl Method 7C2);
- Exchangeable Al (Method 15G1),
- Exchangeable cations (no pre-wash, Method 15A2),
- Colwell P and K (Method 9B),
- Organic carbon (Walkley Black, Method 6A1),
- Available sulfur (KCl 40, Method 10D1);
- Particle size analysis (pipette method),
- Field bulk density (Intact Core Method 503.01);
- Aggregate dispersion index;
- Soil water retention (Pressure Plate Method 504.02); and
- Saturated hydraulic conductivity (Intact Core – Constant Head Method).

The selection of samples for the more detailed testing was undertaken to provide materials from varying soil types and different locations across study. The full suite of analyses and analytical results are presented in Appendix A.

Table 3.3: Physical and chemical properties of the soils measured in the laboratory.

Parameter	Method	Standard Reference
Soil Physical Properties		
Particle size distribution	Pipette sedimentation	McKenzie *et al.* (2002)
Gravel content	Sieve analysis (> 2 mm soil fraction)	
Bulk density	Constant volume	
Aggregate stability	Emerson dispersion	
Hardsetting Potential		Harper and Gilkes (1994)
Soil Hydraulic Properties		
Saturated hydraulic conductivity	Constant head permeameter	McKenzie *et al.* (2002)
Water retention characteristics	Pressure plate equipment	
Soil Chemical Properties		
pH	1:5 soil/water extraction	Rayment and Lyons (2010)
Electrical conductivity (EC; salinity))	1:5 soil/water extraction	
Macro-nutrients		
- Total Nitrogen (N)	Leco	
- Colwell Phosphorus (P)	$NaHCO_3$ extraction	
- Colwell Potassium (K)	$NaHCO_3$ extraction	
- Available Sulfur (S)	KCl extractable S/ICP	
Organic Carbon	Walkley Black Method	Rayment and Lyons (2010)
Exchangeable cations – Calcium (Ca), Magnesium (Mg), Sodium (Na), Potassium (K)	NH_4Cl extraction	Rayment and Lyons (2010)
Effective Cation Exchange Capacity (ECEC)	Sum of exchangeable cations	-
Exchangeable Sodium Percentage (ESP; sodicity)	ESP = (Ex. Na/CEC)×100	-

3.4.2 EROSION TESTING

Laboratory scale erosion testing was undertaken using a flume rainfall simulator to determine simulated erosion rates for representative soil material collected from different trenches across the study area.

The laboratory-scale rainfall simulator (Plate 3.1) was used to measure the interrill (raindrop impact) erodibility of each material. The rainfall simulator was designed to apply water at an intensity of approximately 80 mm/hr, with a raindrop size and spatial distribution closely resembling natural rainfall. An intensity of 80 mm/hr corresponds to a 1:10, 1:20 and 1:100 year ARI storm event of approximately 6, 10, and 20 min duration, respectively (BOM, 2018).

Prior to testing, each of the materials described above was placed into a 0.75 x 0.75 x 0.20 m container and lightly compacted to approximate the expected field conditions. The base of the container was free draining to avoid saturated conditions and air entrapment within the samples. Each material was pre-treated by sequentially wetting and drying the surface to allow natural organisation and settling of the soil particles.

The container was set at a slope angle of 18° to simulate likely batter conditions at the site. The materials were then subjected to a simulated rainfall of approximately 80 mm/hr, and 10 samples of the resulting surface runoff were collected over a 4 hour period. Runoff volume and sediment loss in each sample were determined gravimetrically. Measurements from the rainfall simulator were used to calculate soil erodibility parameters required for the WEPP erosion model. The methods used for calculating these parameters are discussed further in Section 3.5.

Plate 3.1: Laboratory scale rainfall simulator

3.5 EROSION MODELLING

The Watershed Erosion Prediction Project (WEPP; Flanagan & Livingston, 1995) model was used to predict the long-term (100 year duration) erosion rates from the surface of the proposed waste rock landform at the Hinge deposit. The WEPP model used a series of input files describing the soils, climate, slope geometry, and land management regime for the site. Model input values and assumptions are discussed in the following sections.

3.5.1 SOIL PARAMETERS

The soil parameters required by WEPP were derived from the laboratory testing undertaken at SWA Laboratories. These parameters include the effective hydraulic conductivity (K_{eff}), interrill erodibility (K_i), rill erodibility (K_r), and soil critical shear stress (τ_C), and are summarised in Table 3.4

Keff was estimated by fitting the Green-Ampt equation (Green & Ampt, 1911) to the measured infiltration rates using Equation 1:

$$F = K_{eff}\,(1 + Ns / F) \qquad \text{Equation 1}$$

where: f = infiltration rate (mm/h)

K_{eff} = effective saturated hydraulic conductivity (mm/h)

N_s = effective matric potential at the wetting front (m), and

F = cumulative infiltration (m).

K_i was calculated from the inter-rill erosion rate measured in the rainfall simulator, according to Elliot *et al*. (1989) using Equation 2:

$$D_i = K_i\ I^2\ S_f \qquad \text{Equation 2}$$

Where: D_i = interrill erosion rate (kg/(m^2 s)

K_i = interrill erodibility (kg s)/m^4

I = rainfall intensity (m/s), and

S_f = dimensionless slope factor (1.05 - 0.85 $^{-0.85\ \sin(\alpha)}$)

K_r and τ_C were determined from the shear stress (τ) and rill erosion rate (D_c) measurements collected in the laboratory. This was done by a linear regression analysis according to the method described by Foster (1982) and Elliott *et al*., (1989). The rill erodibility parameters are related to the measured parameters τ and D_c by Equation 3:

$$D_c = K_r\,(\tau - \tau_C) \qquad \text{Equation 3}$$

where: D_c = measured erosion rate (kg/m2 s)

K_r = rill erodibility (s/m)

τ = measured shear stress (Pa), and

τ_C = critical shear stress (Pa).

D_c was plotted against τ for each of the rainfall simulator measurements. The slope of the linear regression line was K_r, and the intercept with the horizontal axis was τ_C.

Table 3.4: Key soil parameters used in the WEPP model.

Material ID	Sand (%)	Clay (%)	OM (%)	CEC [meq/100g]	K_{eff} (mm/hr)	$K_i \times 10^5$ (Kg s / m^4)	$K_r \times 10^{-3}$ (s / m)	τ_c (Pa)
Study area soil material	69	11	32	16	34.1	6.45	0.43	11.3

3.5.2 CLIMATE DATA

A 100-year synthetic climate file was generated using the CLIGEN stochastic weather generator (Yu, 2003), using 30 years of observational data gathered from the airport weather station in Kalgoorlie (BOM station #12038). Figure 3.2 a and Figure 3.2 b demonstrate that the CLIGEN file is generally consistent with the 30 years of measured data from which it was generated. Figure 3.2a compares the frequency of 24-hour rainfall totals, indicating that larger 24-hour storms occurred slightly more frequently in the calculated ARI data than in the CIGEN file and measured rainfall data. Figure 3.2b compares average monthly rainfall totals, and shows that the CLIGEN file captures a similar degree of seasonal variability as was observed at the regional climate stations. Figure 3.3 compares 30 years of measured daily rainfall totals at Kalgoorlie to the synthetic 100 year CLIGEN model, showing a similar degree of variability.

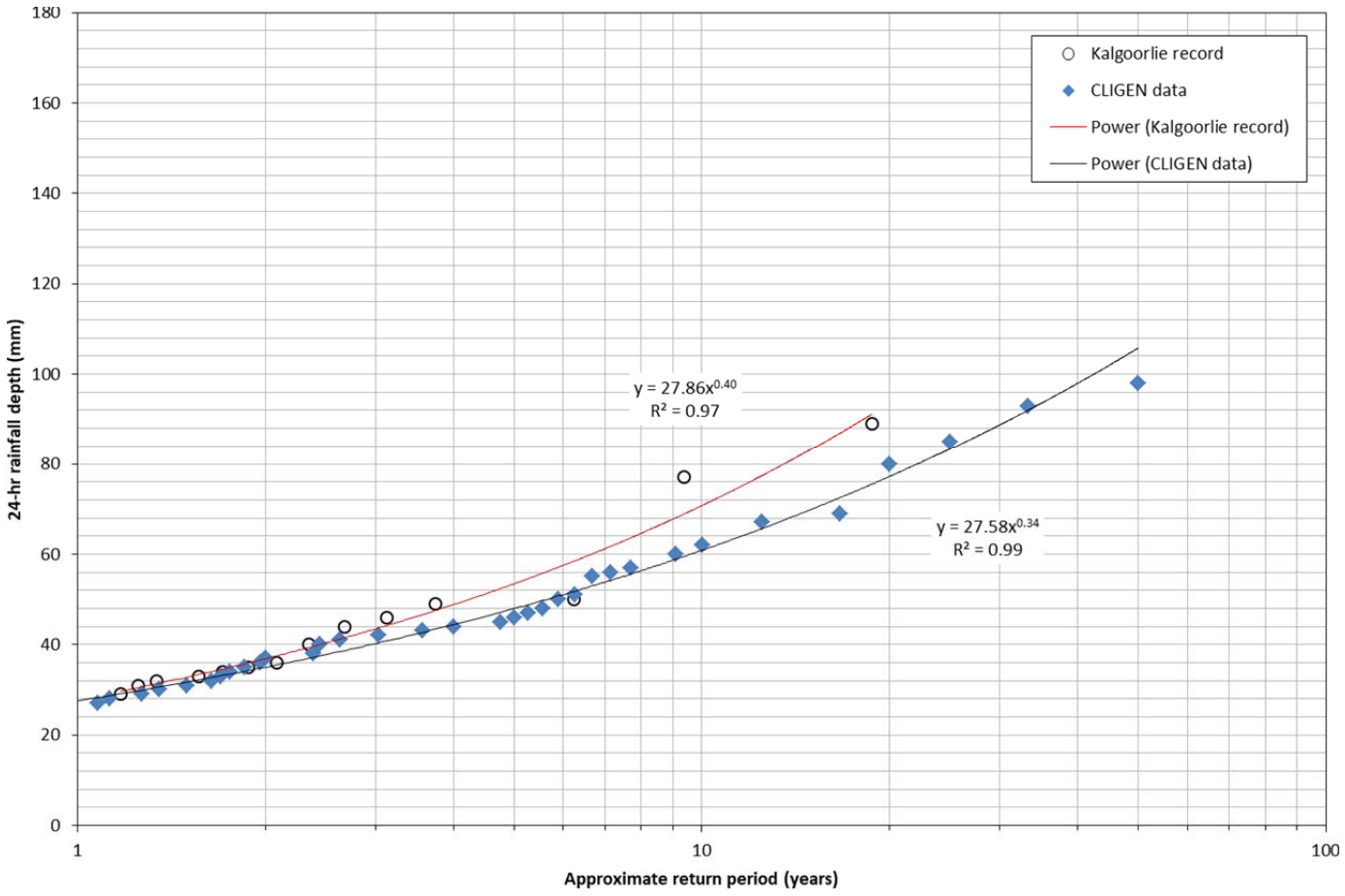
3.5.3 SLOPE PROPERTIES

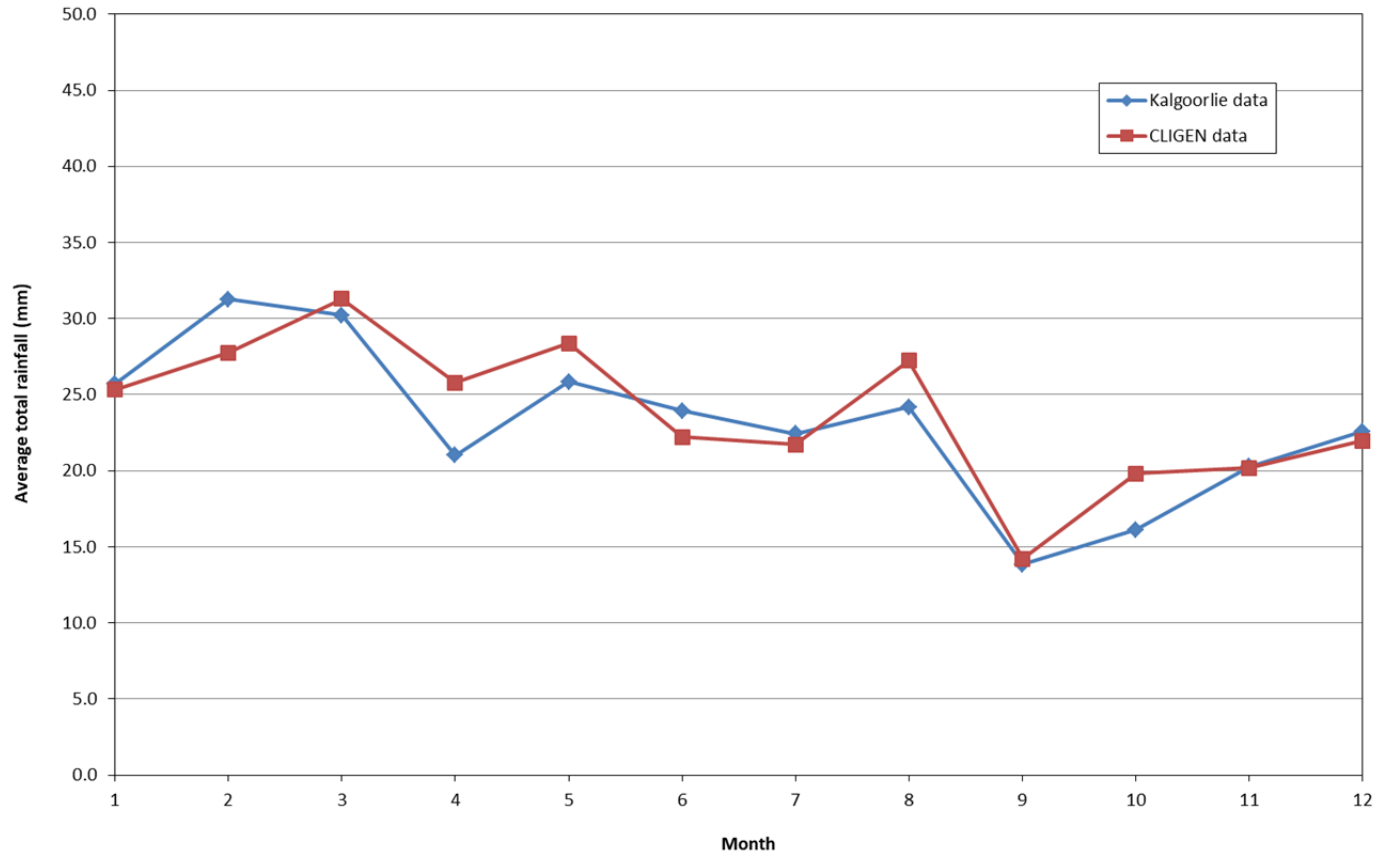
The slopes with WEPP were modelled under the assumption of slope angles between 15° and 18°, with a lift height of 10 and 20 m to simulate likely conditions on post-mine landforms.

3.5.4 MANAGEMENT ASSUMPTIONS

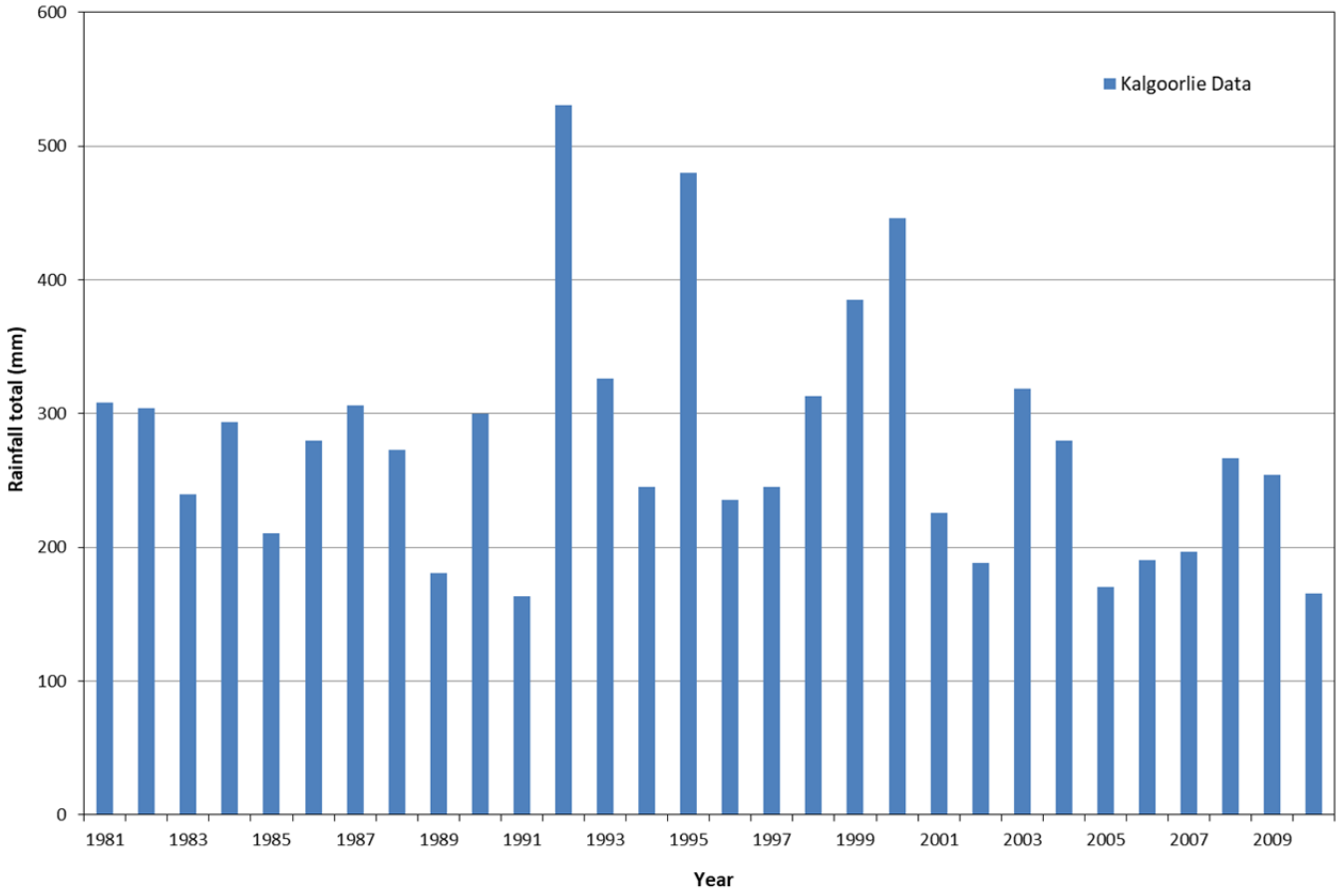
The land management input file used in the WEPP model was designed to describe the expected conditions on the remediated waste rock landform at Paradigm. The key features of the input management file include:

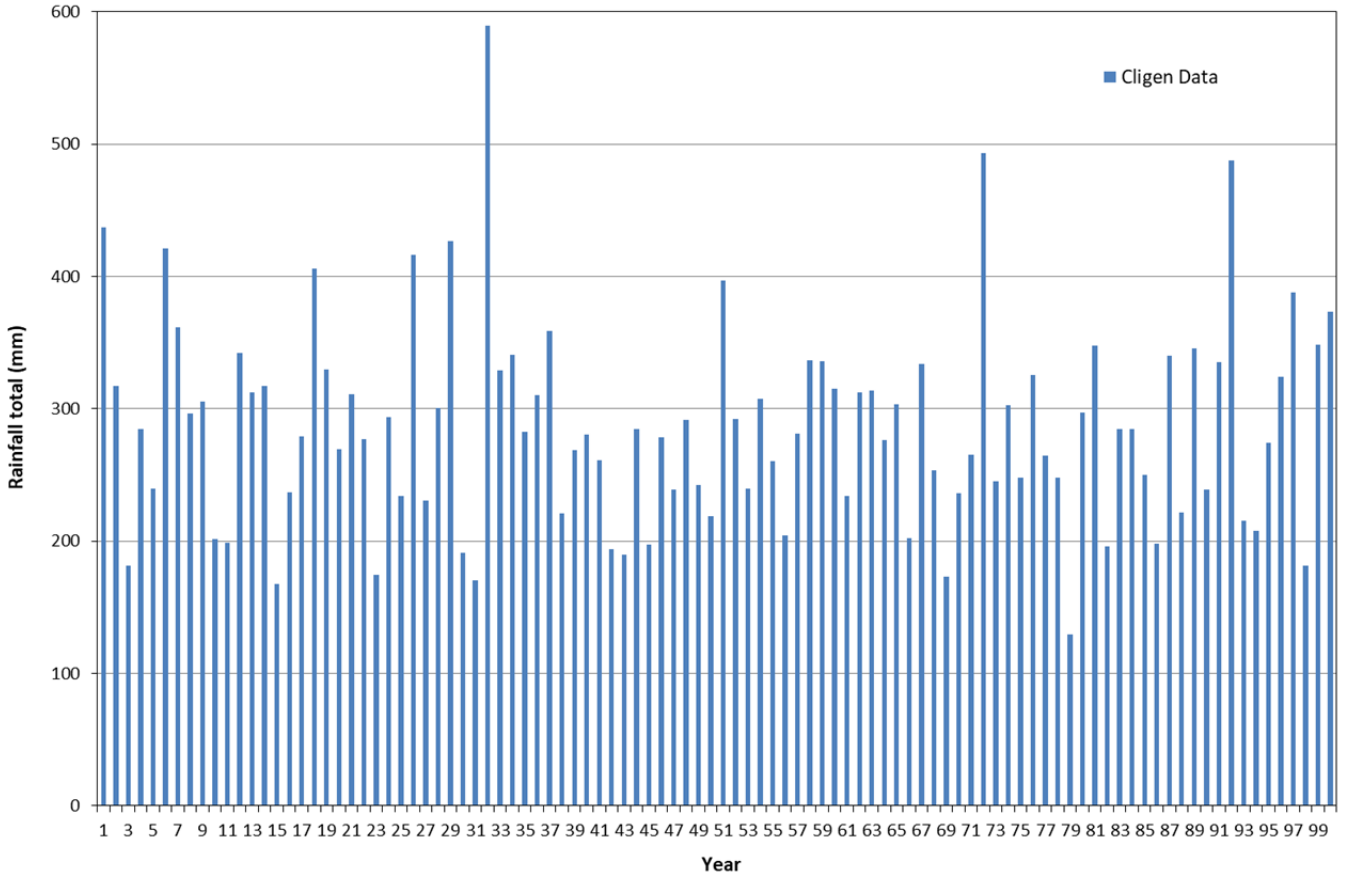
- A pre-consolidated soil surface. This means that no further settling is simulated within the model, and that the measured infiltration rates and runoff characteristics apply for the duration of the model (i.e., no further changes in these properties with time). This is reasonable because the laboratory measurements (from which the input parameters were derived) were conducted on pre-consolidated soil samples.
- No vegetation. This assumption will result in conservative (i.e. “worst-case”) erosion results, and will apply to the landform during the period prior to re-vegetation establishment. Subsequent vegetation growth will act to enhance the stability of the landform by dissipating rainfall impact energy, producing leaf litter as a ground cover, and stabilising the sub-surface and improving infiltration with root growth. The degree of stabilisation will depend on the types of vegetation used, and their rates of establishment.
- Zero initial surface cover (i.e. no woody debris or plant litter). This means that no additional surface cover was expected to be added to the soil surface to reduce erosion rates. This assumption does not have any impact on the armouring effect of the rock and gravel fraction in the soil, which was already accounted for within the measured soil parameters shown in Table 3.4.
- Rill geometry is adjusted internally within the model based on the input soil parameters and on the size of erosion events encountered within the modelled timeframe.





NORTHERN STAR RESOURCES LTD	Figure 3.2: a) 24 hour and b) mean monthly rainfall data	soilwater GROUP
PARADIGM GOLD DEPOSIT - SOIL CHARACTERISATION STUDY		





NORTHERN STAR RESOURCES LTD	Figure 3.3: Annual rainfall data comparison	soilwater GROUP
PARADIGM GOLD DEPOSIT - SOIL CHARACTERISATION STUDY		

4 SOIL CHARACTERISATION

Based on the depositional history of the study area and the morphological characteristics of the soil profiles exposed by trench excavation, just one distinct Soil Mapping Unit (SMU) was defined. The relationship between this SMU and the major soil groups of Western Australia (Schoknecht, 2001) and the Australia Soil Classification (Isbell, 1996) is presented in Table 4.1.

Table 4.1: Relationship between identified SMU and major soil group definitions

SMU (Present study)	Major soil group, WA (Schoknecht, 2001)	Australian Soil Classification (Isbell, 1996)
1. Reddish brown duplex	Red brown shallow loam	Duric Red Kandosol

4.1 SOIL DISTRIBUTION

The soils encountered within the 7 separate investigation locations were generally uniform across the study disturbance area, consisting of varying depths of a reddish-brown sandy loam (between 80 and 140 cm) over stiff brown to red sandy clay. Assessed profiles generally only varied with the thickness of the lower sandy loam layer which contained calcareous nodules. This layer generally appeared at the base of the sandy loam directly overlying the more impermeable underlying stiff clays, but varied in thickness from approximately 1 m down to being almost absent in one trench location (Trench 5). However in general the profiles encountered can be said to be uniform across the study area.

4.2 REDDISH BROWN DUPLEX CHARACTERISTICS

The duplex profile was found to occur over the entire study area. The surface of the soils is typically bare or covered by leaf litter in areas of higher vegetation density (Plate 4.1). The soil cover thickness of the upper profile sandy loam to clay loam overlying the stiff clay varied between 80 and 140 cm, with an average of approximately 100 cm. The boundary between the clay material and overlying loam generally displayed calcareous mottling (Plate 4.2). This is likely to be a result of secondary carbonate precipitation related to perched water movement at the texture contrast boundary. The underlying clays are generally massive in structure, although peds were able to be removed from the trench walls in places. Root exploration was observed to be considerably reduced within the clay zone, however the presence of fine roots suggests that the majority of vegetation is utilising the lower clays for resources. A characteristic soil profile through the red brown loam into the clay showing the duplex nature of the profile is presented in Figure 4.1, along with summary statistics on key physical, chemical and hydraulic properties.

The basic chemical properties (pH and salinity) within the soil profile at each soil investigation location trench are shown in Figure 4.2 through to Figure 4.3. The profiles show a consistent variation in salinity with depth, with the measured EC increasing from non-saline values (0-40 mS/m) within the upper loamy sand materials to moderately saline within the lower loam and clay materials, likely reflecting decreased hydraulic conductivity and higher evaporation rates. The pH was reported to only vary slightly within the profile, generally maintaining an alkaline pH between 8 and 10, which is reflective of the high carbonate content.

Plate 4.1: Sandy surface conditions and leaf litter around vegetation.

Plate 4.2 Calcareous mottling at texture contrast boundary.

Depth (cm)	Unit	Description
0		
	Upper loam	Reddish brown loamy sand with minor sub-rounded to rounded pisolithic gravels (<10 percent); horizon has a friable earthy fabric and is weakly coherent with abundant fine roots and common large lateral roots (1-2 cm diameter)
40		
	Lower loam	Reddish brown sandy loam to clay loam with common calcareous mottling; weakly structured with an earthy fabric. Abundant fine roots throughout. Boundary to underlying hard clay.
80-100		
	Clay	Reddish brown stiff sandy clay to clay. Massive structure with isolated fine to medium roots evident throughout. Minor mottling

Physical properties

Depth (cm)	Structure	Particle size distribution (< 2mm)				Gravel %	Field	Ksat	Structural stability	
		Sand (%)	Silt (%)	Clay (%)	Texture	(> 2mm)	Moisture (%)	(m/day)	Macro (slaking)	Micro (dispersive)
0-40	Granular	77.7	11.9	10.4	Loamy sand	24.9	5.6	0.33	good	good
40-100	Granular	68.7	11.2	20.1	Sandy loam – clay loam	14.2	7.6	0.09	moderate	moderate
100+	Massive	57.6	8.8	33.6	Sandy clay - clay	3.2	13.5	0.01	moderate	moderate

Chemical Properties

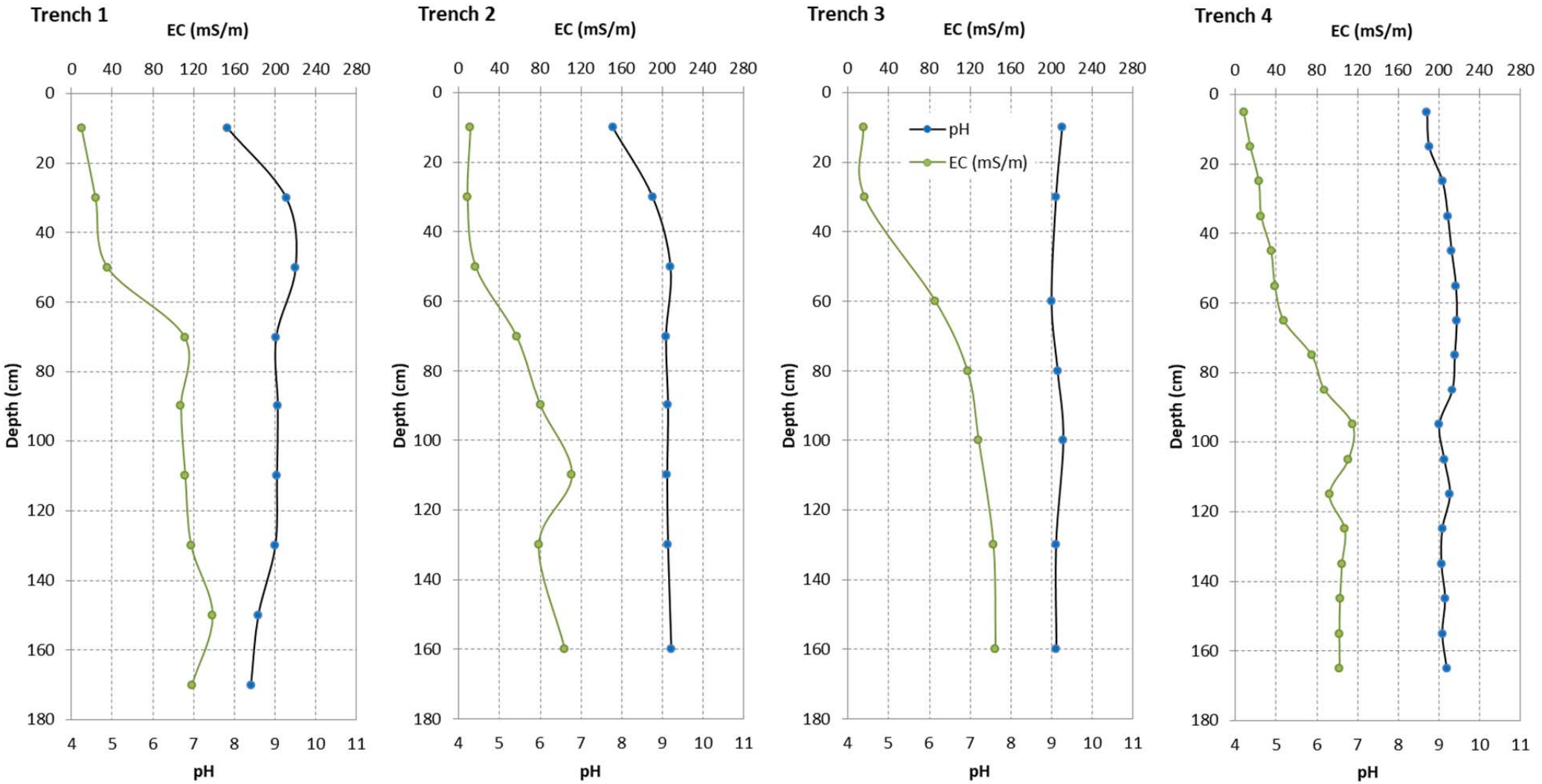
Depth (cm)	Nutrients (mg/kg)					Organic C (%)	Exchangeable Cation (meq/100g)					ESP (%)
	NO_3 - N	NH_4 - N	Colwell P	Colwell K	Ext. S		Ca	K	Mg	Na	CEC	
0-40	7	<1	4	300	5	0.58	11.5	2.96	0.73	0.51	15.75	3.0
40-100	58	<1	<2	214	128	0.16	11.2	2.7	2.8	2.8	19.6	13.9
100+	98	<1	<2	257	282	0.11	6.97	0.4	5.67	1.69	14.73	11.5

NORTHERN STAR RESOURCES LTD

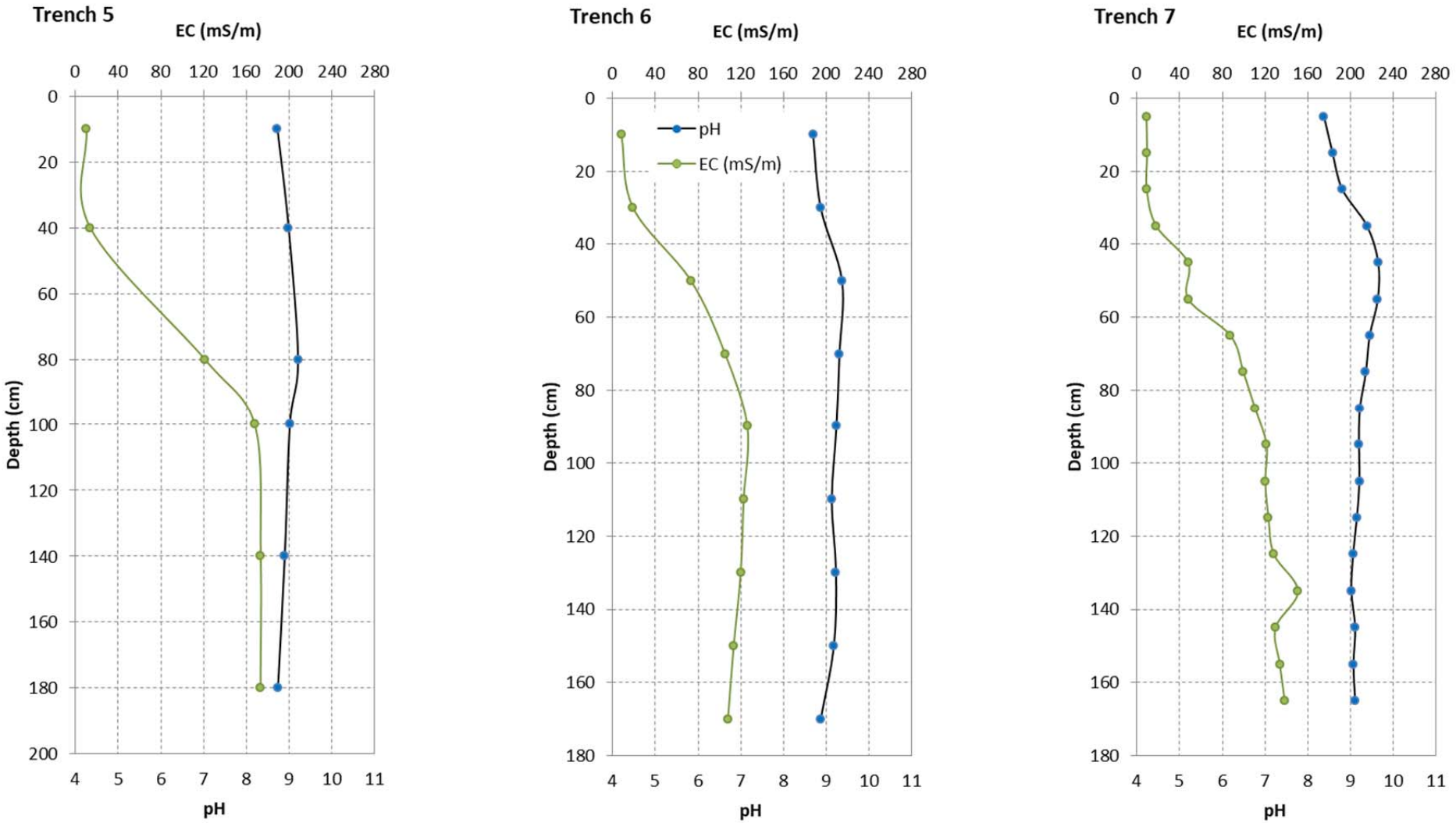
PARADIGM GOLD DEPOSIT - SOIL CHARACTERISATION STUDY

Figure 4.1: Characteristic soil profile within the study area

soilwater GROUP



NORTHERN STAR RESOURCES LTD	Figure 4.2: pH and EC depth profiles	soilwater GROUP
PARADIGM GOLD DEPOSIT - SOIL CHARACTERISATION STUDY		



NORTHERN STAR RESOURCES LTD	Figure 4.3: pH and EC depth profiles	soilwater GROUP
PARADIGM GOLD DEPOSIT - SOIL CHARACTERISATION STUDY		

4.2.1 PHYSICAL PROPERTIES

The physical properties of the samples selected from within the study area are summarised in Table 4.2. The laboratory analysis data shows a clear delineation in physical properties between the loamy material in the top meter of the soil profile and the underlying clay materials. With increasing depth in the profile the sand content decreases and the clay content increases. Interestingly the silt content of the loam material is significantly higher than that of the underlying clay, potentially indicative of its transported nature.

The water retention results from pressure plate testing are summarised in the table and also presented graphically within the moisture profile graphs shown in Figure 4.4 and 4.5. They largely mirror the particle size distribution results, with the sandy upper loam materials having a lower wilting point (1500 kPa) water content than the materials with higher clay content. This is caused by increased micro porosity within the finer textured samples. Water content below the 1500 kPa matric suction level are accepted to be too tightly held to be utilised by plants and are thus unavailable for use. The plant available water (PAW) percentage is therefore calculated by subtracting the 1500 kPa level from the 10 kPa level (freely drained water content). The values for each soil material type are similar, between 20 and 30%. This implies that for each meter of soil profile, there is 300 mm of plant available water content. As the gravel content of the material types is low, an adjustment for gravel content has not been made.

Table 4.2: Particle size distribution and water retention data

Soil unit	Depth	PSD < 2 mm fraction (%)			Water retention data (v/v %)					PAW
	(cm)	Sand	Silt	Clay	0 kPa	10 kPa	33 kPa	100 kPa	1500 kPa	(%)
Upper loam	5	-	-	-	43.0	27.5	19.8	12.7	7.4	20.1
Upper loam	5	81.8	9.3	8.9	-	-	-	-	-	-
Upper loam	10	77.2	11.9	10.9	49.9	35.2	27.6	16.9	11.5	23.7
Upper loam	10	-	-	-	51.3	38.8	25.5	14.6	9.5	29.3
Upper loam	15	76.1	12.7	11.2	-	-	-	-	-	-
Upper loam	30	75.4	8.6	16.1	49.2	29.2	24.3	18.2	10.5	18.7
Upper loam	30	73.9	15.5	10.7	-	-	-	-	-	-
Upper loam	30	74.3	13.5	12.2	-	-	-	-	-	-
Lower loam	50	64.7	11.2	24.1	-	-	-	-	-	-
Lower loam	70	61.2	12.7	26.1	49.3	42.1	34.7	24.6	16.8	25.3
Lower loam	100	57.3	15.0	27.7	52.5	41.8	31.9	24.2	17.7	24.1
Clay	80	56.9	10.9	32.2	-	-	-	-	-	-
Clay	120	58.3	6.8	34.9	54.8	39.8	32.7	24.9	18.1	21.7
Clay	150	-	-	-	53.0	39.6	33.2	26.4	18.3	21.3
Clay	150	64.4	4.5	31.1	-	-	-	-	-	-

4.2.2 CHEMICAL PROPERTIES

The measured chemical properties of the samples selected from within the study area are summarised in Table 4.3. The analytical laboratory results show that upper loam materials have low to very low mineralised N contents, with values generally less than 5 mg/kg. Extractable sulfur and nitrate values increase with depth in the profile, with the quite high extractable sulfur values reported in the lower loam and clay materials indicating the presence of gypsum, a hydrated calcium sulfate, within the mottled zone. The organic carbon contents within the upper horizon are generally low

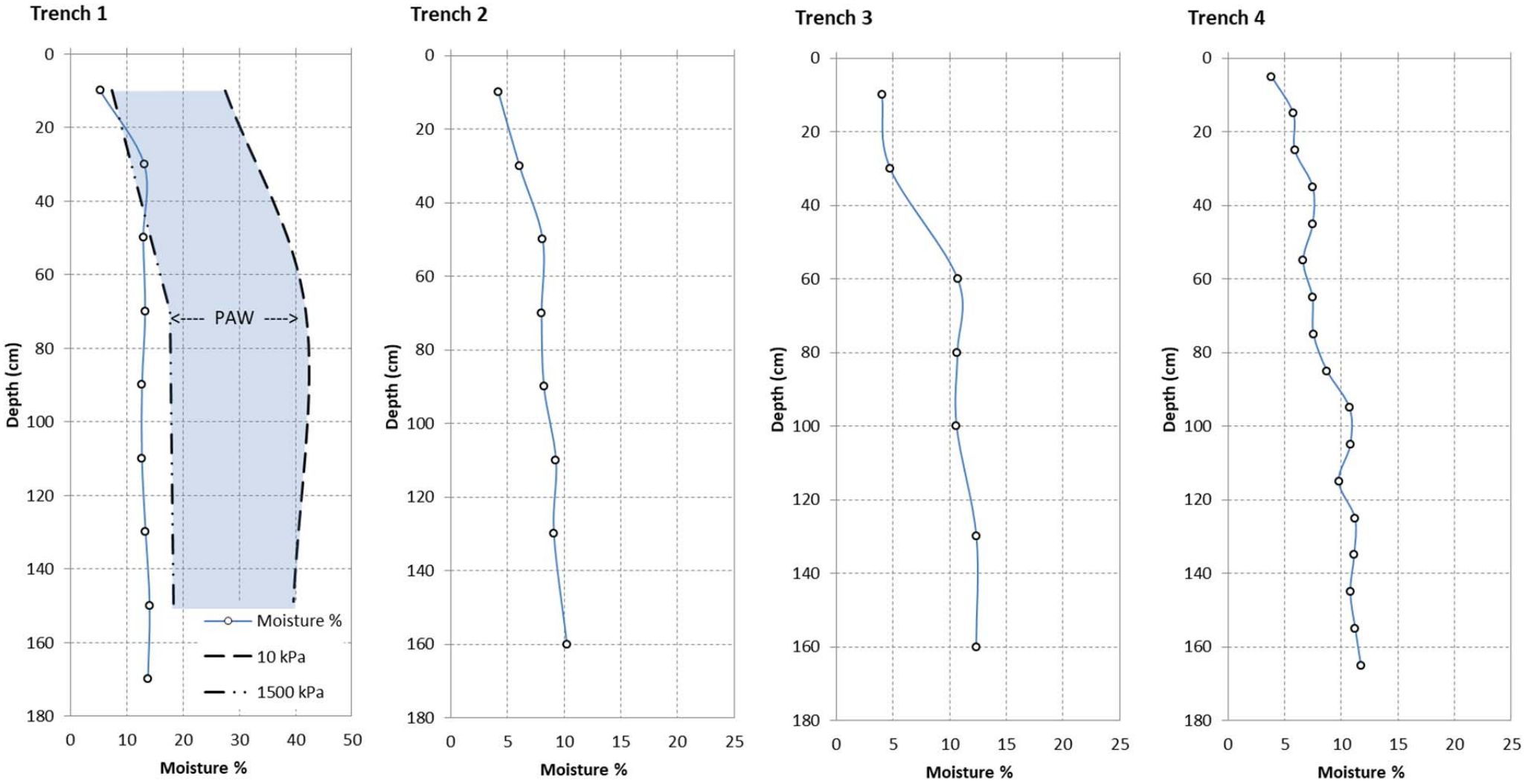
indicative of the general lack of an A horizon across the majority of the site due to lack of organic material build-up and subsequent decomposition. However both the major nutrient contents and organic carbon percentages are typical of the geologically old soils covering the Yilgarn Craton.

The exchangeable cation results indicate a general dominance of calcium ions, with the upper loam generally displaying increase potassium and the underlying clay materials having increased magnesium ion proportions. The exchangeable sodium percentage (ESP) is a measurement of the proportion of the single charge sodium ion compared to the remaining double charge ions. Where the ESP is elevated, finer clay particles show a decreased potential to bind together when in suspension (i.e. saturated) causing dispersion. Higher salinity levels within the soil-water solution change the electrical charge conditions and act to prevent this dispersion. Figure 4.6 shows the relationship between salinity and ESP with regards to a soil materials potential to become dispersive. The figure shows none of the materials are considered to be dispersive, with all samples measured classified as either Class 2a/2b or Class 3a/b. Emerson dispersion testing (Figure 4.1) indicated the materials were unlikely to slake or be dispersive under normal conditions, however stripping and transport of the soil materials should not be carried out during wet conditions to limit the lower loam and clay materials potential to disperse and/or hard set.

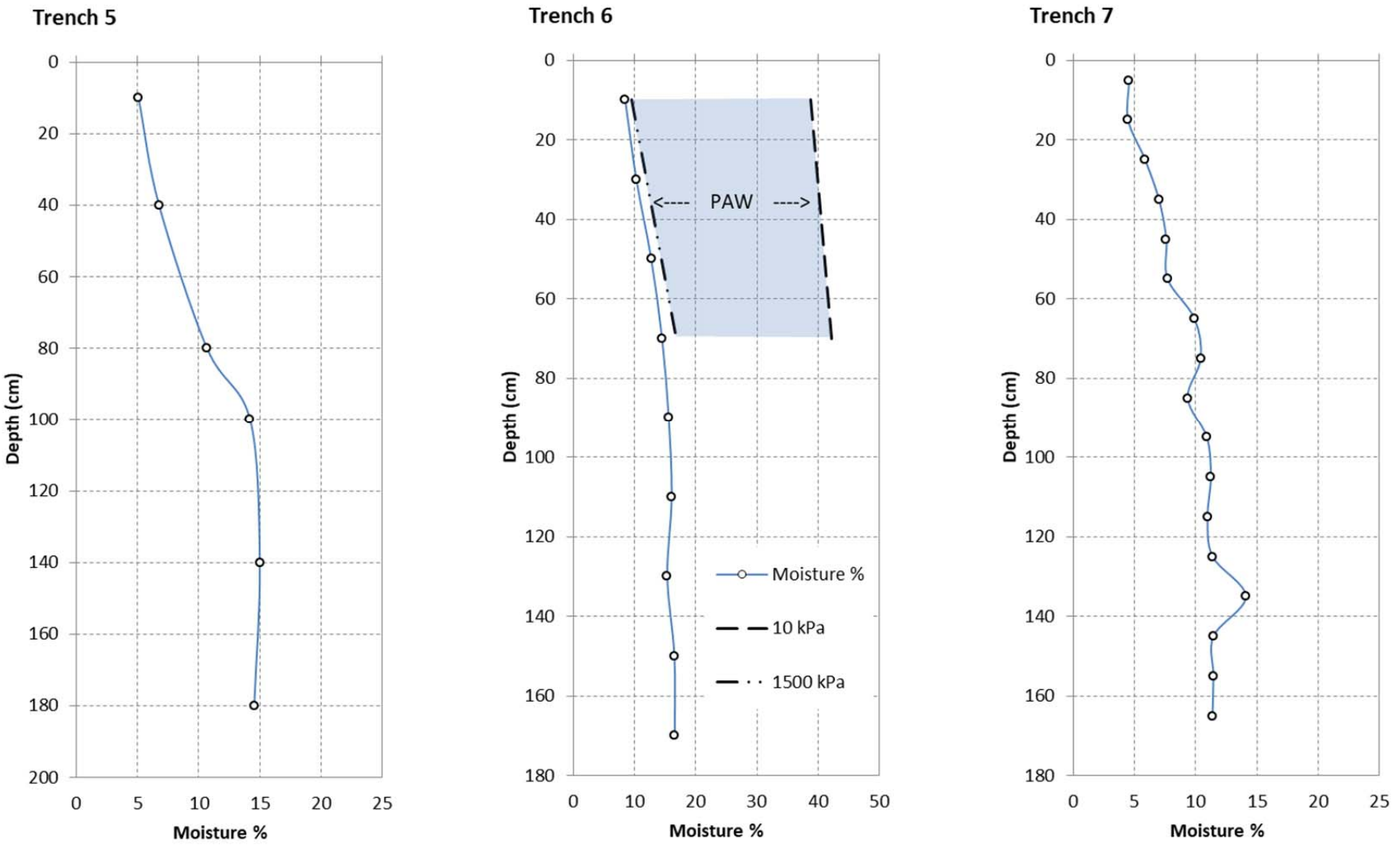
Table 4.3: Measured major nutrient and exchangeable cation contents

Unit	Nutrients (mg/kg)					Organic C	Ex. Cations (meq/100g)				CEC	ESP
	NH_4-N	NO_3-N	P*	K*	S	(%)	Ca	K	Mg	Na		(%)
Upper loam	<1	1	3	221	2.4	0.35	13	2.0	0.6	0.1	15.9	0.5
Upper loam	2	2	6	286	5.3	0.68	5	2.7	0.6	0.3	8.2	3.2
Upper loam	2	1	4	373	7.6	1.25	10	3.0	0.9	0.2	14.2	1.6
Upper loam	<1	3	6	347	3.2	0.32	13	2.1	0.9	0.1	16.3	0.4
Upper loam	<1	21	<2	175	10	0.25	13	4.5	0.5	1.5	19.4	7.8
Upper loam	<1	<1	3	339	2.3	0.44	13	3.0	0.8	0.3	16.8	1.9
Upper loam	<1	12	5	353	5.6	0.41	14	3.5	0.9	1.1	19.5	5.4
Lower loam	<1	25	<2	220	99	0.18	11	5.2	0.6	6.4	23.0	27.7
Lower loam	<1	25	<2	143	19	0.26	10	4.7	0.4	3.1	18.5	16.9
Lower loam	<1	90	<2	202	269	0.13	13	0.4	4.9	1.0	19.3	4.9
Lower loam	<1	91	<2	292	125	0.09	11	0.6	5.4	1.1	17.7	6.2
Clay	<1	98	<2	257	282	0.11	7	0.4	5.7	1.7	14.7	11.5

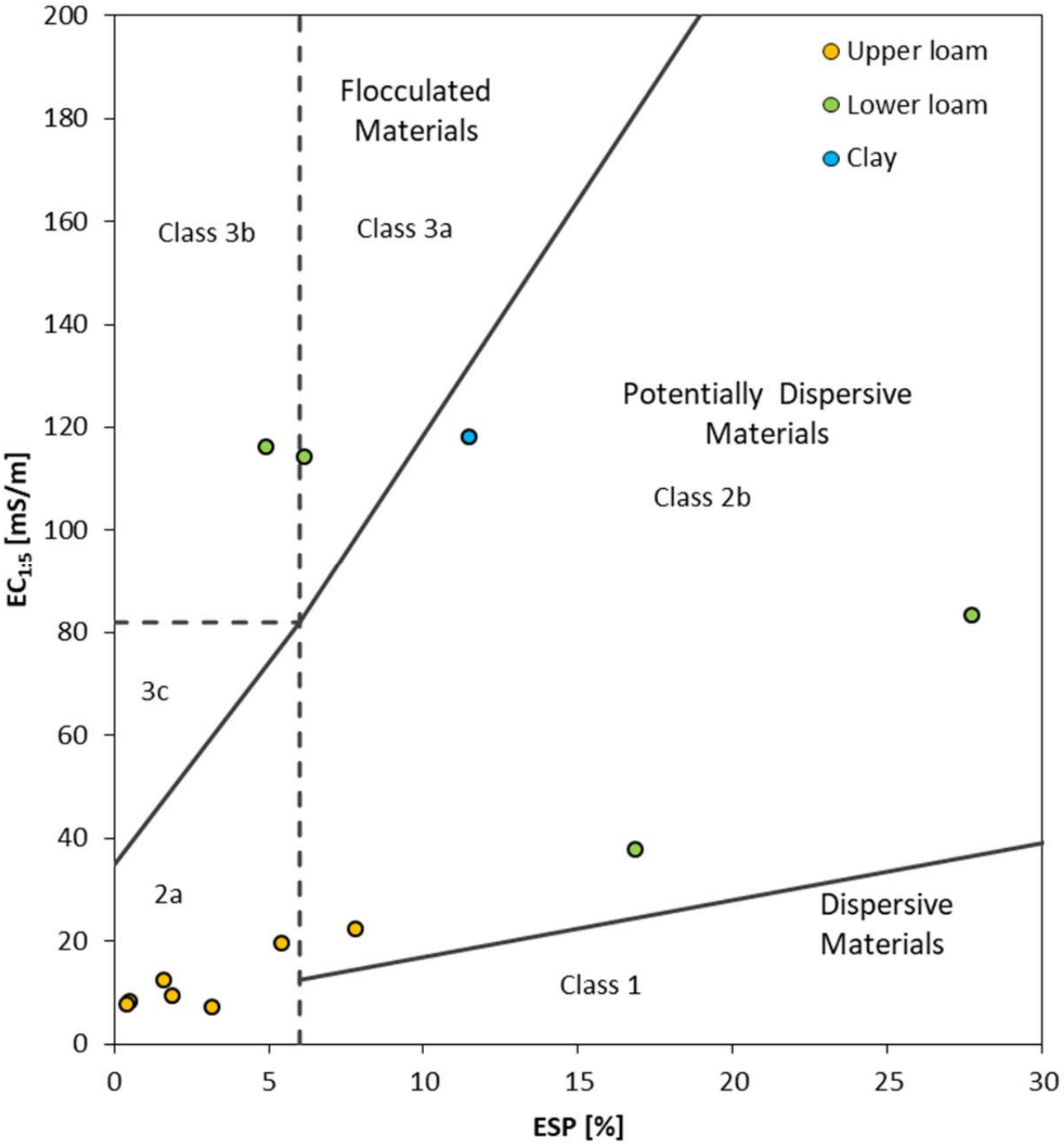
*Colwell method



NORTHERN STAR RESOURCES LTD	Figure 4.4: Field moisture content and PAW content of soil profiles (May)	soilwater GROUP
PARADIGM GOLD DEPOSIT - SOIL CHARACTERISATION STUDY		



NORTHERN STAR RESOURCES LTD	Figure 4.5: Field moisture content and PAW content of soil profiles (May)	soilwater GROUP
PARADIGM GOLD DEPOSIT - SOIL CHARACTERISATION STUDY		



NORTHERN STAR RESOURCES LTD	Figure 4.6: Sodicity – salinity relationship for the surficial soils in the study area	soilwater GROUP
PARADIGM GOLD DEPOSIT - SOIL CHARACTERISATION STUDY		

4.3 EROSION MODELLING RESULTS

Table 4.4 summarises the average runoff and sediment yield values predicted by the WEPP erosion model, given the input parameters previously summarised in Section 3.5. No effort was made to segregate the material types based on the categories described in Section 4.1 and 4.2 and the erosion modelling represent the likely result of placing a mix of material on the landform surface from the upper 2 m of the soil profile. Variability around these averages does however they are within normal limits based on WEPP calibration parameters. The erosion rate is not expected to be uniform in any case and is closely associated with higher intensity storm events.

Table 4.4: Summary of WEPP erosion modelling results.

Lift height (m)	Slope angle	Average annual runoff (mm/yr)	Average erosion rate (mm/yr)	Average erosion rate (t/ha/yr)
10	15°	26	1.2	7.9
	18°	29	1.5	9.7
20	15°	20	2.1	14
	18°	21	2.4	16

The WEPP model indicated average sediment yields ranging from 8 t/ha/yr (1.2 mm soil loss per year) for the lower angle and length batter model to 16 t/ha/yr. The modelling indicates that slopes with lower angles and heights performed better than higher angles for the materials tested. The results show that the materials are moderately stable where the lift height and angles are conservative, however to ensure stability in the long term additional stability measures should be considered, such as rock armouring or ‘mulching’ along with potentially reducing the exposure at the surface of the planned post mine landform of the underlying clay material with increased fines content.

It should be noted that more than the average amount of sediment (e.g. the average t/ha/yr) are likely to be generated in years with greater than average rainfall, and from extreme individual storm events. Runoff and erosion depend largely on the size and intensity of each rainfall event and the infiltration characteristics of each material – Not all rainfall events generate runoff, and not all runoff events generate erosion. It is reasonable to expect that more than one year’s worth of sediment loss (when considered as an average annual loss) will occasionally occur in response to a single large or intense storm event.

5 CONCLUSIONS & SOIL MANAGEMENT RECOMMENDATIONS

This section outlines management recommendations for the handling and utilisation of the surficial soil materials characterised in Section 4. These recommendations are suggested with the aim of:

- Maintaining optimal soil properties during the mining and rehabilitation process.
- Ensuring the appropriate management of soils exhibiting 'good' or favourable properties for use in rehabilitation.
- Minimising environmental impacts through inappropriate handling and placement of soil materials that exhibit adverse properties.
- Implementing management strategies that will facilitate revegetation growth and establishment, and overall rehabilitation success.

5.1 TOPSOIL

- The topsoil in the study area is typically poorly developed with only minor accumulation of organic matter and negligible nutrient content in comparison to underlying soil. The only benefit to rehabilitation outcomes of treating the topsoil (top 10 cm) differently than underlying soil is for the contained seed store, which will need to be utilised within 18 - 24 months.
- If return of stockpiled soil material is not carried out within 24 months of stripping, there is little practical benefit to handling and storing topsoil and subsoil separately, and in this case these units can be managed as one soil material unit.
- Topsoil stockpiles should be limited to a maximum height of 2 m to maintain the soils biological component and retention of any nutrient sources. These stockpiles should ideally be used as soon as possible (i.e. by direct placement) or utilised within 24 months.
- All topsoil within the disturbance areas represents a valuable resource for rehabilitation purposes and should be stripped and stockpiled for this purpose during clearing operations.

5.2 SUBSOIL

- Subsoil in the study area consists of a reddish-brown loam above underlying stiff clays and is likely to extend to a depth of at least 3 m across the study area.
- The subsoil should be categorised as a loamy material approximately 1 m in depth overlying an underlying clay material.
- Neither the loam nor clay unit exhibit any adverse physical or chemical properties that may affect revegetation growth and establishment.
- Both the loam and clay units are only moderately resistant to erosion and are potentially dispersive due to generally low salinity, therefore consideration should be given to the use of competent waste rock armouring as a stabilising agent to reduce erosion during the crucial establishment period of rehabilitation vegetation on post mine landforms. The waste rock can be mixed through within the soil material during rehabilitation earthworks via shallow ripping to increase the stability of the outer surfaces of post-mine landforms.
- It is recommended that where possible the subsoil should be completely stripped down to the upper surface of the clay layer within both the mine pit and WRL footprint disturbance areas and subsequently utilised as the outer surface of the planned post mine landform. The underlying clay material sourced from the mine pit can also be captured if required to aid in the establishment of revegetation species by maximising the overall PAW in the upper WRL surface layer.

- As investigation has indicated that the majority of plant species in the study area are likely to rely on soil moisture below the loam layer (i.e. within the clay material) use of shallow rooting, low transpiring species in revegetation seed mixes should be considered to reduce the required PAW content, which will increase the sustainability of rehabilitation on the post-mine landforms.

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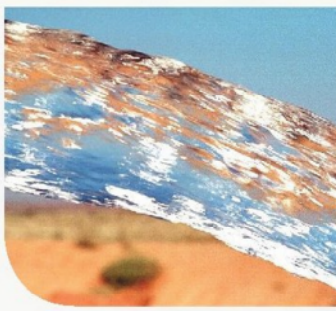
Appendix B:

Rockwater Hydrology and Surface Water Assessment



PARADIGM NORTH PROJECT

HYDROLOGY AND SURFACE-WATER ASSESSMENT

REPORT FOR
NORTHERN STAR RESOURCES

SEPTEMBER 2018

Rockwater
HYDROGEOLOGICAL AND ENVIRONMENTAL CONSULTANTS

Report No. 190-16/18/02

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REVISION	AUTHOR	REVIEW	AUTHORISED	ISSUED
0	CC	PHW		6 September 2018

1. INTRODUCTION

Northern Star Resources (NSR) is planning the development of the Paradigm North deposit, located about 150 m north of the Paradigm pit and underground workings, at Carbine, about 60 km north-west of Kalgoorlie. It is expected that there will be both an open-cut pit and underground workings.

The project lies on a gentle south-east facing slope near a catchment divide.

Rockwater Pty Ltd was commissioned by Northern Star Resources to complete a surface water management plan to assess the potential impact of flood flows on the surface infrastructure and pit (Fig. 1) and to determine the bunding and drainage requirements.

The surface water catchment is delineated in Figure 2, together with topographic contours (1 m interval).

The scope of work covered in this report includes the following:

- Identification of catchment areas and natural water courses that could impact the project's surface installations;
- Hydrological analyses to estimate peak flows for 1 in 2, 5, 10, 20, 50 and 100-year ARI rainfalls for the critical storm duration on the relevant catchment areas; and for a 1-in-2000-year rainfall, taken to be the Probable Maximum Precipitation (PMP) event;
- Surface water hydraulic analyses to examine the impact of the 1 in 100 year ARI peak flow and Probable Maximum Flood; and
- Identify and provide advice and concept design and recommendations for perimeter bunds and any diversionary channels needed to prevent flooding during the 1 in 100 year ARI flow event; and drainage requirements.

1.1. INFORMATION PROVIDED BY NSR

The following information and data were provided by NSR:

- The planned layout of the pit, WSF, roads and infrastructure; and
- 1.0 m-interval topographic contours of the project area.

2. SURFACE WATER HYDROLOGY

The Paradigm North Deposit is located near the top of a catchment divide between the Black Flag palaeodrainage to the east, and an internal drainage system to the west that includes Carnage Lake, Clear Lake and Rowles Lagoon. It lies on generally flat, gently sloping ground (gradient approximately 1-in-100). There are no drainage lines in the local area that could concentrate runoff (Fig. 3).

The Rational Formula was applied to estimate peak flows, as recommended in the Australian Rainfall and Runoff 1987 Guideline (AR&R, 1987) for flood estimation in small catchments. However, in the arid region of Western Australia, these techniques were developed with few data. New methods such as the Leinster flood frequency procedure (Flavell, 2012) were developed for this region with marginally more data. For this analysis, the two methods were used and compared.

2.1. RAINFALL ANALYSIS

Intensity-Frequency-Duration (IFD) curves for the Paradigm North site were obtained from the Bureau of Meteorology web-site, and are based on the statistical and meteorological analyses given in the Australian Rainfall and Runoff 1987 Guideline (Pilgrim et. al., 1987). The IFD tables and curves are included in Appendix A.

The Probable Maximum Precipitation (PMP) was taken to be a 1-in-2000 year event, with a probability of occurring in any year of 0.05%. The design rainfall for this event is also included in a table and chart in Appendix A. The Probable Maximum Flood (PMF) results from a PMP event.

2.2. IDENTIFICATION OF CATCHMENT AREA

The relevant catchment areas were identified from the 1.0 m interval contour plan (Figs. 2 & 3). These areas were used in the peak flow estimation analysis as described in Section 2.6.

2.3. TIME OF CONCENTRATION

The time of concentration is required to estimate the critical storm duration for peak flows in each catchment. This was estimated using Equation 1 for the Arid Region of Western Australia as recommended by AR&R 1987:

$t_c = 0.76 \cdot A^{0.38}$ Equation 1

Where:
t_c is the time of concentration (hours)
A is the catchment area (km^2)

2.4. RATIONAL METHOD

The Statistical Rational Method, used in peak-flow estimation, is presented in Equation 2.

$$Q_y = 0.278 \cdot C_y \cdot I_{tcy} \cdot A$$ Equation 2

Where:
Q_y is the peak flow for return period of y years (m^3/s)
0.278 is a dimensionless metric conversion factor
C_y is the runoff coefficient for y years (dimensionless)
I_{tcy} is rainfall intensity (mm/hr)
A is catchment area (km^2)

2.5. LEINSTER AREA FLOOD FREQUENCY PROCEDURE (FLAVELL 2012)

The procedure includes an equivalent uniform slope and a shape factor. The equations for 1 in 2, 5, 10, 20, 50 and 100 peak flows are presented below:

$$Q_2 = 0.16 \cdot (AS_e^{0.5})^{0.82} \cdot (L^2/A)^{-0.35}$$ Equation 3

$$Q_5 = 0.48 \cdot (AS_e^{0.5})^{0.84} \cdot (L^2/A)^{-0.33}$$ Equation 4

$$Q_{10} = 0.89 \cdot (AS_e^{0.5})^{0.84} \cdot (L^2/A)^{-0.34}$$ Equation 5

$$Q_{20} = 1.45 \cdot (AS_e^{0.5})^{0.85} \cdot (L^2/A)^{-0.33}$$ Equation 6

$$Q_{50} = 2.44 \cdot (AS_e^{0.5})^{0.82} \cdot (L^2/A)^{-0.36}$$ Equation 7

$$Q_{100} = 3.28 \cdot (AS_e^{0.5})^{0.83} \cdot (L^2/A)^{-0.35}$$ Equation 8

Where:

Q_n is the peak discharge for the n-year ARI flow (m^3/s)
A is the catchment area (km^2)
L is the mainstream length (km)
S_e is the equivalent uniform slope (m/km)

2.6. HYDROLOGY RESULTS

The characteristics of the catchments which could impact the Paradigm North project are listed in Table 1. The nearest Bureau of Meteorology (BoM) station is Ora Banda (Stn. 012066), located 16 km north-east of Paradigm. Annual Rainfall (1916 to 2016) averages 241 mm.

Table 1: Catchment Characteristics

Catchment	Area (km^2)	Length (km)	Slope (m/km)
A[1]	2.5	1.9	9.5
B[2]	3.0	2.1	8.6
C[2]	1.4	1.5	8.9

[1] Prior to Paradigm North Pit (Figure 2)
[2] Including Paradigm North Pit and infrastructure (Figure 3) – Catchment C is a sub-catchment of Catchment B

A summary of the design peak flows, as estimated using the Rational and Leinster Area methods, is shown in Table 2. The detailed calculations are presented in Appendix A. Calculated peak flows are similar for both methods: averages of the two methods were adopted for the hydraulic calculations.

Table 2: Estimated Peak Flows for the Catchment

Catchment A	ARI (years) / Discharge (m^3/s)						
Method:	2	5	10	20	50	100	PMF*
Rational - ARR87	0.64	1.89	3.29	5.22	8.51	11.99	
Flavell - 2012	0.75	2.37	4.37	7.29	11.42	15.72	

Adopted (average)	**0.70**	**2.13**	**3.83**	**6.25**	**9.96**	**13.86**	**22.37**

Catchment B	ARI (years) / Discharge (m^3/s)						
Method:	2	5	10	20	50	100	PMF*
Rational - ARR87	0.83	2.43	4.22	6.69	10.91	15.37	
Flavell - 2012	0.82	2.60	4.81	8.03	12.52	17.26	
Adopted (average)	**0.83**	**2.52**	**4.51**	**7.36**	**11.71**	**16.32**	**26.34**

Catchment C	ARI (years) / Discharge (m^3/s)						
Method:	2	5	10	20	50	100	PMF*
Rational - ARR87	0.54	1.59	2.76	4.37	7.12	10.03	
Flavell - 2012	0.44	1.37	2.54	4.21	6.69	9.17	
Adopted (average)	**0.49**	**1.48**	**2.65**	**4.29**	**6.91**	**9.60**	**15.50**

* *PMF estimated using multiplying factors from CRC-FORGE results*

3. HYDRAULIC ANALYSES

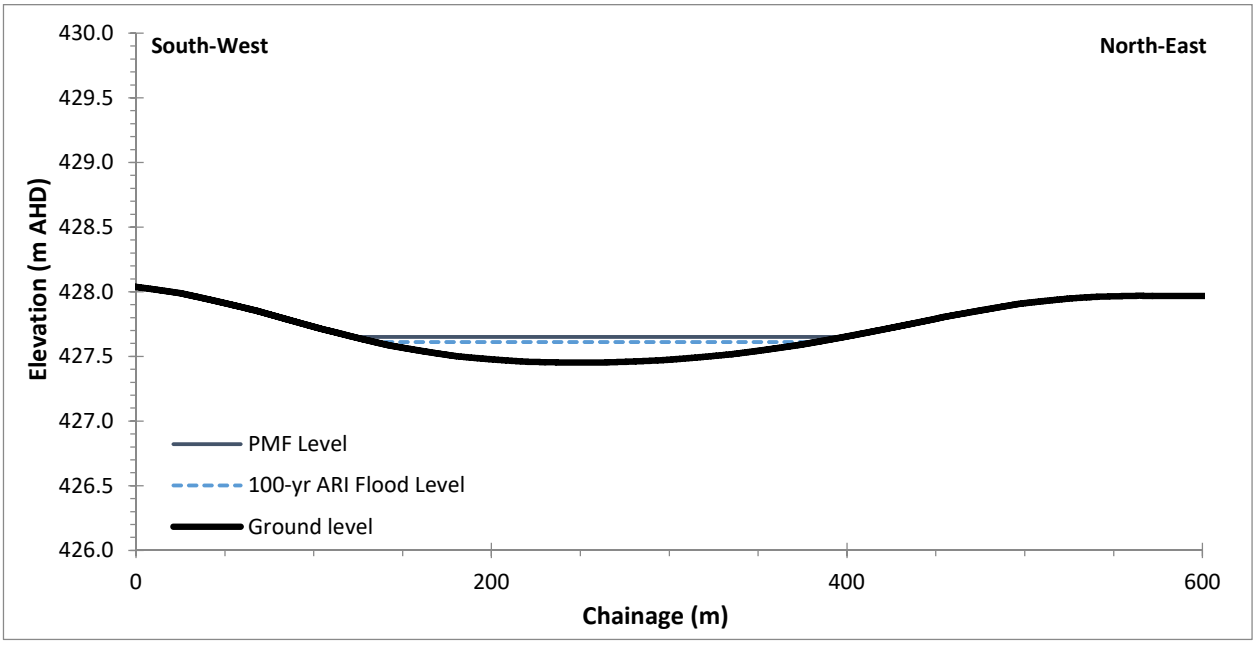
3.1. PRE-MINING

Peak flows were analysed to assess whether the 1 in 100 year ARI peak flows could impact the pit and associated infrastructure.

There are no drainage lines in the vicinity of the deposit to concentrate surface runoff; therefore runoff will mainly take place by shallow sheet flow unless the topography is modified during mine excavation, road construction, etc.

The extent, velocity and depth of flow were estimated at one selected cross-section (pre-mining, Fig. 2) (Text-Figure 1) using Manning's equation, a roughness coefficient of 0.04 and a gradient of 9.5 m/km.

Text-Figure 1 - Cross-section 1 with 1 in 100 year ARI Flood and PMF



In a 1-in-100 year flood, the peak flood level would be up to 0.16 m deep with a velocity of 0.36 m/s. In a PMF, the flood would be 0.04 m deeper.

A levee and a channel would control and divert peak flows during major rainfall events (as shown in Fig. 3).

The walls of the existing and planned waste rock landforms (WRL and WSF) should be sufficient to divert flow around them – the flow velocities would be too low to cause any significant scouring.

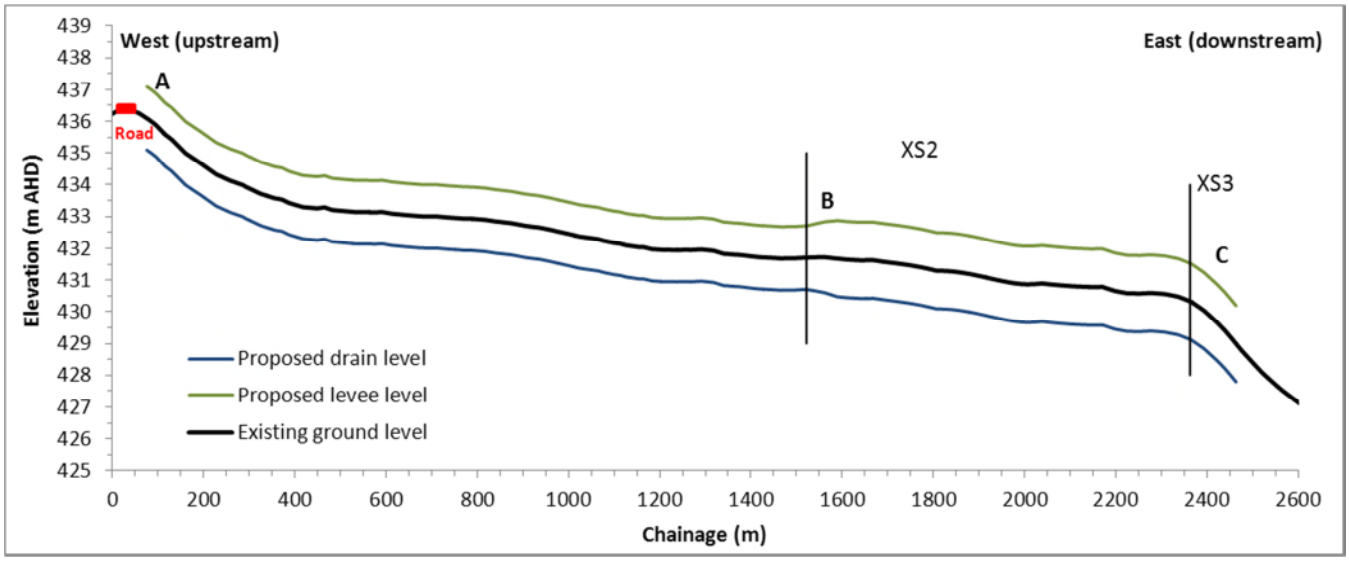
3.2. WITH INFRASTRUCTURE AND DIVERSION CHANNEL

Protective bunds have been planned by NSR, and they are recommended to protect the pit and infrastructure. The addition of a channel along the northern levee would help to divert the flow and form a diversion channel. Also, given the topography of the area, the relocation of this levee along a contour is advised to allow natural flow along it. The recommended diversion channel/levee is shown in Figure 3.

Hydraulic analyses were carried out at two cross-sections to show the estimated peak flood levels along the protective channel-levee system, with the proposed conceptual design. The results are given in Appendix B

A conceptual long-section of the recommended levee and channel is presented in Text-Figure 2 below.

Text-Figure 2 - Long-section of the proposed diversion channel



No additional protective measures should be needed for the existing road.

Excavation of a channel is recommended in conjunction with the levee to form the channel: the excavated material can be used for construction of the levee. The recommended dimensions for the channel and the levee forming the diversion channel are presented in Table 3.

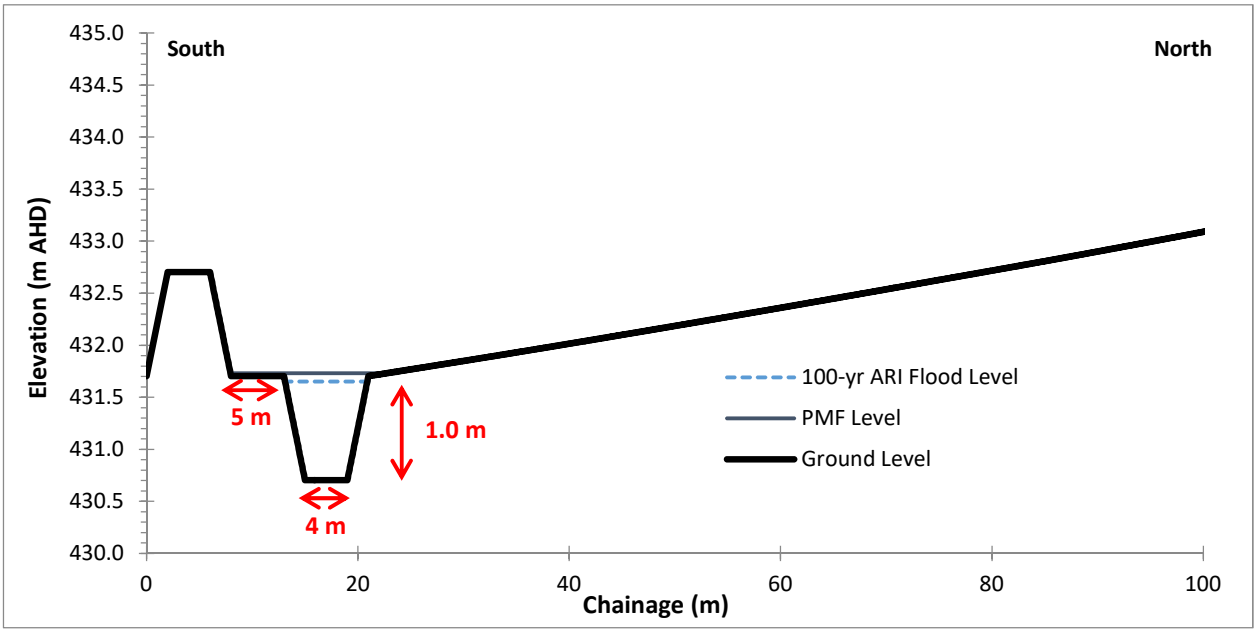
Table 3: Proposed diversion channel dimensions

Section of diversion channel	Channel /Levee Bank Slope	Channel Bed/Top of Levee Width (m)*	Channel Depth/Levee Height (m)*	Cross-sections
A-B	1:2	3.0	1.0	2
B-C	1:2	3.0	1.2	3

*These values are indicative and should be considered as minimum requirements

Cross-section 2 below (Text-Figure 3) shows the flood levels downstream from section A-B of the proposed diversion channel.

Text-Figure 3 - Cross-section 2 with 1 in 100 year ARI Flood and PMF



In the 1-in-100 year flood, the level would be respectively 0.05 m above the proposed channel and the maximum velocity would be in the order of 1.8 m/s (Table 4).

Table 4: Cross-section 2, proposed channel/levee concept design and 100-year flood summary

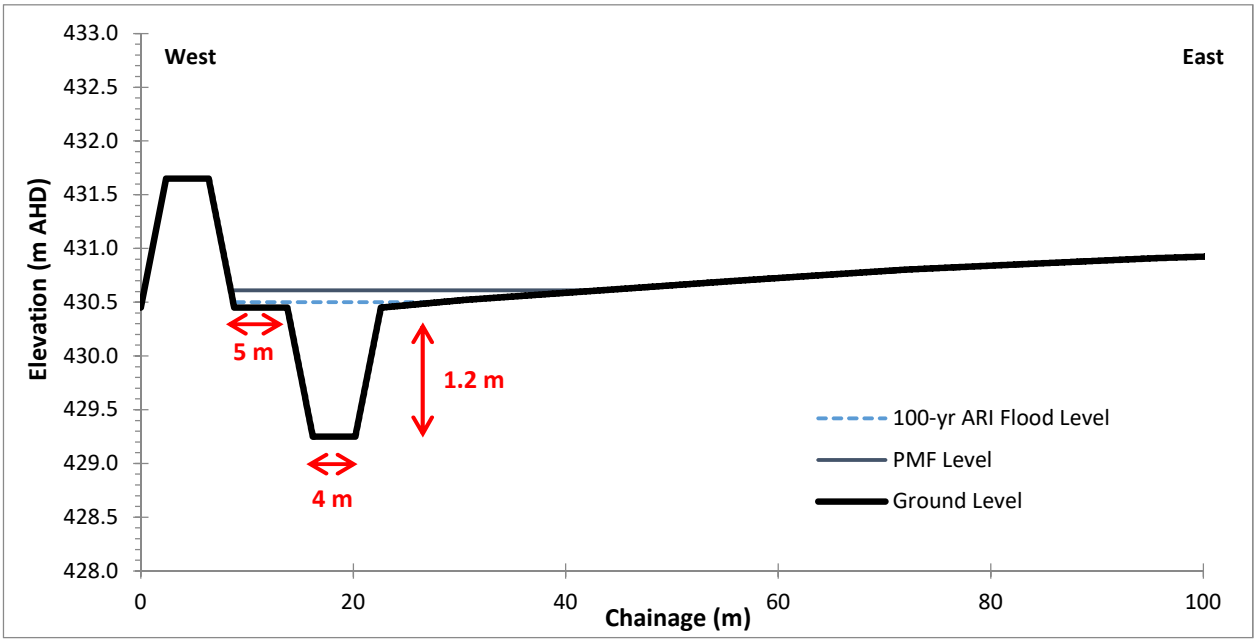
Cross Section	Corresponding long-section chainage (m)	Ground level (m AHD)	Proposed levee level (m AHD)	Proposed channel level (m AHD)	100-year ARI Flood Elevation (m AHD)	100-year ARI Flood Velocity (m/s)
2*	2312	431.70	432.70	430.70	431.65	1.8

* Catchment C

In the PMF, the level would be 0.08 m higher and would spread about 16 m to the north of the levee.

Cross-section 3 below (Text-Figure 4) shows the flood levels downstream from the whole diversion channel (section A-C).

Text-Figure 4 - Cross-section 3 with 1 in 100 year ARI Flood and PMF



In the 1-in-100 year flood, the level would be 0.05 m above the top of the proposed channel, and the maximum velocity would be in the order of 2.0 m/s (Table 5).

Table 5: Cross-section 3, proposed channel/levee concept design and 100-year flood summary

Cross Section	Corresponding long-section chainage (m)	Ground level (m AHD)	Proposed levee level (m AHD)	Proposed channel level (m AHD)	100-year ARI Flood Elevation (m AHD)	100-year ARI Flood Velocity (m/s)
3*	3153	430.45	431.65	429.25	430.50	2.0

* Catchment B

In the PMF, the level would be 0.11 m higher and would spread about 35 m to the east of the levee.

The proposed diversion channel would leave an enclosed area of 0.35 km^2 west of the North pit (Fig. 3). The 1-in-100 year flood flow in that area would be about 4.0 m^3/s. Runoff in that area will take the form of shallow sheet flow with a maximum 0.10 m depth and a low velocity of about 0.3 m/s. There is another similar small area east of the pit.

3.3. IMPACT ON PIT

It is also necessary to determine the volume of water, and resulting water level, that would report to the pit during a major rainfall event, in order to ensure the underground portal is well above the flood level. For this calculation, the pit floor is assumed to be dry prior to the rainfall event, which is taken to be a 72-hour, PMP storm.

From the CRC Forge results (Appendix A) the PMP rainfall would total about 360 mm over the 72 hours. Assuming all the rainfall reports to the base of the Paradigm/Paradigm North pit, with an area inside the perimeter bund of about 219,000 m^2, this could result in a water volume of 79,000 m^3, and the water level rising from the bases of the two lobes of the (combined) pit to about 318 m AHD. This calculation assumes that the configuration of the base of the existing Paradigm pit, as given in paradigm_volume.xls remains

the same, and the configuration of the base of the Paradigm North pit as given in the file paradigm_reserve_dtm_design 1307.dxf applies.

4. CONCLUSIONS AND RECOMMENDATIONS

The Paradigm North project area has a small surface water catchment, and does not include any drainage lines that would concentrate surface water flows. Even in a major runoff event, surface water flows would be of limited depth and velocity.

However, the project lies on a gently south-facing slope and a diversion levee and channel is advised along the northern boundary of the project area to divert flows and to protect the pit and infrastructure. Protective bunds of 1 m height are also recommended around the combined Paradigm/Paradigm North pit.

It is calculated that in a PMP rainfall event, water level in the pit could rise from the bases of the two lobes to a level of about 318 m AHD.

Dated: 6 September 2018

Rockwater Pty Ltd

C Corthier
Engineering Geologist

P Wharton
Principal

REFERENCES

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Flavell, D., 2012, Design flood estimation in Western Australia, Australian Journal and Water Resources, Vol. 16, no. 1.

FIGURES

Figure 1

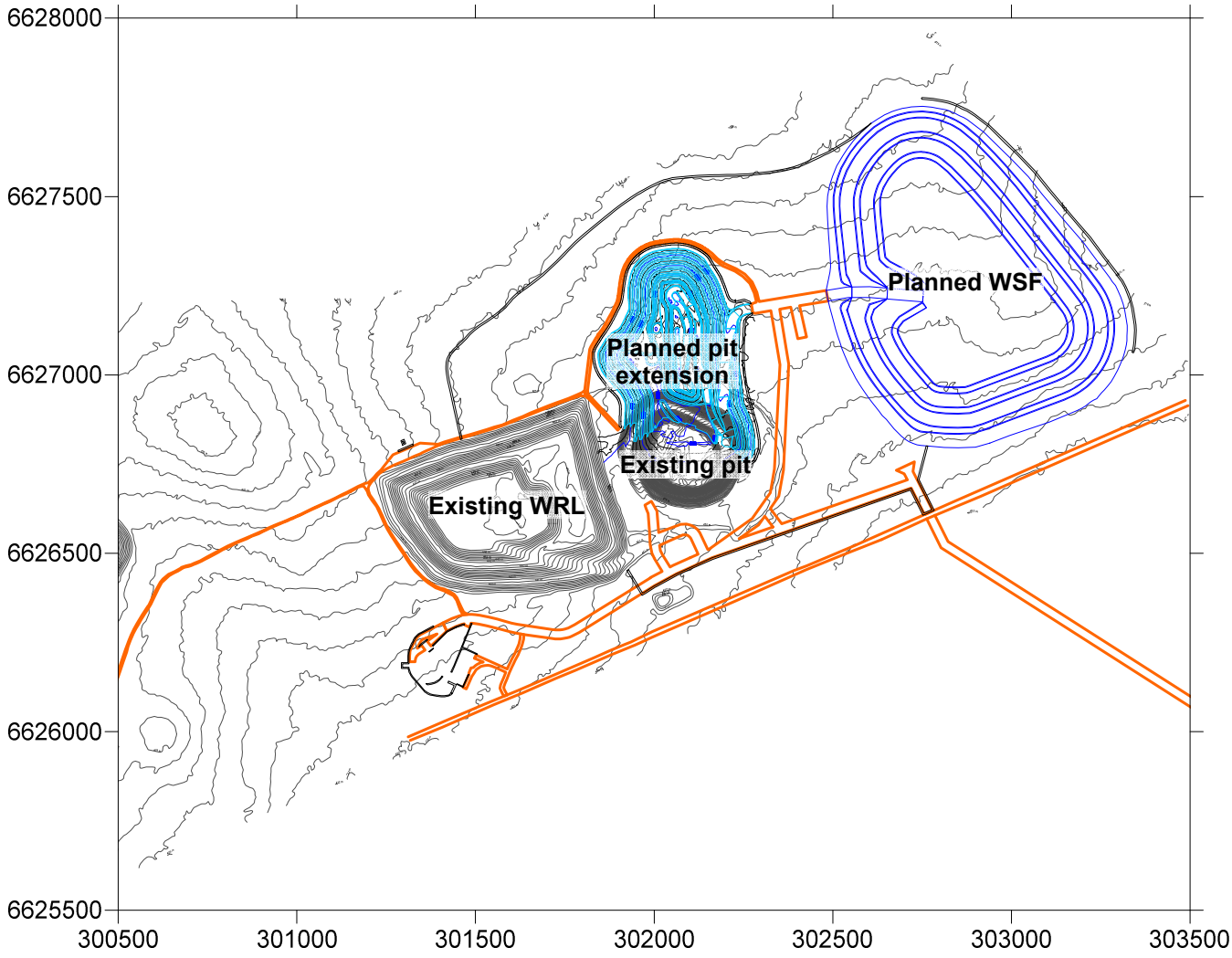

Figure 1 - Layout.srf

CLIENT:	Northern Star Resources
PROJECT:	Paradigm North - Surface Hydrology
DATE:	September 2018
DWG NO:	190-16/18/2-1

LAYOUT PLAN PARADIGM NORTH

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Figure 2

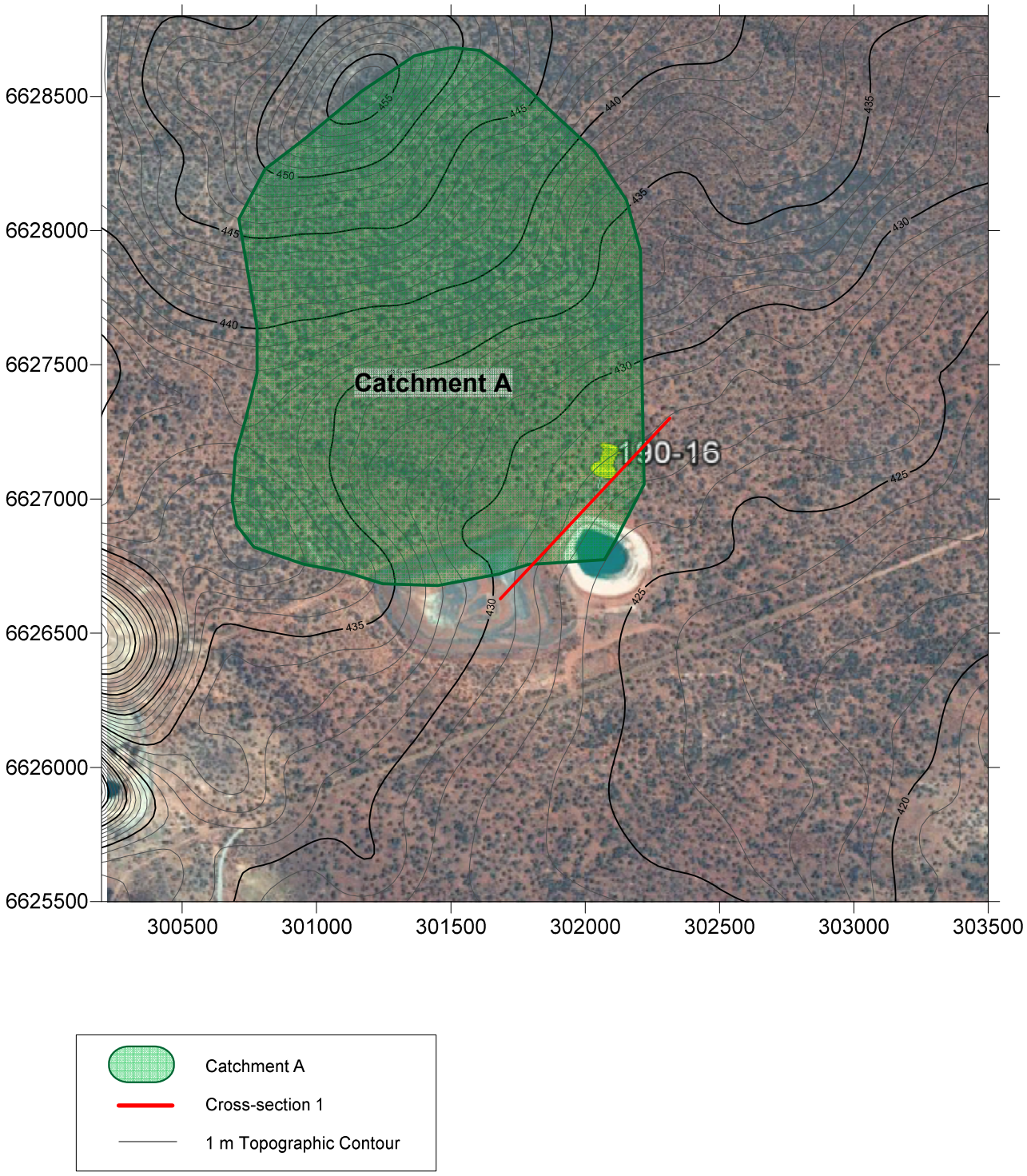

Figure 2 - Pre-Mining Catchment.srf

CLIENT:	Northern Star Resources
PROJECT:	Paradigm North - Surface Hydrology
DATE:	September 2018
DWG NO:	190-16/18/2-3

PRE-MINING CATCHMENT
PARADIGM PIT

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Figure 3

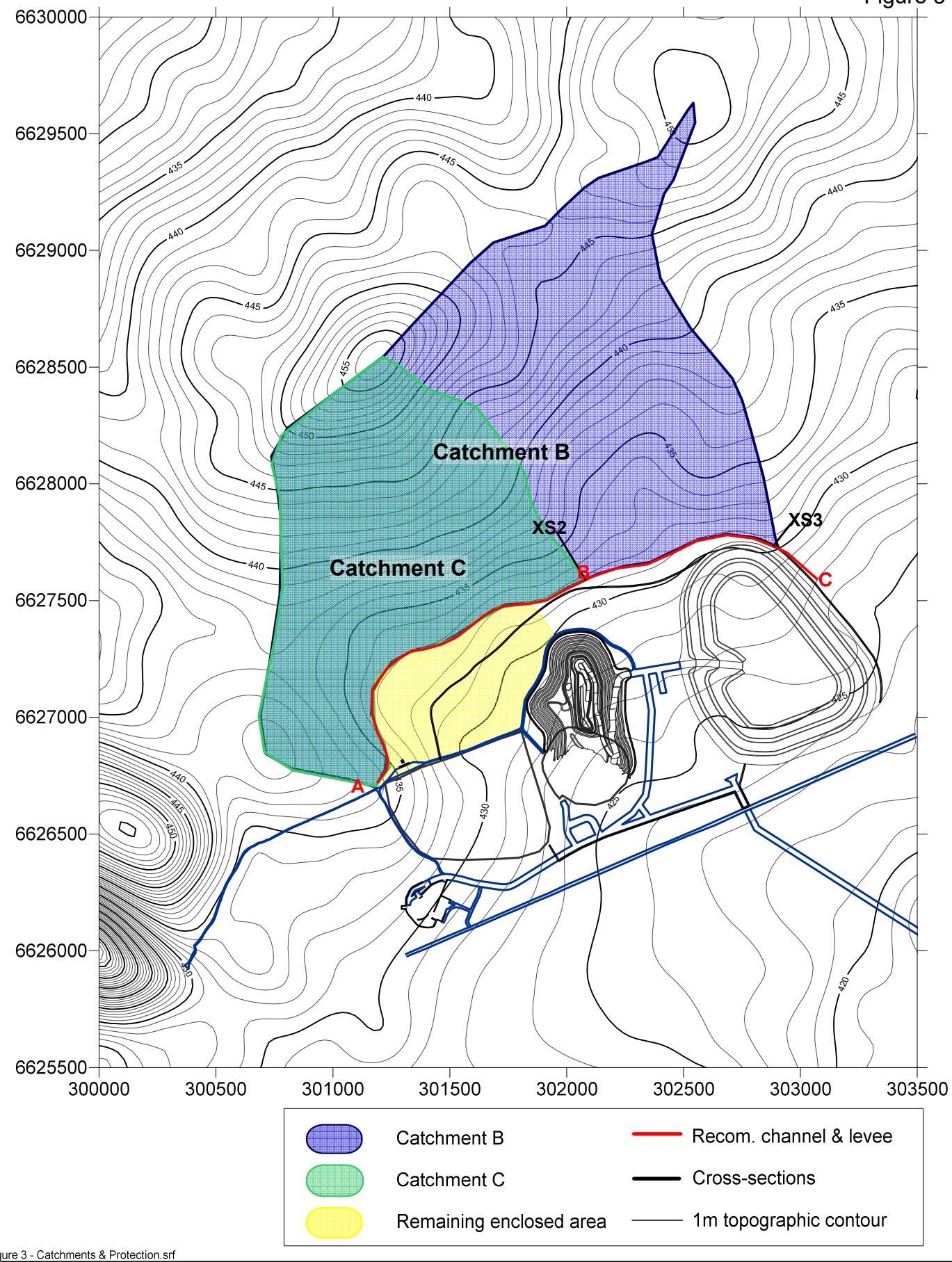

Figure 3 - Catchments & Protection.srf

CLIENT:	Northern Star Resources
PROJECT:	Paradigm North - Surface Hydrology
DATE:	September 2018
DWG NO:	190-16/18/2-3

CATCHMENTS & PROTECTIVE MEASURES PARADIGM NORTH

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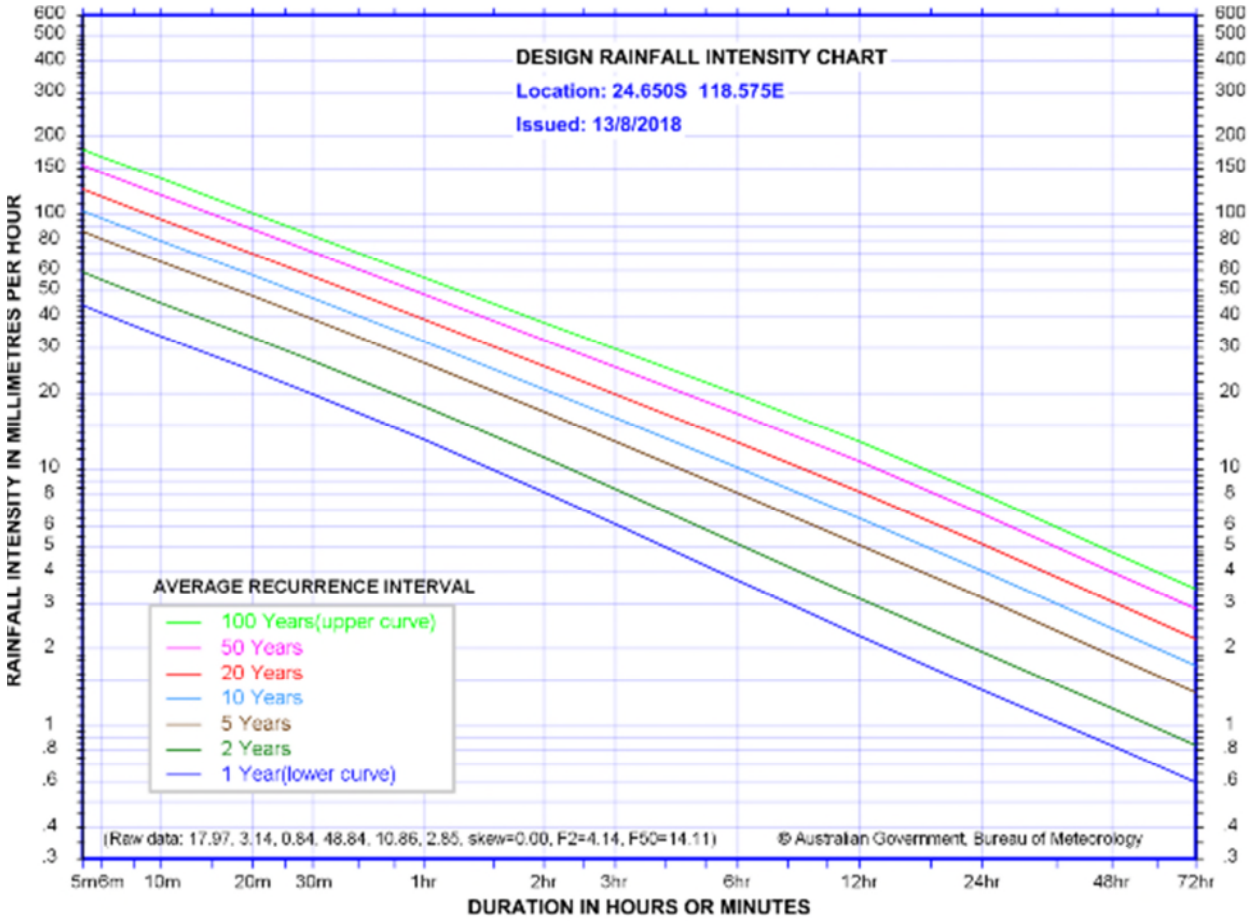
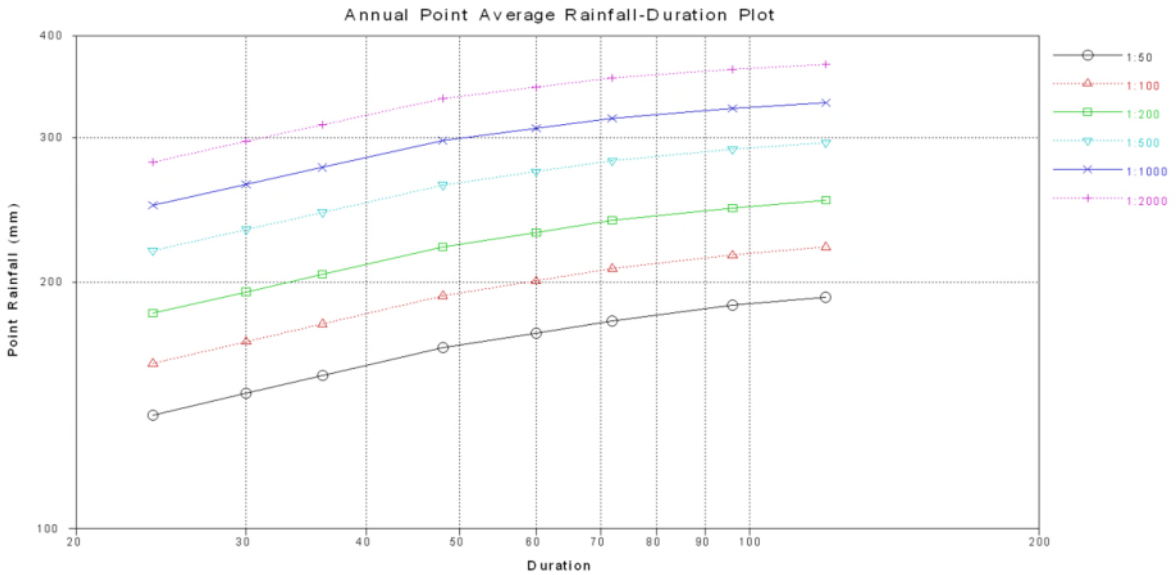
APPENDIX A: HYDROLOGY CHARTS AND CALCULATIONS

AUSTRALIAN RAINFALL AND RUNOFF VOLUME 1 & 2 (1987)
RATIONAL METHOD - WESTERN AUSTRALIA

IFD Curves:



CRC Forge Results:



AUSTRALIAN RAINFALL AND RUNOFF VOLUME 1 & 2 (1987)
RATIONAL METHOD - WESTERN AUSTRALIA

REGION: **ARID INTERIOR**

LOCATION: Paradigm

CATCHMENT: A

Arid Interior Region

Catchment Characteristics	A (km^2)	L (km)	S_e (m/km)	P (mm)
	2.5	1.9	9.5	241

RATIONAL METHOD:

Care needs to be taken when catchment characteristics fall outside the following:

A =	59.0	km^2
L =	11.5	km
S_e =	5.71	m/km
P =	255	mm

$Q_Y = 0.278C_Y.I_{tc,Y}.A$ ..... **(1.1)**

$t_c = 0.76A^{0.38}$ ..... **(1.29)**

t_c = 1.08 Hrs

$C_{10} = 3.46x10^{-1}L^{-0.42}$ ..... **(1.30)**

C_{10} = 0.26

Frequency Factors (C_Y/C_{10})

	ARI (years)					
	2	5	10	20	50	*100*
C_Y/C_{10}	0.34	0.70	1.00	1.28	1.62	*1.91*

100 year ARI extrapolated using the logarithmic trend-line

Therefore:

	ARI (years)					
	2	5	10	20	50	100
C_Y	0.09	0.18	0.26	0.34	0.43	0.50

AUSTRALIAN RAINFALL AND RUNOFF VOLUME 1 & 2 (1987)
RATIONAL METHOD - WESTERN AUSTRALIA

REGION: **ARID INTERIOR**

LOCATION: Paradigm

CATCHMENT: A

RATIONAL METHOD:
CONTINUES

DETERMINE AVERAGE RAINFALL INTENSITY FOR DESIGN DURATION

t_c = 1.08 hours

Use IFD curves

Duration	ARI (Years) [mm/hr]					
(hours)	2	5	10	20	50	100
1.08	10.6	19.7	23.6	28.9	36.7	43.3

Calculate peak discharge using equation (1.1)

Discharge	ARI (Years)					
(m^3/s)	2	5	10	20	50	100
Q	0.64	1.89	3.29	5.22	8.51	11.99

AUSTRALIAN JOURNAL OF WATER RESOURCES
DESIGN FLOOD ESTIMATION IN WESTERN AUSTRALIA (FLAVELL, 2012)

REGION: **ARID INTERIOR**

LOCATION: Paradigm

CATCHMENT: A

LEINSTER FLOOD FREQUENCY PROCEDURE:

$$Q_2 = 0.16 \cdot (\mathrm{A}{S_e}^{0.5})^{0.82} \cdot (L^2/A)^{-0.35}$$ Equation 3

$$Q_5 = 0.48 \cdot (\mathrm{A}{S_e}^{0.5})^{0.84} \cdot (L^2/A)^{-0.33}$$ Equation 4

$$Q_{10} = 0.89 \cdot (\mathrm{A}{S_e}^{0.5})^{0.84} \cdot (L^2/A)^{-0.34}$$ Equation 5

$$Q_{20} = 1.45 \cdot (\mathrm{A}{S_e}^{0.5})^{0.85} \cdot (L^2/A)^{-0.33}$$ Equation 6

$$Q_{50} = 2.44 \cdot (\mathrm{A}{S_e}^{0.5})^{0.82} \cdot (L^2/A)^{-0.36}$$ Equation 7

$$Q_{100} = 3.28 \cdot (\mathrm{A}{S_e}^{0.5})^{0.83} \cdot (L^2/A)^{-0.35}$$ Equation 8

Therefore the peak discharge

Discharge	ARI (Years)					
(m^3/s)	2	5	10	20	50	100
Q	0.75	2.37	4.37	7.29	11.42	15.72

SUMMARY OF RESULTS
FLOOD ESTIMATION IN WESTERN AUSTRALIA

REGION: **ARID INTERIOR**

LOCATION: Paradigm

CATCHMENT: A

SUMMARY OF RATIONAL AND FLAVELL METHODS:

Arid Interior Region

Catchment A	ARI (years) / Discharge (m^3/s)						
Method:	2	5	10	20	50	100	PMF*
Rational - ARR87	0.64	1.89	3.29	5.22	8.51	11.99	
Flavell - 2012	0.75	2.37	4.37	7.29	11.42	15.72	
Adopted (average)	**0.70**	**2.13**	**3.83**	**6.25**	**9.96**	**13.86**	**22.37**

*PMF estimated using multiplying factors from CRC-FORGE results

REGION: **ARID INTERIOR**

LOCATION: Paradigm

CATCHMENT: B

Arid Interior Region

Catchment Characteristics	A (km^2)	L (km)	S_e (m/km)	P (mm)
	2.98	2.1	8.6	241

RATIONAL METHOD:

Care needs to be taken when catchment characteristics fall outside the following:

A =	59.0	km^2
L =	11.5	km
S_e =	5.71	m/km
P =	255	mm

$Q_Y = 0.278 C_Y . I_{tc,Y} . A$ ..... **(1.1)**

$t_c = 0.76A^{0.38}$ ..... **(1.29)**

t_c = 1.15 Hrs

$C_{10} = 3.46x10^{-1}L^{-0.42}$ ..... **(1.30)**

C_{10} = 0.25

AUSTRALIAN RAINFALL AND RUNOFF VOLUME 1 & 2 (1987)
RATIONAL METHOD - WESTERN AUSTRALIA

Frequency Factors (C_Y/C_{10})

	ARI (years)					
	2	5	10	20	50	*100*
C_Y/C_{10}	0.34	0.70	1.00	1.28	1.62	*1.91*

100 year ARI extrapolated using the logarithmic trend-line

Therefore:

	ARI (years)					
	2	5	10	20	50	100
C_Y	0.09	0.18	0.25	0.32	0.41	0.48

AUSTRALIAN RAINFALL AND RUNOFF VOLUME 1 & 2 (1987)
RATIONAL METHOD - WESTERN AUSTRALIA

REGION: **ARID INTERIOR**

LOCATION: Paradigm

CATCHMENT: B

RATIONAL METHOD:
CONTINUES

DETERMINE AVERAGE RAINFALL INTENSITY FOR DESIGN DURATION

t_c = 1.15 hours

Use IFD curves

Duration	ARI (Years) [mm/hr]					
(hours)	2	5	10	20	50	100
1.15	11.6	16.5	20.1	24.9	32.1	38.3

Calculate peak discharge using equation (1.1)

Discharge	ARI (Years)					
(m^3/s)	2	5	10	20	50	100
Q	0.83	2.43	4.22	6.69	10.91	15.37

AUSTRALIAN JOURNAL OF WATER RESOURCES
DESIGN FLOOD ESTIMATION IN WESTERN AUSTRALIA (FLAVELL, 2012)

REGION: **ARID INTERIOR**

LOCATION: Paradigm

CATCHMENT: B

LEINSTER FLOOD FREQUENCY PROCEDURE:

$$Q_2 = 0.16 \cdot (\mathrm{A}{S_e}^{0.5})^{0.82} \cdot (L^2/A)^{-0.35}$$ Equation 3

$$Q_5 = 0.48 \cdot (\mathrm{A}{S_e}^{0.5})^{0.84} \cdot (L^2/A)^{-0.33}$$ Equation 4

$$Q_{10} = 0.89 \cdot (\mathrm{A}{S_e}^{0.5})^{0.84} \cdot (L^2/A)^{-0.34}$$ Equation 5

$$Q_{20} = 1.45 \cdot (\mathrm{A}{S_e}^{0.5})^{0.85} \cdot (L^2/A)^{-0.33}$$ Equation 6

$$Q_{50} = 2.44 \cdot (\mathrm{A}{S_e}^{0.5})^{0.82} \cdot (L^2/A)^{-0.36}$$ Equation 7

$$Q_{100} = 3.28 \cdot (\mathrm{A}{S_e}^{0.5})^{0.83} \cdot (L^2/A)^{-0.35}$$ Equation 8

Therefore the peak discharge

Discharge	ARI (Years)					
(m^3/s)	2	5	10	20	50	100
Q	0.82	2.60	4.81	8.03	12.52	17.26

SUMMARY OF RESULTS
FLOOD ESTIMATION IN WESTERN AUSTRALIA

REGION: **ARID INTERIOR**

LOCATION: Paradigm

CATCHMENT: B

SUMMARY OF RATIONAL AND FLAVELL METHODS:

Arid Interior Region

Catchment B	ARI (years) / Discharge (m^3/s)						
Method:	2	5	10	20	50	100	PMF*
Rational - ARR87	0.83	2.43	4.22	6.69	10.91	15.37	
Flavell - 2012	0.82	2.60	4.81	8.03	12.52	17.26	
Adopted (average)	**0.83**	**2.52**	**4.51**	**7.36**	**11.71**	**16.32**	**26.34**

*PMF estimated using multiplying factors from CRC-FORGE results

REGION: **ARID INTERIOR**

LOCATION: Paradigm

CATCHMENT: C

Arid Interior Region

Catchment Characteristics	A (km^2)	L (km)	S_e (m/km)	P (mm)
	1.41	1.5	8.9	241

RATIONAL METHOD:

Care needs to be taken when catchment characteristics fall outside the following:

A =	59.0	km^2
L =	11.5	km
S_e =	5.71	m/km
P =	255	mm

$Q_Y = 0.278 C_Y . I_{tc,Y} . A$ ..... **(1.1)**

$t_c = 0.76A^{0.38}$ ..... **(1.29)**

t_c = 0.87 Hrs

$C_{10} = 3.46x10^{-1}L^{-0.42}$ ..... **(1.30)**

C_{10} = 0.29

AUSTRALIAN RAINFALL AND RUNOFF VOLUME 1 & 2 (1987)
RATIONAL METHOD - WESTERN AUSTRALIA

Frequency Factors (C_Y/C_{10})

	ARI (years)					
	2	5	10	20	50	*100*
C_Y/C_{10}	0.34	0.70	1.00	1.28	1.62	*1.91*

100 year ARI extrapolated using the logarithmic trend-line

Therefore:

	ARI (years)					
	2	5	10	20	50	100
C_Y	0.10	0.20	0.29	0.37	0.47	0.56

AUSTRALIAN RAINFALL AND RUNOFF VOLUME 1 & 2 (1987)
RATIONAL METHOD - WESTERN AUSTRALIA

REGION: **ARID INTERIOR**

LOCATION: Paradigm

CATCHMENT: C

RATIONAL METHOD:
CONTINUES

DETERMINE AVERAGE RAINFALL INTENSITY FOR DESIGN DURATION

t_c = 0.87 hours

Use IFD curves

Duration	ARI (Years) [mm/hr]					
(hours)	2	5	10	20	50	100
0.87	13.9	19.8	24.1	29.9	38.4	45.9

Calculate peak discharge using equation (1.1)

Discharge	ARI (Years)					
(m^3/s)	2	5	10	20	50	100
Q	0.54	1.59	2.76	4.37	7.12	10.03

AUSTRALIAN JOURNAL OF WATER RESOURCES
DESIGN FLOOD ESTIMATION IN WESTERN AUSTRALIA (FLAVELL, 2012)

REGION: **ARID INTERIOR**

LOCATION: Paradigm

CATCHMENT: C

LEINSTER FLOOD FREQUENCY PROCEDURE:

$$Q_2 = 0.16 \cdot (\mathrm{A}{S_e}^{0.5})^{0.82} \cdot (L^2/A)^{-0.35}$$ Equation 3

$$Q_5 = 0.48 \cdot (\mathrm{A}{S_e}^{0.5})^{0.84} \cdot (L^2/A)^{-0.33}$$ Equation 4

$$Q_{10} = 0.89 \cdot (\mathrm{A}{S_e}^{0.5})^{0.84} \cdot (L^2/A)^{-0.34}$$ Equation 5

$$Q_{20} = 1.45 \cdot (\mathrm{A}{S_e}^{0.5})^{0.85} \cdot (L^2/A)^{-0.33}$$ Equation 6

$$Q_{50} = 2.44 \cdot (\mathrm{A}{S_e}^{0.5})^{0.82} \cdot (L^2/A)^{-0.36}$$ Equation 7

$$Q_{100} = 3.28 \cdot (\mathrm{A}{S_e}^{0.5})^{0.83} \cdot (L^2/A)^{-0.35}$$ Equation 8

Therefore the peak discharge

Discharge	ARI (Years)					
(m^3/s)	2	5	10	20	50	100
Q	0.49	1.37	2.65	4.29	6.69	9.17

SUMMARY OF RESULTS
FLOOD ESTIMATION IN WESTERN AUSTRALIA

REGION: **ARID INTERIOR**

LOCATION: Paradigm

CATCHMENT: C

SUMMARY OF RATIONAL AND FLAVELL METHODS:

Arid Interior Region

Catchment C	ARI (years) / Discharge (m^3/s)						
Method:	2	5	10	20	50	100	PMF*
Rational - ARR87	0.54	1.59	2.76	4.37	7.12	10.03	
Flavell - 2012	0.44	1.37	2.54	4.21	6.69	9.17	
Adopted (average)	**0.49**	**1.48**	**2.65**	**4.29**	**6.91**	**9.60**	**15.50**

*PMF estimated using multiplying factors from CRC-FORGE results

APPENDIX B: HYDRAULIC ANALYSES

Manning's Formula: $$Q = \frac{1}{n}\left(\frac{A}{P}\right)^{2/3} S^{1/2}$$

Cross-section 1 (Catchment A)

Stage	Top Length (m)	A (m2)	P (m)	Manning's n	Slope (m/m)	V (m/s)	Q (m3/s)
427,5	0	0	0	0,04	0,009	0.00	0.00
427,6	240,00	24,00	240,00	0,04	0,009	0,51	12,27
427,7	308,92	51,53	308,92	0,04	0,009	0,72	37,04
427,8	371,32	85,61	371,32	0,04	0,009	0,89	76,34

Cross-section 2 (Catchment C)

In drain							
Stage	**Top Length (m)**	**A (m2)**	**P (m)**	**Manning's n**	**Slope (m/m)**	**V (m/s)**	**Q (m3/s)**
430,7	0	0	0	0,02	0,002	0.00	0.00
430,8	3,30	0,31	3,34	0,02	0,002	0,46	0,14
431	4,10	1,06	4,23	0,02	0,002	0,89	0,95
431,5	6,10	3,66	6,47	0,02	0,002	1,53	5,59
431,6	7,50	5,19	7,91	0,02	0,002	1,69	8,76
431,7	7,90	5,97	8,36	0,02	0,002	1,79	10,66
Above drain							
Stage	**Conveyance K**		**Manning's n**		**Channel slope (m/m)**		**Q (m3/s)**
431,73	373,21		0.04		0.002		16,69

Cross-section 3 (Catchment B)

In drain							
Stage	**Top Length (m)**	**A (m2)**	**P (m)**	**Manning's n**	**Slope (m/m)**	**V (m/s)**	**Q (m3/s)**
429,25	0,00	0,00	0,00	0,02	0,002	0,00	0,00
429,3	4,20	0,21	4,22	0,02	0,002	0,30	0,06
429,5	5,00	1,13	5,12	0,02	0,002	0,82	0,92
430,4	8,60	7,25	9,14	0,02	0,002	1,92	13,88
430,45	8,70	7,67	9,25	0,02	0,002	1,97	15,14
Above drain							
Stage	**Conveyance K**		**Manning's n**		**Channel slope (m/m)**		**Q (m3/s)**
430,5	356,67		0.04		0.002		15,951
430,6	563,72		0.04		0.002		25,210

Appendix C:

Botanica Reconnaissance Flora and Fauna Survey

Reconnaissance Flora & Fauna Survey
Carbine - Paradigm
Prepared For
Northern Star Resources Limited

JUNE 2018
Version 1

Prepared by:
Botanica Consulting
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90930024

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Glossary

Acronym	Description
ANCA	Australian Nature Conservation Agency.
BA	Birdlife Australia (Formerly RAOU, Birds Australia).
BAM Act	Biosecurity and Agriculture Management Act 2007, WA Government.
BC	Botanica Consulting.
BoM	Bureau of Meteorology.
CAMBA	China Australia Migratory Bird Agreement 1998.
DAFWA	Department of Agriculture and Food (now DPIRD), WA Government.
DBCA	Department of Biodiversity, Conservation and Attractions (formerly DPaW), WA Government.
DEC	Department of Environment and Conservation (now DBCA), WA Government.
DER	Department of Environment Regulation (now DWER), WA Government.
DMIRS	Department of Mines, Industry Regulation and Safety (formerly DMP), WA Government
DMP	Department of Mines and Petroleum (now DMIRS), WA Government.
DotEE	Department of the Environment and Energy (formerly DSEWPaC), Australian Government.
DoW	Department of Water (now DWER), WA Government.
DPaW	Department of Parks and Wildlife (now DBCA), WA Government.
DPIRD	Department of Primary Industries and Regional Development, WA Government
DSEWPaC	Department of Sustainability, Environment, Water, Population and Communities (now DotEE,), Australian Government.
DWER	Department of Water and Environmental Regulation (formerly EPA, DER and DoW), WA Government
EP Act	Environmental Protection Act 1986, WA Government.

Acronym	Description
EP Regulations	Environmental Protection (Clearing of Native Vegetation) Regulations 2004, WA Government.
EPA	Environmental Protection Authority, WA Government.
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999, Australian Government.
ESA	Environmentally Sensitive Area.
Ha	Hectare (10,000 square metres).
IBRA	Interim Biogeographic Regionalisation for Australia.
IUCN	International Union for the Conservation of Nature and Natural Resources – commonly known as the World Conservation Union.
JAMBA	Japan Australia Migratory Bird Agreement 1981.
Km	Kilometre (1,000 metres).
MVG	Major Vegetation Groups.
Northern Star	Northern Star Resources Limited
NVIS	National Vegetation Information System.
OEPA	Office of the Environmental Protection Authority (now DWER), WA Government.
PEC	Priority Ecological Community.
RAOU	Royal Australia Ornithologist Union.
ROKAMBA	Republic of Korea-Australia Migratory Bird Agreement 2007.
SRE	Short Range Endemic.
SSC	Species Survival Commission, International.
Survey Area	Carbine – Paradigm
TEC	Threatened Ecological Community.
WA	Western Australia.
WAHERB	Western Australian Herbarium.
WAM	Western Australian Museum, WA Government.
WC Act	Wildlife Conservation Act 1950, WA Government.

Executive Summary

Botanica Consulting (BC) was commissioned by Northern Star Resources (NSR) to undertake a reconnaissance flora and fauna survey of the Carbine – Paradigm Project (referred to as the 'survey area'). The survey was conducted in Spring (15th October 2015), and Autumn (20th to 21st May 2018), covering an area of 1,903 ha. The survey area is located approximately 58 km north-west of Kalgoorlie-Boulder

The survey area comprised of twelve broad vegetation types which were represented by a total 23 Families, 43 Genera and 94 Taxa, including sub-species and variants. The broad scale terrestrial fauna habitats within the survey area have been identified as comprising a mosaic of clay-loam plain, hillslopes, open depressions, closed depression and existing disturbed areas.

Results of the literature review identified 40 mammals (including 11 bat species), 109 bird, 73 reptiles and four frog species that have previously been recorded in the general area, some of which have the potential to occur subject to the identified habitats being suitable. Forty-five species were recorded during the field survey.

No Threatened Flora, Threatened Fauna, Migratory Fauna or TEC as listed under the *Wildlife Conservation* WC) *Act 1950* or Commonwealth *Environment Protection and Biodiversity Conservation (EPBC) Act 1999* were identified within the survey area. No Priority Flora or Fauna taxa as listed by the Department of Biodiversity, Conservation and Attractions (DBCA) were identified within the survey area.

A review of the EPBC Act threatened fauna list, DBCA's Threatened Fauna Database and Priority List, unpublished reports and scientific publications identified a number of specially protected, migratory or priority fauna species as having been previously recorded or as being potentially present in the general vicinity of the survey area. However, no fauna of conservation significance is likely to be significantly impacted on by the proposed development. This conclusion is primarily based on the lack of suitable habitats, the known local extinction of some species, the relatively small size of the impact footprint and the extensive habitat connectivity with adjoining areas. Impacts on fauna and fauna habitat are therefore anticipated to be localised, small/negligible and as a consequence manageable.

No Priority Ecological Communities (PEC) were identified within the survey area. The nearest known PEC is the Perrinvale/Walling vegetation complexes banded ironstone community (Priority 1) which is located approximately 86 km north-west of the survey area. The survey area does not contain any world or national heritage places and does not occur within a Bush Forever site. There are no wetlands of international importance (Ramsar Wetlands), national importance (Australian Nature Conservation Agency (ANCA) Wetlands) or conservation category wetlands within the survey area.

The survey area does not contain any Environmentally Sensitive Areas (ESA) or Schedule 1 Areas as listed under the Environmental Protection (EP) Act 1986. The survey is not located within DBCA managed land. The nearest DBCA managed by is the Credo Station ex. Pastoral lease located approximately 800m north of the survey area.

Based on the vegetation condition rating scale adapted from Keighery, 1994 and Trudgen, 1988 (ranging from 'pristine' to 'completely degraded'), ten of the twelve vegetation types were classed as 'good'. The remaining two were rated as 'very good'. Four introduced taxa were identified within the survey area. According to the Department of Primary Industries and Regional Development (DPIRD) none of these taxa are listed as a Declared Plant under the *Biosecurity and Agriculture Management* (BAM) *Act 2007.*

1 Introduction

1.1 Project Description

Botanica Consulting (BC) was commissioned by Northern Star Resources (NSR) to undertake a reconnaissance flora and fauna survey of the Carbine – Paradigm Project (referred to as the 'survey area'). The survey was conducted in Spring (15th October 2015), and Autumn (20th to 21st May 2018), covering an area of 1,903 ha. The survey area is located approximately 58 km north-west of Kalgoorlie-Boulder (Figure 1-1).

1.2 Objectives

The flora survey was conducted in accordance with the requirements of a reconnaissance flora survey as defined in *Technical Guidance - Flora and Vegetation Surveys for Environmental Impact Assessment – December 2016* (EPA, 2016). The objectives of the assessment were to:

- gather background information on flora and vegetation in the target area (literature review, database and map-based searches);
- identify significant flora, vegetation/ecological communities and assess the potential sensitivity to impact;
- conduct a field survey to verify / ground truth the desktop assessment findings through survey;
- undertake floristic community mapping to a scale appropriate for the bioregion and described according to the National Vegetation Information System (NVIS) structure and floristics;
- undertake vegetation condition mapping;
- assess the project area's plant species diversity, density, composition, structure and weed cover, using NVIS classification system for vegetation description;
- assess Matters of National Environmental Significance (MNES) and indicate whether potential impacts on MNES as protected under the EPBC Act are likely to require referral of the project to the Commonwealth DotEE; and
- determine the State legislative context of environmental aspects required for the assessment.

The fauna survey was conducted in accordance with the requirements of a reconnaissance terrestrial fauna survey as defined in *Technical Guidance - Terrestrial Fauna Surveys for Environmental Impact Assessment – December 2016* (EPA, 2016). The objectives of the assessment were to:

- Gather background information on fauna in the survey area (literature review, database and map-based searches);
- Delineate and characterise the faunal assemblages and fauna habitats present in the survey area;
- Document and map locations of any Threatened or Priority listed fauna species located; and
- Assess the regional and local conservation status of fauna species and fauna habitats within the survey area.

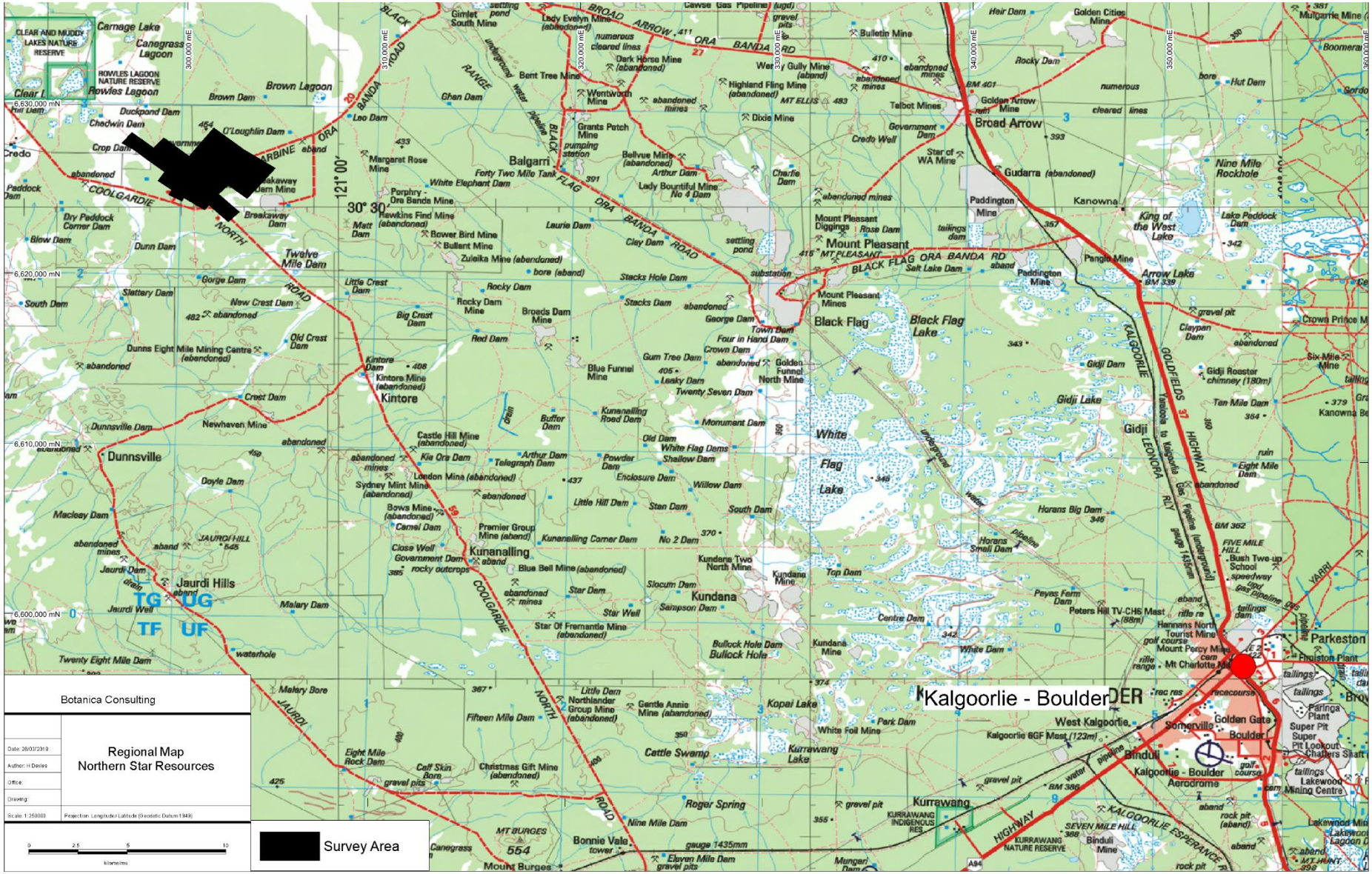


Figure 1-1: Regional map of the survey area

2 Regional Biophysical Environment

2.1 Regional Environment

The survey area lies within the South-West Interzone of WA in a region known as the Coolgardie Botanical District. Based on the Interim Biogeographic Regionalisation of Australia (IBRA, Version 7 (DotEE, 2012) the survey area is located within the Coolgardie Bioregion of WA. The Coolgardie Bioregion is further divided into three subregions; Mardabilla (COO1, Southern Cross (COO2) and Eastern Goldfields (COO3) subregion with the survey area located within the Eastern Goldfields subregion (Figure 2-1).

The Coolgardie bioregion is within the Yilgarn Craton. Its granite basement includes Archaean Greenstone intrusions in parallel belts. Drainage is occluded. The climate is arid to semi-arid warm Mediterranean with 250-300mm of mainly winter rainfall (McKenzie, May & McKenna, 2002). Diverse woodlands, rich in endemic eucalypts, occur on low greenstone hills, on alluvial soils on the valley floors, around the saline playas of the region's occluded drainage system, and on broad plains of calcareous earths (McKenzie, May & McKenna, 2002).

The Eastern Goldfields subregion comprises gently undulating plains interrupted in the west by low hills and ridges of Archaean greenstones and in the east by a horst of Proterozoic basic granulite. The underlying strata are eroded flat and covered with Tertiary sand and gravel soils, scattered exposures of bedrock, and plains of calcareous earths. (Cowan, 2001).

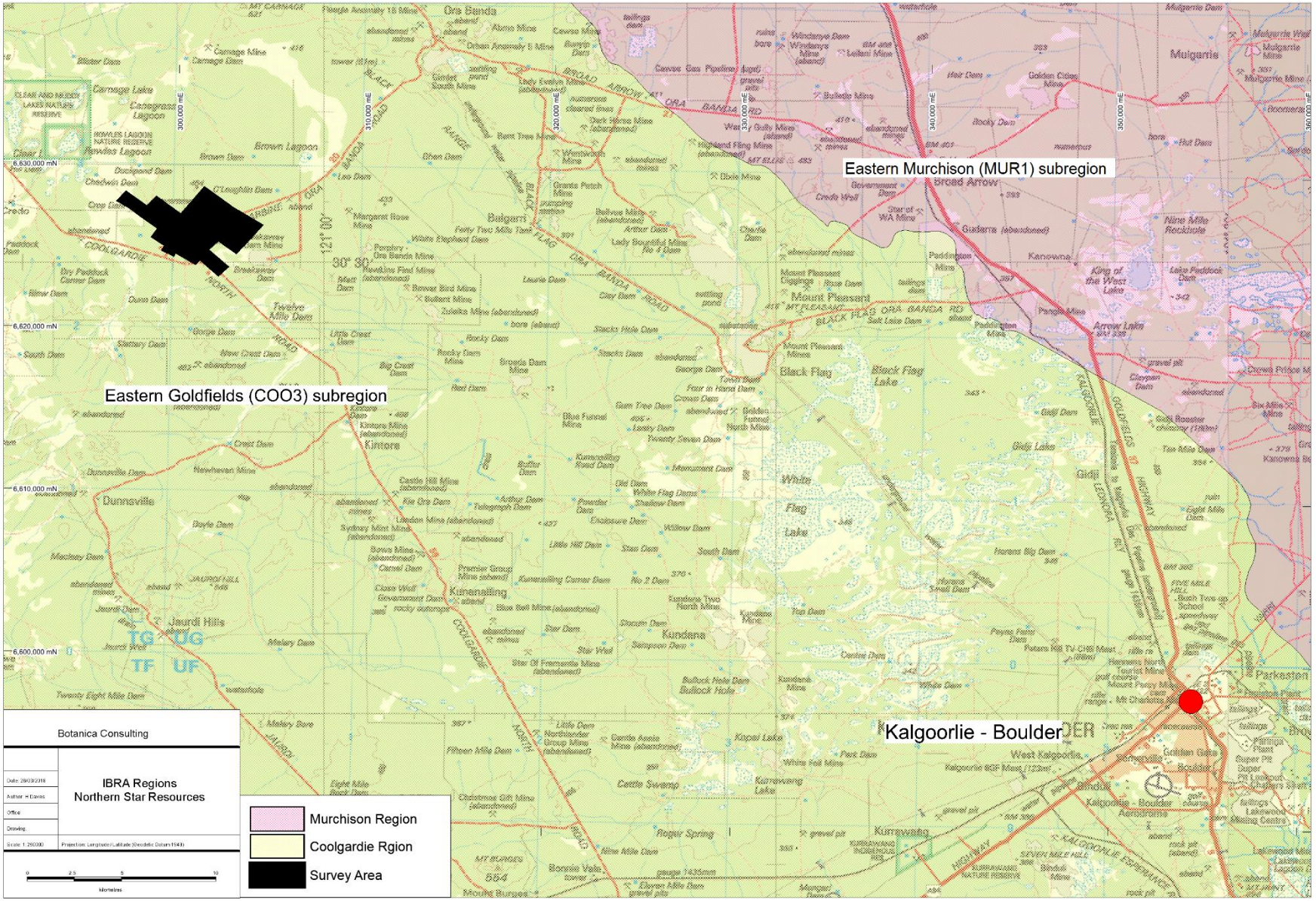


Figure 2-1: Map of IBRA bioregions in relation to the survey area

2.2 Great Western Woodlands

The survey area lies within the Great Western Woodlands, located approximately 40km from the northern boundary. The Great Western Woodlands is considered by The Wilderness Society of WA to be of global biological and conservation importance as one of the largest and healthiest temperate woodlands on Earth, containing many endemic taxa. The region covers almost 16 million hectares, 160,000 square kilometres, from the southern edge of the Western Australian Wheat belt to the pastoral lands of the Mulga country in the north, the inland deserts to the northeast, and the treeless Nullarbor Plain to the east (Figure 2-2).

The area provides an eastward connection between southwest forests and inland deserts (Gondwana Link) as well as linking the north-west passage to Shark Bay. The majority of the Great Western Woodlands is unallocated crown land (61.1%) with other interests including pastoral leases (20.4%), conservation reserves (15.4%) unallocated crown land ex pastoral managed by the (DBCA 2011a) (2%) and private land (approximately 1%) (Watson *et. al.,* 2008).

No specific management strategy applies to the Great Western Woodlands, rather an approach to conservation which occurs across all land tenures and when different stakeholders work together with biodiversity in mind. The central component of this approach is to identify and conserve key large-scale, long term ecological processes that drive connectivity between ecosystems and taxa. The Great Western Woodlands currently includes towns, highways, roads, railways, private property, Crown Reserves, agricultural activities and mining tenements.

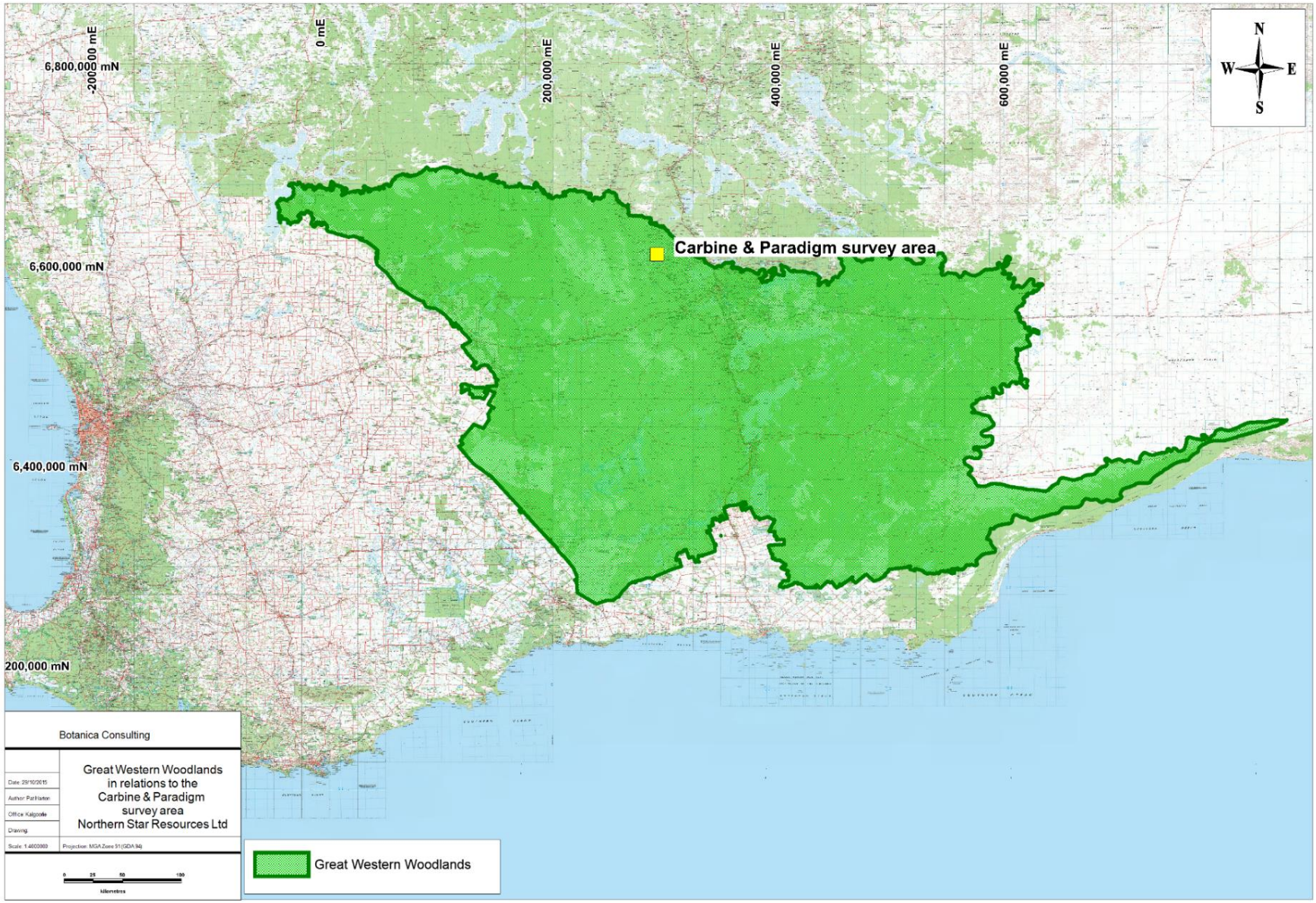


Figure 2-2: Location of survey area within the Great Western Woodlands (DBCA, 2011a)

Note-survey area not to scale

2.3 Soils and Landscape Systems

The survey area lies within the Kalgoorlie Province, which consists of Undulating plains (with some sandplains, hills and salt lakes) on the granitic rocks and greenstone of the Yilgarn Craton. Calcareous loamy earths and Red loamy earths with some Salt Lake soils, Red deep sands, Yellow sandy earths, Shallow loams and Loamy duplexes. Eucalypt woodlands with some acacia-casuarina thickets, mulga shrublands, halophytic shrublands and spinifex grasslands. Located in the southern Goldfields between Payne's Find, Menzies, Southern Cross and Balladonia (Tille, 2006).

The Kalgoorlie Province is located on the central eastern portion of the Yilgarn Craton, mostly overlying Archaean rocks of the Southern Cross Domain and the Eastern Goldfields Superterrane. To the north-west is the Murchison Domain. The basement rocks are a mix of granite, gneiss and greenstone. Even-grained porphyritic granitic rocks (intruded by quartz veins and dolerite dykes) are most common across the north as well as in the western half and the north-east. The largest areas of migmatite and gneiss are found in the south-west (Tille, 2006).

The greatest concentration of greenstone belts is in the center of the eastern half, between Norseman and Kalgoorlie. They are also common along the south-western margin and to the south of Lake Barlee. These greenstone belts contain a mixture of metamorphosed mafic to ultra-mafic volcanic rocks (including basalt, amphibolite, dolerite and gabbro), felsic volcanic rocks, and metasedimentary rocks (including cherts and banded iron formations). Mesoproterozoic rocks of the Albany-Fraser Orogen are found in the south-eastern corner. These include the gneiss of the Biranup Complex and the weakly to strongly deformed granite of the Nornalup Complex. Overlying much of the Albany-Fraser Orogen is a veneer of Eocene sediments belonging to the Balladonia Shelf of the Eucla Basin. Also present north-east of Norseman is an outcrop of Mesoproterozoic arenaceous and argillaceous metasedimentary sandstone and shale of the Woodline Formation (Tille, 2006).

The Kalgoorlie Province is further divided into seven soil-landscape zones, with the survey area located within the Kambalda Zone (265). This zone is characterised by flat to undulating plains (with hills, ranges and some salt lakes and stony plains) on greenstone and granitic rocks of the Yilgarn Craton. Soils are calcareous loamy earths and red loamy earths with salt lakes soils and some red brown hardpan shallow loams and red sandy duplexes. Vegetation includes red mallee blackbutt-salmon gum-gimlet woodlands with mulga and halophytic shrublands (and some spinifex grasslands). This zone is located in the south-eastern Goldfields between Menzies, Norseman and the Fraser Range (Tille, 2006). The Kambalda Zone is further divided into soil landscape systems within the soil landscape systems of the survey area described in Table 2-1 and Figure 2-3 below.

Table 2-1: Soil Landscape Systems within the survey area

Landscape System Mapping Unit	Description
265 BB5	Rocky ranges and hills of greenstones-basic igneous rocks
265 Mx40	Flat to undulating valley plains and pediments; some rock outcrop
265 Mx43	Gently undulating valley plains and pediments; some outcrop of basic rock

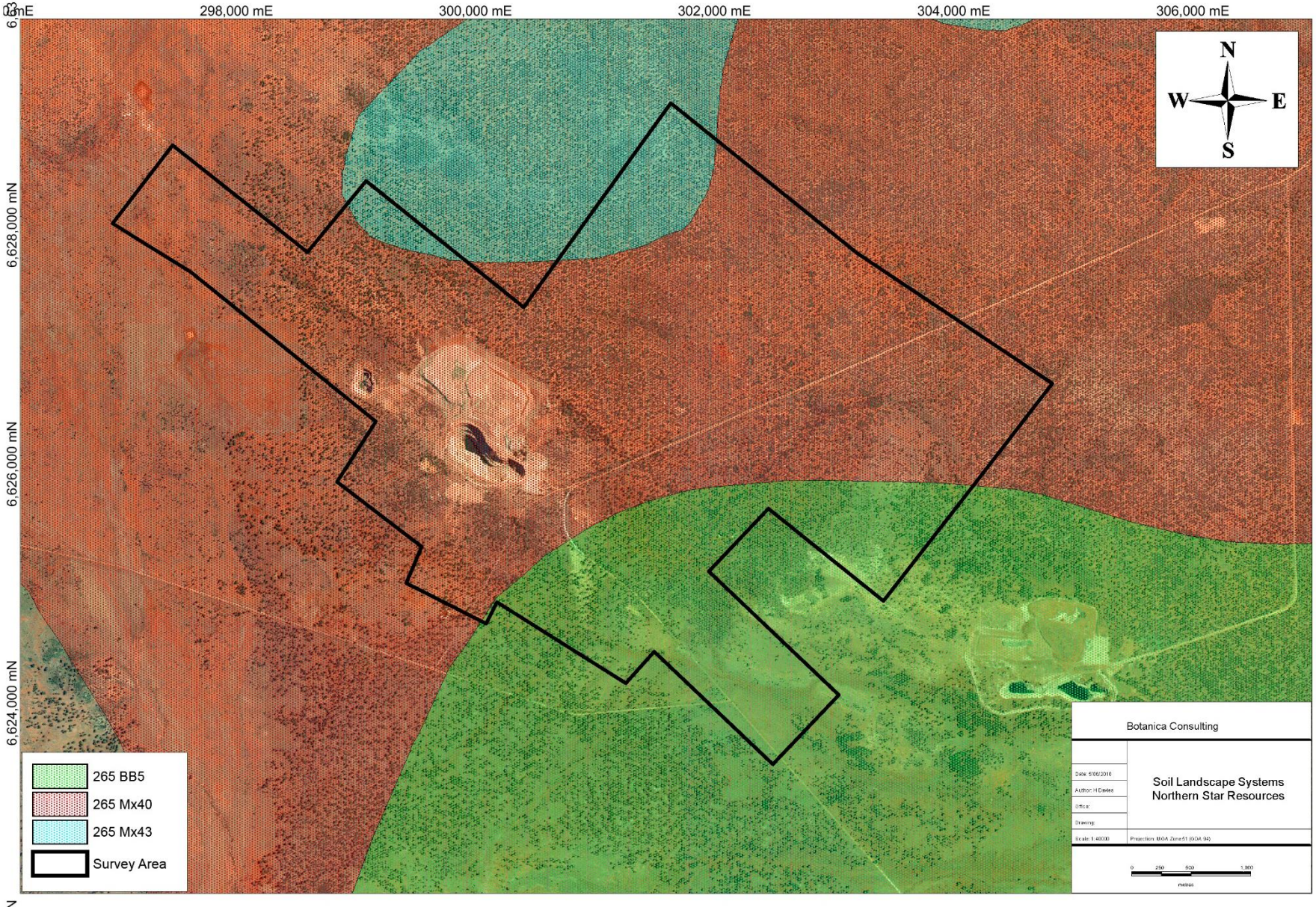


Figure 2-3: Map of Soil Landscape Systems within the survey area

2.4 Remnant Vegetation

The vegetation of the Eastern Goldfields subregion is comprised of Mallee's, Acacia thickets and shrub heaths on sandplains. Diverse Eucalyptus woodlands occur around salt lakes, on ranges, and in valleys. Salt lakes support dwarf shrublands of samphires and the area is rich in endemic Acacias (Cowan, 2001).

The Department of Agriculture and Food Western Australia (DAFWA) GIS file (2011) indicates that the survey area is located within Pre-European Beard vegetation associations Kununulling 468 and 555. The extent of these vegetation associations, as specified in the 2015 Statewide Vegetation Statistics (DPaW, 2015) is provided in Table 2-2 and Figure 2-4.

Table 2-2: Pre-European Vegetation Associations within the survey area

Vegetation association	Pre-European Extent (ha)	Current Extent (ha)	Pre-European extent remaining (%)	% of Current extent within DBCA managed lands	Vegetation Description (Beard, 1990)
Kununulling 468	184812.50	181666.50	98.30	53.70	Medium woodland; salmon gum & goldfields blackbutt
Kununulling 555	13245.55	13090.72	98.83	50.36	Hummock grassland, mallee steppe; red mallee over spinifex *Triodia scariosa*

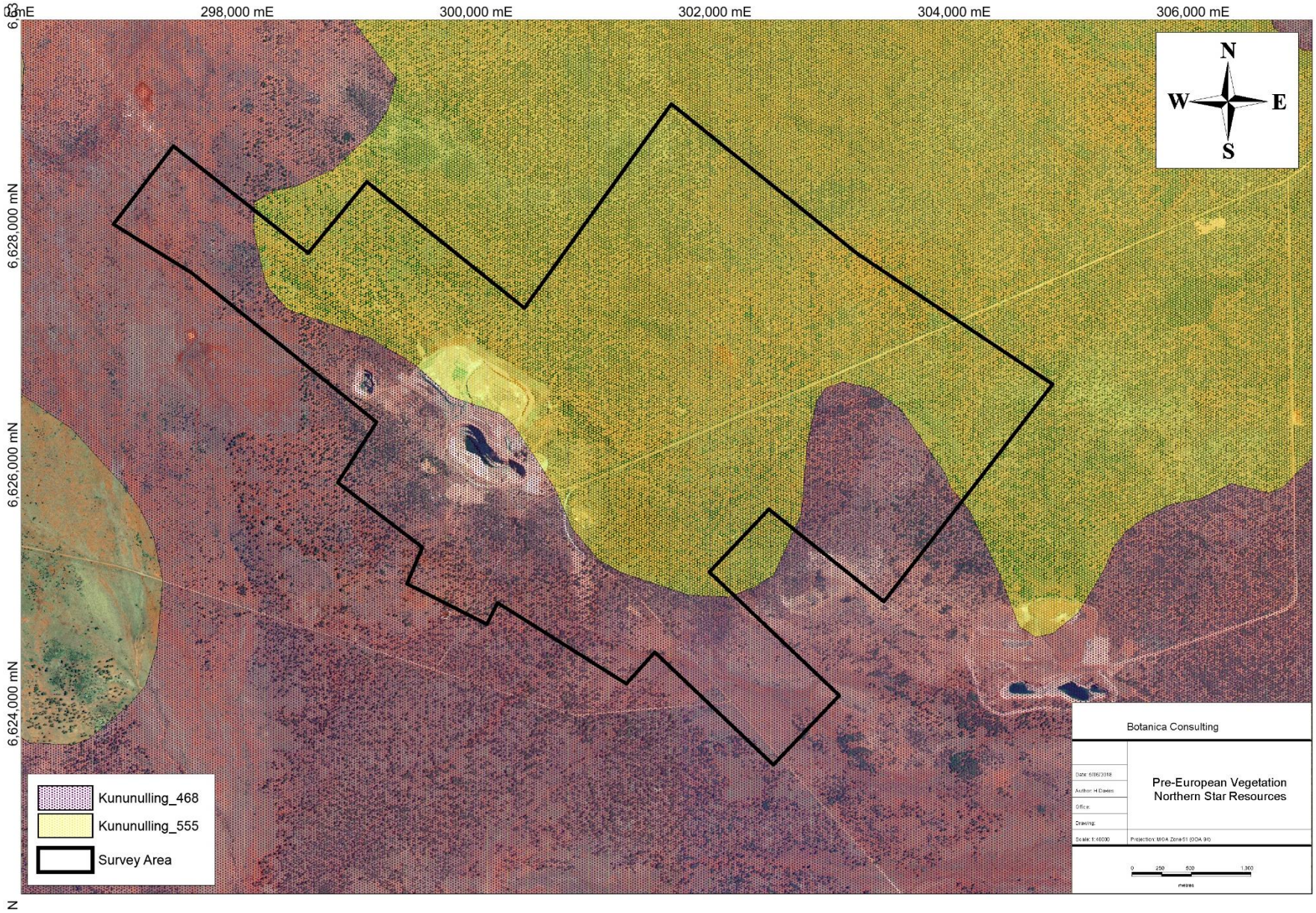
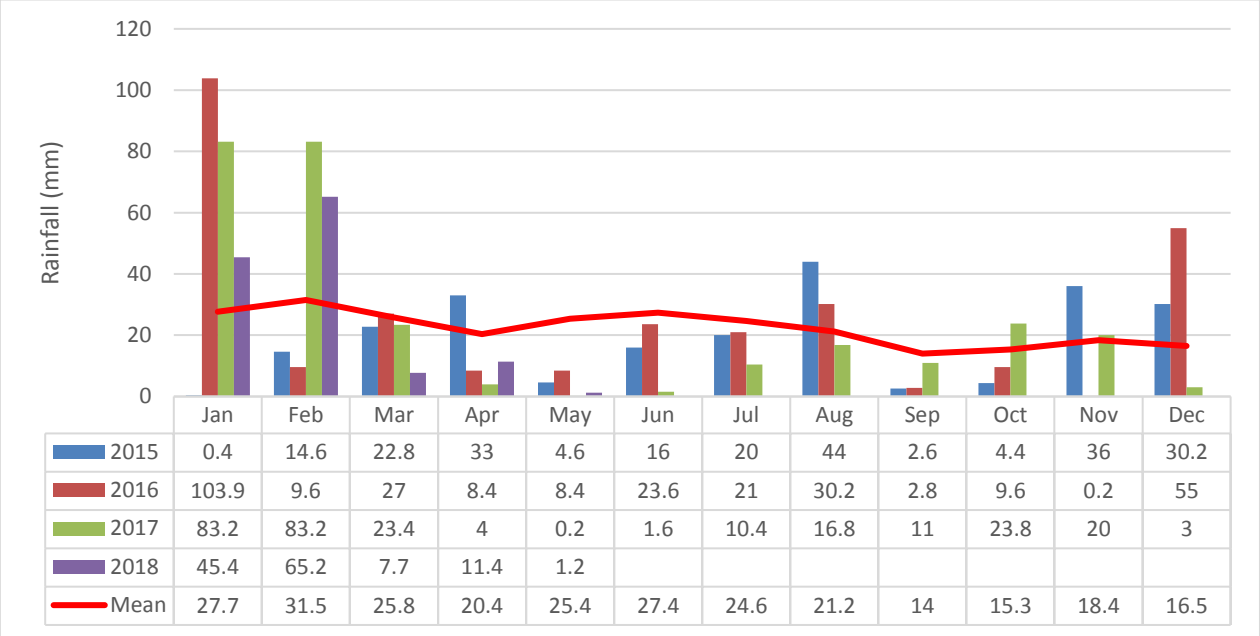


Figure 2-4: Pre-European Vegetation Associations within the survey area

2.5 Climate

The climate of the Eastern Goldfields subregion is characterised as an arid to semi-arid climate with rainfall sometimes in summer but mainly winter rainfall and annual rainfall of approximately 200-300mm (Beard, 1990; Cowan, 2001). Rainfall data for the Kalgoorlie-Boulder Airport weather station (#12038), located approximately 58 km south-east of the survey area, is shown in Figure 2-5 and the annual rainfall data from 2015 to 2018 is shown in Figure 2-6 (BOM, 2018).



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2015	0.4	14.6	22.8	33	4.6	16	20	44	2.6	4.4	36	30.2
2016	103.9	9.6	27	8.4	8.4	23.6	21	30.2	2.8	9.6	0.2	55
2017	83.2	83.2	23.4	4	0.2	1.6	10.4	16.8	11	23.8	20	3
2018	45.4	65.2	7.7	11.4	1.2							
Mean	27.7	31.5	25.8	20.4	25.4	27.4	24.6	21.2	14	15.3	18.4	16.5

Figure 2-5: Monthly rainfall (2015 to 2018) for the Kalgoorlie – Boulder Airport weather station (#12038) (BoM, 2018)

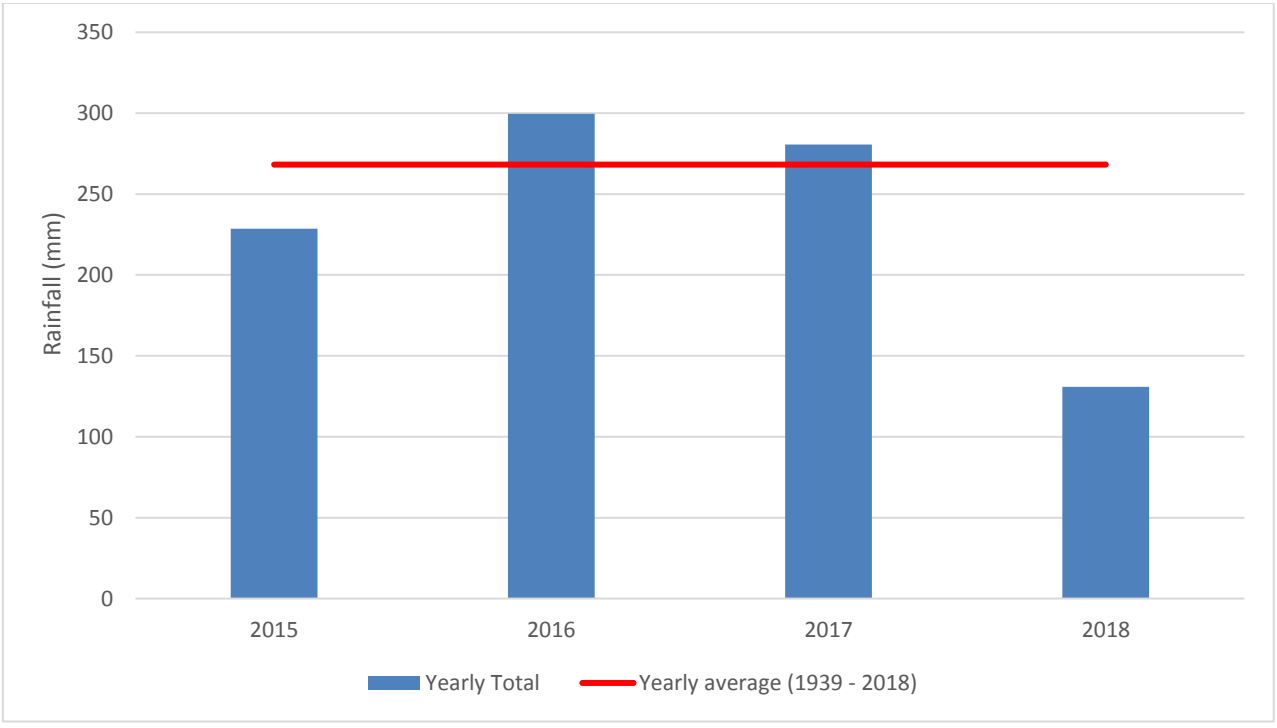


Figure 2-6: Total annual rainfall from 2014 to 2018 for the Kalgoorlie-Boulder Airport weather station (#12038) compared to the long-term average (1939 – 2018) (BoM, 2018)

2.6 Hydrology

According to the Geoscience Australia database (2001) there are no drainage lines or inland waters within the survey area. A map showing the hydrology of the survey area is provided in Figure 2-7.

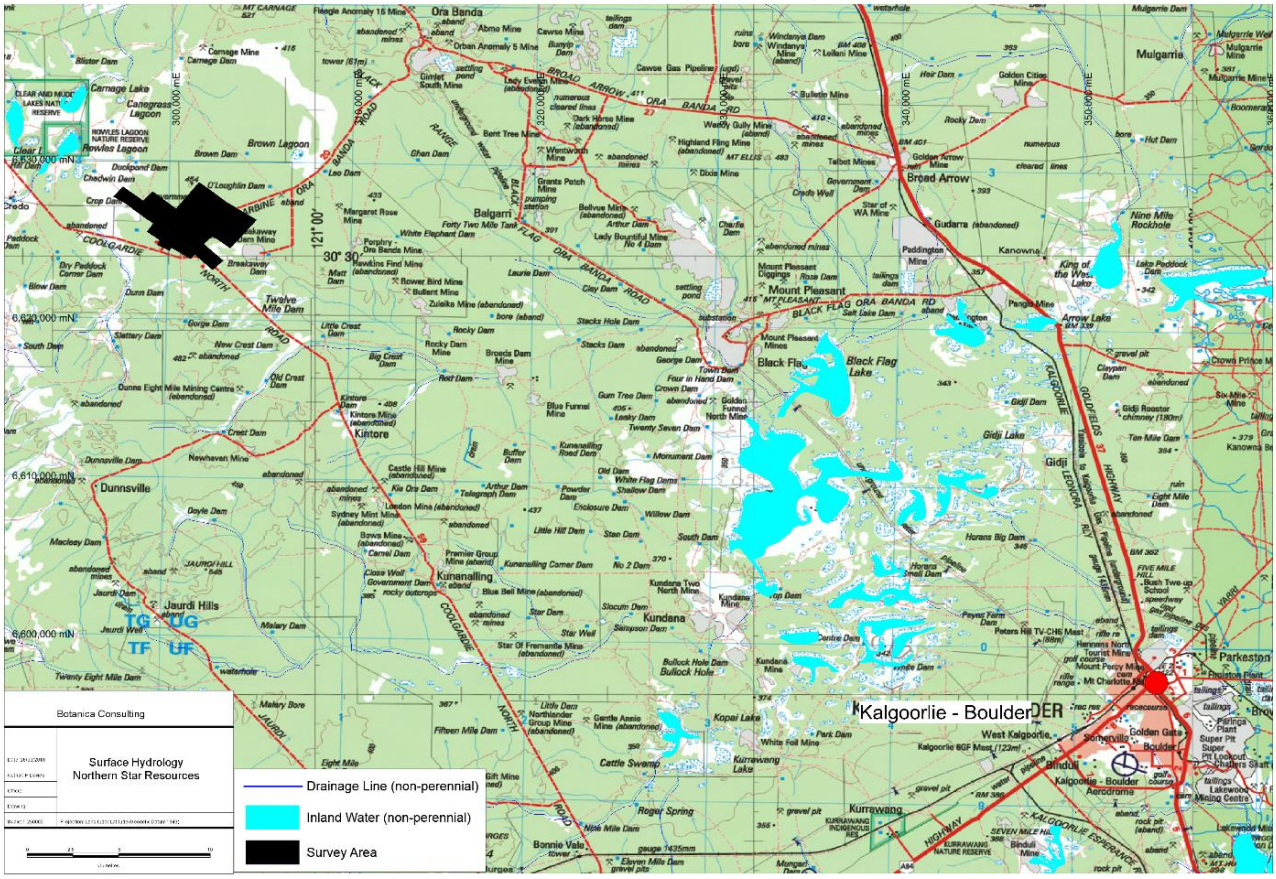


Figure 2-7: Hydrology of the survey area (data obtained from Geoscience Australia, 2001)

2.7 Land Use

The dominant land uses of the Eastern Goldfields subregion include Unallocated Crown Land and Crown Reserves, grazing-native pastures-leasehold, freehold, conservation and mining leases (Cowan, 2001). The survey area is located within the Mt Burges Pastoral Lease.

3 Survey Methodology

3.1 Desktop Assessment

Searches of the following databases were undertaken to aid in the compilation of a list of flora and fauna taxa within the survey area:

- DBCA's NatureMap Database (DBCA, 2018a);
- DotEE Protected matters search tool (DotEE, 2018a); and
- DBCA's Threatened and Priority Flora search.

The NatureMap and Protected Matters Search were conducted for an area encompassing a 20km radius of the centre coordinates –120°55' 28" E,30°28' 41" S. It should be noted that these lists are based on observations from a broader area than the survey area (20km radius) and therefore may include taxon not present. The databases also often included very old records that may be incorrect or in some cases the taxa in question have become locally or regionally extinct. Information from these sources should therefore be taken as indicative only and local knowledge and information also needs to be taken into consideration when determining what actual species may be present within the specific area being investigated.

Prior to the field survey, a combined search of the DBCA's Flora of Conservation Significance databases (DBCA, 2018) was undertaken within a 20km radius of the survey area. These significant flora species were examined on the Western Australian Herbarium's (WAHERB) web page prior to the survey, to familiarise staff with their appearance. Locations of Threatened Flora and Priority Flora were overlaid on aerial photography of the area. Vegetation descriptions and available images of the Priority Flora were also obtained from Florabase.

The conservation significance of flora and fauna taxa was assessed using data from the following sources:

- EPBC Act. Administered by the Australian Government (DotEE);
- WC Act. Administered by the WA Government (DBCA);
- Red List produced by the Species Survival Commission (SSC) of the World Conservation Union (also known as the IUCN Red List – the acronym derived from its former name of the International Union for Conservation of Nature and Natural Resources). The Red List has no legislative power in Australia but is used as a framework for State and Commonwealth categories and criteria; and
- Priority Flora/ Fauna list. A non-legislative list maintained by DBCA for management purposes (DBCA).

The EPBC Act also requires the compilation of a list of migratory species that are recognised under international treaties including the:

- Japan Australia Migratory Bird Agreement 1981 (JAMBA)[1];
- China Australia Migratory Bird Agreement 1998 (CAMBA);
- Republic of Korea-Australia Migratory Bird Agreement 2007 (ROKAMBA); and
- Bonn Convention 1979 (The Convention on the Conservation of Migratory Species of Wild Animals).

[1] Species listed under JAMBA are also specially protected under Schedule 5 of the WC Act.

All migratory bird species listed in the annexes to these bilateral agreements are protected in Australia as Matters of National Environmental Significance (MNES) under the EPBC Act.

Table 3-1 and Table 3-2 below provide the definitions of conservation significant flora and fauna.

Table 3-1: **Definitions of Conservation Significant Flora**

Code	Category
State categories of threatened and priority species	
T	Threatened Flora "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."
P1	Priority One – Poorly Known Taxa "Taxa which are known from one or a few (generally <5) populations which are under threat, either due to small population size, or being on lands under immediate threat. Such taxa are under consideration for declaration as 'rare flora', but are in urgent need of further survey."
P2	Priority Two – Poorly Known Taxa "Taxa which are known from one or a few (generally <5) populations, at least some of which are not believed to be under immediate threat (i.e. not currently endangered). Such taxa are under consideration for declaration as 'rare flora', but urgently need further survey."
P3	Priority Three – Poorly Known Taxa "Taxa which are known from several populations and the taxa are not believed to be under immediate threat (i.e. not currently endangered), either due to the number of known populations (generally >5), or known populations being large, and either widespread or protected. Such taxa are under consideration for declaration as 'rare flora' but needs further survey."
P4	Priority Four – Rare Taxa "Taxa which are considered to have been adequately surveyed and which, whilst being rare (in Australia), are not currently threatened by any identifiable factors. These taxa require monitoring every 5 – 10 years."
P5	Priority Five-Conservation Dependent Taxa Taxa that are not threatened but are subject to a specific conservation program, the cessation of which would result in the species becoming threatened within five years.
Commonwealth categories of threatened species	
Extinct	Taxa where there is no reasonable doubt that the last member of the species has died.
Extinct in the wild	Taxa where it is known only to survive in cultivation, in captivity or as a naturalised population well outside its past range; or it has not been recorded in its known and/or 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	Taxa that are facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with the prescribed criteria.
Endangered	Taxa which are not critically endangered and is facing a very high risk of extinction in the wild in the near future, as determined in accordance with the prescribed criteria.
Vulnerable	Taxa which are not critically endangered or endangered and is facing a high risk of extinction in the wild in the medium-term future, as determined in accordance with the prescribed criteria.

Code	Category
Conservation dependent	Taxa which are the focus of a specific conservation program the cessation of which would result in the species becoming vulnerable, endangered or critically endangered; or (b) the following subparagraphs are satisfied: (i) the species is a species of fish; (ii) the species is the focus of a plan of management that provides for actions necessary to stop the decline of, and support the recovery of, the species so that its chances of long term survival in nature are maximised; (iii) the plan of management is in force under a law of the Commonwealth or of a State or Territory; (iv) cessation of the plan of management would adversely affect the conservation status of the species.

Table 3-2: Definitions of Conservation Significant Fauna

Code	Category
State categories of threatened and priority species	
Schedule 1	Critically Endangered – Threatened species considered to be facing an extremely high risk of extinction in the wild.
Schedule 2	Endangered – Threatened species considered to be facing a very high risk of extinction in the wild.
Schedule 3	Vulnerable – Threatened species considered to be facing a high risk of extinction in the wild.
Schedule 4	Species which have been adequately searched for and there is no reasonable doubt that the last individual has died.
Schedule 5	Birds that are subject to an agreement between the government of Australia and the governments of Japan (JAMBA), China (CAMBA) and The Republic of Korea (ROKAMBA), and the Bonn Convention, relating to the protection of migratory birds.
Schedule 6	Fauna of special conservation need being species dependent on ongoing conservation intervention to prevent it becoming eligible for listing as threatened.
Schedule 7	Fauna otherwise in need of special protection to ensure their conservation.
P1	Priority One – Poorly Known Taxa 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.
P2	Priority Two – Poorly Known Taxa 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.
P3	Priority Three – Poorly Known Taxa 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.

Code	Category
P4	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 do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable. (c) Species that have been removed from the list of threatened species during the past five years for reasons other than taxonomy.
Commonwealth categories of threatened species	
Extinct	Taxa where there is no reasonable doubt that the last member of the species has died.
Extinct in the wild	Taxa where it is known only to survive in cultivation, in captivity or as a naturalised population well outside its past range; or it has not been recorded in its known and/or 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	Taxa that are facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with the prescribed criteria.
Endangered	Taxa which are not critically endangered and is facing a very high risk of extinction in the wild in the near future, as determined in accordance with the prescribed criteria.
Vulnerable	Taxa which are not critically endangered or endangered and is facing a high risk of extinction in the wild in the medium-term future, as determined in accordance with the prescribed criteria.
Near Threatened	Taxa which has been evaluated but does not qualify for CR, EN or VU now but is close to qualifying or likely to qualify in the near future.
Least Concern	Taxa which has been evaluated but does not qualify for CR, EN, VU, or NT but is likely to qualify for NT in the near future.
Data Deficient	Taxa for which 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 search of the DBCA PEC and TEC database was also conducted within a 20 km radius of the survey area (DBCA, 2015c). Table 3-3 represents the definitions of Threatened and Priority Ecological Communities.

Table 3-3: Definition of conservation significant communities

Category Code	Category
State categories of Threatened Ecological Communities (TEC)	
PTD	**Presumed Totally Destroyed** An ecological community will be listed as Presumed Totally Destroyed if there are no recent records of the community being extant and either of the following applies: records within the last 50 years have not been confirmed despite thorough searches or known likely habitats or;

Category Code	Category
	all occurrences recorded within the last 50 years have since been destroyed.
CE	**Critically Endangered** An ecological community will be listed as Critically Endangered when it has been adequately surveyed and is found to be facing an extremely high risk of total destruction in the immediate future, meeting any one of the following criteria: The estimated geographic range and distribution has been reduced by at least 90% and is either continuing to decline with total destruction imminent, or is unlikely to be substantially rehabilitated in the immediate future due to modification; The current distribution is limited i.e. highly restricted, having very few small or isolated occurrences, or covering a small area; The ecological community is highly modified with potential of being rehabilitated in the immediate future.
E	**Endangered** An ecological community will be listed as Endangered when it has been adequately surveyed and is not Critically Endangered but is facing a very high risk of total destruction in the near future. The ecological community must meet any one of the following criteria: The estimated geographic range and distribution has been reduced by at least 70% and is either continuing to decline with total destruction imminent in the short-term future, or is unlikely to be substantially rehabilitated in the short-term future due to modification; The current distribution is limited i.e. highly restricted, having very few small or isolated occurrences, or covering a small area; The ecological community is highly modified with potential of being rehabilitated in the short-term future.
V	**Vulnerable** An ecological community will be listed as Vulnerable when it has been adequately surveyed and is not Critically Endangered or Endangered but is facing high risk of total destruction in the medium to long term future. The ecological community must meet any one of the following criteria: The ecological community exists largely as modified occurrences that are likely to be able to be substantially restored or rehabilitated; The ecological community may already be modified and would be vulnerable to threatening process, and restricted in range or distribution; The ecological community may be widespread but has potential to move to a higher threat category due to existing or impending threatening processes.
Commonwealth categories of Threatened Ecological Communities (TEC)	
CE	**Critically Endangered** If, at that time, an ecological community is facing an extremely high risk of extinction in the wild in the immediate future (indicative timeframe being the next 10 years).

Category Code	Category
E	**Endangered** If, at that time, an ecological community is not critically endangered but is facing a very high risk of extinction in the wild in the near future (indicative timeframe being the next 20 years).
V	**Vulnerable** If, at that time, an ecological community is not critically endangered or endangered, but is facing a high risk of extinction in the wild in the medium–term future (indicative timeframe being the next 50 years).
Priority Ecological Communities (PEC)	
P1	**Poorly-known ecological communities** Ecological communities with apparently few, small occurrences, all or most not actively managed for conservation (e.g. within agricultural or pastoral lands, urban areas, active mineral leases) and for which current threats exist.
P2	**Poorly-known ecological communities** Communities that are known from few small occurrences, all or most of which are actively managed for conservation (e.g. within national parks, conservation parks, nature reserves, State forest, un-allocated Crown land, water reserves, etc.) and not under imminent threat of destruction or degradation.
P3	**Poorly known ecological communities** Communities that are known from several to many occurrences, a significant number or area of which are not under threat of habitat destruction or degradation or: Communities known from a few widespread occurrences, which are either large or within significant remaining areas of habitat in which other occurrences may occur, much of it not under imminent threat, or; Communities made up of large, and/or widespread occurrences, that may or not be represented in the reserve system, but are under threat of modification across much of their range from processes such as grazing and inappropriate fire regimes.
P4	**Ecological communities that are adequately known, rare but not threatened** or meet criteria for near threatened, or that have been recently removed from the threatened list. These communities require regular monitoring.
P5	**Conservation Dependent ecological communities** Ecological communities that are not threatened but are subject to a specific conservation program, the cessation of which would result in the community becoming threatened within five years.

3.2 Field Assessment

Botanica conducted a reconnaissance flora and fauna survey covering an area of 1,903 ha. The survey was conducted in Spring 2015 (15th October) and Autumn (20th to 21st May 2018), with the area traversed on foot and 4WD by two staff members (Figure 3-1).

3.2.1 Flora Assessment

Prior to the commencement of field work, aerial photography was inspected and obvious differences in the vegetation assemblages were identified. The different vegetation communities identified were then inspected during the field survey to assess their validity. A handheld GPS unit was used to record the coordinates of the boundaries between existing vegetation communities. At each sample point, the following information was recorded:

- GPS location;
- Photograph of vegetation;
- Dominant taxa for each stratum;
- All vascular taxa (including annual taxa);
- Landform classification;
- Vegetation condition rating;
- Collection and documentation of unknown plant specimens; and
- GPS location, photograph and collection of flora of conservation significance if encountered.

Unknown specimens collected during the survey were identified with the aid of samples housed at the BC Herbarium and WAHERB. Floristic communities were classified in accordance with the NVIS classification.

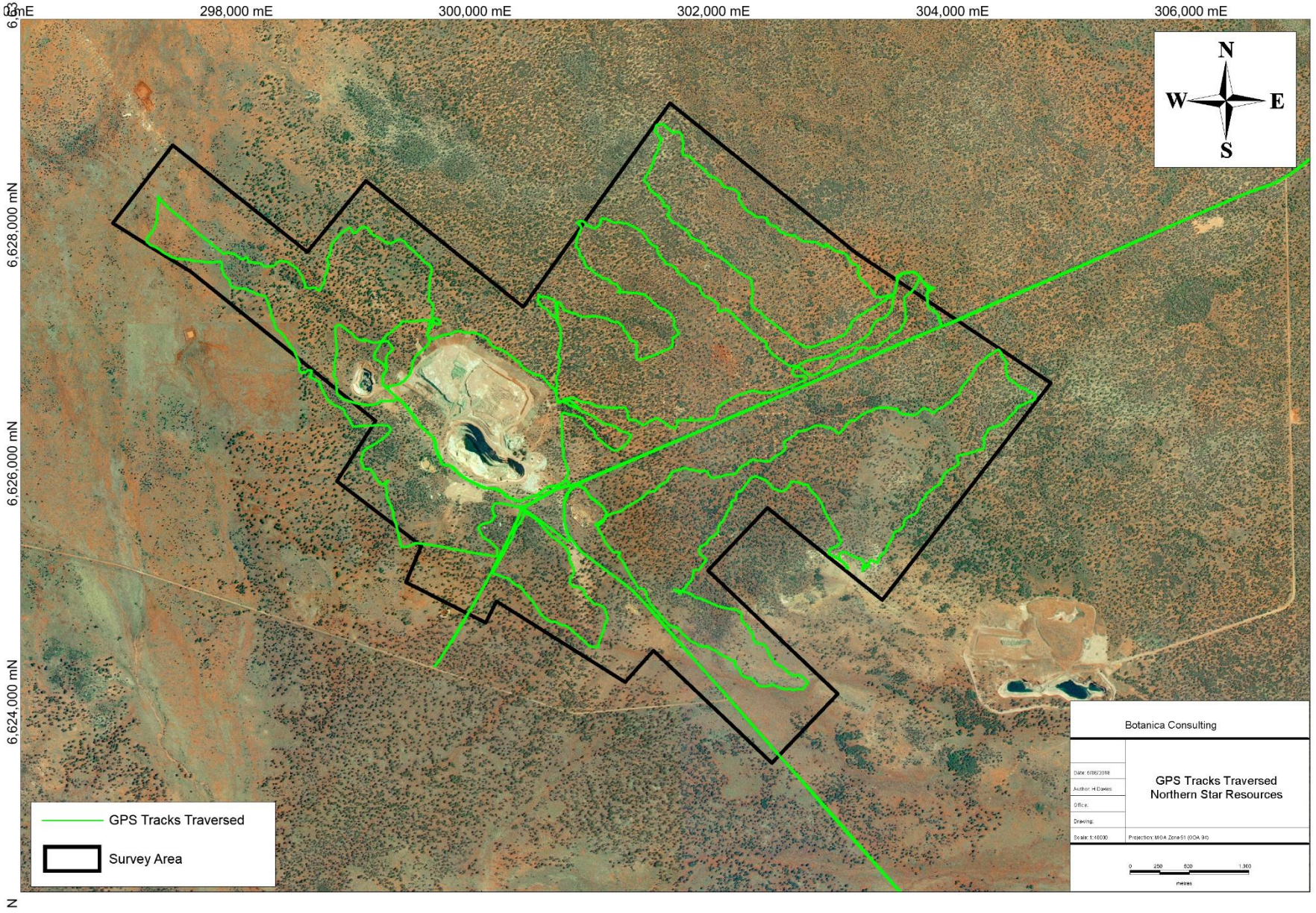


Figure 3-1: Survey area boundary and GPS tracks traversed throughout the survey area

3.2.2 Fauna Assessment

Vegetation and landform units identified during the flora assessment have been used to define broad fauna habitat types across the site. This information has been supplemented with observations made during the fauna assessment.

The main aim of the fauna habitat assessment was to determine if it was likely that any species of conservation significance would be utilising the areas that maybe impacted on as a consequence of development at the site. The habitat information obtained was also used to aid in finalising the overall potential fauna list.

As part of the desktop literature review, available information on the habitat requirements of the species of conservation significance listed as possibly occurring in the area was researched. During the field survey, the habitats within the study area were assessed and specific elements identified, if present, to determine the likelihood of listed threatened species utilising the area and its significance to them.

Opportunistic observations of fauna species were made during all field survey work which involved a series of transects across the study area during the day while searching microhabitats such as logs, rocks, leaf litter and observations of bird species with binoculars. Secondary evidence of a species presence such as tracks, scats, skeletal remains, foraging evidence or calls were also noted if observed/heard.

3.2.3 Personnel involved

Jim Williams - Environmental Consultant/ Director (Diploma of Horticulture)
Andrea Williams - Environmental Consultant/ Director (Bachelor of Science)
Pat Harton - Environmental Consultant (Bachelor of Environmental Science)
Greg Harewood - Zoologist (Bachelor of Science-Zoology)

3.2.4 Scientific licences

Table 3-4: Scientific Licences of Botanica Staff coordinating the survey

Licensed staff	Permit Number	Valid Until
Jim Williams	SL012116	21-05-2018
Andrea Williams	SL012115	21-05-2018

3.3 Survey limitations and constraints

It is important to note that flora surveys will entail limitations notwithstanding careful planning and design. Potential limitations are listed in Table 3-5.

The conclusions presented in this report are based upon field data and environmental assessments and/or testing carried out over a limited period of time and are therefore merely indicative of the environmental condition of the site at the time of the field assessments. Also, it should be recognised that site conditions can change with time. Information not available at the time of this assessment which may subsequently become available may alter the conclusions presented.

Some species are reported as potentially occurring based on there being suitable habitat (quality and extent) within the survey area or immediately adjacent. The habitat requirements and ecology of many of the species known to occur in the wider area are however often not well understood or documented. It can therefore be difficult to exclude species from the potential list based on a lack of a specific habitats or

microhabitats within the survey area. As a consequence of this limitation, the potential species list produced is most likely an overestimation of those species that actually utilise the survey area for some purpose.

In recognition of survey limitations, a precautionary approach has been adopted for this assessment. Any flora and fauna species that would possibly occur within the survey area (or immediately adjacent), as identified through ecological databases, publications, discussions with local experts/residents and the habitat knowledge of the author, has been listed as having the potential to occur.

Table 3-5: Limitations and constraints associated with the survey

Variable	Potential Impact on Survey	Details
Access problems	Not a constraint	Access was not limited with the area was sufficiently covered through the use of 4WD and on foot.
Competency/ Experience	Not a constraint	The BC personnel that conducted the survey were regarded as suitably qualified and experienced. **Coordinating Botanist/ Zoologist:** Jim Williams, & Greg Harewood **Data Interpretation:** Jim Williams, Andrea Williams, Haydn Davies & Greg Harewood.
Timing of survey, weather & season	Not a constraint	The initial survey was completed during the EPA's recommended time period (i.e. Spring) for detecting most ephemeral flora and when the majority of species are in flower. Additional surveys were conducted in Autumn. Rainfall in the month preceding the survey was below average and as a result, presence of annual species were limited, however many species were in flower.
Area disturbance	Minor constraint	The survey area has been subject to multiple land use disturbance (historic mining, pastoralism and exploration activities).
Survey Effort/ Extent	Not a constraint	Survey intensity was appropriate for the size/significance of the area with a reconnaissance survey completed to identify vegetation/fauna habitats and any flora/fauna of Conservation Significance.
Availability of contextual information at a regional and local scale	Not a constraint	Threatened flora database searches provided by the DBCA were used to identify any potential locations of Threatened/Priority taxa. BoM, DWER, DPIRD, DBCA and DotEE databases were reviewed to obtain appropriate regional desktop information on the biophysical environment of the local region. BC were able to obtain information about the area from previous flora/ fauna assessments conducted within the Coolgardie region and reconnaissance surveys conducted by BC which provided context on the local environment.
Completeness	Minor constraint	In the opinion of BC, the survey area was covered sufficiently in order to identify vegetation assemblages. Few of the plants during the survey were in flower and there were very few annual species present. It is estimated that approximately 90% of the flora within the survey area were able to be fully identified.

Variable	Potential Impact on Survey	Details
		The vegetation types for this study were based on visual descriptions of locations in the field. The distribution of these vegetation communities/ fauna habitats outside the study area is not known, however vegetation types identified were categorised via comparison to vegetation distributions throughout WA specified in the NVIS Major Vegetation Groups (DotEE, 2017b).

4 Results

4.1 Desktop Assessment

Flora and fauna surveys, assessments and reviews have been undertaken in nearby areas in the past, though not all are publicly available and could not be referenced. The most significant of those available have been used as the primary reference material for the flora and fauna as listed below.

- McKenzie, N.L. and Hall, N.J. (1992). The Biological Survey of the Eastern Goldfields of WA - Pt 8: Kurnalpi – Kalgoorlie study area. Records of the WAM, Supplement 41: 1 – 125.
- Jim's Seeds Weeds and Trees (2005), *Carbine and Paradigm Flora and Vegetation survey.* Prepared for Barrick
- Botanica Consulting, (2009), *Carbine Flora and Vegetation survey*. Prepared For Barrick Kanowna
- KLA (2009a). Barrick (Kanowna) Shamrock Project Level 1 Fauna Survey. Unpublished report for Barrick (Kanowna) Ltd. January 2009.
- KLA (2009b). Barrick (Kanowna) Crossroads Project Level 1 Fauna Survey. Unpublished report for Barrick (Kanowna) Ltd. January 2009.
- KLA (2009c). Barrick (Kanowna) Moonlight Project Level 1 Fauna Survey. Unpublished report for Barrick (Kanowna) Ltd. March 2009.
- Harewood G (2010a). Terrestrial Fauna Survey (Level 1) of the proposed Isabella Mine Area. Unpublished report for Barrick (Kanowna) Ltd. January 2010.
- Harewood G (2010b). Terrestrial Fauna Survey (Level 1) of the proposed Golden Valley Mine Area. Unpublished report for Barrick (Kanowna) Ltd. January 2010.
- Harewood G (2010c). Terrestrial Fauna Survey (Level 1) of the proposed Fenceline Mine Area. Unpublished report for Barrick (Kanowna) Ltd. January 2010.
- Barrick Gold Corporation (2011). Miscellaneous Fauna Survey Records 2006 - 2011. Kanowna Belle Area. Unpublished internal data. Acquired May 2011.
- Harewood, G. (2012). Terrestrial Fauna Survey (Level 1) of Proposed Powerline and Infrastructure Area, KCGM – Gidgi Operations. Unpublished report for KCGM Pty Ltd. January 2012.
- Botanica Consulting, (2013a), *Level 2 Flora & Vegetation Survey for the Red Dam Project,* Prepared For Phoenix Gold Ltd
- Botanica Consulting (2013b), *Level 2 Flora & Vegetation Survey for the Castle Hill Project,* Prepared For Phoenix Gold Ltd
- Botanica Consulting (2014), *Level 2 Flora & Vegetation Survey for the Kintore Extension,* Prepared For Phoenix Gold Ltd
- Harewood, G. (2015). Fauna Survey (Level 2 - Phase 1 and 2) of Proposed Tails Storage Facility Expansion. Unpublished report for KCGM Pty Ltd. June 2015.

Some of the abovementioned reports refer to flora surveys carried out a considerable distance from the survey area being assessed and therefore, as with the databases searches, some refer to species that would not occur in the survey area due it being out of their normal range or due to a lack of suitable habitat (extent and/or quality) and this fact was taken into consideration when compiling the potential flora/ fauna species list for the survey area.

The results of the literature review, combined search of the DBCA's Flora of Conservation Significance databases (DBCA, 2015b), NatureMap search and DotEE protected matters search recorded no Threatened Flora or Priority Flora within the survey area[2]. Six Priority Flora taxa were listed by on the databases as occurring within a 20km radius of the survey area (map of flora locations provided in Appendix 1). These taxa were assessed and ranked for their likelihood of occurrence within the survey area. The rankings and criteria used were:

- Unlikely: Area is outside of the currently documented distribution for the species/no suitable habitat (type, quality and extent) was identified as being present during the field/desktop assessment.
- Possible: Area is within the known distribution of the species in question and habitat of at least marginal quality was identified as being present during the field/desktop assessment, supported in some cases by recent records being documented from within or near the area.
- Known to Occur: The species in question was positively identified as being present during the field survey.

A total of four Priority Flora taxa were ranked as 'possible' to occur within the survey area (Table 4-1) below. All remaining flora of conservation significance were ranked 'unlikely' to occur within the survey area.

Table 4-1: Likelihood of occurrence for Flora of Conservation Significance within the survey area

Taxon	Conservation Code	Description (WAHERB, 2018)	Likelihood of Occurrence
Angianthus prostratus	P3	Prostrate annual, herb. Fl. white-yellow, Jul to Sep. Red clay or loamy soils. Saline depressions.	Unlikely
Atriplex lindleyi subsp. *conduplicata*	P3	Monoecious, short-lived annual or perennial, herb, ca 0.2 m high. Crabhole plains	Possible
Eremophila praecox	P1	Broom-like shrub, 1.5-3 m high. Fl. purple, Oct or Dec. Red/brown sandy loam. Undulating plains.	Possible
Ptilotus chortophytus	P1	Small perennial herb to 12 cm high, 12 cm wide, green flowers, small succulent basal leaves.	Possible
Rhagodia sp. Yeelirrie Station (K.A. Shepherd et al. KS 1396)	P1	An erect, very compact shrub, 1.5 metres high	Possible
Gompholobium cinereum	P3	Shrub, to 0.3 m high. Yellow sand, clayey sand, brown loam, sandy gravel, laterite. Well-drained open sites, slopes, plains, roadsides.	Unlikely

[2] Database previously had a record of *Gnephosis* sp. Norseman (K.R. Newbey 8096) within the survey area which was listed as a Priority 3 Flora taxon in 2015. This taxon has been revised (currently known as *Gnephosis brevifolia)* and is no longer listed by DBCA as a Priority Flora taxon.

Fauna of conservation significance identified during the literature review as previously being recorded in the general area were assessed and ranked for their likelihood of occurrence within the survey area itself (Table 4-2). The rankings and criteria used were:

- Would Not Occur: There is no suitable habitat for the species in the survey area and/or there is no documented record of the species in the general area since records have been kept and/or the species is generally accepted as being locally/regionally extinct (supported by a lack of recent records).
    - Locally Extinct: Populations no longer occur within a small part of the species natural range, in this case within 10 or 20 km of the survey area. Populations do however persist outside of this area.
    - Regionally Extinct: Populations no longer occur in a large part of the species natural range, in this case within the southern and south-eastern goldfields region. Populations do however persist outside of this area.

- Unlikely to Occur: The survey area is outside of the currently documented distribution for the species in question, or no suitable habitat (type, quality and extent) was identified as being present during the field assessment. Individuals of some species may occur occasionally as vagrants/transients especially if suitable habitat is located nearby but the site itself would not support a population or part population of the species

- Possibly Occurs: Survey area is within the known distribution of the species in question and habitat of at least marginal quality was identified as likely to be present during the field survey and literature review, supported in some cases by recent records being documented in literature from within or near the survey area. In some cases, while a species may be classified as possibly being present at times, habitat may be marginal (e.g. poor quality, fragmented, limited in extent) and therefore the frequency of occurrence and/or population levels may be low.

- Known to Occur: The species in question has been positively identified as being present (for sedentary species) or as using the survey area as habitat for some other purpose (for non-sedentary/mobile species) during field surveys within or near the survey area. This information may have been obtained by direct observation of individuals or by way of secondary evidence (e.g. tracks, foraging debris, scats). In some cases, while a species may be classified as known to occur, habitat may be marginal (e.g. poor quality, fragmented, limited in extent) and therefore the frequency of occurrence and/or population levels may be low.

Table 4-2: Likelihood of Occurrence – Fauna Species of Conservation Significance

Species	Conservation Status			Potential Habitats Within Survey Area			Likelihood of Occurrence
	EPBC Act	WC Act	DBCA Priority	Foraging Habitat	Breeding Habitat	Total Extent (ha)	
Malleefowl *Leipoa ocellata*	VU	S3	-	Clay/Loam Plains & Hillslopes	None identified.	621 ha (76.9.5% of total area).	Unlikely. Habitat very marginal/unsuitable. No recent nearby records. Occasional transients only. Would not breed within the survey area.
Peregrine Falcon *Falco peregrinus*	-	S7	-	Air space above all habitats.	None identified.	807 ha (100% of total area).	Possibly Occurs but probably only rarely. No significant impact likely
Blue-billed Duck *Oxyura australis*	-	-	P4	None identified.		0 ha	Would Not Occur. No suitable habitat
Migratory Shorebirds (Various species)	Mig	S5	-	None identified.		0 ha	Would Not Occur. No suitable habitat
Grey Wagtail *Motacilla cinerea*	Mig	S5	-	None identified.		0 ha	Would Not Occur. No Suitable Habitat. Never Recorded in the Goldfields.
Fork-tailed Swift *Apus pacificus*	Mig	S5	-	Air space above all habitats.	None Identified	4,386 ha (100% of total area).	Unlikely to Occur. Very occasional vagrants only for very brief periods/Negligible impact anticipated.
Night Parrot *Pezoporus occidentalis*	EN	S1	-	None identified.		0 ha	Would Not Occur. No Suitable Habitat. Never Recorded in this area of Goldfields.
Chuditch *Dasyurus geoffroii*	VU	S3	-	Clay-Loam Plains & Hillslopes		621 ha (76.9.5% of total area).	Would not Occur No recent records nearby and very likely to be locally extinct.
Central Long-eared Bat *Nyctophilus major tor*	-	-	P4	Air space above all habitats.	Hollow trees	807 ha (100% of total area).	Possibly Occurs. Potential for loss/modification of some habitat but no significant impact on the species overall status likely

The current status of some species on site and/or in the general area is difficult to determine, however, based on the habitats present and, in some cases, direct observations or recent nearby records, the following species of conservation significance can be regarded as possibly utilising the survey area for some purpose at times, these being:

- **Peregrine Falcon *Falco peregrinus*** – S7 (*WC Act*)
  The species potentially utilises some sections of the survey area as part of a much larger home range, though records in this area are rare and while listed as a potential species, it can be expected to occur only very occasionally. No potential nest sites observed.

- **Central Long-eared Bat *Nyctophilus major tor*** – P4 (DBCA Priority Species)
  Exact status in the study area is difficult to determine but must be assumed to be present. This species has been recorded during bat surveys at the Kanowna Belle mine site (Barrick 2011) and so potentially may occur.

It should be noted that while habitats onsite for one or more of the species listed above are considered possibly suitable, some or all may be marginal in extent/quality and therefore the fauna species considered as possibly occurring may in fact only visit the area for short periods as infrequent vagrants.

A number of other species of conservation significance, while possibly present in the general area and/or the Goldfields region are not listed as potential species due to the survey area being outside of their currently recognised range, a lack of suitable habitat or known/very likely local or regional extinction (and no subsequent recruitment from adjoining areas).

4.2 Field Assessment

4.2.1 Vegetation Types

Twelve broad vegetation types were identified within the survey area. These vegetation types were identified within four landform types and comprised of four major vegetation groups according to the NVIS, Major Vegetation Group (MVG) definition (Table 4-3). These vegetation types were represented by a total 23 Families, 43 Genera and 94 Taxa, as listed in Appendix 2. A map showing the vegetation types present in the survey area is provided in Figure 4-1.

Table 4-3: Summary of vegetation types within the survey area

Landform	NVIS Vegetation Group	Code	Vegetation Type	Area (ha)	Area (%)
Clay-Loam Plain	Casuarina Forests and Woodlands	CLP-CFW1	Low open forest of *Casuarina pauper* over mid open shrubland of *Acacia hemiteles* and low open shrubland of *Olearia muelleri/ Scaevola spinescens* on clay-loam plain	65	3.4
		CLP-CFW2	Low open woodland of *Casuarina pauper* over mid chenopod shrubland of *Maireana sedifolia/ M. pyramidata* and low open forbland of *Sclerolaena diacantha* on clay-loam plain	66	3.5
	Eucalypt Woodland	CLP-EW1	Mid woodland of *Eucalyptus salubris* over mid shrubland of *Eremophila scoparia* and low open shrubland of *Olearia muelleri/* low open forbland of *Sclerolaena diacantha* on clay-loam plain	341	17.9

Landform	NVIS Vegetation Group	Code	Vegetation Type	Area (ha)	Area (%)
		CLP-EW2	Mid woodland of *Eucalyptus clelandiorum/ E. transcontinentalis* over mid open shrubland of *Acacia hemiteles/ Eremophila caperata* and low open shrubland of *Eremophila parvifolia/ Olearia muelleri* on clay-loam plain	305	16.0
		CLP-EW3	Mid woodland of *Eucalyptus salmonophloia* over mid open shrubland of *Acacia hemiteles/ Eremophila scoparia* and low open shrubland of *Ptilotus obovatus* on clay-loam plain	528	27.7
		CLP-EW4	Low open forest of *Eucalyptus ravida* over mid sparse shrubland of *Eremophila scoparia* and low chenopod shrubland of *Maireana oppositifolia/* low shrubland of *Ptilotus obovatus* on clay-loam plain	103	5.4
		CLP-EW5	Mid open woodland of *Eucalyptus salmonophloia* over mid sparse shrubland of *Eremophila interstans* subsp. *virgata* and low chenopod shrubland of *Maireana sedifolia/ Atriplex nummularia* subsp. *spathulata* on clay-loam plain	34	1.8
	Eucalypt Woodlands/ Mallee woodlands and shrublands	CLP-EW/MWS1	Low woodland of *Eucalyptus clelandiorum*/ Open mallee woodland of *E. griffithsii/ E. oleosa* over mid open shrubland of *Eremophila caperata* and low open shrubland of *Scaevola spinescens/ Senna artemisioides* subsp. *filifolia* on clay-loam plain	102	5.4
Closed Depression	Chenopod Shrublands, Samphire Shrublands and Forblands	CD-CSSSF1	Isolated *Eucalyptus clelandiorum/ E. celastroides* over mid sparse shrubland of *Melaleuca lateriflora* and samphire shrubland of *Tecticornia disarticulata/T. halocnemoides* in closed depression	3	0.2
Hillslope	Eucalypt Woodlands	HS-EW1	Mid woodland *Eucalyptus clelandiorum/E. oleosa* over mid open shrubland of *Eremophila caperata* and low sparse shrubland of *Cratystylis conocephala/ Eremophila pustulata* on hillslope	114	6.0
		HS-EW2	Mid open woodland of *Eucalyptus salubris/E. clelandiorum* over mid sparse shrubland of *Eremophila* sp. Mt Jackson (G.J. Keighery 4372) and low sparse shrubland of *Cratystylis subspinescens* on hillslope	34	1.8
Open Depression	Eucalypt Woodlands	OD-EW1	Mid woodland of *Eucalyptus salmonophloia* over mid open shrubland of *Acacia hemiteles/ Eremophila scoparia* and low open shrubland of *Ptilotus obovatus* in open depression	20	1.1
N/A	N/A	CV	Mining Disturbance	189	9.9
TOTAL				**1903**	**100**

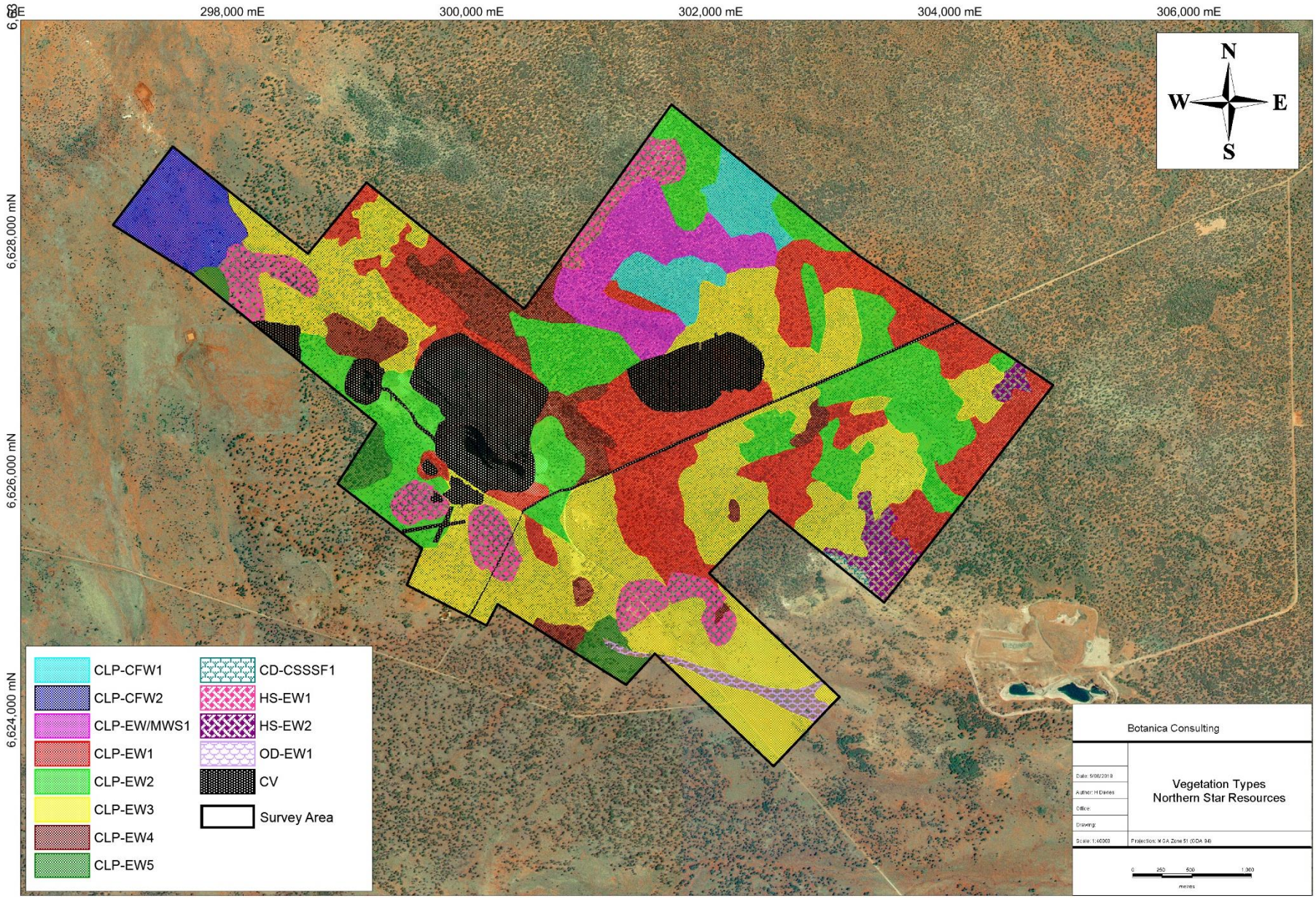


Figure 4-1: Vegetation Types within the survey area

Clay-Loam Plain: Casuarina Forests and Woodlands

4.2.1.1 Low open forest of *Casuarina pauper* over mid open shrubland of *Acacia hemiteles* and low open shrubland of *Olearia muelleri/ Scaevola spinescens* on clay-loam plain (CLP-CFW1)

The total flora recorded within this vegetation type was represented by a total of 10 Families, 14 Genera and 20 Taxa (Plate 4-1). No Threatened or Priority Flora taxa were identified within this vegetation type. Dominant taxa are shown in Table 4-4. According to the NVIS, this vegetation community is best represented by the MVG8- Casuarina Forests and Woodlands (DotEE, 2017b).

Table 4-4: Vegetation assemblage for Low open forest of *Casuarina pauper* over mid open shrubland of *Acacia hemiteles* and low open shrubland of *Olearia muelleri/ Scaevola spinescens* on clay-loam plain

Life Form/Height Class	Canopy Cover	Dominant taxa present
Tree <10m	30-70%	*Casuarina pauper*
Shrub 1-2m	10-30%	*Acacia hemiteles*
Shrub <1m	10-30%	*Olearia muelleri* *Scaevola spinescens*

Plate 4-1: Low open forest of *Casuarina pauper* over mid open shrubland of *Acacia hemiteles* and low open shrubland of *Olearia muelleri/ Scaevola spinescens* on clay-loam plain

4.2.1.2 Low open woodland of *Casuarina pauper* over mid chenopod shrubland *of Maireana sedifolia/ M. pyramidata* and low open forbland of *Sclerolaena diacantha* on clay-loam plain (CLP-CFW2)

The total flora recorded within this vegetation type was represented by a total of 10 Families, 11 Genera and 15 Taxa (Plate 4-2). No Threatened or Priority Flora taxa were identified within this vegetation type. The introduced species *Cucumis myriocarpus* was identified within this vegetation type. Dominant taxa are shown in Table 4-5. According to the NVIS, this vegetation community is best represented by the MVG8- Casuarina Forests and Woodlands (DotEE, 2017b).

Table 4-5: Vegetation assemblage for Low open woodland of *Casuarina pauper* over mid chenopod shrubland *of Maireana sedifolia/ M. pyramidata* and low open forbland of *Sclerolaena diacantha* on clay-loam plain

Life Form/Height Class	Canopy Cover	Dominant taxa present
Tree <10m	5-10%	*Casuarina pauper*
Shrub 1-2m	30-70%	*Maireana sedifolia* *Maireana pyramidata*
Forb <0.5m	10-30%	*Sclerolaena diacantha*

Plate 4-2: Low open woodland of *Casuarina pauper* over mid chenopod shrubland *of Maireana sedifolia/ M. pyramidata* and low open forbland of *Sclerolaena diacantha* on clay-loam plain

Clay-Loam Plain: Eucalypt Woodlands

4.2.1.3 Mid woodland of *Eucalyptus salubris* over mid shrubland of *Eremophila scoparia* and low open shrubland of *Olearia muelleril* low open forbland of *Sclerolaena diacantha* on clay-loam plain (CLP-EW1)

The total flora recorded within this vegetation type was represented by a total of 9 Families, 14 Genera and 26 Taxa (Plate 4-3). No Threatened or Priority Flora taxa were identified within this vegetation community. One introduced taxa were recorded within this vegetation type; *Dittrichia graveolens* (Stinkwort). Dominant taxa are shown in Table 4-6. According to the NVIS, this vegetation community is best represented by the MVG5-Eucalypt Woodlands (DotEE, 2017b).

Table 4-6: Vegetation assemblage for Mid woodland of *Eucalyptus salubris* over mid shrubland of *Eremophila scoparia* and low open shrubland of *Olearia muelleril* low open forbland of *Sclerolaena diacantha* on clay-loam plain

Life Form/Height Class	Canopy Cover	Dominant taxa present
Tree >10m	10-30%	*Eucalyptus salubris*
Shrub 1-2m	30-70%	*Eremophila scoparia*
Shrub <1m	10-30%	*Olearia muelleri* *Sclerolaena diacantha*

Plate 4-3: Mid woodland of *Eucalyptus salubris* over mid shrubland of *Eremophila scoparia* and low open shrubland of *Olearia muelleril* low open forbland of *Sclerolaena diacantha* on clay-loam plain

4.2.1.4 Mid woodland of *Eucalyptus clelandiorum/ E. transcontinentalis* over mid open shrubland of *Acacia hemiteles/ Eremophila caperata* and low open shrubland of *Eremophila parvifolia/ Olearia muelleri* on clay-loam plain (CLP-EW2)

The total flora recorded within this vegetation type was represented by a total of 13 Families, 16 Genera and 28 Taxa (Plate 4-4). No Threatened or Priority Flora taxa were identified within this vegetation community. No introduced taxa were recorded within this vegetation community. Dominant taxa are shown in Table 4-7. According to the NVIS, this vegetation community is best represented by the MVG-Eucalypt Woodlands (DotEE, 2017b).

Table 4-7: Vegetation assemblage for Mid woodland of *Eucalyptus clelandiorum/ E. transcontinentalis* over mid open shrubland of *Acacia hemiteles/ Eremophila caperata* and low open shrubland of *Eremophila parvifolia/ Olearia muelleri* on clay-loam plain

Life Form/Height Class	Canopy Cover	Dominant taxa present
Tree >10m	10-30%	*Eucalyptus clelandiorum* *Eucalyptus transcontinentalis*
Shrub 1-2m	10-30%	*Acacia hemiteles* *Eremophila caperata*
Shrub <1m	10-30%	*Eremophila parvifolia* *Olearia muelleri*

Plate 4-4: Mid woodland of *Eucalyptus clelandiorum/ E. transcontinentalis* over mid open shrubland of *Acacia hemiteles/ Eremophila caperata* and low open shrubland of *Eremophila parvifolia/ Olearia muelleri* on clay-loam plain

4.2.1.5 Mid woodland of *Eucalyptus salmonophloia* over mid open shrubland of *Acacia hemiteles/ Eremophila scoparia* and low open shrubland of *Ptilotus obovatus* on clay-loam plain (CLP-EW3)

The total flora recorded within this vegetation types was represented by a total of 15 Families, 23 Genera and 41 Taxa (Plate 4-5). No Threatened or Priority Flora taxa were identified within this vegetation type. Two introduced taxa were recorded within this vegetation type; *Dittrichia graveolens* (Stinkwort) and *Salvia verbenaca* (Wild Sage). Dominant taxa are shown in Table 4-8. According to the NVIS, this vegetation community is best represented by the MVG5- Eucalypt Woodlands (DotEE, 2017b).

Table 4-8: Vegetation assemblage for Mid woodland of *Eucalyptus salmonophloia* over mid open shrubland of *Acacia hemiteles/ Eremophila scoparia* and low open shrubland of *Ptilotus obovatus* on clay-loam plain

Life Form/Height Class	Canopy Cover	Dominant taxa present
Tree >10m	10-30%	*Eucalyptus salmonophloia*
Shrub 1-2m	10-30%	*Acacia hemiteles* *Eremophila scoparia*
Shrub <1m	10-30%	*Ptilotus obovatus*

Plate 4-5: Mid woodland of *Eucalyptus salmonophloia* over mid open shrubland of *Acacia hemiteles/ Eremophila scoparia* and low open shrubland of *Ptilotus obovatus* on clay-loam plain

4.2.1.6 Low open forest of *Eucalyptus ravida* over mid sparse shrubland of *Eremophila scoparia* and low chenopod shrubland of *Maireana oppositifolial* low shrubland of *Ptilotus obovatus* on clay-loam plain (CLP-EW4)

The total flora recorded within this vegetation type was represented by a total of 6 Families, 10 Genera and 20 Taxa (Plate 4-6). No Threatened or Priority Flora taxa were identified within this vegetation type. One introduced taxon, *Carthamus lanatus* (Saffron Thistle) was recorded within this vegetation type. Dominant taxa are shown in Table 4-9. According to the NVIS, this vegetation community is best represented by the MVG5- Eucalypt Woodlands (DotEE, 2017b).

Table 4-9: Vegetation assemblage for Low open forest of *Eucalyptus ravida* over mid sparse shrubland of *Eremophila scoparia* and low chenopod shrubland of *Maireana oppositifolial* low shrubland of *Ptilotus obovatus* on clay-loam plain

Life Form/Height Class	Canopy Cover	Dominant taxa present
Tree <10m	30-70%	*Eucalyptus ravida*
Shrub 1-2m	5-10%	*Eremophila scoparia*
Chenopod Shrub <1m	30-70%	*Maireana oppositifolia*
Shrub <1m	30-70%	*Ptilotus obovatus*

Plate 4-6: Low open forest of *Eucalyptus ravida* over mid sparse shrubland of *Eremophila scoparia* and low chenopod shrubland of *Maireana oppositifolial* low shrubland of *Ptilotus obovatus* on clay-loam plain

4.2.1.7 Mid open woodland of *Eucalyptus salmonophloia* over mid sparse shrubland of *Eremophila interstans* subsp. *virgata* and low chenopod shrubland of *Maireana sedifolia/ Atriplex nummularia* subsp. *spathulata* on clay-loam plain (CLP-EW5)

The total flora recorded within this vegetation type was represented by a total of 14 Families, 18 Genera and 26 Taxa (Plate 4-7). No Threatened or Priority Flora taxa were identified within this vegetation type. The introduced species *Salvia verbenaca* was identified within this vegetation community. Dominant taxa are shown in Table 4-10. According to the NVIS, this vegetation community is best represented by the MVG5- Eucalypt Woodlands (DotEE, 2017b).

Table 4-10: Vegetation assemblage for Mid open woodland of *Eucalyptus salmonophloia* over mid sparse shrubland of *Eremophila interstans* subsp. *virgata* and low chenopod shrubland of *Maireana sedifolia/ Atriplex nummularia* subsp. *spathulata* on clay-loam plain

Life Form/Height Class	Canopy Cover	Dominant taxa present
Tree >10m	5-10%	*Eucalyptus salmonophloia*
Tree <10m	5-10%	*Casuarina pauper*
Shrub 1-2m	5-10%	*Eremophila interstans* subsp. *virgata*
Chenopod Shrub <1m	30-70%	*Maireana sedifolia* *Atriplex nummularia* subsp. *spathulata*

Plate 4-7: Mid open woodland of *Eucalyptus salmonophloia* over mid sparse shrubland of *Eremophila interstans* subsp. *virgata* and low chenopod shrubland of *Maireana sedifolia/ Atriplex nummularia* subsp. *spathulata* on clay-loam plain

Clay-Loam Plain: Eucalypt Woodlands/Mallee Woodlands and Shrublands

4.2.1.8 Low woodland of *Eucalyptus clelandiorum*/ Open mallee woodland of *E. griffithsii/ E. oleosa* over mid open shrubland of *Eremophila caperata* and low open shrubland of *Scaevola spinescens/ Senna artemisioides* subsp*. filifolia* on clay-loam plain (CLP-EW/MWS1)

The total flora recorded within this vegetation type was represented by a total of 15 Families, 21 Genera and 29 Taxa (Plate 4-8). No Threatened or Priority Flora taxa were identified within this vegetation type. No introduced taxon was recorded within this vegetation type. Dominant taxa are shown in Table 4-11. According to the NVIS, this vegetation community is best represented by the MVG5- Eucalypt Woodlands and MVG14- Mallee Woodlands and Shrublands (DotEE, 2017b).

Table 4-11: Vegetation assemblage for Low woodland of *Eucalyptus clelandiorum*/ Open mallee woodland of *E. griffithsii/ E. oleosa* over mid open shrubland of *Eremophila caperata* and low open shrubland of *Scaevola spinescens/ Senna artemisioides* subsp*. filifolia* on clay-loam plain

Life Form/Height Class	Canopy Cover	Dominant taxa present
Tree <10m	10-30%	*Eucalyptus clelandiorum*
Mallee Tree 3-10m	10-30%	*Eucalyptus griffithsii* *Eucalyptus oleosa*
Shrub 1-2m	10-30%	*Eremophila caperata*
Shrub <1m	10-30%	*Scaevola spinescens* *Senna artemisioides* subsp. *filifolia*

Plate 4-8: Low woodland of *Eucalyptus clelandiorum*/ Open mallee woodland of *E. griffithsii/ E. oleosa* over mid open shrubland of *Eremophila caperata* and low open shrubland of *Scaevola spinescens/ Senna artemisioides* subsp*. filifolia* on clay-loam plain

Closed Depression: Chenopod Shrublands, Samphire Shrublands and Forblands

4.2.1.9 Isolated *Eucalyptus clelandiorum/ E. celastroides* over mid sparse shrubland of *Melaleuca lateriflora* and samphire shrubland of *Tecticornia disarticulata/T. halocnemoides* in closed depression (CD-CSSSF1)

The total flora recorded within this vegetation type was represented by a total of 6 Families, 9 Genera and 13 Taxa (Plate 4-9). No Threatened or Priority Flora taxa were identified within this vegetation type. Dominant taxa are shown in Table 4-12. According to the NVIS, this vegetation community is best represented by the MVG22- Chenopod Shrublands, Samphire Shrublands and Forblands (DotEE, 2017b).

Table 4-12: Vegetation assemblage for Isolated *Eucalyptus clelandiorum/ E. celastroides* over mid sparse shrubland of *Melaleuca lateriflora* and samphire shrubland of *Tecticornia disarticulata/T. halocnemoides* in closed depression

Life Form/Height Class	Canopy Cover	Dominant taxa present
Tree <10m	0-5%	*Eucalyptus clelandiorum* *Eucalyptus celastroides*
Shrub 1-2m	5-10%	*Melaleuca lateriflora*
Samphire Shrub <0.5m	30-70%	*Tecticornia disarticulata* *Tecticornia halocnemoides*

Plate 4-9: Isolated *Eucalyptus clelandiorum/ E. celastroides* over mid sparse shrubland of *Melaleuca lateriflora* and samphire shrubland of *Tecticornia disarticulata/T. halocnemoides* in closed depression

Hillslope: Eucalypt Woodlands

4.2.1.10 Mid woodland *Eucalyptus clelandiorum/E. oleosa* over mid open shrubland of *Eremophila caperata* and low sparse shrubland of *Cratystylis conocephala/ Eremophila pustulata* on hillslope (HS-EW1)

The total flora recorded within this vegetation type was represented by a total of 8 Families, 12 Genera and 20 Taxa (Plate 4-10). No Threatened or Priority Flora taxa were identified within this vegetation type. No introduced taxa were recorded within this vegetation type. Dominant taxa are shown in Table 4-13. According to the NVIS, this vegetation community is best represented by the MVG5-Eucalypt Woodlands (DotEE, 2017b).

Table 4-13: Vegetation assemblage for Mid woodland *Eucalyptus clelandiorum/E. oleosa* over mid open shrubland of *Eremophila caperata* and low sparse shrubland of *Cratystylis conocephala/ Eremophila pustulata* on hillslope

Life Form/Height Class	Canopy Cover	Dominant taxa present
Tree >10m	10-30%	*Eucalyptus clelandiorum* *Eucalyptus oleosa*
Shrub >2m	10-30%	*Eremophila caperata*
Shrub <1m	5-10%	*Cratystylis conocephala* *Eremophila pustulata*

Plate 4-10: Low woodland *Eucalyptus clelandiorum/ E. oleosa* over open low scrub of *Eremophila caperata* and low heath of *Cratystylis conocephala/ Eremophila pustulata* on hillslope

4.2.1.11 Mid open woodland of *Eucalyptus salubris/E. clelandiorum* over mid sparse shrubland of *Eremophila* sp. Mt Jackson (G.J. Keighery 4372) and low sparse shrubland of *Cratystylis subspinescens* on hillslope (HS-EW2)

The total flora recorded within this vegetation community was represented by a total of 8 Families, 12 Genera and 19 Taxa (Plate 4-11). No Threatened or Priority Flora taxa were identified within this vegetation community. No introduced taxa were recorded within this vegetation community. Dominant taxa are shown in Table 4-14. According to the NVIS, this vegetation community is best represented by the MVG5- Eucalypt Woodlands (DotEE, 2017b).

Table 4-14: Vegetation assemblage for Mid open woodland of *Eucalyptus salubris/E. clelandiorum* over mid sparse shrubland of *Eremophila* sp. Mt Jackson (G.J. Keighery 4372) and low sparse shrubland of *Cratystylis subspinescens* on hillslope

Life Form/Height Class	Canopy Cover	Dominant taxa present
Tree >10m	5-10%	*Eucalyptus salubris* *Eucalyptus clelandiorum*
Shrub 1-2m	5-10%	*Eremophila* sp. Mt Jackson (G.J. Keighery 4372)
Shrub <1m	5-10%	*Cratystylis subspinescens*

Plate 4-11: Mid open woodland of *Eucalyptus salubris/E. clelandiorum* over mid sparse shrubland of *Eremophila* sp. Mt Jackson (G.J. Keighery 4372) and low sparse shrubland of *Cratystylis subspinescens* on hillslope

Open Depression: Eucalypt Woodlands

4.2.1.12 Mid woodland of *Eucalyptus salmonophloia* over mid open shrubland of *Acacia hemiteles/ Eremophila scoparia* and low open shrubland of *Ptilotus obovatus* in open depression (OD-EW1)

The total flora recorded within this vegetation community was represented by a total of 15 Families, 23 Genera and 41 Taxa (Plate 4-12). No Threatened or Priority Flora taxa were identified within this vegetation type. No introduced taxa were recorded within this vegetation type. Dominant taxa are shown in Table 4-15. According to the NVIS, this vegetation community is best represented by the MVG5- Eucalypt Woodlands (DotEE, 2017b).

Table 4-15: Vegetation assemblage for Mid woodland of *Eucalyptus salmonophloia* over mid open shrubland of *Acacia hemiteles/ Eremophila scoparia* and low open shrubland of *Ptilotus obovatus* in open depression

Life Form/Height Class	Canopy Cover	Dominant taxa present
Tree >10m	10-30%	*Eucalyptus salmonophloia*
Shrub >2m	10-30%	*Acacia hemiteles* *Eremophila scoparia*
Shrub <1m	10-30%	*Ptilotus obovatus*

Plate 4-12: Mid woodland of *Eucalyptus salmonophloia* over mid open shrubland of *Acacia hemiteles/ Eremophila scoparia* and low open shrubland of *Ptilotus obovatus* in open depression

4.2.2 Vegetation Condition

Based on the vegetation condition rating scale adapted from Keighery, 1994 and Trudgen, 1988 (Appendix 3), ten of the twelve vegetation types were rated as 'good' (Table 4-11). The remaining two groups were rated as 'very good'. Approximately 189 ha of the survey area (9.9%) was completely degraded from previous mining activities. A map of the vegetation condition within the survey area is provided in Figure 4-2.

'Good' condition depicts that vegetation structure has been significantly altered by very obvious signs of multiple disturbances, however it retains its basic vegetation structure or has ability to regenerate it. Disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds, partial clearing, dieback and grazing.

'Very Good' condition depicts that vegetation structure has been altered by obvious signs of disturbance, including repeated fires, the presence of some more aggressive weeds, dieback, logging and grazing.

Table 4-16: Vegetation Condition Rating of the survey area

Landform	NVIS Vegetation Group	Code	Vegetation Type	Condition Rating
Clay-Loam Plain	Casuarina Forests and Woodlands	CLP-CFW1	Low open forest of *Casuarina pauper* over mid open shrubland of *Acacia hemiteles* and low open shrubland of *Olearia muelleri/ Scaevola spinescens* on clay-loam plain	Good
		CLP-CFW2	Low open woodland of *Casuarina pauper* over mid chenopod shrubland of *Maireana sedifolia/ M. pyramidata* and low open forbland of *Sclerolaena diacantha* on clay-loam plain	Good
	Eucalypt Woodland	CLP-EW1	Mid woodland of *Eucalyptus salubris* over mid shrubland of *Eremophila scoparia* and low open shrubland of *Olearia muelleri/* low open forbland of *Sclerolaena diacantha* on clay-loam plain	Good
		CLP-EW2	Mid woodland of *Eucalyptus clelandiorum/ E. transcontinentalis* over mid open shrubland of *Acacia hemiteles/ Eremophila caperata* and low open shrubland of *Eremophila parvifolia/ Olearia muelleri* on clay-loam plain	Good
		CLP-EW3	Mid woodland of *Eucalyptus salmonophloia* over mid open shrubland of *Acacia hemiteles/ Eremophila scoparia* and low open shrubland of *Ptilotus obovatus* on clay-loam plain	Good
		CLP-EW4	Low open forest of *Eucalyptus ravida* over mid sparse shrubland of *Eremophila scoparia* and low chenopod shrubland of *Maireana oppositifolia/* low shrubland of *Ptilotus obovatus* on clay-loam plain	Good
		CLP-EW5	Mid open woodland of *Eucalyptus salmonophloia* over mid sparse shrubland of *Eremophila interstans* subsp. *virgata* and low chenopod shrubland of *Maireana sedifolia/ Atriplex nummularia* subsp. *spathulata* on clay-loam plain	Very Good

Landform	NVIS Vegetation Group	Code	Vegetation Type	Condition Rating
	Eucalypt Woodlands/ Mallee woodlands and shrublands	CLP-EW/MWS1	Low woodland of *Eucalyptus clelandiorum*/ Open mallee woodland of *E. griffithsii/ E. oleosa* over mid open shrubland of *Eremophila caperata* and low open shrubland of *Scaevola spinescens/ Senna artemisioides* subsp. *filifolia* on clay-loam plain	Good
Closed Depression	Chenopod Shrublands, Samphire Shrublands and Forblands	CD-CSSSF1	Isolated *Eucalyptus clelandiorum/ E. celastroides* over mid sparse shrubland of *Melaleuca lateriflora* and samphire shrubland of *Tecticornia disarticulata/T. halocnemoides* in closed depression	Good
Hillslope	Eucalypt Woodlands	HS-EW1	Mid woodland *Eucalyptus clelandiorum/E. oleosa* over mid open shrubland of *Eremophila caperata* and low sparse shrubland of *Cratystylis conocephala/ Eremophila pustulata* on hillslope	Good
		HS-EW2	Mid open woodland of *Eucalyptus salubris/E. clelandiorum* over mid sparse shrubland of *Eremophila* sp. Mt Jackson (G.J. Keighery 4372) and low sparse shrubland of *Cratystylis subspinescens* on hillslope	Very Good
Open Depression	Eucalypt Woodlands	OD-EW1	Mid woodland of *Eucalyptus salmonophloia* over mid open shrubland of *Acacia hemiteles/ Eremophila scoparia* and low open shrubland of *Ptilotus obovatus* in open depression	Good
N/A	N/A	CV	Mining Disturbance	Completely Degraded
TOTAL				**1903**

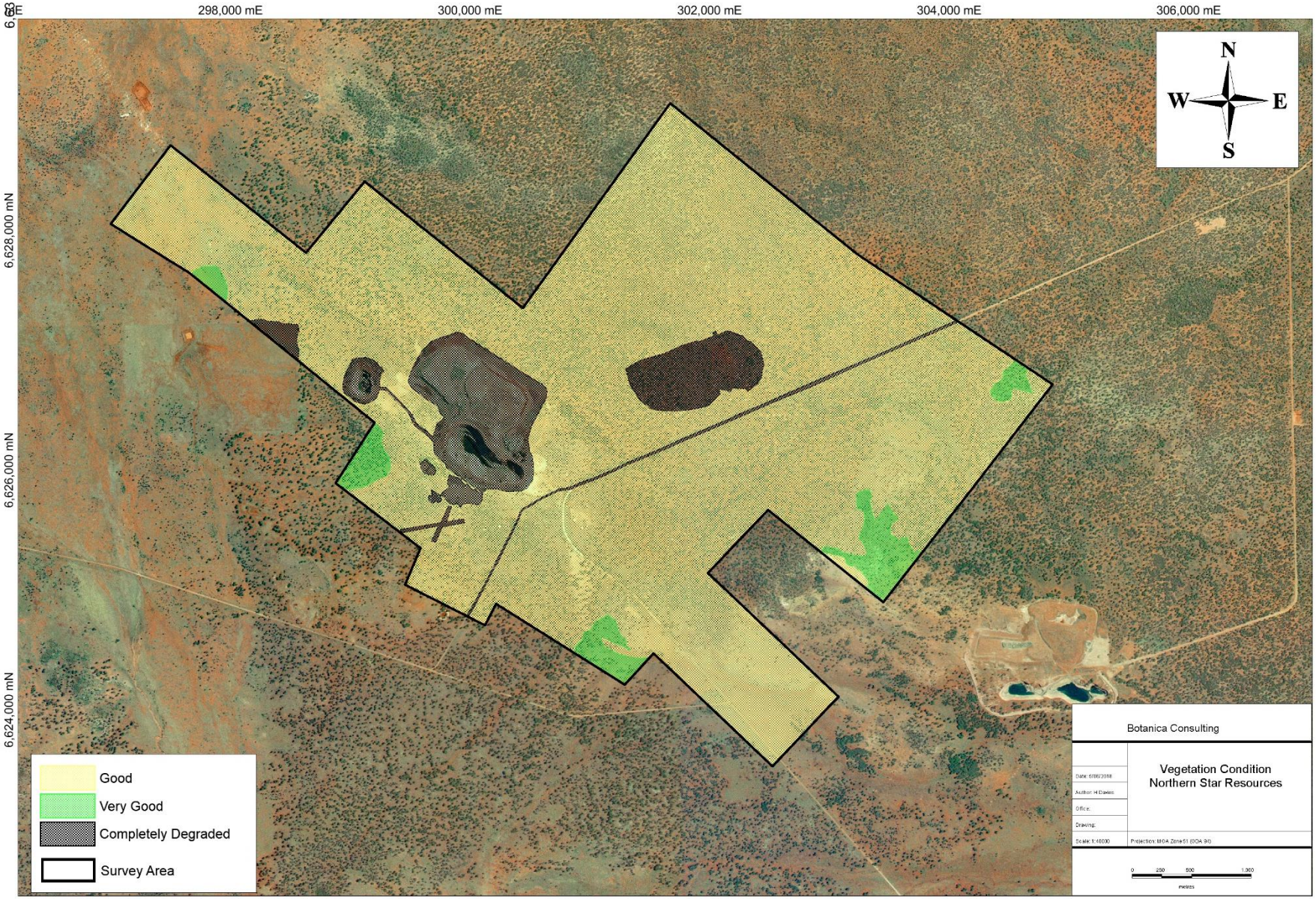


Figure 4-2: Vegetation Condition Rating of the survey area

4.2.3 Introduced Plant Species

Four introduced taxa were identified within the survey area:

1. *Carthamus lanatus* (Saffron Thistle)
2. *Dittrichia graveolens* (Stinkwort)
3. *Salvia verbenaca* (Wild Sage)
4. *Cucumis myriocarpus* (Prickly Paddy Melon)

According to the DPIRD, none of these taxa are listed as a Declared Plant under the BAM Act.

4.2.3.1 *Carthamus lanatus* (Saffron Thistle)

This taxon is described as an erect, spiny annual, herb, which grows between 0.15-0.7m high, and has leaves with rigid, spiny lobes (Plate 4-13). It produces yellow flowers from December/January to April. It occurs on a variety of soils and is a common weed of crops, pastures and waste grounds (WAHERB, 2018). *Carthamus lanatus* was identified within one vegetation type; CLP-EW4.

Plate 4-13: *Carthamus lanatus* (Saffron Thistle)

4.2.3.2 *Dittrichia graveolens* (Stinkwort)

This taxon is described as an erect, bushy, viscid, aromatic annual, herb, which grows between 0.1–0.5 metres high (Plate 4-14). It produces yellow or white flowers from January to November. It occurs on a variety of soils and is a weed of waste grounds, along rivers and roadsides (WAHERB, 2018). *Dittrichia graveolens* was recorded within two vegetation types; CLP-EW1 and CLP-EW3.

Plate 4-14: Image of *Dittrichia graveolens* (Stinkwort)

4.2.3.3 *Salvia verbenaca* (Wild Sage)

This taxon is described as a slightly aromatic annual herb that grows to 0.1-1 m high (Plate 4-15). It produces blue-pink-purple flowers in April or July to October and is often along roadsides (WAHERB, 2018). *Salvia verbenaca* was recorded within three vegetation types; CLP-CFW2, CLP-EW3 and CLP-EW5.

Plate 4-15: *Salvia verbenaca* (Wild Sage)

4.2.3.4 *Cucumis myriocarpus* (Prickly Paddy Melon)

This species is described as a prostrate, annual herb. It produces yellow flower from January to February, or April to May (Plate 4-16). It is found in disturbed areas (WAHERB, 2018). This taxon was identified in one vegetation type; CLP-CFW2.

Plate 4-16: *Cucumis myriocarpus* (Prickly Paddy Melon)

4.2.4 Fauna Habitat

The broad scale terrestrial fauna habitats within the survey area presented below are based on vegetation and associated landforms identified during the flora and vegetation assessment. The extent of the identified fauna habitats and a summary description of each are provided in Table 4-17 below.

Table 4-17: Main Terrestrial Fauna Habitats within the survey area

Fauna Habitat Description	Example Image
Clay-Loam Plains *Casuarina* Forests and Woodlands. Total Area = ~131 ha (~7%)	
Clay-Loam Plains Eucalypt Woodlands. Total Area = ~1,311 ha (~69%)	
Clay-Loam Plains Eucalypt Woodlands/ Mallee Woodlands and Shrublands. Total Area = ~102 ha (~5%)	

Fauna Habitat Description	Example Image
<u>Closed Depression</u> Chenopod Shrublands, Samphire Shrublands and Forblands Total Area = ~3 ha (~0.2%)	
<u>Hillslope</u> Eucalypt Woodlands Total Area = ~147 ha (~8%)	
<u>Open Depression</u> Eucalypt Woodlands Total Area = ~20 ha (~1%)	

Fauna Habitat Description	Example Image
Existing Cleared Areas Historical Mining Disturbance. Total Area = ~189 ha (~10%)	

A list of expected vertebrate fauna species likely to occur in the survey area was compiled from information obtained during the literature review and is presented in Appendix 4. The results of some previous fauna surveys carried out in the general area are also summarised in this species listing as are the DBCA NatureMap database search results.

Table 4-18 summarises the numbers of potential species based on vertebrate class considered likely to be present in the general vicinity of the survey area based on the complete list held Appendix 4.

Not all species listed in existing databases and publications as potentially occurring within the region (i.e. *EPBC Act* Threatened Fauna and Migratory species lists, DBCA NatureMap Fauna Database and various publications) are considered likely to be present within the survey area. The list of potential fauna takes into consideration that firstly the species in question is not known to be locally/regionally extinct and secondly that suitable habitat for each species, as identified during the habitat assessment, is present within the survey area, though compiling an accurate list has limitations (see **Section 3.3 Survey limitations and constraints**).

Table 4-18: Summary of Potential Vertebrate Fauna Species

Group	Total number of potential species	Potential number of specially protected species	Potential number of migratory species	Potential number of priority species
Amphibians	4	0	0	0
Reptiles	73	0	0	0
Birds	109	1	0	0
Non-Volant Mammals	19[7]	0	0	0
Volant Mammals (Bats)	11	0	0	1
Total	**216[7]**	**1**	**0**	**1**

Superscript = number of introduced species included in the total. Note: Where a species state and federal conservation status is different, the highest category is used.

Despite the omission of some species it should be noted that the list provided is still very likely an over estimation of the fauna species utilising the survey area (either on a regular or infrequent basis) as a result of the precautionary approach adopted for the assessment. At any one time, only a subset of the listed potential species is likely to be present within the bounds of the study area.

Forty-five fauna species (~21% of the potential species) were observed/recorded during the field survey carried out in 2018. No fauna of conservation significance were recorded, with most animals observed being relatively common widespread bird species.

4.2.5 Flora of Conservation Significance

According to the EPA *Environmental Factor Guideline for Flora and Vegetation* (EPA, 2016b) flora of conservation significance includes:

- Flora being identified as threatened or priority species
- Locally endemic flora or flora associated with a restricted habitat type (e.g. surface water or groundwater dependent ecosystems)
- New species or anomalous features that indicate a potential new species
- Flora representative of the range of a species (particularly, at the extremes of range, recently discovered range extensions, or isolated outliers of the main range)
- Unusual species, including restricted subspecies, varieties or naturally occurring hybrids
- Flora with relictual status, being representative of taxonomic groups that no longer occur widely in the broader landscape.

No flora of conservation significance were identified within the survey area. A map showing regional Threatened and Priority Flora known records in relation to the survey area is provided in Appendix 1.

4.2.6 Fauna of Conservation Significance

According to the EPA *Environmental Factor Guideline for Terrestrial Fauna* (EPA, 2016d) fauna of conservation significance includes:

- Fauna being identified as a threatened or priority species
- Fauna species with restricted distribution
- Fauna subject to a high degree of historical impact from threatening processes
- Fauna providing an important function required to maintain the ecological integrity of a significant ecosystem.

No fauna of conservation significance was identified within the survey area.

4.2.7 Vegetation of Conservation Significance

According to the EPA *Environmental Factor Guideline for Flora and Vegetation* (EPA, 2016b) vegetation of conservation significance includes:

- Vegetation being identified as threatened or priority ecological communities
- Vegetation with restricted distribution
- Vegetation subject to a high degree of historical impact from threatening processes
- Vegetation which provides a role as a refuge
- Vegetation providing an important function required to maintain ecological integrity of a significant ecosystem.

No vegetation of conservation significance was identified within the survey area.

4.2.8 Matters of National Environmental Significance

None of the following matters of national environmental significance as defined by the Commonwealth EPBC Act were identified within the survey area:

- world heritage properties
- national heritage places
- wetlands of international importance (often called 'Ramsar' wetlands after the international treaty under which such wetlands are listed)
- nationally threatened species and ecological communities
- Commonwealth marine areas
- the Great Barrier Reef Marine Park
- nuclear actions (including uranium mining) a water resource, in relation to coal seam gas development and large coal mining development.

4.2.9 Matters of State Environmental Significance

There are no wetlands of national importance (ANCA Wetlands) or conservation category wetlands within the survey area. The survey area does not contain any TEC as listed under the WC Act or EP Act. No Threatened Flora taxon listed under the WC Act were recorded within the survey area. The survey area does not contain any ESA or Schedule 1 Areas listed under the EP Act. No DBCA managed lands are located within the survey area.

A map showing areas of conservation significance in relation to the survey area is provided in Appendix 1.

4.3 Native Vegetation Clearing Principles

Based on the outcomes from the survey undertaken, as presented in this report, Botanica provides the following comments regarding the native vegetation clearing principles listed under Schedule 5 of the EP Act (Table 4-19).

Table 4-19: Assessment of development within the survey area against native vegetation clearing principles

Letter	Principle	Assessment	Outcome
(a)	Native vegetation should not be cleared if it comprises a high level of biological diversity.	Vegetation identified within the survey area is not considered to be of high biological diversity and is well represented outside of the proposed impact area.	Development within the survey area is unlikely to be at variance to this principle
(b)	Native vegetation should not be cleared it comprises the whole or part of, or is necessary for the maintenance of, a significant habitat for fauna indigenous to WA.	No significant fauna habitat identified within the project area. Fauna habitats are well represented outside of the project area. No significant fauna were observed within the survey area.	Development within the survey area is unlikely to be at variance to this principle
(c)	Native vegetation should not be cleared if it includes or is necessary for the continued existence of rare flora.	No Threatened Flora taxa, pursuant to the WC Act and the EPBC Act were identified within the survey area	Development within the survey area is unlikely to be at variance to this principle
(d)	Native vegetation should not be cleared if it comprises the whole or part of or is necessary for the	No TEC listed under the EPBC Act or by the WC Act occur within the survey area.	Development within the survey area is unlikely to

Letter	Principle	Assessment	Outcome
	maintenance of a threatened ecological community (TEC).		be at variance to 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.	According to DAFWA (2011), the survey area occurs in pre-European Beard vegetation associations Kununulling 468 and 555, both of which retain approximately >98% of the original vegetation extent.	Development within the survey area is unlikely to be at variance to 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.	According to the Geoscience Australia GIS database, there are no drainage lines or inland waters within the survey area. No riparian vegetation was identified within the survey area.	Development within the survey area is unlikely to be at variance to this principle
(g)	Native vegetation should not be cleared if the clearing of the vegetation is likely to cause appreciable land degradation.	According to DAFWA (2011), the survey area occurs in pre-European Beard vegetation associations Kununulling 468 and 555, both of which retain approximately >98% of the original vegetation extent. Clearing within these vegetation associations are not likely to lead to land degradation issues such as salinity, water logging or acidic soils.	Development within the survey area is unlikely to be at variance to this principle
(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.	The survey area is not located within a Conservation Area.	Development within the survey area is unlikely to be at variance to this principle
(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.	According to the Geoscience Australia GIS database, there are no drainage lines or inland waters within the survey area. No riparian vegetation was identified within the survey area. The survey area is located in an arid to semi-arid environment with most rainfall lost by evaporation or surface runoff. Only a small portion infiltrates the soil and recharges the groundwater.	Development within the survey area is unlikely to be at variance to this principle
(j)	Native vegetation should not be cleared if clearing the vegetation is likely to cause, or exacerbate, the incidence of flooding	Rainfall is unreliable and highly variable with an average rainfall of 200-300mm and an evaporation rate of 2400 mm. The region is not prone to flooding and does not contain riparian vegetation.	Development within the survey area is unlikely to be at variance to this principle

5 Summary

The survey area comprised of twelve broad vegetation types which were represented by a total 23 Families, 43 Genera and 94 Taxa, including sub-species and variants. The broad scale terrestrial fauna habitats within the survey area have been identified as comprising a mosaic of clay-loam plain, hillslopes, open depressions, closed depression and existing disturbed areas.

Results of the literature review identified 40 mammals (including 11 bat species), 109 bird, 73 reptiles and four frog species that have previously been recorded in the general area, some of which have the potential to occur subject to the identified habitats being suitable. Forty-five species were recorded during the field survey.

No Threatened Flora, Threatened Fauna, Migratory Fauna or TEC as listed under the WC Act or Commonwealth EPBC Act 1999 were identified within the survey area. No Priority Flora or Fauna taxa as listed by DBCA were identified within the survey area.

A review of the EPBC Act threatened fauna list, DBCA's Threatened Fauna Database and Priority List, unpublished reports and scientific publications identified a number of specially protected, migratory or priority fauna species as having been previously recorded or as being potentially present in the general vicinity of the survey area. However, no fauna of conservation significance is likely to be significantly impacted on by the proposed development. This conclusion is primarily based on the lack of suitable habitats, the known local extinction of some species, the relatively small size of the impact footprint and the extensive habitat connectivity with adjoining areas. Impacts on fauna and fauna habitat are therefore anticipated to be localised, small/negligible and as a consequence manageable.

No PECs were identified within the survey area. The survey area does not contain any world or national heritage places and does not occur within a Bush Forever site. There are no wetlands of international importance (Ramsar Wetlands), national importance (ANCA Wetlands) or conservation category wetlands within the survey area. The survey area does not contain any ESA or Schedule 1 Areas as listed under the EP Act. The survey is not located within DBCA managed land.

Based on the Keighery vegetation health rating scale, ten vegetation types were classed as 'good' and two vegetation types were classed as 'very good'. Four introduced taxa were identified within the survey area, none of which are listed as a Declared Plant under Section 22 of the BAM Act.

5.1 Recommendations

- Avoidance of clearing mature Eucalypts where possible.
- Implement weed management/ vehicle hygiene procedures during clearing/ site access to prevent spread of introduced species.

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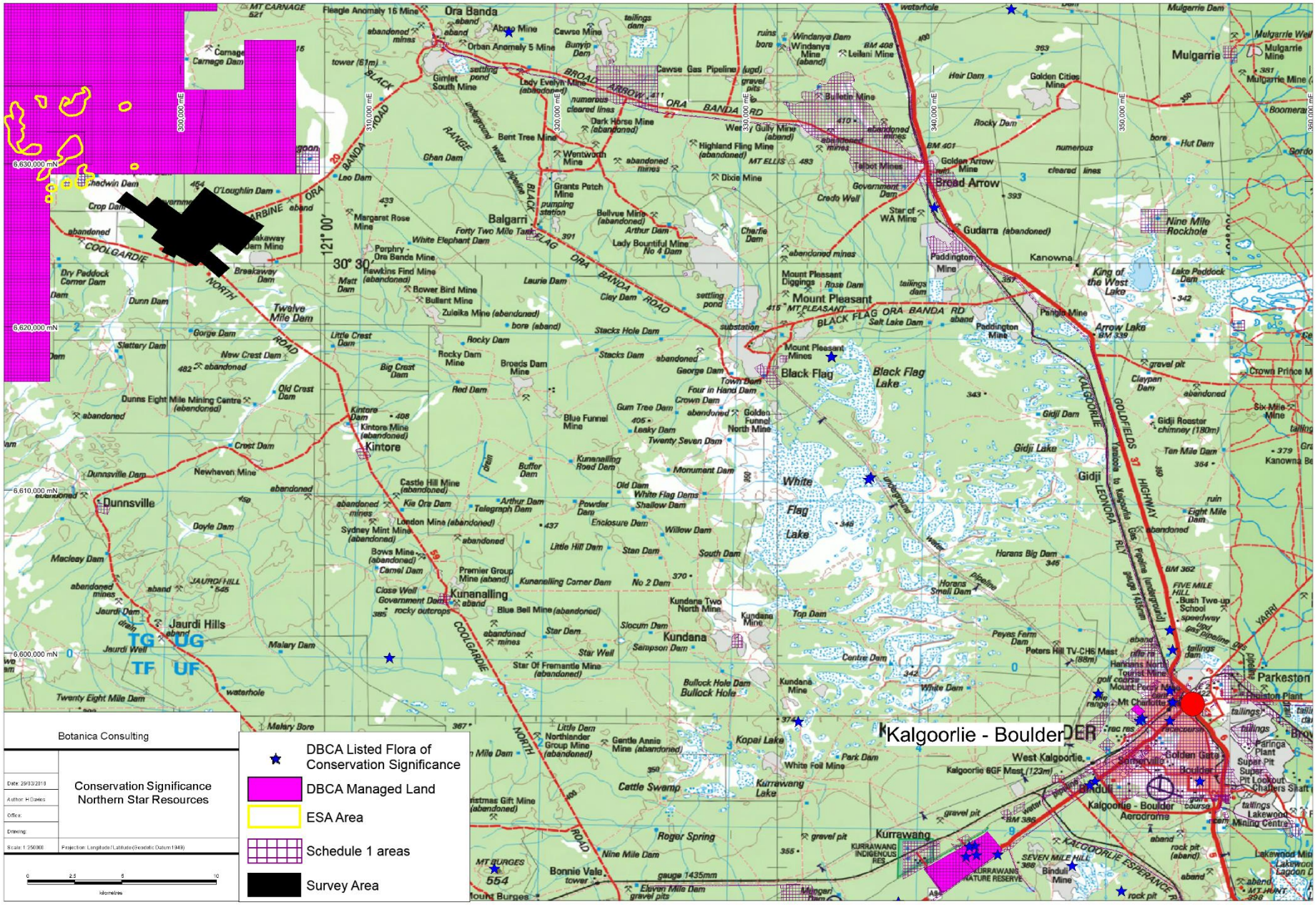
Wilson, S. and Swan, G. (2013)*, A Complete Guide to Reptiles of Australia*. Third Edition, Reed, New Holland, Sydney

Appendix 1: Regional map of the survey area including DBCA Flora of Conservation Significance and areas of Conservation Significance



Appendix 2: List of species identified within each vegetation types

(A) Denotes Annual species; (W) Denotes Introduced species as listed on Florabase (WAHERB, 2018)

Family	Genus	Taxon	CLP-CFW1	CLP-CFW2	CLP-EW1	CLP-EW2	CLP-EW3	CLP-EW4	CLP-EW5	CLP-EW/MWS1	CLP-CS1	HS-EW1	HS-EW2	OD-EW1
Amaranthaceae	*Ptilotus*	*nobilis (A)*						*						
Amaranthaceae	*Ptilotus*	*obovatus*	*		*	*	*	*	*	*			*	*
Amaranthaceae	*Ptilotus*	*helichrysoides*									*		*	
Amaranthaceae	*Ptilotus*	sp. (sterile)									*			
Apiaceae	*Daucus*	*glochidiatus* (A)								*				
Apocynaceae	*Alyxia*	*buxifolia*			*		*							*
Asteraceae	*Carthamus*	*lanatus* (W)						*						
Asteraceae	*Cratystylis*	*conocephala*										*	*	
Asteraceae	*Cratystylis*	*microphylla*											*	
Asteraceae	*Cratystylis*	*subspinescens*		*		*			*					
Asteraceae	*Dittrichia*	*graveolens (W)*			*		*							*
Asteraceae	*Lemooria*	*burkittii (A)*						*						
Asteraceae	*Olearia*	*muelleri*	*		*	*	*			*		*	*	*
Boraginaceae	*Halgania*	*andromedifolia*				*	*			*		*		*
Casuarinaceae	*Casuarina*	*pauper*	*	*		*	*		*	*				*
Chenopodiaceae	*Atriplex*	*bunburyana*					*	*						*
Chenopodiaceae	*Atriplex*	*codonocarpa (A)*						*			*			
Chenopodiaceae	*Atriplex*	*nummularia* subsp. *spathulata*				*	*	*	*	*		*		*
Chenopodiaceae	*Atriplex*	*vesicaria*								*		*	*	
Chenopodiaceae	*Enchylaena*	*tomentosa*			*		*	*						*
Chenopodiaceae	*Maireana*	*georgei*		*	*		*	*	*	*	*			*
Chenopodiaceae	*Maireana*	*glomerifolia*									*			
Chenopodiaceae	*Maireana*	*oppositifolia*				*		*						
Chenopodiaceae	*Maireana*	*pyramidata*			*		*	*	*					*
Chenopodiaceae	*Maireana*	*sedifolia*		*	*	*	*	*	*					*
Chenopodiaceae	*Maireana*	*trichoptera*						*						
Chenopodiaceae	*Maireana*	*triptera*			*		*		*	*				*
Chenopodiaceae	*Rhagodia*	*eremaea*								*				
Chenopodiaceae	*Sclerolaena*	*diacantha*		*	*		*		*				*	*
Chenopodiaceae	*Sclerolaena*	*drummondii*						*						
Chenopodiaceae	*Sclerolaena*	*parviflora*			*		*					*		*
Chenopodiaceae	*Tecticornia*	*disarticulata*									*		*	
Chenopodiaceae	*Tecticornia*	*halocnemoides*									*			
Cucurbitaceae	*Cucumis*	*myriocarpus (W)*		*										
Disphyma	*Disphyma*	*crassifolium*									*			
Fabaceae	*Acacia*	*acuminata*				*								
Fabaceae	*Acacia*	*colletioides*								*		*		
Fabaceae	*Acacia*	*erinacea*				*				*		*	*	
Fabaceae	*Acacia*	*hemiteles*	*		*	*	*		*	*				*
Fabaceae	*Acacia*	*jennerae*								*				
Fabaceae	*Acacia*	*tetragonophylla*	*				*							*
Fabaceae	*Senna*	*artemisioides* subsp. *filifolia*	*		*		*			*		*		*
Fabaceae	*Senna*	*artemisioides* subsp. *helmsii*											*	
Fabaceae	*Senna*	*cardiosperma*			*		*							*
Fabaceae	*Swainsona*	*canescens*	*				*							*
Fabaceae	*Templetonia*	*egena*								*				
Frankeniaceae	*Frankenia*	*setosa*						*			*			
Goodeniaceae	*Scaevola*	*spinescens*	*			*			*	*			*	
Lamiaceae	*Salvia*	*verbenaca (W)*		*			*		*					*

Family	Genus	Taxon	CLP-CFW1	CLP-CFW2	CLP-EW1	CLP-EW2	CLP-EW3	CLP-EW4	CLP-EW5	CLP-EW/MWS1	CLP-CS1	HS-EW1	HS-EW2	OD-EW1
Lamiaceae	*Westringia*	*rigida*								*				
Malvaceae	*Alyogyne*	*hakeifolia*					*							*
Malvaceae	*Sida*	sp. Golden calyces glabrous (H.N. Foote 32)		*										
Malvaceae	*Sida*	*spodochroma*							*					
Myrtaceae	*Eucalyptus*	*celastroides*			*	*	*	*			*	*	*	*
Myrtaceae	*Eucalyptus*	*clelandiorum*	*			*	*			*	*	*	*	*
Myrtaceae	*Eucalyptus*	*griffithsii*	*						*	*		*		
Myrtaceae	*Eucalyptus*	*oleosa*				*				*		*		
Myrtaceae	*Eucalyptus*	*ravida*			*			*						
Myrtaceae	*Eucalyptus*	*salmonophloia*		*	*		*		*					*
Myrtaceae	*Eucalyptus*	*salubris*			*		*	*	*				*	*
Myrtaceae	*Eucalyptus*	*transcontinentalis*		*	*	*	*							*
Myrtaceae	*Eucalyptus*	*yilgarnensis*	*			*								
Myrtaceae	*Melaleuca*	*elliptica*												
Myrtaceae	*Melaleuca*	*lateriflora*									*			
Pittosporaceae	*Pittosporum*	*angustifolium*				*			*	*		*		
Poaceae	*Austrostipa*	*elegantissima*					*							*
Poaceae	*Enneapogon*	*caerulescens*		*					*					
Poaceae	*Enneapogon*	*ramosus*		*										
Proteaceae	*Grevillea*	*nematophylla*	*											
Santalaceae	*Exocarpos*	*aphyllus*			*	*	*			*		*	*	*
Santalaceae	*Santalum*	*acuminatum*			*		*					*		*
Santalaceae	*Santalum*	*spicatum*	*		*	*	*			*				*
Sapindaceae	Alectryon	*oleifolius*	*	*	*		*		*	*				*
Sapindaceae	*Dodonaea*	*lobulata*	*			*				*				
Sapindaceae	*Dodonaea*	*viscosa* subsp. *angustissima*					*		*		*			*
Scrophulariaceae	*Eragrostis*	*eriopoda*	*											
Scrophulariaceae	*Eragrostis*	*setifolia*		*										
Scrophulariaceae	*Eragrostis*	sp. (sterile)		*										
Scrophulariaceae	*Eremophila*	*caperata*			*	*	*			*		*		*
Scrophulariaceae	*Eremophila*	*clarkei*					*							*
Scrophulariaceae	*Eremophila*	*decipiens*	*			*		*	*			*		
Scrophulariaceae	*Eremophila*	*glabra*	*										*	
Scrophulariaceae	*Eremophila*	*interstans* subsp. *virgata*					*		*			*		*
Scrophulariaceae	*Eremophila*	*ionantha*			*		*							*
Scrophulariaceae	*Eremophila*	*oldfieldii* subsp. *angustifolia*	*			*	*		*				*	*
Scrophulariaceae	*Eremophila*	*parvifolia*				*							*	
Scrophulariaceae	*Eremophila*	*pustulata*				*				*		*		
Scrophulariaceae	*Eremophila*	*scoparia*	*		*		*	*	*					*
Scrophulariaceae	*Eremophila*	sp. Mt Jackson (G.J. Keighery 4372)				*							*	
Solanaceae	Solanum	*hoplopetalum*					*			*				*
Solanaceae	*Solanum*	*nummularium*					*							*
Solanaceae	*Solanum*	*orbiculatum*							*					
Solanaceae	*Lycium*	*australe*							*					
Zygophyllaceae	*Zygophyllum*	*eremaeum (A)*				*								

Appendix 3: Vegetation Condition Rating

Vegetation Condition Rating	South West and Interzone Botanical Provinces	Eremaean and Northern Botanical Provinces
Pristine	Pristine or nearly so, no obvious signs of disturbance or damage caused by human activities since European settlement.	
Excellent	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species. Damage to trees caused by fire, the presence of non-aggressive weeds and occasional vehicle tracks.	Pristine or nearly so, no obvious signs of damage caused by human activities since European settlement.
Very Good	Vegetation structure altered, obvious signs of disturbance. Disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback, logging and grazing.	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	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate it. Disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds, partial clearing, dieback and grazing.	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	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management. Disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds at high density, partial clearing, dieback and grazing.	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	The structure of the vegetation is no longer intact and the area is completely or almost completely without native species. These areas are often described as 'parkland cleared' with the flora comprising weed or crop species with isolated native trees and shrubs.	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 4: Potential Fauna Species List

Observed and Potential Vertebrate Fauna List

Compiled by Greg Harewood - March 2018

Recorded (Captured/Sighted/Heard/Signs) = X

Carbine and Paradigm Project Area, Northern Star Resources Ltd, Kalgoorlie, W.A.

Approximate centroid 3057705°S and 121.53857°E

Harewood, G. (2015b). Fauna Assessment - Carbine and Paradigm Project Area. Unpublished report for Northern Start Resources Limited. December 2015.

Harewood, G. (2015a). Fauna Survey (Level 2 - Phase 1 and 2) Proposed Tails Storage Facility Expansion. Unpublished report for KCGM Pty Ltd. June 2015.

Harewood, G. (2011). Terrestrial Fauna Survey (Level 1) Proposed Powerline and Infrastucture Areas KCGM - Gidji Operations. Unpublished report for KCGM. January 2012.

Barrick Gold Corporation (2011). Miscellaneous Fauna Survey Records 2006 - 2011. Kanowna Belle Area. Unpublished internal data. May 2011.

Harewood, G. (2010a). Terrestrial Fauna Survey (Level 1) of the proposed Isabella Mine Area. Unpublished report for Barrick (Kanowna) Ltd. January 2010.

Harewood, G. (2010b). Terrestrial Fauna Survey (Level 1) of the proposed Golden Valley Mine Area. Unpublished report for Barrick (Kanowna) Ltd. January 2010.

Harewood, G. (2010c). Terrestrial Fauna Survey (Level 1) of the proposed Fenceline Mine Area. Unpublished report for Barrick (Kanowna) Ltd. January 2010.

KLA (2009a). Barrick (Kanowna) Shamrock Project Level 1 Fauna Survey. Unpublished report for Barrick (Kanowna) Ltd. January 2009.

KLA (2009b). Barrick (Kanowna) Crossroads Project Level 1 Fauna Survey. Unpublished report for Barrick (Kanowna) Ltd. January 2009.

KLA (2009c). Barrick (Kanowna) Moonlight Project Level 1 Fauna Survey. Unpublished report for Barrick (Kanowna) Ltd. March 2009.

WAM (1992). The Biological Survey of the Eastern Goldfields of Western Australia. Part 8. The Kurnalpi - Kalgoorlie Study Area. Rec. West. Aust. Mus. Supplement No. 41. (Black Flag Records).

DBCA (2018). NatureMap Database Search – "By Circle" Centre 120°55' 45" E, 30°28' 24" S, (plus 40km buffer). Accessed 28th March 2018.

Class **Family** *Species*	Common Name	Conservation Status	Harewood 2015b	Harewood 2015a	Harewood 2011	Barrick GC 2011	Harewood 2010a/b/c	KLA 2009a/b/c	WAM 1992	DBCA 2018
Amphibia										
Myobatrachidae Ground or Burrowing Frogs										
Neobatrachus kunapalari	Kunapalari Frog	LC		X						
Neobatrachus sutor	Shoemaker Frog	LC		X					X	
Neobatrachus wilsmorei	Plonking Frog	LC							X	
Pseudophryne occidentalis	Western Toadlet	LC		X						

WC Act Status - S1 to S7, EPBC Act Status - EN = Endangered, VU = Vulnerable, EX = Extinct, Mig = Migratory, DBCA Priority Status - P1 to P4, Int. Agmts - CA = CAMBA, JA = JAMBA, RK = ROKAMBA, IUCN Red List Category Definitions see Appendix A and http://www.iucnredlist.org/technical-documents/categories-and-criteria/2001-categories-criteria

Class **Family** *Species*	Common Name	Conservation Status	Harewood 2015b	Harewood 2015a	Harewood 2011	Barrick GC 2011	Harewood 2010a/b/c	KLA 2009a/b/c	WAM 1992	DBCA 2018
Reptilia										
Carphodactylidae Knob-tailed Geckos										
Nephrurus laevissimus	Smooth Knob-tail									
Nephrurus vertebralis	Midline Knob-tailed Gecko								X	
Underwoodisaurus milii	Barking Gecko			X					X	
Diplodactylidae Geckoes										
Diplodactylus conspicillatus	Fat-tailed Gecko									
Diplodactylus granariensis	Western Stone Gecko			X					X	
Diplodactylus pulcher	Pretty Gecko			X					X	
Lucasium damaeum	Beaded Gecko									
Lucasium maini	Main's Ground Gecko			X					X	
Oedura reticulata	Reticulated Velvet Gecko			X					X	
Rhynchoedura ornata	Western Beaked Gecko			X					X	
Strophurus assimilis	Thorn-tailed Gecko			X						
Strophurus elderi	Jewelled Gecko								X	

Class **Family** *Species*	Common Name	Conservation Status	Harewood 2015b	Harewood 2015a	Harewood 2011	Barrick GC 2011	Harewood 2010a/b/c	KLA 2009a/b/c	WAM 1992	DBCA 2018
Gekkonidae Geckoes										
Gehyra purpurascens	Purple Arid Dtella			X						
Gehyra variegata	Variegated Dtella			X					X	
Heteronotia binoei	Bynoe's Gecko			X					X	
Pygopodidae Legless Lizards										
Delma australis	Marble-faced Delma			X					X	
Delma butleri	Unbanded Delma								X	
Lialis burtonis	Burton’s Legless Lizard								X	
Pygopus lepidopodus	Common Scaly Foot									
Pygopus nigriceps	Hooded Scaly Foot									

Class **Family** *Species*	Common Name	Conservation Status	Harewood 2015b	Harewood 2015a	Harewood 2011	Barrick GC 2011	Harewood 2010a/b/c	KLA 2009a/b/c	WAM 1992	DBCA 2018
Agamidae Dragon Lizards										
Caimanops amphiboluroides	Mulga Dragon									
Ctenophorus caudicinctus	Ring-tailed Dragon			X						
Ctenophorus cristatus	Bicycle Dragon		X	X	X		X	X	X	
Ctenophorus fordi	Mallee Sand Dragon								X	
Ctenophorus nuchalis	Central Netted Dragon									
Ctenophorus reticulatus	Western Netted Dragon								X	
Ctenophorus scutulatus	Lozenge-marked Bicycle Dragon		X		X				X	
Moloch horridus	Thorny Devil								X	
Pogona minor	Western Bearded Dragon									
Tympanocryptis cephalus	Pebble Dragon									
Varanidae Monitor's or Goanna's										
Varanus caudolineatus	Stripe-tailed Pygmy Monitor			X					X	
Varanus gouldii	Sand Monitor		X	X				X	X	
Varanus tristis	Racehorse Monitor									

Class **Family** *Species*	Common Name	Conservation Status	Harewood 2015b	Harewood 2015a	Harewood 2011	Barrick GC 2011	Harewood 2010a/b/c	KLA 2009a/b/c	WAM 1992	DBCA 2018
Scincidae Skinks										
Cryptoblepharus buchananii	Buchanan's Snake-eyed Skink								X	
Cryptoblepharus plagiocephalus	Peron's Snake-eyed Skink			X						
Ctenotus atlas	Southern Malle Ctenotus								X	
Ctenotus leonhardii	Leonhardi's Skink								X	
Ctenotus schomburgkii	Barred Wedge-snout Ctenotus								X	
Ctenotus uber	Western Spotted Ctenotus			X					X	
Cyclodomorphus melanops elongatus	Eastern Slender Blue-tongue								X	
Egernia depressa	Pygmy Spiny-tailed Skink									
Egernia formosa	Goldfields Crevise Skink								X	
Egernia inornata	Desert Skink								X	
Eremiascincus richardsonii	Broad-banded Sand Swimmer									
Hemiergis initialis initialis	Sth Five-toed Mulch Skink			X						
Hemiergis peronii peronii	Four-toed Earless Skink									
Lerista kingi	King's Three-toed Slider								X	
Lerista picturata	Goldfields Robust Lerista			X					X	
Lerista timida	Dwarf Three-toed Slider			X						
Menetia greyii	Common Dwarf Skink			X					X	
Morethia adelaidensis	Saltbush Flecked Morethia								X	

WC Act Status - S1 to S7, EPBC Act Status - EN = Endangered, VU = Vulnerable, EX = Extinct, Mig = Migratory, DBCA Priority Status - P1 to P4, Int. Agmts - CA = CAMBA, JA = JAMBA, RK = ROKAMBA, IUCN Red List Category Definitions see Appendix A and http://www.iucnredlist.org/technical-documents/categories-and-criteria/2001-categories-criteria

Class **Family** *Species*	Common Name	Conservation Status	Harewood 2015b	Harewood 2015a	Harewood 2011	Barrick GC 2011	Harewood 2010a/b/c	KLA 2009a/b/c	WAM 1992	DBCA 2018
Morethia butleri	Woodland Dark-flecked Morethia									
Morethia obscura	Shrubland Pale-flecked Morethia									
Tiliqua occipitalis	Western Bluetongue			X					X	
Tiliqua rugosa	Bobtail			X			X	X	X	
Typhlopidae Blind Snakes										
Anilios australis	Southern Blind Snake									
Anilios bicolor	Dark-spined Blind Snake									
Anilios bituberculatus	Prong-snouted Blind Snake									
Anilios hamatus	Northern Hook-snouted Blind Snake									
Anilios waitii	Common Beaked Blind Snake									
Boidae Pythons, Boas										
Morelia spilota imbricata	Southern Carpet Python	LC								

Class **Family** *Species*	Common Name	Conservation Status	Harewood 2015b	Harewood 2015a	Harewood 2011	Barrick GC 2011	Harewood 2010a/b/c	KLA 2009a/b/c	WAM 1992	DBCA 2018
Elapidae Elapid Snakes										
Acanthophis pyrrhus	Desert Death Adder									
Brachyurophis fasciolata	Southern Shovel-nosed Snake			X						
Demansia psammophis	Yellow-faced Whipsnake			X						
Furina ornata	Moon Snake									
Neelaps bimaculatus	Black-naped Snake									
Parasuta gouldii	Gould's Hooded Snake									
Parasuta monachus	Monk Snake								X	
Pseudechis australis	Mulga Snake			X						
Pseudonaja modesta	Ringed Brown Snake								X	
Pseudonaja nuchalis	Gwardar			X					X	
Simoselaps bertholdi	Jan's Banded Snake			X						
Suta fasciata	Rosen's Snake									
Aves										
Casuariidae Emus, Cassowarries										
Dromaius novaehollandiae	Emu	LC		X			X	X	X	
Anatidae Geese, Swans, Ducks										
Cygnus atratus	Black Swan	LC				X				

WC Act Status - S1 to S7, EPBC Act Status - EN = Endangered, VU = Vulnerable, EX = Extinct, Mig = Migratory, DBCA Priority Status - P1 to P4, Int. Agmts - CA = CAMBA, JA = JAMBA, RK = ROKAMBA, IUCN Red List Category Definitions see Appendix A and http://www.iucnredlist.org/technical-documents/categories-and-criteria/2001-categories-criteria

Class **Family** *Species*	Common Name	Conservation Status	Harewood 2015b	Harewood 2015a	Harewood 2011	Barrick GC 2011	Harewood 2010a/b/c	KLA 2009a/b/c	WAM 1992	DBCA 2018
Accipitridae Kites, Goshawks, Eagles, Harriers										
Accipiter cirrocephalus	Collared Sparrowhawk	LC								
Accipiter fasciatus	Brown Goshawk	LC			X	X				
Aquila audax	Wedge-tailed Eagle	LC		X		X				
Aquila morphnoides	Little Eagle	LC								
Circus approximans	Swamp Harrier	LC								
Circus assimilis	Spotted Harrier	LC								
Elanus caeruleus	Black-shouldered Kite	LC		X						
Haliastur sphenurus	Whistling Kite	LC								
Hamirostra isura	Square-tailed Kite	LC								
Falconidae Falcons										
Falco berigora	Brown Falcon	LC		X					X	
Falco cenchroides	Australian Kestrel	LC		X		X				
Falco longipennis	Australian Hobby	LC		X		X				
Falco peregrinus	Peregrine Falcon	S7 LC				X				
Otididae Bustards										
Ardeotis australis	Australian Bustard	LC								

Class **Family** *Species*	Common Name	Conservation Status	Harewood 2015b	Harewood 2015a	Harewood 2011	Barrick GC 2011	Harewood 2010a/b/c	KLA 2009a/b/c	WAM 1992	DBCA 2018
Turnicidae Button-quails										
Turnix velox	Little Button-quail	LC			X					
Recurvirostridae Stilts, Avocets										
Cladorhynchus leucocephalus	Banded Stilt	LC				X				
Himantopus himantopus	Black-winged Stilt	LC								
Charadriidae Lapwings, Plovers, Dotterels										
Vanellus tricolor	Banded Lapwing	LC				X				
Columbidae Pigeons, Doves										
Ocyphaps lophotes	Crested Pigeon	LC		X	X	X		X	X	
Phaps chalcoptera	Common Bronzewing	LC		X	X	X	X			

Class **Family** *Species*	Common Name	Conservation Status	Harewood 2015b	Harewood 2015a	Harewood 2011	Barrick GC 2011	Harewood 2010a/b/c	KLA 2009a/b/c	WAM 1992	DBCA 2018
Psittacidae Parrots										
Cacatua roseicapilla	Galah	LC		X	X	X			X	
Cacatua sanguinea	Little Corella	LC								
Glossopsitta porphyrocephala	Purple-crowned Lorikeet	LC	X	X		X			X	
Melopsittacus undulatus	Budgerigar	LC			X					
Nymphicus hollandicus	Cockatiel	LC							X	
Platycercus varius	Mulga Parrot	LC		X					X	
Platycercus zonarius	Australian Ringneck Parrot	LC	X	X	X	X	X	X	X	
Cuculidae Parasitic Cuckoos										
Cacomantis flabelliformis	Fan-tailed Cuckoo	LC								
Chrysococcyx basalis	Horsfield's Bronze Cuckoo	LC		X	X				X	
Chrysococcyx osculans	Black-eared Cuckoo	LC								
Cuculus pallidus	Pallid Cuckoo	LC							X	
Strigidae Hawk Owls										
Ninox novaeseelandiae	Boobook Owl	LC								
Tytonidae Barn Owls										
Tyto alba	Barn Owl	LC								

Class **Family** *Species*	Common Name	Conservation Status	Harewood 2015b	Harewood 2015a	Harewood 2011	Barrick GC 2011	Harewood 2010a/b/c	KLA 2009a/b/c	WAM 1992	DBCA 2018
Podargidae Frogmouths										
Podargus strigoides	Tawny Frogmouth	LC		X		X				
Caprimulgidae Nightjars										
Eurostopodus argus	Spotted Nightjar	LC				X				
Aegothelidae Owlet-nightjars										
Aegotheles cristatus	Australian Owlet-nightjar	LC								
Halcyonidae Tree Kingfishers										
Todiramphus pyrrhopygia	Red-backed Kingfisher	LC	X	X			X			
Todiramphus sanctus	Sacred Kingfisher	LC	X							
Meropidae Bee-eaters										
Merops ornatus	Rainbow Bee-eater	JA LC	X	X	X		X	X	X	
Climacteridae Treecreepers										
Climacteris affinis	White-browed Treecreeper	LC								
Climacteris rufa	Rufous Treecreeper	LC	X						X	

Class **Family** *Species*	Common Name	Conservation Status	Harewood 2015b	Harewood 2015a	Harewood 2011	Barrick GC 2011	Harewood 2010a/b/c	KLA 2009a/b/c	WAM 1992	DBCA 2018
Maluridae Fairy Wrens, GrassWrens										
Malurus leucopterus	White-winged Fairy-wren	LC	X	X	X	X			X	
Malurus pulcherrimus	Blue-breasted Fairy-wren	LC					X			
Malurus splendens	Splendid Fairy-wren	LC	X	X	X		X			
Acanthizidae Thornbills, Geryones, Fieldwrens & Whitefaces										
Acanthiza apicalis	Broad-tailed Thornbill	LC		X	X		X		X	
Acanthiza chrysorrhoa	Yellow-rumped Thornbill	LC	X	X			X		X	
Acanthiza uropygialis	Chestnut-rumped Thornbill	LC		X	X		X		X	
Aphelocephala leucopsis	Southern Whiteface	LC		X						
Calamanthus campestris	Rufous Fieldwren	LC								
Gerygone fusca	Western Gerygone	LC			X					
Pyrrholaemus brunneus	Redthroat	LC	X	X	X					
Smicrornis brevirostris	Weebill	LC	X	X	X	X	X	X	X	
Pardalotidae Pardalotes										
Pardalotus punctatus	Spotted Pardalote	LC								
Pardalotus striatus	Striated Pardalote	LC	X	X	X	X	X	X	X	

Class **Family** *Species*	Common Name	Conservation Status	Harewood 2015b	Harewood 2015a	Harewood 2011	Barrick GC 2011	Harewood 2010a/b/c	KLA 2009a/b/c	WAM 1992	DBCA 2018
Meliphagidae Honeyeaters, Chats										
Acanthagenys rufogularis	Spiny-cheeked Honeyeater	LC	X	X	X				X	
Anthochaera carunculata	Red Wattlebird	LC	X	X	X	X	X	X	X	
Certhionyx variegatus	Pied Honeyeater	LC								
Epthianura albifrons	White-fronted Chat	LC								
Epthianura tricolor	Crimson Chat	LC								
Lichenostomus leucotis	White-eared Honeyeater	LC	X	X	X	X			X	
Lichenostomus ornatus	Yellow-plumed Honeyeater	LC	X	X	X	X	X			
Lichenostomus plumulus	Grey-fronted Honeyeater	LC		X						
Lichenostomus virescens	Singing Honeyeater	LC	X	X	X	X			X	
Lichmera indistincta	Brown Honeyeater	LC	X	X	X	X	X		X	
Manorina flavigula	Yellow-throated Miner	LC	X	X	X	X	X	X	X	
Melithreptus brevirostris	Brown-headed Honeyeater	LC	X	X						
Phylidonyris albifrons	White-fronted Honeyeater	LC		X	X		X		X	
Petroicidae Australian Robins										
Microeca fascinans	Jacky Winter	LC	X	X	X		X		X	
Petroica cucullata	Hooded Robin	LC							X	
Petroica goodenovii	Red-capped Robin	LC		X			X	X	X	

Class **Family** *Species*	Common Name	Conservation Status	Harewood 2015b	Harewood 2015a	Harewood 2011	Barrick GC 2011	Harewood 2010a/b/c	KLA 2009a/b/c	WAM 1992	DBCA 2018
Pomatostomidae Babblers										
Pomatostomus superciliosus	White-browed Babbler	LC		X					X	
Cinclosomatidae Whipbirds, Wedgebills, Quail Thrushes										
Cinclosoma castaneothorax	Chestnut-breasted Quail-thrush	LC	X							
Cinclosoma castanotus	Chestnut Quail-thrush	LC		X	X					
Neosittidae Sitellas										
Daphoenositta chrysoptera	Varied Sittella	LC		X					X	
Pachycephalidae Crested Shrike-tit, Crested Bellbird, Shrike Thrushes, Whistlers										
Colluricincla harmonica	Grey Shrike-thrush	LC	X	X	X			X	X	
Oreoica gutturalis	Crested Bellbird	LC	X	X	X		X	X	X	
Pachycephala inornata	Gilbert's Whistler	LC		X						
Pachycephala rufiventris	Rufous Whistler	LC	X	X						
Dicruridae Monarchs, Magpie Lark, Flycatchers, Fantails, Drongo										
Grallina cyanoleuca	Magpie-lark	LC	X	X	X	X				
Rhipidura fuliginosa	Grey Fantail	LC								
Rhipidura leucophrys	Willie Wagtail	LC	X	X			X	X		

Class **Family** *Species*	Common Name	Conservation Status	Harewood 2015b	Harewood 2015a	Harewood 2011	Barrick GC 2011	Harewood 2010a/b/c	KLA 2009a/b/c	WAM 1992	DBCA 2018
Campephagidae Cuckoo-shrikes, Trillers										
Coracina maxima	Ground Cuckoo-shrike	LC								
Coracina novaehollandiae	Black-faced Cuckoo-shrike	LC	X	X	X	X	X		X	
Lalage tricolor	White-winged Triller	LC	X	X					X	
Artamidae Woodswallows, Butcherbirds, Currawongs										
Artamus cinereus	Black-faced Woodswallow	LC							X	
Artamus cyanopterus	Dusky Woodswallow	LC	X	X	X		X			
Artamus minor	Little Woodswallow	LC								
Artamus personatus	Masked Woodswallow	LC								
Artamus superciliosus	White-browed Woodswallow	LC								
Cracticidae Currawongs, Magpies & Butcherbirds										
Cracticus nigrogularis	Pied Butcherbird	LC	X	X	X	X	X	X	X	
Cracticus tibicen	Australian Magpie	LC		X		X	X	X	X	
Cracticus torquatus	Grey Butcherbird	LC	X	X	X		X		X	
Strepera versicolor	Grey Currawong	LC	X	X	X	X		X	X	

Class **Family** *Species*	Common Name	Conservation Status	Harewood 2015b	Harewood 2015a	Harewood 2011	Barrick GC 2011	Harewood 2010a/b/c	KLA 2009a/b/c	WAM 1992	DBCA 2018
Corvidae Ravens, Crows										
Corvus bennetti	Little Crow	LC								
Corvus coronoides	Australian Raven	LC	X	X	X	X		X		
Corvus orru	Torresian Crow	LC								
Corvus sp	Corvid	LC				X			X	
Motacillidae Old World Pipits, Wagtails										
Anthus australis	Australian Pipit	LC		X		X			X	
Estrilidae Grass Finches & Mannikins										
Taeniopygia guttata	Zebra Finch	LC								
Dicaeidae Flowerpeckers										
Dicaeum hirundinaceum	Mistletoebird	LC		X						
Hirundinidae Swallows, Martins										
Cheramoeca leucosternus	White-backed Swallow	LC		X		X				
Hirundo ariel	Fairy Martin	LC	X							
Hirundo neoxena	Welcome Swallow	LC	X	X		X	X		X	
Hirundo nigricans	Tree Martin	LC		X		X			X	

Class **Family** *Species*	Common Name	Conservation Status	Harewood 2015b	Harewood 2015a	Harewood 2011	Barrick GC 2011	Harewood 2010a/b/c	KLA 2009a/b/c	WAM 1992	DBCA 2018
Sylviidae Old World Warblers										
Cincloramphus cruralis	Brown Songlark	LC							X	
Cincloramphus mathewsi	Rufous Songlark	LC								
Zosteropidae White-eyes										
Zosterops lateralis	Silvereye	LC								
Mammalia										
Tachyglossidae Echidnas										
Tachyglossus aculeatus	Echidna	LC	X	X			X	X		
Dasyuridae Carnivorous Marsupials										
Ningaui yvonneae	Southern Ningaui	LC								
Sminthopsis crassicaudata	Fat-tailed Dunnart	LC							X	
Sminthopsis dolichura	Little long-tailed Dunnart	LC		X					X	
Sminthopsis gilberti	Gilbert's Dunnart	LC								
Sminthopsis ooldea	Ooldea Dunnart	LC		X						
Burramyidae Pygmy Possums										
Cercartetus concinnus	Western Pygmy-possum	LC		X					X	

WC Act Status - S1 to S7, EPBC Act Status - EN = Endangered, VU = Vulnerable, EX = Extinct, Mig = Migratory, DBCA Priority Status - P1 to P4, Int. Agmts - CA = CAMBA, JA = JAMBA, RK = ROKAMBA, IUCN Red List Category Definitions see Appendix A and http://www.iucnredlist.org/technical-documents/categories-and-criteria/2001-categories-criteria

Class **Family** *Species*	Common Name	Conservation Status	Harewood 2015b	Harewood 2015a	Harewood 2011	Barrick GC 2011	Harewood 2010a/b/c	KLA 2009a/b/c	WAM 1992	DBCA 2018
Macropodidae Kangaroos, Wallabies										
Macropus fuliginosus	Western Grey Kangaroo	LC	X	X	X			X	X	
Macropus robustus	Euro	LC	X				X			
Macropus rufus	Red Kangaroo	LC		X			X		X	
Emballonuridae Sheath-tailed Bats										
Taphozous hilli	Hill's Sheathtail-bat	LC		X						
Molossidae Freetail Bats										
Mormopterus petersi	Inland Freetail-bat	LC		X		X			X	
Tadarida australis	White-striped Freetail-bat	LC		X		X			X	
Vespertilionidae Ordinary Bats										
Chalinolobus gouldii	Gould's Wattled Bat	LC		X		X			X	
Chalinolobus morio	Chocolate Wattled Bat	LC		X		X			X	
Nyctophilus geoffroyi	Lesser Long-eared Bat	LC		X		X			X	
Nyctophilus major tor	Central Long-eared Bat	P4				X				
Scotorepens balstoni	Inland Broad-nosed Bat	LC		X		X			X	
Vespadelus baverstocki	Inland Forest Bat	LC		X		X				
Vespadelus finlaysoni	Finlayson's Cave Bat	LC		X						
Vespadelus regulus	Southern Forest Bat	LC		X					X	

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Class **Family** *Species*	Common Name	Conservation Status	Harewood 2015b	Harewood 2015a	Harewood 2011	Barrick GC 2011	Harewood 2010a/b/c	KLA 2009a/b/c	WAM 1992	DBCA 2018
Muridae Rats, Mice										
Mus musculus	House Mouse	Introduced		X					X	
Pseudomys bolami	Bolam's Mouse	LC		X						
Pseudomys hermannsburgensis	Sandy Inland Mouse	LC								
Canidae Dogs, Foxes										
Canis lupus	Dingo/Dog	Introduced		X						
Felidae Cats										
Felis catus	Cat	Introduced		X						
Bovidae Horned Ruminants										
Bos taurus	European Cattle	Introduced	X	X						
Capra hircus	Goat	Introduced	X	X		X	X	X		
Ovis aries	Sheep	Introduced		X				X		
Leporidae Rabbits, Hares										
Oryctolagus cuniculus	Rabbit	Introduced	X	X	X		X	X		

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Appendix D:

Botanica Targeted Malleefowl Assessment

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Yvonne Hynes
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Northern Star Resources Limited
Kalgoorlie Operations
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30th September 2020

RE: Targeted Malleefowl Assessment-CPS8165/1

Dear Yvonne,

In September 2020, Botanica Consulting (Botanica) was commissioned by Northern Star Resources Limited (Northern Star) to undertake a targeted survey for Malleefowl activity within the proposed clearing footprint of CPS8165/1 (referred to as the 'target survey area') to fulfill the following clearing permit condition:

6. Fauna Management
(a) Prior to undertaking any clearing authorised under this Permit, the Permit Holder shall engage a fauna specialist to conduct a fauna survey within the area to be cleared to identify *Leipoa ocellata* (Malleefowl) mounds and *Leipoa ocellata* (Malleefowl) critical habitat.

(b) Prior to undertaking any clearing authorised under this Permit, the Permit Holder shall provide the results of the fauna survey in a report to the CEO.

(c) The fauna survey report must include;
(i) the location of each *Leipoa ocellata* (Malleefowl) mound, recorded using a Global Positioning System (GPS) unit set to Geocentric Datum Australia 1994 (GDA94), expressing the geographical coordinates in Eastings and Northings or decimal degrees, to the CEO.
(ii) The location of the *Leipoa ocellata* (Malleefowl) critical habitat, recorded using a Global Positioning System (GPS) unit set to Geocentric Datum Australia 1994 (GDA94), expressing the geographical coordinates in Eastings and Northings or decimal degrees, to the CEO.
(iii) the methodology used to survey the Permit Area and to establish the *Leipoa ocellata* (Malleefowl) critical habitat and identify the mound/s;
(iv) the extent of the critical habitat of the *Leipoa ocellata* (Malleefowl) shown on a map; and
(v) a description of the critical habitat found.

(d) Where *Leipoa ocellata* (Malleefowl) mounds are identified under condition 6(a) of this Permit, the Permit Holder shall ensure that no clearing of critical habitat of the identified *Leipoa ocellata* (Malleefowl) mounds occurs, unless first approved by the CEO.

The survey covered an area of approximately 539ha within the Permit Area. In accordance with the clearing permit requirements, clearing within the Permit Area will not exceed 300 ha however a larger footprint was assessed as part of the targeted survey. A map of the survey area is provided in Appendix 1.

Malleefowl are protected under State and Commonwealth legislation as a threatened fauna species and impacts on this species or its potential habitat must be avoided or minimized during the course of mining and exploration activities to ensure the long-term survival of this species within the local area is not compromised.

Methodology

The field survey was conducted by Botanica and Northern Star personnel (two-person survey team) on 11th September 2020. The survey area was traversed on foot, with multiple traverses conducted within the survey area. A handheld GPS was used to record any observations (i.e. Malleefowl mounds, suspected Malleefowl mounds, Malleefowl tracks, Malleefowl individuals).

Malleefowl mound criteria published by the National Heritage Trust (Hopkins nd) and those used by Bamford and Metcalf (2009) during a previous assessment in the Goldfields region were used to categorize any Malleefowl mounds observed.

The two category systems is used as both appear to have some benefits/shortcomings when describing a mound's age and/or status. This is particularly relevant for those obviously unused mounds constructed of a very stony material, which despite their apparent old age (Last used >20 years ago – Bamford and Metcalf, 2009) have in some cases retained an obvious crater rim (therefore Profile 1 and not Profile 6 (disused or extinct) - Hopkins nd). This is due to the mounds inherent stability compared to more typical mounds created of sandy material, which when no longer maintained, become obviously eroded and flattened (and therefore Profile 6 – Hopkins nd).

Survey Limitations

The results and conclusions presented here are based upon field data and monitoring carried out over a limited period of time and must therefore be considered merely indicative of the environmental condition of the site at the time of the field assessment.

Results

No evidence of Malleefowl activity (i.e. active or inactive mounds, tracks, feathers) was identified within the target survey area. No critical habitat for Malleefowl was identified within the target survey area.

The habitat observed within the target survey area and the greater Permit Area is considered marginal and lacking sufficient cover to support breeding or critical habitat for Malleefowl. The vegetation was relatively sparse and has been impacted by historical mining/ exploration activities and grazing. A description of the fauna habitats within the Permit Area are provided in the table below.

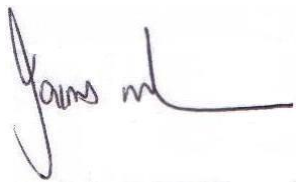
Fauna Habitat Description	Example Image
Clay-Loam Plains *Casuarina* Forests and Woodlands. Total Area = ~131 ha (~7%)	
Clay-Loam Plains Eucalypt Woodlands. Total Area = ~1,311 ha (~69%)	
Clay-Loam Plains Eucalypt Woodlands/ Mallee Woodlands and Shrublands. Total Area = ~102 ha (~5%)	

Fauna Habitat Description	Example Image
<u>Closed Depression</u> Chenopod Shrublands, Samphire Shrublands and Forblands Total Area = ~3 ha (~0.2%)	
<u>Hillslope</u> Eucalypt Woodlands Total Area = ~147 ha (~8%)	
<u>Open Depression</u> Eucalypt Woodlands Total Area = ~20 ha (~1%)	

Fauna Habitat Description	Example Image
<u>Existing Cleared Areas</u> Historical Mining Disturbance. Total Area = ~189 ha (~10%)	

Should you have any questions, please do not hesitate to contact me.

Regards,



Jim Williams
Director
Botanica Consulting Pty Ltd

References

Bamford M.J. and Metcalf, B. (2009). *Malleefowl Surveys in the Mt Jackson Area 2003 – 2008.* Report produced for Cliffs' natural resources.

Benshemesh, J. (2007). *National Recovery Plan for Malleefowl.* Department for Environment and Heritage, South Australia.

Hopkins, L. (nd). *National Manual for the Malleefowl Monitoring System*. National Heritage Trust, Canberra.

Appendix 1: Malleefowl Survey Map