Appendix D

Soil Characterisation Assessment
(Soilwater Consultants 2019)

SOILWATER CONSULTANTS

NORTH KIAKA SOIL CHARACTERISATION

Prepared for:	SIMCOA OPERATIONS PTY LTD
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Electronic Copy – Michael Ashley (GHD)

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SOILWATER CONSULTANTS | SOILWATER ANALYSIS | SOILWATER TECHNOLOGIES
www.soilwatergroup.com
45 Gladstone Street, East Perth, WA 6004 | Tel: +61 8 9228 3060 | Email: swc@soilwatergroup.com

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Revision History

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			Originator	Reviewer	Approved
A	27/05/2019	Internal Review	ASP	SB	ASP
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Revision Code*

A - Report issued for internal review

B - Draft report issued for client review

0 - 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 for the proposed North Kiaka Quartzite Mine to be developed by Simcoa Operations Pty Ltd. This work was conducted in accordance with the Scope of Work presented to GHD ('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 North Kiaka Disturbance Area. 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

Simcoa Operations Pty Ltd (Simcoa) are proposing to expand the existing Moora Quartzite Operations to the north of the Kiaka Road (North Kiaka Operations) on tenement M70/1292. The existing Moora Operations occur on the eastern side of The Midlands Road, approximately 15 km north of Moora, and 170 km north of Perth (Figure 1.1 and Figure 1.2).

The North Kiaka Operations will involve the excavation of the quartzite orebody from four large open pits and three smaller mine pits, with waste materials permanently stored in two above-ground Waste Rock Landforms (WRLs) (Figure 1.3). A Process Area and Workshops will be centrally located and a large Administration Area, including Product Stockpiles and Weighbridge, will be located in the southwest corner of the Project Area. The North Kiaka Operations will be linked to the existing Operations via an Access Corridor (Figure 1.3).

The proposed Disturbance Footprint (DF) associated with the North Kiaka Operations is provided in Table 1.1.

Table 1.1: North Kiaka Disturbance Footprint

Feature	Area (ha)
Administration, Product Stockpiles & Weighbridge	20.68
Process Area and Workshops	2.84
Pit 4	6.64
East Waste Rock Landform	13.39
Small Open Pit (SOP)	1.09
Small Open Pit (SOP)	2.4
Small Open Pit (SOP)	1.38
Pit 1	11.94
Pit 2	26.44
Pit 3	21.43
North Waste Rock Landform	18.59
Access Road Corridor	12.12
TOTAL DISTURBANCE (ha)	138.94

The primary purpose of this Soil Characterisation was to identify and characterise all surficial soil materials within the proposed disturbance area and suggest management strategies for their handling and utilisation. This information provides baseline data that can be used to assist in the mining of these materials, and in the construction and rehabilitation of any post-mine landforms. Implementation of the soil management recommendations suggested in this report will ensure that only optimal materials are used in the construction of the outer surface of the waste rock landform (WRL), thus facilitating stability and revegetation, and ultimately closure and bonds return.

1.1 OBJECTIVES OF WORK

The objectives of the soil characterisation were to:

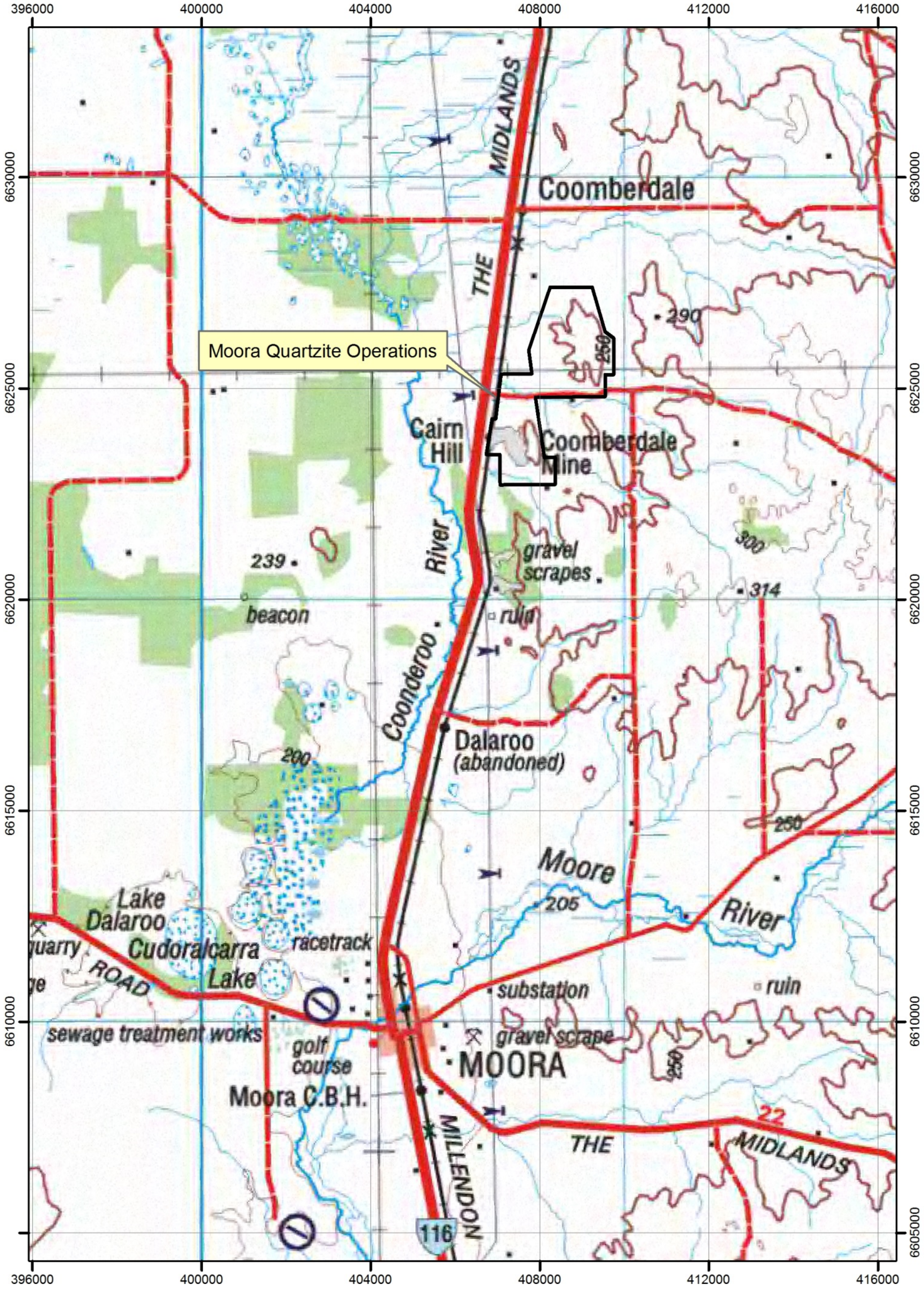
- Define the distribution of soil materials in the North Kiaka Operations;
- Characterise the physical and chemical properties of these materials;
- Identify materials that may be beneficial to the rehabilitation and materials that may have an adverse impact on rehabilitation;

- Suggest management strategies for the handling and utilisation of these materials during mining and rehabilitation.

1.2 SCOPE OF WORK

The Scope of work completed by SWC included:

- Collection of soil material samples from the proposed disturbance areas.
- Describe the surface soil materials and their distribution throughout the disturbance areas.
- Conduct laboratory tests to quantify soil material properties, stability and erodibility.
- Preparation of this report



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NORTH KIAKA SOIL CHARACTERISATION

Figure 1.1: Regional location

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NORTH KIAKA SOIL CHARACTERISATION	

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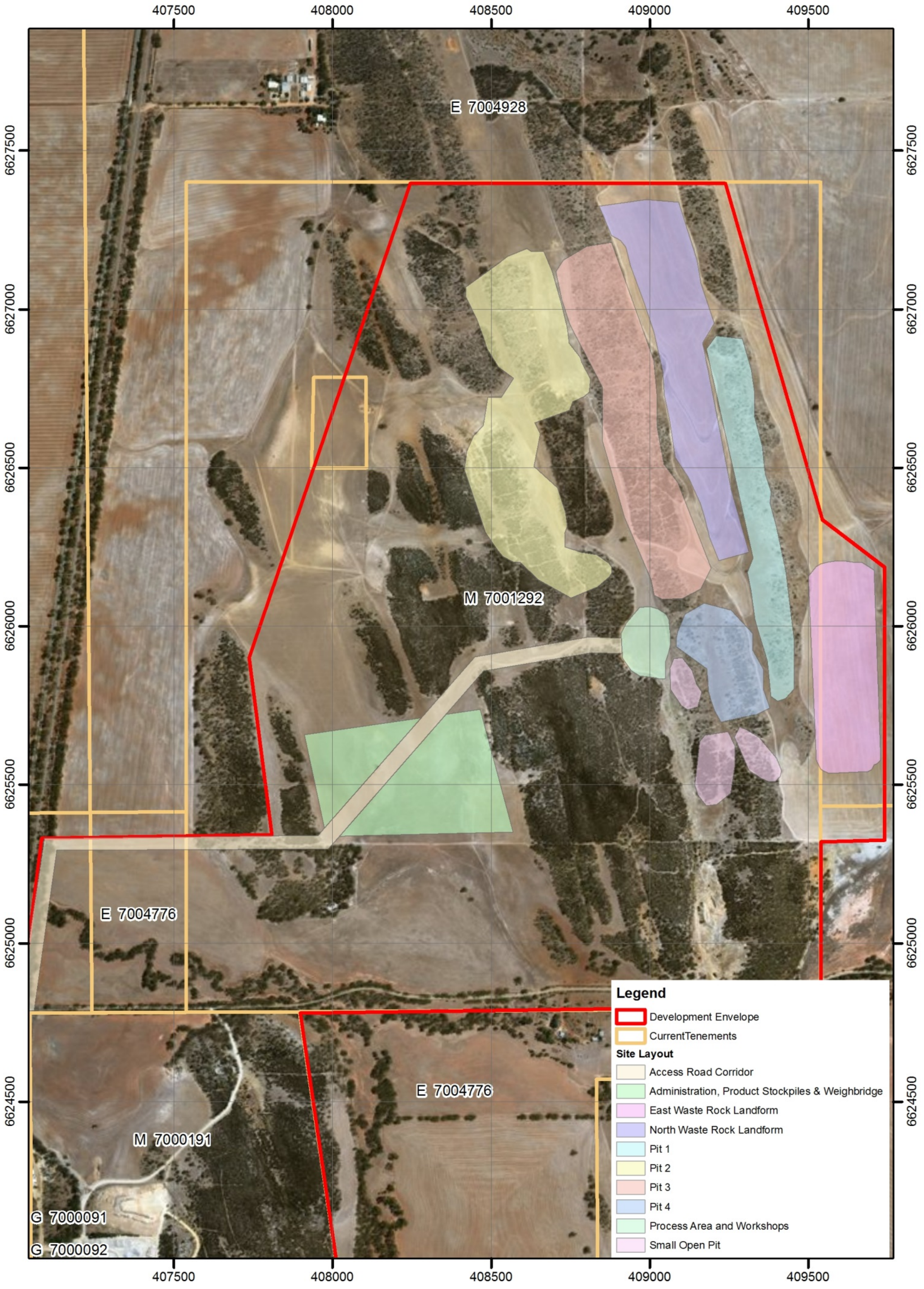

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Figure 1.3: Site Layout

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2 STUDY METHODOLOGY

2.1 SOIL SAMPLING

The soils throughout the North Kiaka Operations were investigated by trench excavation, utilising a 20 t excavator (Plate 2.1). A total of 17 soil sites were investigated across the Project Area, with the location and details provided in Figure 2.1 and Table 2.1. At each site soil trenches were excavator to a maximum depth of 3 m or until refusal.

Plate 2.1: Trench excavation for the North Kiaka Soil Characterisation

Table 2.1: Details of the soil sampling sites

Site ID	Easting	Northing	Depth (m)
T2	408574	6626664	2.5
T3	409666	6626947	1.5
T4	408977	6626921	2.4
T5	409037	6626227	2
T7	408510	6626325	2
T8	409297	6626259	2
T9	409065	6626514	1.5
T10	409254	6626597	1.5
T11	409333	6626051	2.3
T12	409090	6626952	2.5

Site ID	Easting	Northing	Depth (m)
T13	409151	6626684	2.2
T14	409568	6626019	1
T15	409560	6625706	0.9
T16	408136	6625660	1.3
T17	408348	6625486	1.1
T18	409332	6625933	2.5

The sampling protocol at each location involved:

- Recording the location in a hand-held GPS.
- 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 2.2).

Table 2.2: 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

2.2 LABORATORY ANALYSIS

The physical and chemical properties of the soil materials were assessed at Soilwater Analysis (SWA) and CSBP Laboratories in Perth. All samples collected in the field were analysed for pH, EC, field (gravimetric) moisture content and gravel 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 2.3) were assessed on a select number of samples that 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),
- Aggregate dispersion index;
- Soil water retention (Pressure Plate Method 504.02); and
- Saturated hydraulic conductivity (Intact Core – Constant Head Method).

Table 2.3: 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) - Colwell Phosphorus (P) - Colwell Potassium (K) - Available Sulfur (S)	 Leco $NaHCO_3$ extraction $NaHCO_3$ extraction 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	-

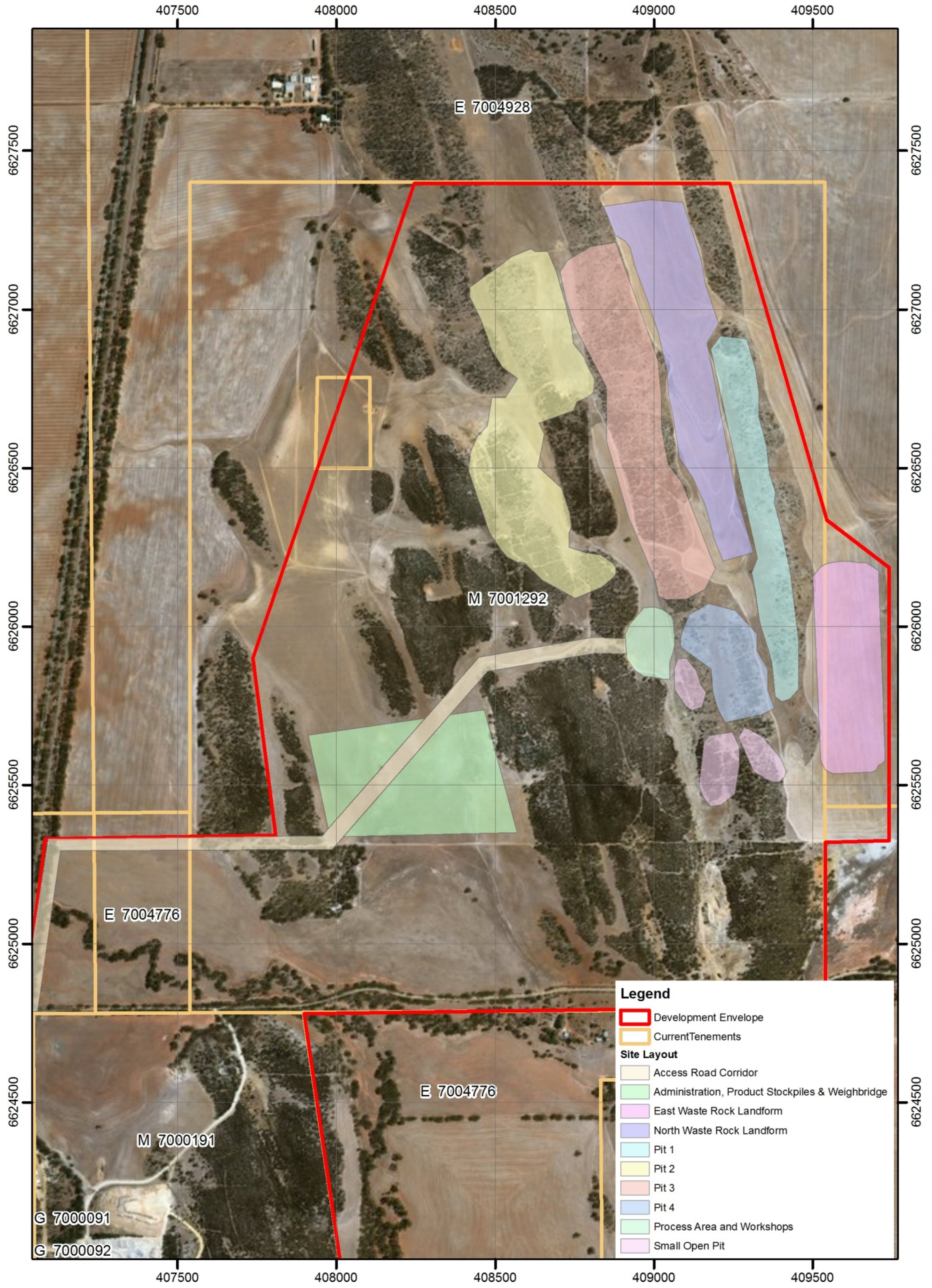

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Figure 2.1: Soil sampling locations

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3 EXISTING ENVIRONMENT

3.1 GEOMORPHOLOGY

The geomorphology across the North Kiaka Project Area is shown in Figure 3.1 and Figure 3.2, and Plate 3.1. The relief across the site varies from 210 mAHD to 285 mAHD, and the relationship between the quartz orebody and the ridge lines can clearly be seen (Plate 3.2), with the proposed mine pits occurring on, and following, the positive topographic features whilst the North and East WRLs and the Administration Area occur on the lower topographic areas.

The slope within the Project Area varies < 5° to a maximum of 25 ° (Figure 3.1; Plate 3.3). Whilst the majority of the area is generally flat (< 5°), the slopes associated with the quartz ridges are typically between 15 – 18 ° (Figure 3.1).

Plate 3.1: General geomorphology within the Project Area

Plate 3.2: Elevated quartz ridge representing the orebody within the Project Area

Plate 3.3: Relief and slope within the Project Area

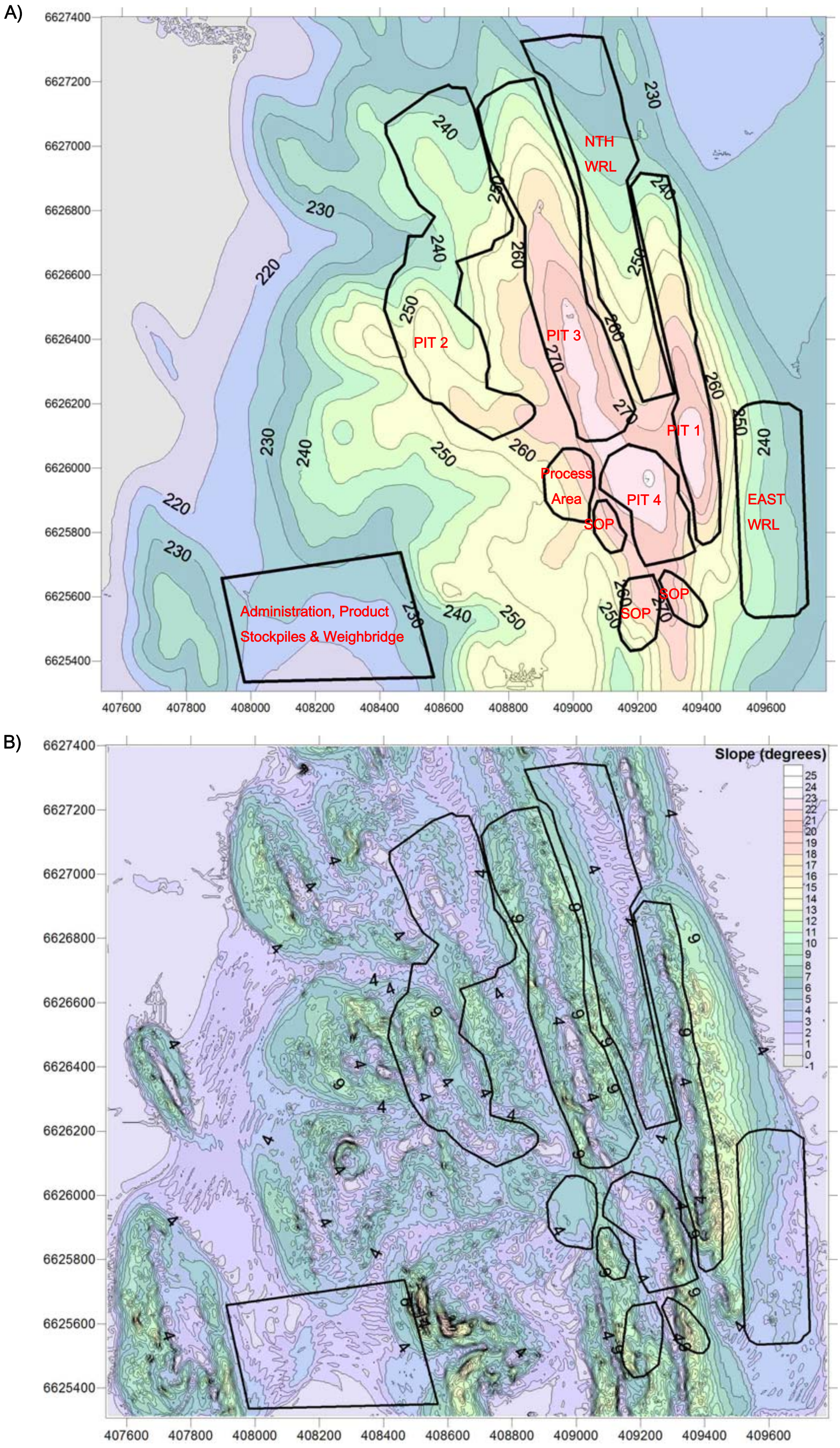

Figure 3.1: A) Surface elevation and B) slope within the Project Area

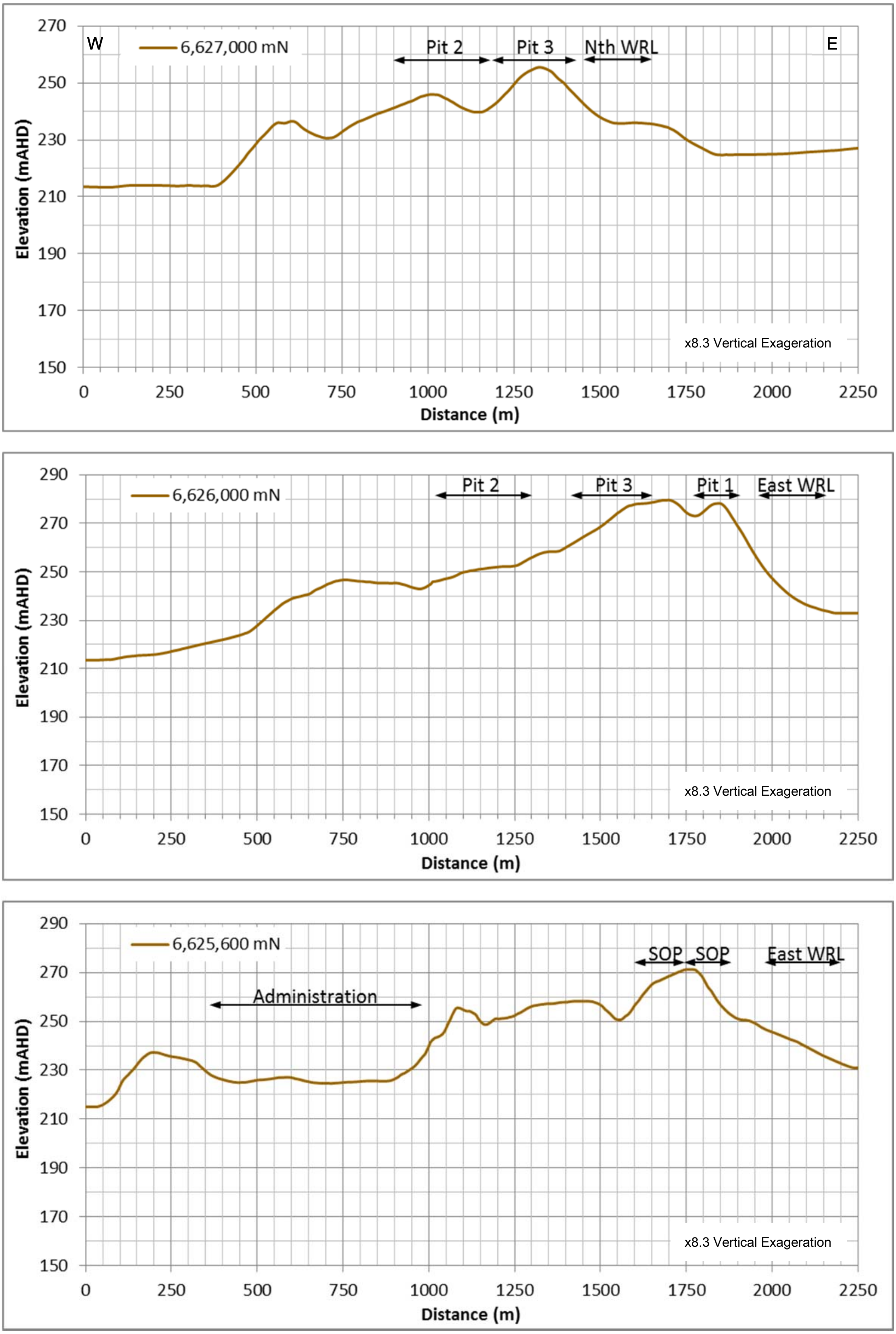

Figure 3.2: Topographic cross section within the Project Area (SOP = Small Open Pit)

3.2 REGIONAL SOILS

The regional soils across the Project Area are shown in Figure 3.3. The soils associated with the remnant quartz ridges belong to the Zone of Ancient Drainage, which represent residual soils that have experienced prolonged weathering and lateritisation. The soils in the lower topographic areas belong to the Northern Zone of Rejuvenated Drainage, which is characterised by erosional surfaces producing a gently undulating landscape. Colluvial processes are highly active in this region and the soils represent either colluvium or *in-situ* weathered rock, mainly from Jimperding Metamorphic Rocks.

A description of the regional soils covering the Project Area is provided in Table 4.6.

Map Unit	Soil Name	Description
256Bg	Burabidge Hill System	Undulating rises to low hills with rock outcrop. granite, migmatite, gneiss. Brown and red loamy and sandy earths, yellow/brown shallow loamy duplex and some stony soil. York gum-jam woodland
256Ra	Ranfurly System	Level to gently undulating plain being a relict flood plain, partially rejuvenated; loamy earths and clay, some duplex; from alluvium
258Cw	Coorow System	Undulating to gently undulating rises and intervening level to gently undulating flats; Yellow deep sand, pale deep sand and grey sandy duplexes (some alkaline), some yellow sandy earths, and minor loamy earths and duplexes and rock

3.3 GEOLOGY

The North Kiaka Deposit occurs on the western margin of the Yilgarn Craton, approximately 8 km east of the Darling Fault. Given its proximity to the Darling Fault, which has been active since the Proterozoic, the geology is dominated by intrusives (e.g. quartz, dolerite) which have been injected into the existing granitic country rock.

The quartz orebody to be mined at the North Kiaka belongs to the Proterozoic Noondine Chert (P_{Occ}), comprising chert and orthoquartzite, with minor siltstone, sandstone, claystone and dolomite (Figure 3.4).

The massive nature of the intruded quartzite has resulted in less weathering and thus the intruded quartzite represents the ridges seen in Section 3.1. A schematic diagram showing the intruded quartzite and the surrounding granitic bedrock is provided in Figure 3.5. The pertinent point with this figure is that in vertical profile, the quartzite remains unweathered and massive, whilst the adjacent granitic rocks have weathered to form a typical saprolitic regolith, resulting in an abrupt contact between the quartzite and the weathered granite.

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Figure 3.3: Regional soils across the Project Area

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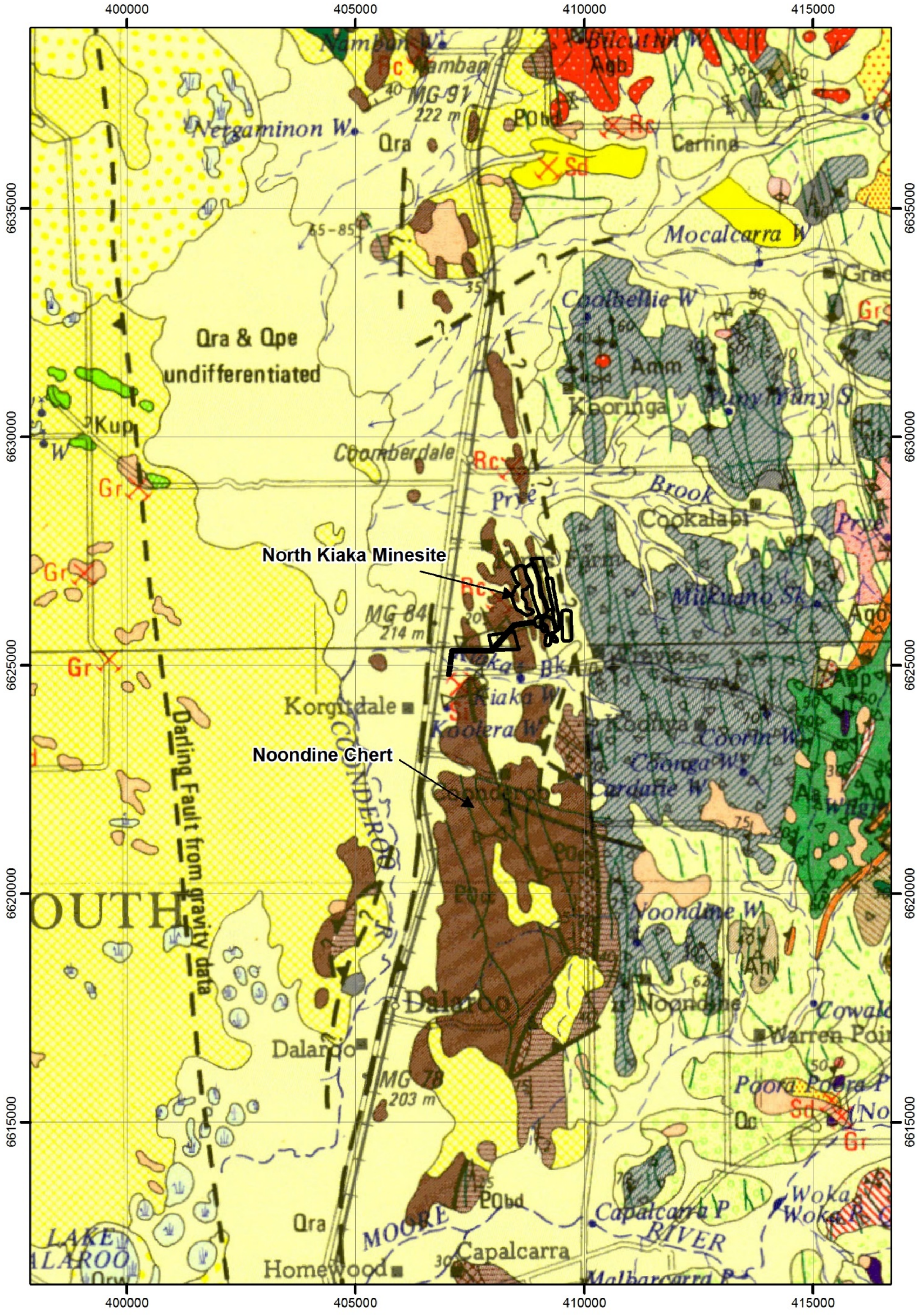

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Figure 3.4: Regional geology across the Project Area

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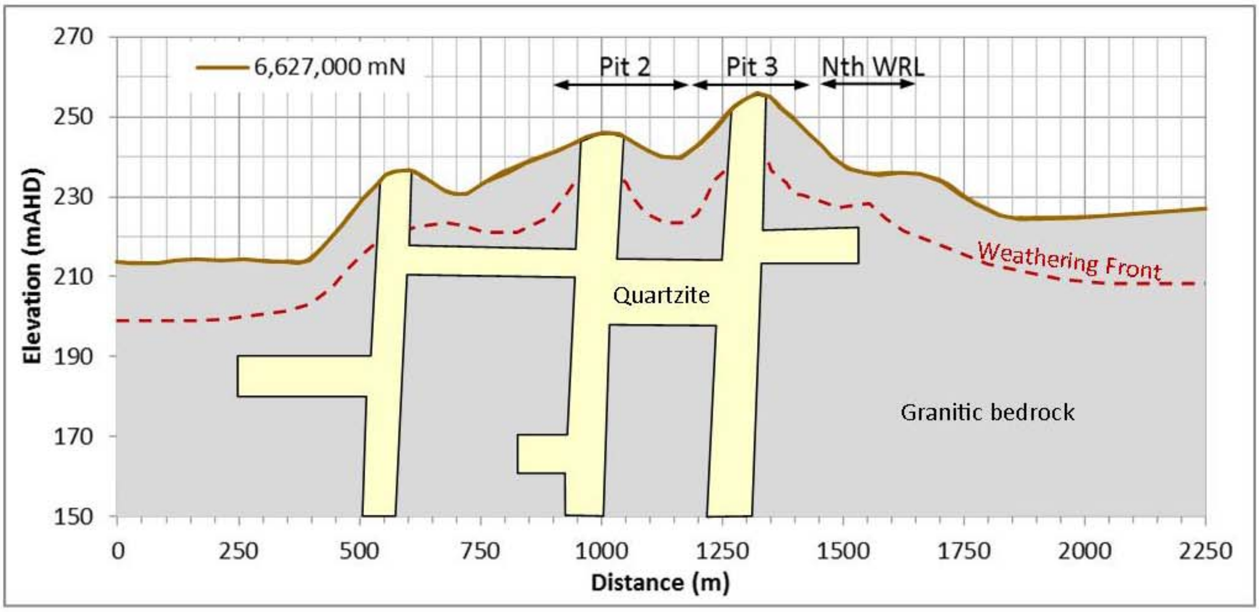
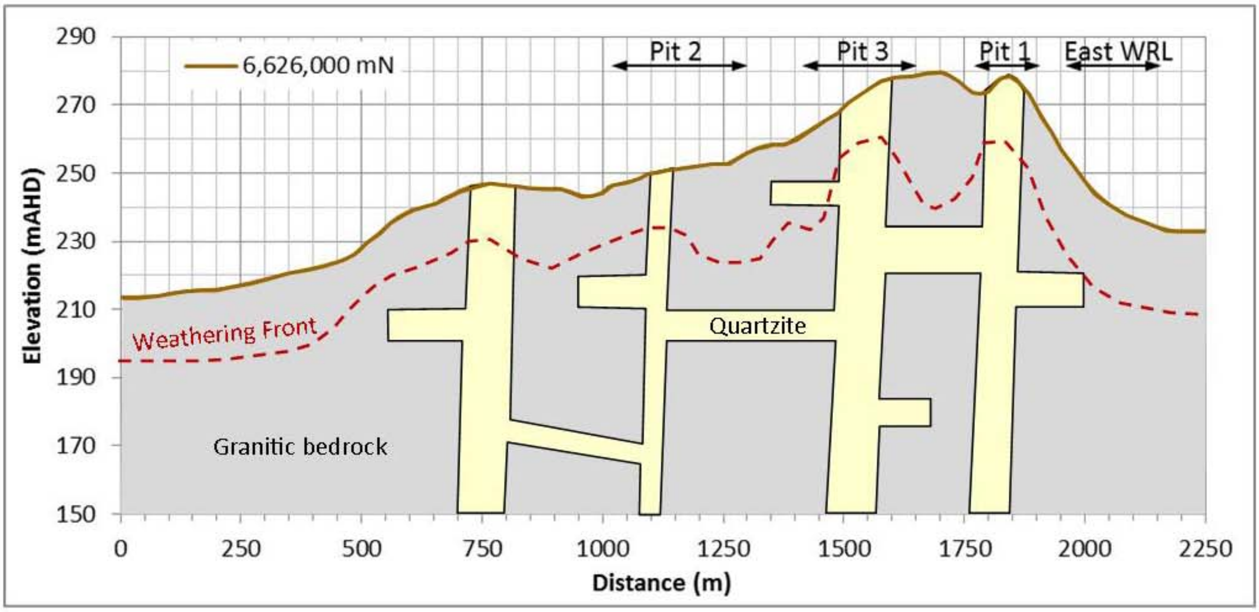
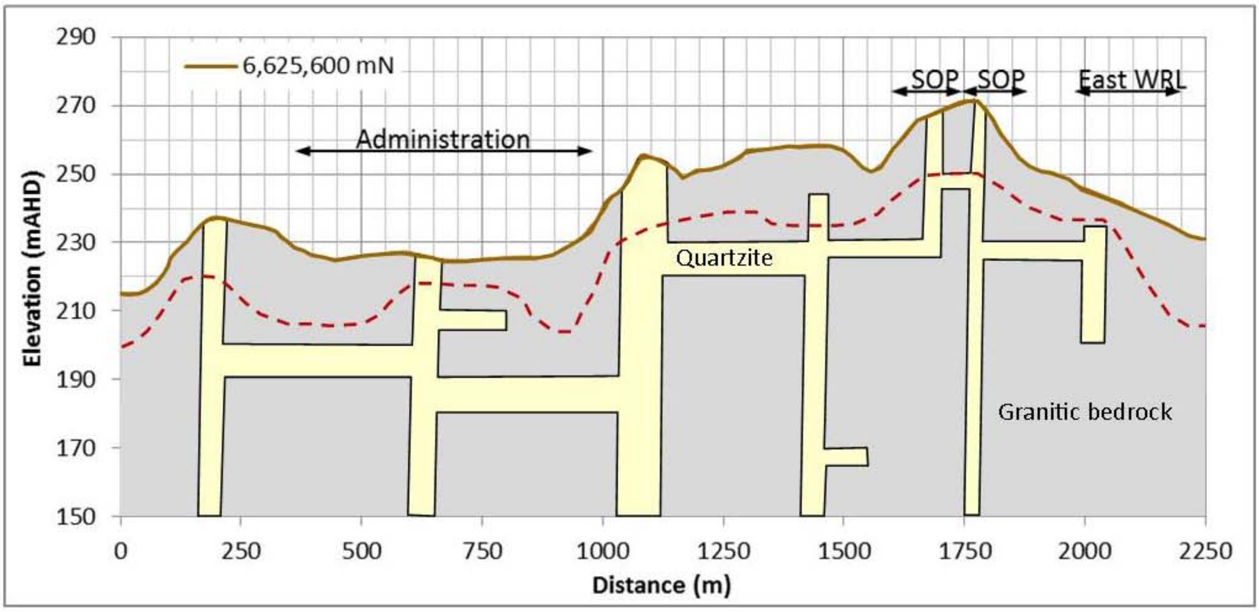






x8.3 vertical exaggeration

Figure 3.5: Local geology across the Project Area

4 STUDY RESULTS

4.1 SOIL DISTRIBUTION

Based on the field survey and the laboratory results there are three distinct Soil Mapping Units (SMUs) across the Project Area:

- SMU 1: Skeletal Stony Soil
- SMU 2: Shallow Gravelly Duplex
- SMU 3: Deep Gravelly Duplex

The distribution of the three SMUs is shown spatially in and schematically in Figure 4.1 and Figure 4.2, whilst the area of each SMU in the proposed Disturbance Footprint is provided in Table 4.1.

Table 4.1: SMU distribution within the Disturbance Footprint

Mine Feature	SMU 1	SMU 2	SMU 3	TOTAL (ha)
Pit 1	6.63	5.08	0.23	11.94
Pit 2	8.74	8.45	9.25	26.44
Pit 3	9.24	9.38	2.81	21.43
Pit 4	4.91	1.39	0.34	6.64
Small Open Pits (3 in total)	1.39	3.10	0.38	4.87
North WRL	0	0.47	18.12	18.59
East WRL	0	0	13.39	13.39
Process Area & Workshops	0	0.33	2.51	2.84
Administration Area	0	0.04	20.64	20.68
TOTAL (ha)	30.91	28.24	67.67	126.82

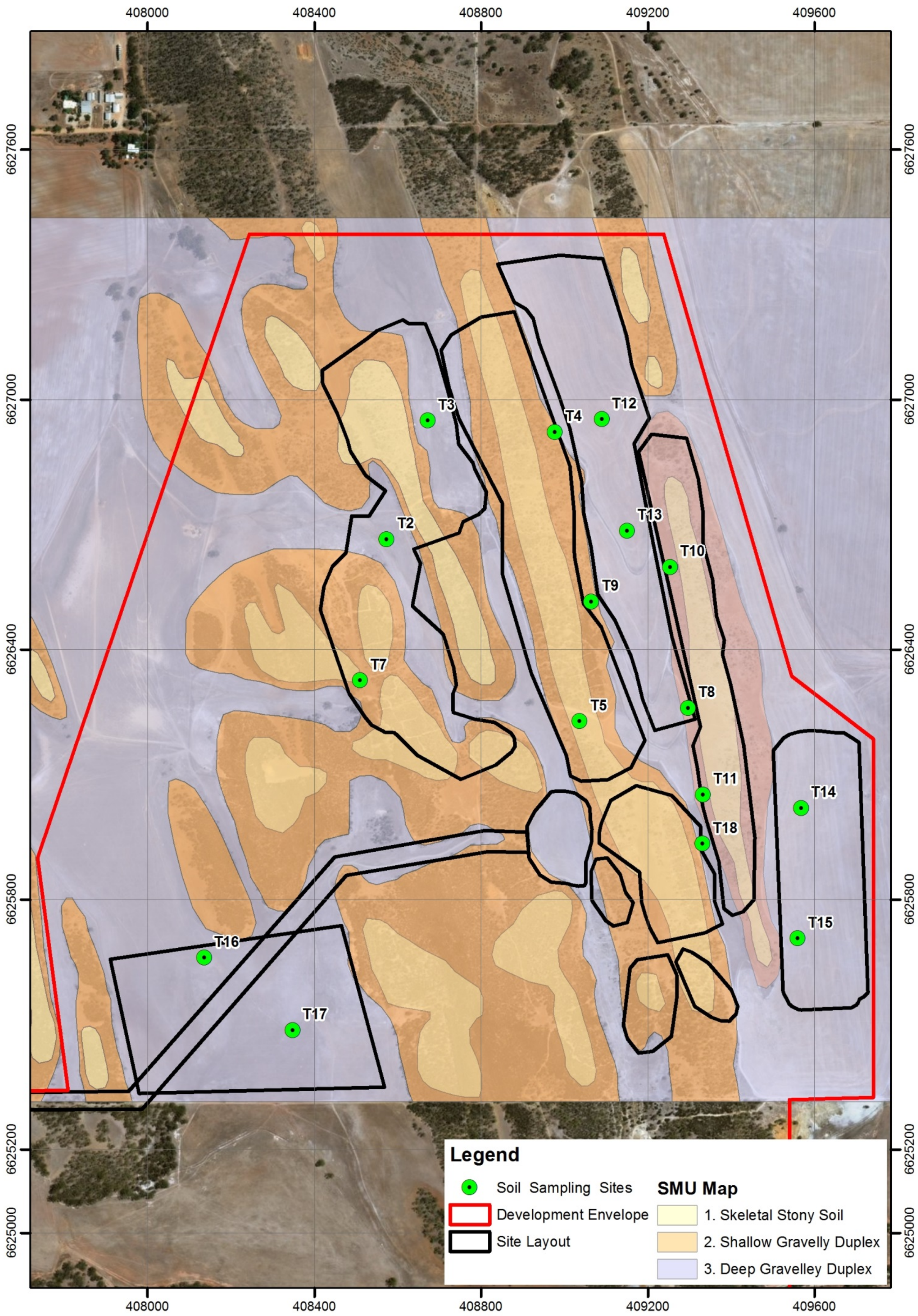
As discussed in Section 3, the geology within the Project Area is relatively simple, comprising only of massive, unweathered quartzite, which form the observed ridges (SMU 1), and adjacent weathered granite, which forms the intervening lower topographic areas. All of the granitic regolith is covered by a surficial gravel layer which shows a defined topographic sequence, such that the gravel layer is thinner and coarser along the ridge crest and upper slope (SMU 2), and is thicker and finer on the mid to lower slope positions (SMU 3).

The relationship of the identified to the SMUs to the WA Soil Groups (Schoknecht and Pathan, 2013) and the Australian Soil Classification (ASC; Isbell, 2002) is provided in Table 4.2.

Table 4.2: Relationship between the SMU's, WA Soil Groups and ASC

SMU	Parent Geology	WA Soil Group	ASC
1. Skeletal Stony Soil	Quartzite	Stony Soil	Lithosolic Clastic Rudosol
2. Shallow Gravelly Duplex	Granite	Shallow Gravel	Ferric Petroferric Tenosol
3. Deep Gravelly Duplex		Duplex Sandy Gravel	Ferric Chromosol

A detailed description of the three SMUs identified within the Project Area are provided in Section 4.1.1 and Section4.1.2.



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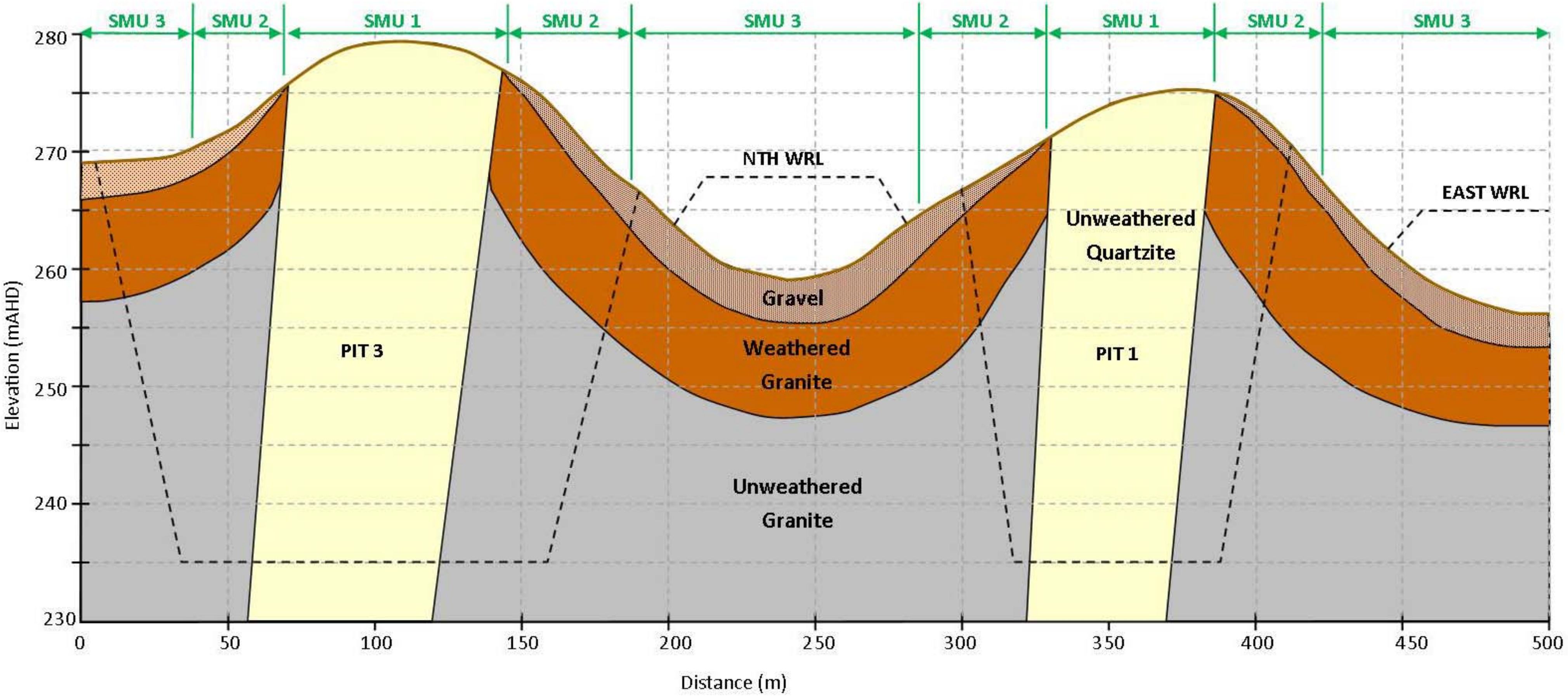

x4 vertical exaggeration

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NORTH KIAKA SOIL CHARACTERISATION	

4.1.1 SMU 1 – SKELETAL STONY SOIL

The Skeletal Stony Soils are associated with the outcropping quartzite intrusion, which represents the orebody (Plate 4.1). The surface soils are < 10 cm in depth and are composed of weathered quartzite and organic debris. Given the irregular surface of the outcropping quartzite it would be impractical to try and strip this surface soil (or topsoil) from SMU 1.

Plate 4.1: Skeletal Stony Soils in SMU 1

4.1.2 SMU 2 (SHALLOW GRAVELLY DUPLEX) AND SMU 3 (DEEP GRAVELLY DUPLEX)

SMU 2 and SMU 3 are morphologically and functionally similar, with the only difference being the depth of the surficial gravels. The soil profile in SMU 2 and SMU 3 consists of the following three Soil Material Management Units (SMMUs):

- SMMU 1: Topsoil – Friable sandy gravels, with minor organic accumulation (transported)
- SMMU 2: Subsoil – Friable sandy gravels, with negligible organic accumulation (transported)
- SMMU 3: Overburden – Granitic (mottled) saprolite (*in-situ*)

Characteristic soil profiles for SMU 2 and SMU 3 are shown in Figure 4.3.

The physical, chemical and hydraulic properties of each of these SMMUs are provided in Table 4.3 to Table 4.5. These results highlight the sandy gravelly nature of the Topsoil and Subsoil materials, having been derived from the weathering of the upslope quartzite and deposited onto the lateritised upper portion of the granitic saprolite. The sandy gravels are friable and structurally stable, with Emerson Classes typically between 5 and 6, and have high saturated permeabilities. However, the organic-enriched topsoil exhibits high to severe water repellence which will restrict the infiltration of rainfall, and result in infiltration-excess overland runoff.

Given the high gravel content of the Topsoil and Subsoil materials they contain negligible water holding and plant available water contents, with values of only 6.5 – 8.5 % (or 65 – 85 mm/m) and 5.4 – 6.7 % (or 54 – 67 mm/m), respectively.

In contrast to the surficial gravels, the underlying granitic saprolite contains only minor gravels (10 %; although this may be as high as 25% depending on the extent of lateritisation) and is typically classified as a Sandy Loam. The fine fraction is structurally unstable and will slake and dispersive readily, but this is likely due to lack of salinity in this material, and thus there is insufficient electrolyte concentration to flocculate the clays.

Chemically the gravelly Topsoil and Subsoil materials contain elevated plant available nutrients, with mineralised N (NH4-N and NO3-N) levels up to 20 mg/kg and 10 mg/kg, respectively. Similarly the Colwell P, K and Ext. S are elevated and the Topsoil and Subsoil materials have Organic C contents of 2.6 % and 0.6 %, respectively. The underlying granitic saprolite is considered chemically infertile, with very low levels if plant available nutrients.

All soil materials are slightly to moderately acidic and are non-saline. The CEC values vary from 6.5 meq/100g for the Topsoil to 1.5 meq/100g for Subsoil and 2.9 meq/100g for granitic saprolite. These low CEC values reflect the dominance of kaolinite in the clay mineral structure and the general lack of sodium (Na) in the exchange complex, as shown by the low sodicities (ESP typically below 6).

Table 4.3: Physical properties of the SMMUs within SMU 2 and SMU 3

Parameter	Statistic	Topsoil	Subsoil	Overburden
Gravel content (%)	Min	15	45	< 5
	Max	65	90	25
	Average	**45**	**75**	**10**
% Sand*	Min	81.40	84.61	80.65
	Max	85.43	91.58	83.32
	Average	**83.34**	**88.56**	**81.99**

Parameter	Statistic	Topsoil	Subsoil	Overburden
% Silt*	Min	7.99	5.62	7.18
	Max	10.00	12.14	7.74
	Average	**9.33**	**6.47**	**7.46**
% Clay*	Min	6.80	2.68	8.94
	Max	8.60	9.95	12.17
	Average	**7.33**	**4.97**	**10.55**
Texture*	**Average**	**Loamy Sand**	**Loamy Sand**	**Sandy Loam**
Water Repellence	-	**High**	**Moderate**	**Low**
Emerson Class	-	5 - 6	5 - 6	2 - 3

*<2.36 mm soil fraction

Table 4.4: Chemical properties of the SMMUs within SMU 2 and SMU 3

Parameter	Statistic	Topsoil	Subsoil	Overburden
pH_{Ca}	Min	4.2	4.4	5.4
	Max	6	5.6	5.8
	Average	**5.05**	**4.83**	**5.63**
pH_{W}	Min	5.2	5.1	6.1
	Max	6.6	6.2	6.4
	Average	**5.83**	**5.61**	**6.23**
EC (mS/m)	Min	4.3	1.7	2.4
	Max	13.9	7.1	3.8
	Average	**7.82**	**3.56**	**3**
Nutrients				
NH_4-N (mg/kg)	Min	5	0.5	0.5
	Max	12	20	0.5
	Average	**8.33**	**4.21**	**0.50**
NO_3-N (mg/kg)	Min	14	0.5	1
	Max	31	14	2
	Average	**20.50**	**5.79**	**1.67**
Colwell P (mg/kg)	Min	26	6	1
	Max	54	45	4
	Average	**34.17**	**25.43**	**2.00**
Colwell K (mg/kg)	Min	70	34	23
	Max	178	168	37
	Average	**114.83**	**75.00**	**29.00**
Ext. S (mg/kg)	Min	6.8	2.1	9.5
	Max	15.1	9.4	22.9
	Average	**9.58**	**3.73**	**14.23**
Organic C (%)	Min	1.54	0.1	0.06
	Max	4.96	1.86	0.19

Parameter	Statistic	Topsoil	Subsoil	Overburden
	Average	**2.94**	**0.62**	**0.13**
Exchangeable Cations				
Ca (meq/100g)	Min	2.82	0.3	1.33
	Max	10	2.86	1.58
	Average	**5.39**	**1.06**	**1.47**
Mg (meq/100g)	Min	0.33	0.09	0.69
	Max	1.7	0.34	1.88
	Average	**0.79**	**0.19**	**1.19**
K (meq/100g)	Min	0.14	0.05	0.03
	Max	0.37	0.36	0.06
	Average	**0.24**	**0.15**	**0.04**
Na (meq/100g)	Min	0.09	0.03	0.11
	Max	0.17	0.11	0.22
	Average	**0.12**	**0.06**	**0.15**
CEC (meq/100g)	Min	3.58	0.56	2.19
	Max	12.23	3.67	3.64
	Average	**6.54**	**1.46**	**2.86**
Sodicity (%)	Min	1.31	2.27	3.99
	Max	3.91	8.93	6.04
	Average	**2.15**	**4.81**	**5.32**

Table 4.5: Hydraulic properties of the SMMUs within SMU 2 and SMU 3

Parameter	Statistic	Topsoil	Subsoil	Overburden
Ksat (m/day)	Min	1.1	3.2	0.01
	Max	8.6	11.6	0.1
	Average	**4.2**	**7.8**	**0.05**
Water Retention Properties (adjusted for gravel content)				
0 kPa (%; v/v)	Min	8.2	4.6	35.6
	Max	14.8	12.5	48.5
	Average	**11.0**	**9.2**	**43.6**
10 kPa (%; v/v)	Min	6.4	3.9	21.4
	Max	11.3	10.7	32.6
	Average	**8.5**	**6.5**	**28.2**
33 kPa (%; v/v)	Min	6.1	2.8	19.0
	Max	9.4	8.7	26.5
	Average	**7.6**	**5.8**	**23.9**
100 kPa (%; v/v)	Min	3.2	1.5	15.6
	Max	5.2	4.3	19.5
	Average	**3.7**	**3.2**	**17.8**
1,500 kPa (%; v/v)	Min	1.6	0.9	12.9

Parameter	Statistic	Topsoil	Subsoil	Overburden
	Max	2.2	2.5	13.8
	Average	**1.8**	**1.1**	**13.5**
PAWC (%; v/v)	Min	4.8	3.0	8.5
	Max	9.1	8.25	18.8
	Average	**6.7**	**5.4**	**14.7**

4.2 EROSION TESTING

Laboratory-scale erosion tests were undertaken on bulk composites taken of the following material types:

- Topsoil,
- Subsoil, and
- Weathered Granite.

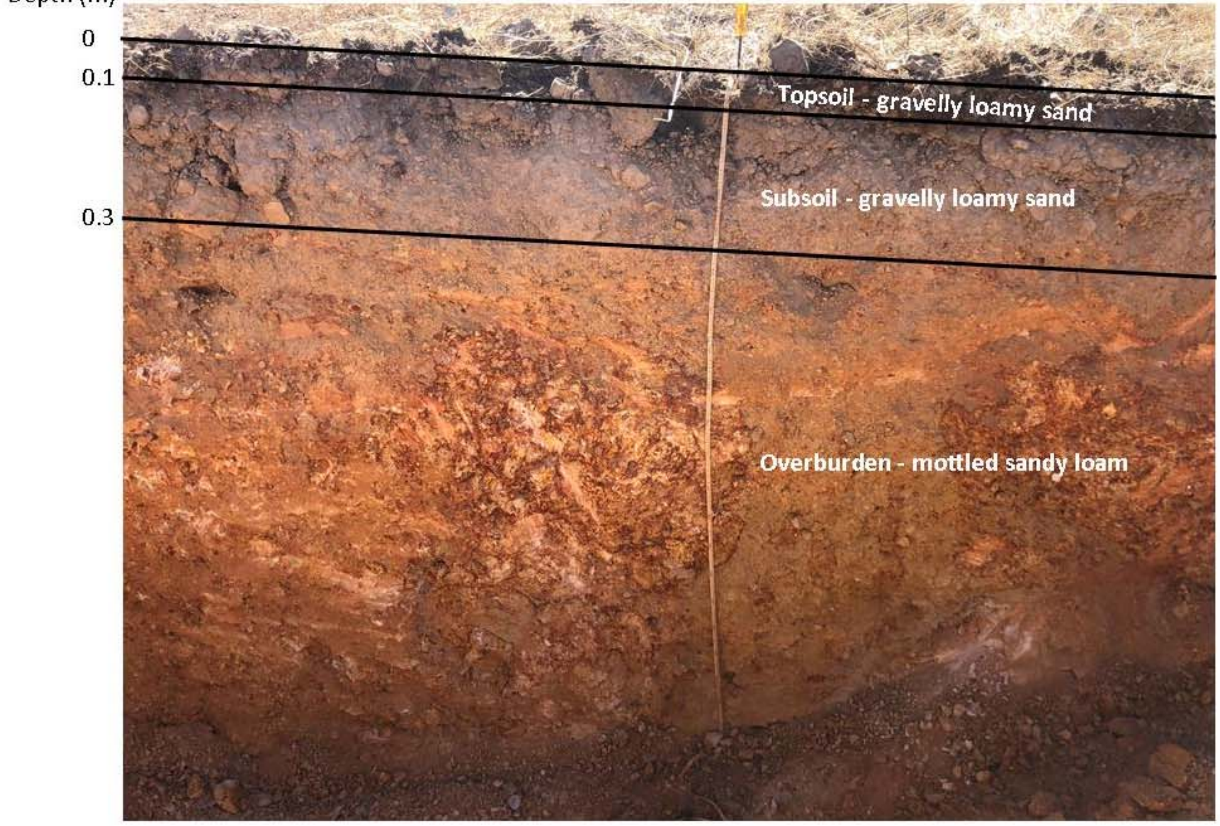
The objective of the testing was to establish the erosion potential for the range of soil materials most likely to be used as surface cover for the Waste Dump(s).

4.2.1 RAINFALL SIMULATOR

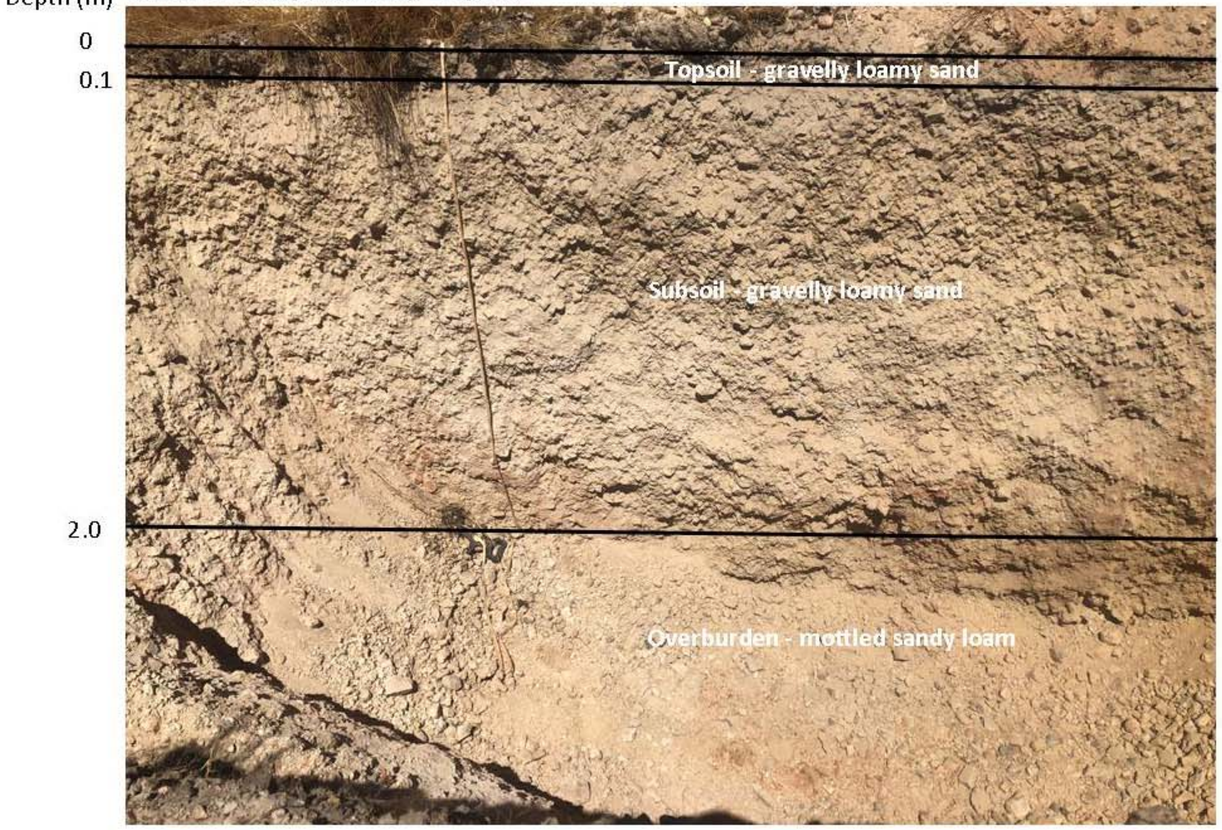
A laboratory-scale rainfall simulator (Plate 4.2) was used to measure the interrill (raindrop impact) erodibility of each material. The rainfall simulator was designed to apply water at an intensity of approximately 85-100 mm/hr, with a raindrop size and spatial distribution closely resembling natural rainfall. An intensity of 85 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, for this region.

Plate 4.2: Laboratory rainfall simulator.

SMU 2: Shallow Gravelly Duplex



SMU 3: Deep Gravelly Duplex



GHD

NORTH KIAKA SOIL CHARACTERISATION

Figure 4.3: Characteristic soil profiles for SMU 2 and 3

Prior to testing, each material 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, with a final bulk density of approximately 1.8 g/cm3 being achieved.

The container was set at a slope angle of 15°, and the materials were subjected to a simulated rainfall of approximately 85 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 4.3.

4.2.2 RILL EROSION MEASUREMENTS

Laboratory scale testing was completed to measure the rill erodibility (Kr) and critical shear stress (τC) of the materials under overland flow conditions. The laboratory testing was designed to expose the materials to a range of overland flows to simulate storm events of different sizes, and to measure the resulting sediment content in the surface runoff, generated by rill erosion.

An erosion flume was used to subject each material to 5 different overland flow rates (Plate 4.3), and the following measurements were made in triplicates for each:

- A timed sample of the resulting surface runoff was collected. Surface flow rate and sediment loss were then determined gravimetrically.
- A measurement of average flow velocity was made visually, using a blue dye and stopwatch according to the method described by Zhang *et al* (2010).
- Measurements of rill width were made at three standardised locations along the rill.

Measurements from the erosion flume were used to calculate rill erodibility parameters required for the WEPP erosion model. The methods used for calculating these parameters are discussed further in Section 4.3.

4.3 EROSION MODELLING

The Watershed Erosion Prediction Project (WEPP) (Flanagan and Livingston, 1995) model was used to predict the long-term (100 year duration) erosion rates from the surface of the proposed waste rock landforms. 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.

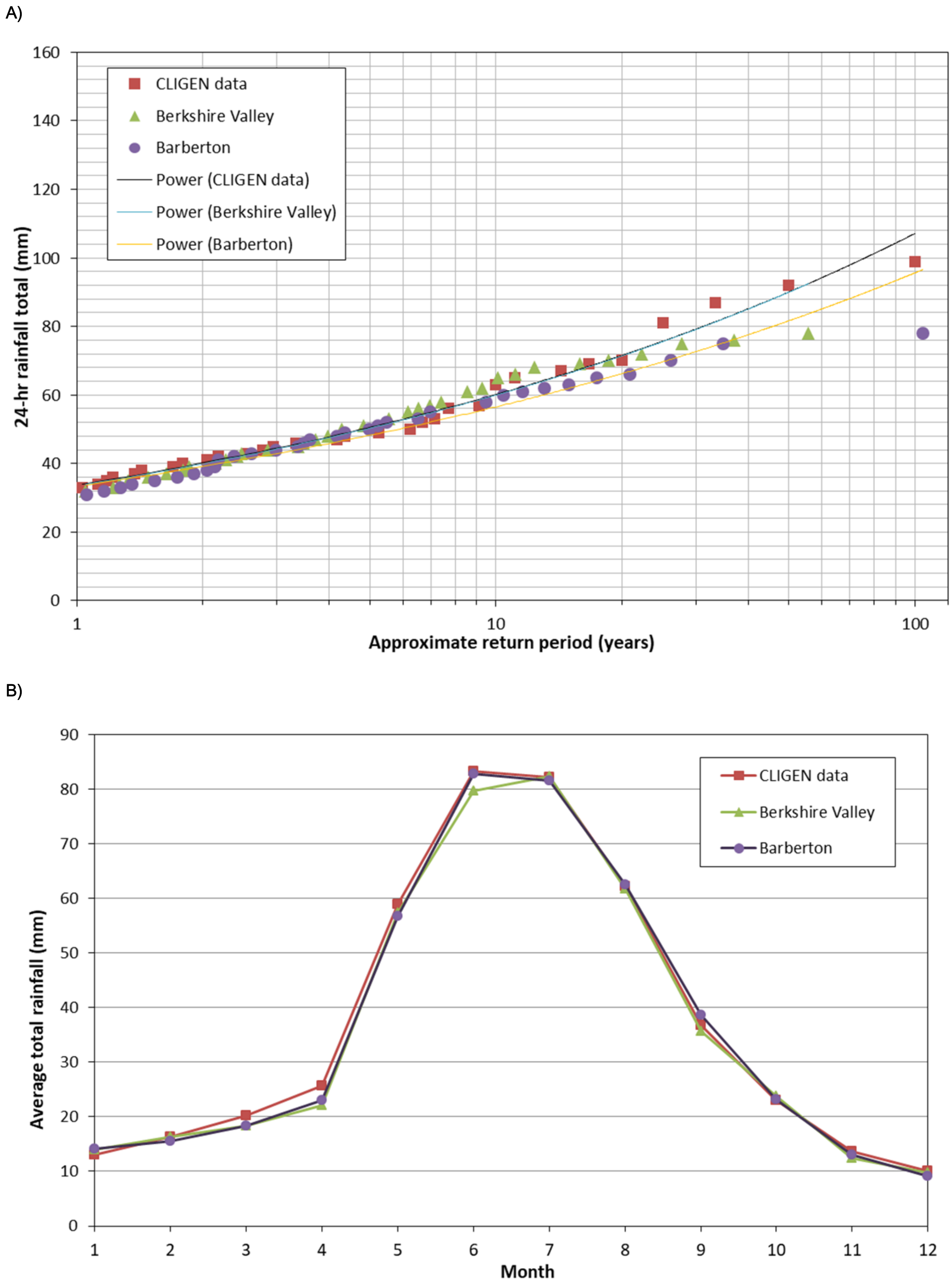
4.3.1 CLIMATE DATA

A synthetic climate file was generated using the CLIGEN stochastic weather generator (Yu, 2003), and was used in the WEPP model to simulate 100 years of rainfall, runoff, and erosion. The following climate data was input to CLIGEN to generate this file from BOM station 8297 (Dalwallinu):

- 0.5 hourly rainfall data from Jan 1997 to Mar 2019.
- Daily rainfall, maximum and minimum temperatures and solar radiation.
- As the Dalwallinu climate station is located only approximately 30 km from the Project, the climate data is considered sufficiently representative to form the baseline data when creating a reliable CLIGEN climate file

- An analysis of the available data from Berkshire Valley (BOM station #8008); 15 km west of the Project Area and Barberton (BOM station #8005); 15 km south suggests that the CLIGEN file generated from the Dalwallinu data is consistent with local weather patterns. Figure 3.2 compares the frequency of 24-hour rainfall totals, indicating that larger 24-hour storms occur at a similar frequency in the measured local data as in the CLIGEN file. Figure 3.3 compares the monthly and annual rainfall depths, and shows that the CLIGEN file captures a similar degree of variability in rainfall depths within and between years as was observed over the previous 100 years at Berkshire Valley and Barberton.

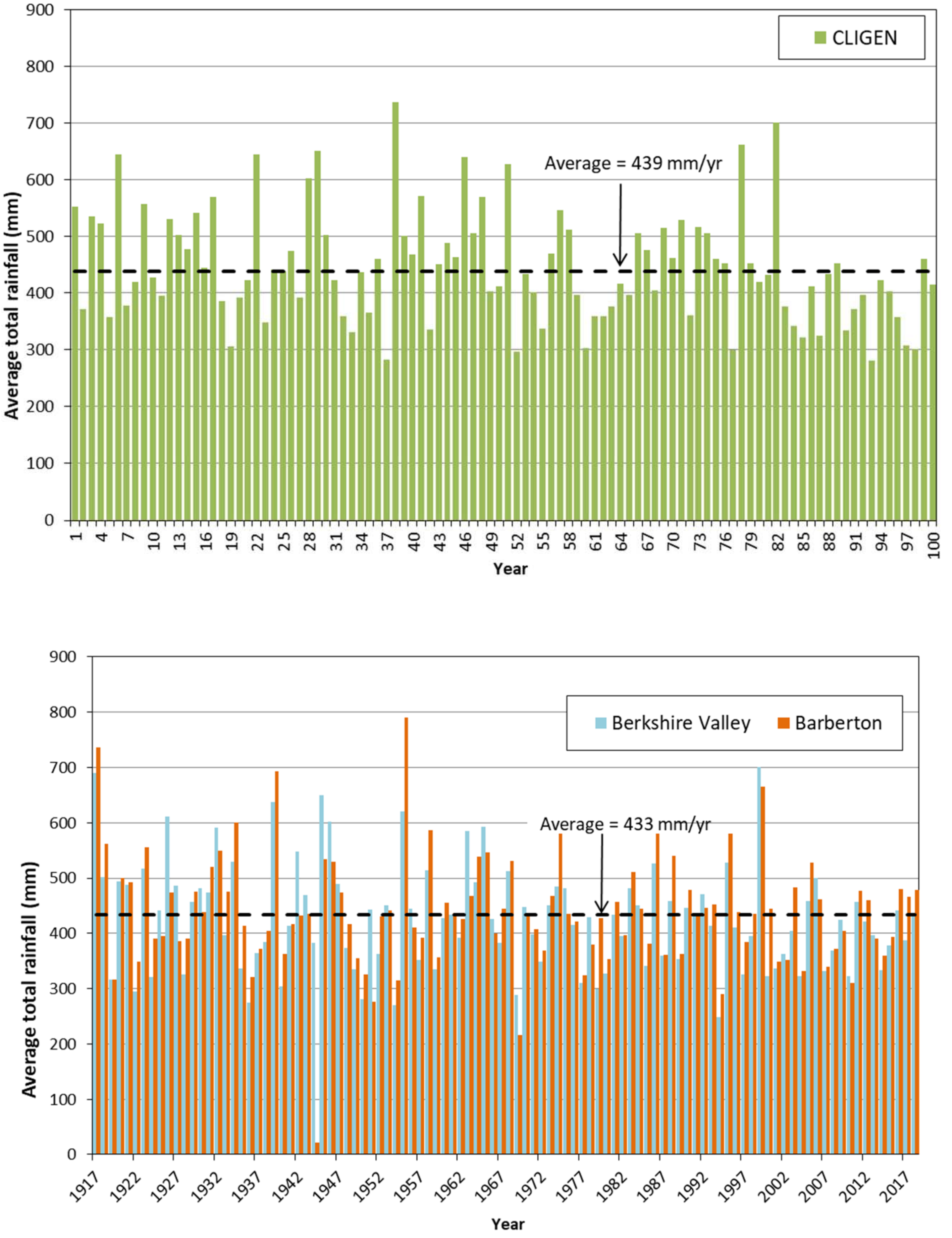
Plate 4.3: Laboratory-scale, rill erosion flume



GHD

NORTH KIAKA SOIL CHARACTERISATION

Figure 4.4: a) 24-hour and b) mean monthly rainfall data



GHD	Figure 4.5: Annual rainfall data
NORTH KIAKA SOIL CHARACTERISATION	

4.3.2 SOIL PARAMETERS

The soil parameters required by WEPP were derived from the laboratory testing undertaken at SWA Laboratories. These parameters include the particle size distribution, effective hydraulic conductivity (Keff), interrill erodibility (Ki), rill erodibility (Kr), and soil critical shear stress (τC), and are summarised in Table 4.6.

Keff was estimated by fitting the Green-Ampt equation (Green and 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)
Keff = effective saturated hydraulic conductivity (mm/h)
Ns = 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 Elliott *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 Dc 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 flume measurements. The slope of the linear regression line was K_r, and the intercept with the horizontal axis was τ_C.

Table 4.6: Key soil parameters used in the WEPP model.

Material ID	Sand (%)	Clay (%)	OM (%)	CEC [meq/100g]	K_{eff} (mm/hr)	K_i (Kg s / m^4)	K_r (s / m)	τ_C (Pa)
Topsoil	83	7	2.94	6.54	21.7	5.2	0.0016	3.3
Subsoil	84	8	0.62	1.46	20.2	12	0.0341	1.1
Weathered Granite	82	10	0.13	2.86	68.1	17	0.0394	6.0

4.3.3 SLOPE PROPERTIES

Batter slopes were modelled assuming slope angles of 15° and 18°, with lift heights of 10-20 m, to simulate the range of batter-berm scenarios being considered for the Waste Dump designs.

4.3.4 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. 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 is likely to 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 is already accounted for within the measured soil parameters discussed in Section 4.3.2.
- Expected rill geometry is adjusted internally in the model based on the input soil parameters and on the size of the erosion events encountered.

4.3.5 EROSION MODELLING RESULTS

Table 4.7 summarises the average runoff and sediment yield values predicted by the WEPP erosion model, given the input parameters previously summarised in Section 4.3.

The WEPP model indicated that the lowest average sediment yields of <3 t/ha/yr were reported for the Gravelly Subsoil under both slope configurations tested, indicating that this material can be considered highly erosion resistant, and is expected to perform well on the slopes of waste landforms. The Gravelly Subsoil was seen to readily self-armour (Plate 4.4), and subsequently showed a high degree of resistance to erosion, producing a maximum of 3.0 t/ha/yr from the range of potential slope configurations tested. This is considered a very low erosion rate for material under these conditions.

As expected the granitic saprolite performed the worst, in response to its structural instability and elevated silt and clay contents. Interestingly, the Gravelly Topsoil performed worse that the equivalent Gravelly Subsoil, and this is due to the high water repellence of the Topsoil materials.

Table 4.7: Summary of WEPP erosion modelling results

Material Type	Lift height (m)	Slope angle	Average annual runoff (mm/yr)	Average erosion rate (mm/yr)	Average erosion rate (t/ha/yr)
Topsoil	10	15°	7	0.2	2.0
		18°	9	0.3	5.1
	20	15°	5	0.4	6.4
		18°	12	0.6	10.1
Subsoil	10	15°	2	0.1	1.9
		18°	2	0.1	1.9
	20	15°	2	0.2	2.9
		18°	3	0.2	3.0
Weathered Granite	10	15°	8	0.3	4.9
		18°	10	0.5	8.1
	20	15°	7	0.8	12.1
		18°	14	1.2	18.5

Plate 4.4: Self-armouring of gravelly material during erosion testing

5 SOIL MANAGEMENT

5.1 REHABILITATION RESOURCES

As shown in Table 4.1, the majority of the areas within the proposed mine pits belong to SMU 1 (Skeletal Stony Soils) and SMU 2 (Shallow Gravelly Duplex). As specified in Section 4.1.1, there is limited ability to strip soils from SMU 1 due to the outcropping quartzite. The total area of SMU 1 within the proposed mine pits is approximately 31 ha, which is around 43 % of the total mine pit area. SMU 2 covers a further 24.3 ha of the proposed mine pits (34 % of the total mine pit area). Based on the dominance of SMU 1 and 2 within the mine pits, close to 80 % of the mine pit areas will only yield minimal soil resources for use in rehabilitation. It is therefore likely that there will be a shortage of rehabilitation resources, and highlights the need to strip the gravelly subsoils below the proposed WRLs to obtain sufficient resources to effectively rehabilitate the WRLs.

The estimated soil resources that are likely to be captured for rehabilitation purposes are provided in Table 5.1. The estimated volumes are based on the following stripping depths:

- Topsoil (SMU 2 and 3): 10 cm (0-10 cm depth)
- Subsoil: SMU 2 = 20 cm (10-30 cm depth); SMU 3: 30 cm (10-40 cm depth)

It is important to note that surface soils stripped from the Administration Area, Process Area and Workshops, and the Access Corridor will simply be stockpiled around the perimeter of these areas for later return during rehabilitation works; hence they are not factored into any rehabilitation resource material balance.

Table 5.1: Proposed rehabilitation resources to be captured

Mine Feature	Total Area to be Stripped (ha)	SMU 1 (m^3)	SMU 2		SMU 3		TOTAL (m^3)
			Topsoil (m^3)	Subsoil (m^3)	Topsoil (m^3)	Subsoil (m^3)	
Pit 1	5.3	0	5,080	10,160	230	690	16,160
Pit 2	17.7	0	8,450	16,900	9,250	27,750	62,350
Pit 3	12.2	0	9,380	18,760	2,810	8,430	39,380
Pit 4	1.7	0	1,390	2,780	340	1,020	5,530
Small Open Pits	3.5	0	3,100	6,200	380	1,140	10,820
North WRL	18.6	0	470	940	18,120	54,360	73,890
East WRL	13.4	0	0	0	13,390	40,170	53,560
TOTAL	72.4	0	27,870	55,740	44,520	133,560	261,690

5.2 REHABILITATION REQUIREMENTS

Assuming that no backfilling of mine pits will occur, all of the excavated soil and waste material will be permanently stored in either the North or East WRL. Given the disturbance footprint of these features, and allowing for a 30 % increase in surface area when the WRL is constructed, the total surface area to be rehabilitated for the two WRLs is:

- North WRL: 24.2 ha
- East WRL: 17.4 ha

If the rehabilitation profile is to consist of 0.1 m of Topsoil and 0.4 m of Subsoil, then the required rehabilitation resources are provided in Table 5.2. As can be seen, a total of 208,000 m^3 of soil will be required to effectively rehabilitate both the North and East WRLs, comprising 41,600 m^3 of Topsoil and 166,400 m^3 of subsoil.

When the rehabilitation requirements specified in Table 5.2 (208,000 m^3) are compared with the available rehabilitation resources from the open pits (147,250 m^3), it is clear there is a deficit of soil resources. It is therefore imperative that the topsoil and some of the subsoil is stripped from the WRL areas to ensure sufficient soil resources are available for rehabilitation.

Table 5.2: Rehabilitation resource requirements

Feature	Rehabilitation Area (ha)	Topsoil (m^3)	Subsoil (m^3)	TOTAL (m^3)
North WRL	24.2	24,200	96,800	121,000
East WRL	17.4	17,400	69,600	87,000
TOTAL (m^3)	41.6	41,600	166,400	208,000

5.3 HANDLING AND UTILISATION

Based on the results of this study the following materials management strategies are recommended:

- All gravelly soils (Topsoil and Subsoil) are structurally stable and friable and represent optimal soil materials for use in rehabilitation of the outer surface of the WRLs.
- All granitic saprolite is structurally unstable, dispersive and highly erodible, and therefore should not be used in the reconstruction of the outer surfaces of the WRLs.
- Given the limited water holding and plant available water content of the gravelly soils, it is recommended that only small (i.e. < 30 cm) shallow-rooted revegetation species are used on the batter slopes to ensure the sustainability of the rehabilitation. Taller (i.e. > 50 cm high), higher water holding capacity revegetation species should be restricted to the flat berms and WRL top as the vertical infiltration into the deeper soil profile will support the transpiration requirements of these species.
- Based on the erosion testing and modelling, a batter slope of 18° is acceptable to produce a stable and sustainable WRL at closure.

6 REFERENCES

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Appendix E

Geotechnical Desktop Assessment (GHD 2019a)

Simcoa Operations Pty. Ltd.

North Kiaka Approvals and Supporting Studies
Geotechnical Desktop Study

September 2021

Executive Summary

Introduction

Simcoa Operations Pty. Ltd. (Simcoa) operates the Moora Quartzite Mine (the Existing Mine) located 15 km north of Moora, Western Australia. Simcoa propose to develop a new greenfield quartzite mine (the Proposed Mine) located approximately 2.5 km north of the Existing Mine.

As part of the proposal, various mine infrastructure will be relocated from the Existing Mine to the Proposed Mine. This geotechnical desktop study examines the haul roads, haul road bridge, and two earthwork pads. The study assesses existing information and provides recommendations for geotechnical site investigation.

Information Extents

Previous ground information data has been gathered from 21 sources. The information is predominantly focussed on the Existing Mine, providing a commentary on the regional and local geology, and historical groundwater pumping trials. A database of 674 assay exploration boreholes undertaken at the Proposed Mine is available. The boreholes were drilled open-hole and basic geology is therefore, inferred from arisings at 2 m centres. No geotechnical lithological descriptions, insitu tests, geotechnical laboratory testing data or geotechnical parameters are available.

Geology

The site is underlain by Noondine Chert, which outcrops in NNW-SSE trending parallel ridges. Between the ridges are gentle sloping valleys infilled with Colluvium at the margins and Alluvium elsewhere. Historical investigations are limited to the ridges and no information is available regarding the depth of valley soils. Where valleys are narrow and aligned parallel/perpendicular with ridges, they may represent preferentially weathered Dolerite Dykes.

Groundwater

Groundwater levels at the Existing Mine were monitored every month in 2018. Groundwater depths at the Proposed Mine are inferred to be between 11 to 14 m depth at the West Earthworks Pad and 42 to 45 m depth at the East Earthworks Pad.

Acid Sulphate Soils (ASS)

There are no known occurrences of ASS in the Coomberdale Sub-group. There is a low probability of encountering ASS in the Alluvium.

Geotechnical Risks

Limited information is available for the geological model and material engineering characteristics, particularly at the bridge and earthwork pads. Key risks stemming from this include: total settlement and differential settlement of structures, haul road sub-grade suitability, rock excavatability and support measures, karst collapse and Acid Sulphate Soils.

Recommended Site Investigation

The recommended scope is a total of four geotechnical boreholes with groundwater monitoring installations, 20 No test pits paired with Dynamic Cone Penetrometers, and four geophysical transects. Target depths range between 3 m for test pits and 30 m for boreholes.

This report is subject to, and must be read in conjunction with, the limitations set out in section 1.4 and the assumptions and qualifications contained throughout the report.

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1. Introduction

1.1 General

Simcoa Operations Pty. Ltd. (Simcoa) is considering implementing three potential projects for their Western Australia (WA) operations. GHD Pty. Ltd. (GHD) has been commissioned to provide engineering support services for Proposal No. 2, whereby it is proposed to develop a new greenfield quartzite mine at North Kiaka.

As part of engineering support to this proposal, a geotechnical desktop study will be conducted for the haul roads, access roads and earthwork pads (study area), as shown in Figure 1. This report represents the findings of the study, which was carried out in accordance with the scope of work outlined in GHD's proposal: Proposal for North Kiaka Mine Expansion, Approvals Engineering Support, Revision 1, dated 30th October 2018.

1.2 Purpose of this Report

The purpose of this report is to provide the following:

- A summary of the available geotechnical information relevant to the study area;
- An overall understanding of the likely ground and groundwater conditions at the study area, including any available information regarding soil parameters; and
- Recommendations regarding the extent and type of future geotechnical investigation fieldwork.

1.3 Scope

The scope of work outlined in GHD's proposal to Simcoa comprised a desktop study, undertaken to identify geotechnical data including soil parameters and geological information relevant to the site engineering.

1.4 Limitations

This report has been prepared by GHD for Simcoa Operations Pty. Ltd. and may only be used and relied on by Simcoa Operations Pty. Ltd. for the purpose agreed between GHD and Simcoa Operations Pty. Ltd. as set out in Section 1.2 of this report.

GHD otherwise disclaims responsibility to any person other than Simcoa Operations Pty. Ltd. arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Simcoa Operations Pty. Ltd. and others who provided information to GHD (including Government authorities), which

GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

2. Project Background

2.1 Existing Infrastructure and Proposed Development

Simcoa operates the Moora Quartzite Mine (the Existing Mine) and the Kemerton Silicon Smelter (the Smelter). The Existing Mine is located 15 km north of Moora, in the Shire of Moora, WA. The Existing Mine produces high purity quartzite which is transported offsite via truck to the Smelter, located near Bunbury, WA.

Proposal option No. 2 is to develop a new greenfield quartzite mine at North Kiaka (the Proposed Mine), located approximately 2.5 km northeast of the Existing Mine, as shown in Figure 1.

As part of the proposal, various mine infrastructure will be relocated from the Existing Mine to the Proposed Mine. This study will examine the haul roads, access roads and two earthwork pads. Various infrastructure will be required, including but not limited to:

- Haul Road:
    - Cut and fill; and
    - Bridge over Kyaka Brook.
- East Earthworks Pad (approx. 213,300 m^2):
    - Processing Area; and
    - Workshops.
- West Earthworks Pad (approx. 29,400 m^2):
    - Administration buildings;
    - Product stockpiles; and
    - Weighbridge.

2.2 Existing Information

A review of data from previous investigations conducted in the vicinity of the study area was carried out by GHD. Data from multiple past investigations were reviewed, along with publicly available geological and groundwater information. The data and findings are outlined overleaf, in Table 1.

Table 1: Existing Geotechnical, Geological and Groundwater Information

Source	Database, project and/or document	Content	Data relevant to this project	Past investigation locations with the site boundary	Ground and groundwater data summary; other relevant information
Geological Survey of Western Australia	1:250,000 Geological Series – MOORA, Sheet SH 50-10, 1st Edition, 1982	Geological map of Moora	Regional surface geology	-	Surface geology in study area is mapped as Coomberdale Sub-group intruded by northeast-southwest trending Amphibolite dykes. The Coomberdale Sub-group is surrounded by Alluvium Normal faults trending north-south are inferred to be present to the west and east of the Proposed Mine site. The hanging walls face each other and are centred on the site The Darling Fault is inferred to be approximately 6.3 km west of the site Map extract has been used in Figure 2
Geological Survey of Western Australia	1:250,000 Geological Series – Explanatory Notes: Sheet SH 50-10: Moora, Western Australia, 1982	Explanatory notes to the geological map	Regional geological history	-	Dykes are between 1 m and 10 m thick and tend not to exceed 1 or 2 km in length. Dykes are doleritic and vary in grain size
Government of Western Australia	Landgate Online Viewer; 2019	Historical aerial images	Aerial images dating between 2000 and 2017 showing change	-	No visible ground surface disturbances or fill placements

Source	Database, project and/or document	Content	Data relevant to this project	Past investigation locations with the site boundary	Ground and groundwater data summary; other relevant information
			in surrounding land use		
Commenwealth Scientific and Industrial Research Organisation	Australian Soil Resource Information System; 2015	Digital maps of Acid Sulphate Soil (ASS) Risk	Shows local site geology in terms of ASS risk	-	Areas mapped as Coomberdale Sub-group are shown to have “No Known Occurrence” of ASS risk; Areas mapped as Alluvium show an ASS risk of “Low Probability”
Simcoa Operations Pty Ltd	Moora Project, Mineralisation Report; August 2010	Discussion of historical assay exploration drilling	Regional and local geology summary	Four HQ rotary drilled holes (MKDDH1-MKDDH4) to a maximum depth of 30 m in 2010. The precise location, factual core logs and core photographs are not included	The Coomberdale Sub-group consists of bedded chert, chert breccia, orthoquartzite, silicified limestone and dolomite, and contains significant siliceous sandstone and siltstone beds, and minor claystone The chert contains significant quantities of kaolin and other clays, particularly at depth Dolerite dykes are present within the Coomberdalte sub-group Cavities are noted during drilling, with no scale of the void given
Simcoa Operations Pty Ltd	Moora Quartzite Mine, Closure Plan; January 2018	Existing Mine closure plan	Site historical milestones, local geology, soil and	-	The Coomberdale Sub-group outcrop as a series of low stony hills and ridges. The chert is fine grained, exhibits banding which is brecciated and strongly faulted

Source	Database, project and/or document	Content	Data relevant to this project	Past investigation locations with the site boundary	Ground and groundwater data summary; other relevant information
			groundwater summaries pH and sulphate laboratory assessment summary		The area is characterised by shallow soils of red sandy earth and loam. Soil is generally absent on the hill slopes and crests The Kyaka Brook, 500 m north of the Existing Mine discharges to the clay pans and samphire flats of the Coonderoo River The principal groundwater aquifer in the region is hosted by the Noondine Chert which is extensively fractured and cavernous. The salinity of the water ranges from fresh to brackish and pH is slightly alkaline A groundwater well on site showed water levels in the aquifer to vary with minor seasonal water level fluctuations correlated with direct rainfall recharge
Simcoa Operations Pty Ltd	Moora Quartzite Mine (M70/191) – Notice of Intent; March 1992	Discussion on a proposed pit expansion	Geological summary at 2 m centres	-	Chert beds dip at between 20° to 30° west
Simcoa Operations Pty Ltd	Excel database: Expl_Data_Tonkin.xlsx; no date	Survey coordinates and assay details for 674 boreholes	Drilling comments and very basic lithology	674 boreholes	Ferruginous chert beds encountered at ground level may be up to 10 m thick (MK009)

Source	Database, project and/or document	Content	Data relevant to this project	Past investigation locations with the site boundary	Ground and groundwater data summary; other relevant information
					Kaolin beds have been encountered at 10 to 12 m depth and can be up to 24 m thick (MK018) Combinations of ferruginous, kaolin and chert may form beds between 2 to 14 m thick (MK039) Dolerite is typically weathered Cavities stopped drilling in 48 boreholes and clay was observed throughout two holes up to 22 m depth (MK226 and MK231)
Simcoa Operations Pty Ltd	Excel database: 109290 Soil and Waste Rock Analysis; (no date)	Chemical test results on five soil samples	Sulphate and pH test results	-	Sulphate and pH test results
Simcoa Operations Pty Ltd	Email from Kees Visser (Simcoa) to Michael Ashley (GHD); 15th January 2019; Subject: Materials Characterisation	A series of responses from Simcoa to questions direct by GHD regarding available site information	Explanation of lithology symbols used in assay borehole database Local geology summary	-	Cavities have been encountered throughout the deposit, which are sometimes empty and sometimes filled with gravel of quartz. The area contains surface depressions from collapsed underground caverns

Source	Database, project and/or document	Content	Data relevant to this project	Past investigation locations with the site boundary	Ground and groundwater data summary; other relevant information
Snowden Group Pty Ltd	Kiaka Hills Mine Development Plan; November 2012	Development plan for the Proposed Mine and discussion on mineral resources	Discussion on historical assay drilling	-	Many past boreholes have not reached a target depth of 40 m during open hole drilling due to cavities or blockages
Maunsell & Partners Pty Ltd	Report of the survey for aboriginal sites at the area proposed for a quarry development by Cliffs International Ltd; July 1985	Review of aboriginal sites at the Existing Mine	Geological summary	-	The region is part of the Yilgarn Block, a sub-division of the ancient Western shield that comprises Archaean rocks. In the survey area, a group of sedimentary rocks of the Proterozoic, known as the Moora Group, lie unconformally over these. A member of this group, the Coomberdale chert, forms numerous groups of stony hills and ridges The area is 8 km east of the Darling Fault, on the Darling Plateau The landscape is gently undulating, dissected by the stony hills and ridges Surface hydrology comprises a system of southwest flowing intermittent streams such as the Kyaka Brook which flows north of the Existing Mine
Industrial Mineral Services Pty Ltd	Moora Quartzite Mine (M70/191) – Notice of Intent; May 2001	Discussion on a proposed pit expansion	Groundwater summary	-	The groundwater level is approximately 20 m below surface at the Existing Mine

Source	Database, project and/or document	Content	Data relevant to this project	Past investigation locations with the site boundary	Ground and groundwater data summary; other relevant information
Saprolite Pty Ltd	E0201-02_A Moora Quartz Mine – Phase 2 Hydrogeological Investigations, October – November 2011; March 2012	Discussion of a groundwater pumping trial	Composite drilling log with basic lithological description for four wells Groundwater summary	-	Borehole MB02 encountered a combination of laterite and quartz between ground level and 2 m depth, with samples comprising iron rich red-brown hard siliceous ferricrete fragments and red-brown clay. This extended to 4 m depth in MB03. The laterite was underlain by light to dark grey amorphous quartz for a further 28 m+ BH02 recorded a 4 m deep siliceous void at 28 m depth (188 m above Australian Height Datum (mAHD)) which gave no drilling resistance
Saprolite Pty Ltd	Memorandum; Moora Quartz Mine – Technical Desktop Review; August 2016	Desktop review of groundwater pumping trials at site	Hydrology	-	The direction of natural groundwater flow is from south-east to north-west towards the wetlands and discharge playa lakes some 3 to 5 km to the north-west
Saprolite Pty Ltd	E0202-07_A Annual Groundwater Monitoring Summary for GWL 104693 – Moora Quartz Mine January to December 2018; February 2019	Discussion on regional hydrogeology and a groundwater monitoring regime	Groundwater level data summarised on a monthly bases Chemical analysis of groundwater	-	A groundwater well on site showed water levels in the aquifer to vary with minor seasonal water level fluctuations correlated with direct rainfall recharge Groundwater levels vary annually between 210.94 to 214.24 mAHD

Source	Database, project and/or document	Content	Data relevant to this project	Past investigation locations with the site boundary	Ground and groundwater data summary; other relevant information
M.E. Trudgen & Associates	Comparison of the Flora and Vegetation of the proposed North Kiaka Mine Area to Other Parts of the Coomberdale Chert Threatened Ecological Community; March 2018	Discussion on Flora	Geology, topography and soils summary	-	The survey area contains parts of a series of more or less parallel northerly-southerly trending ridges of chert, with swales between them. The ridges are formed from the higher, more resistant to erosion, parts of the Noondine Chert Formation. There is a larger valley just east of the survey area and more chert ridges to the west. The ridges vary in cross section, some having gentle slopes on both sides, or steeper slopes on one side. There are some steep rocky areas, but the slopes are mainly gentle to moderate, with a few being quite steep The soils on the chert ridges vary in depth from skeletal on the blocky outcropping chert, to gravelly, loamy sands lower down the slopes. The surface soil was often pale grey, silty, fine sand. The soils in the valleys between the ridges are deeper over clay and broken rock
M.E. Trudgen & Associates	An Extension of a Flora Survey, Floristic Analysis and Vegetation Survey of Area of the Coomberdale Chert	Discussion on Flora	Topographical summary	-	The areas north of Kiaka Road that were surveyed have a series of more or less parallel north-south trending ridges of chert, with small valleys between them. East of the easternmost of these there is a larger valley. There is an overall slope

Source	Database, project and/or document	Content	Data relevant to this project	Past investigation locations with the site boundary	Ground and groundwater data summary; other relevant information
	TEC to Include a Further Area; March 2012				from east to west, with the western ridges lower than the eastern ones. The ridges vary considerably in cross section, some having gentle slopes on both sides and others (often narrower) having quite steep sides. There were some steep rocky areas, but the slopes are mainly gentle to moderate, with a few being quite steep
Actis Environmental Services	Proposed Discharge Evaluation: Coonderoo River Wetlands; December 2011	Analysis of potential mine water discharge sites	Hydrology Summary	-	Palaeo-channels cross the Proposed Mine site and are the mechanism for deposition of the Alluvium
Google Inc.	Google Earth Pro; 2019	Historical aerial imagery and street view imagery	Geo-spatial site imagery	-	Shallow depth of Kyaka Brook visually confirmed
Department of Parks and Wildlife	Jingemia Cave Interpretation	Visitor information to Jingemia Cave	Extent of karst landforms	-	Bedrock is confirmed to have karst present

2.3 Information Extents

Previous ground information data has been gathered from 21 sources. The information is predominantly focussed on the Existing Mine, providing a commentary on the regional and local geology, and historical groundwater pumping trials.

A database of 674 assay exploration boreholes undertaken between 2004 and 2014 at the Proposed Mine is available. The boreholes have been open-hole drilled to a maximum depth of 42 m. Lithological comments based on gravel chip arisings are available at 2 m centres. No geotechnical lithological descriptions, insitu tests, geotechnical laboratory testing data or geotechnical parameters are available. The extent of the boreholes has been displayed on Figure 3.

3. Regional Information

3.1 Regional Geology

The geological map providing 1:250,000 coverage of the study area is the MOORA sheet SH 50 – 10 (Geological Survey of Western Australia, 1982). An excerpt of the map relative to the Proposed Mine site is presented in Figure 2.

The region is part of the Yilgarn Block, a sub-division of the ancient Western shield that comprises Archaean rocks (4000 – 2500 Ma). Across the study area, a group of sedimentary and volcaniclastic rocks of the Middle Proterozoic (1600 – 1000 Ma), known as the Moora Group, lie unconformally over these Archaean basement rocks. The Noondine Chert (previously Coomberdale Chert), a member of the Coomberdale Sub-group of the Moora Group, stretches approximately 150 km north of Moora to Three Springs and outcrops as a series of low stony hills and ridges across the study area. The unit is typically between 700 m to 1000 m thick. (Geological Survey of Western Australia, 1982).

The Noondine Chert appears to have been formed by the surface silicification of carbonate rocks (siliceous limestone/dolomite). The silicification has been observed to a depth of 75 m below surface, the date of which is uncertain but is considered to be Tertiary (66 – 2.58 Ma) in age. The regional strike is generally between 10 and 20 degrees west of north and dips are westwards at about 20 degrees (Simcoa Operations Pty Ltd, 1992).

The Noondine Chert is intruded by dolerite dykes and is broken up by strike and transverse faults. Dolerite dykes are generally steeply dipping, up to 10 m wide and strike in a NNW direction, parallel to major faults. (Parker, 2010). Approximately 750 m east of the East Earthworks Pad is a major normal fault (downthrown west) which marks the contact with Archaean basement rocks. Over 6 km west of the study area is the Darling Fault (downthrown west), which marks a contact with younger Cretaceous (145 – 66 Ma) sedimentary rocks. At the southwest boundary of the study area, a normal fault (downthrown east) trends NNE/SSW along the general alignment of Midlands road.

The area between exposed bedrock outcrops is covered by Cainozoic sediments (<66 Ma), the genesis of which was complex and protracted such that distinguishing more recent Quaternary deposits (<2.58 Ma) is subjective. Additionally, continual reworking of sediments by historical rivers and more recent agricultural practices has resulted in the merging of one unit with another. The principally mapped sediment being Alluvium (Geological Survey of Western Australia, 1982).

3.2 Regional Groundwater

The surface hydrology comprises a system of west flowing intermittent shallow streams such as Kyaka Brook (between the Existing Mine and the Proposed Mine), and Prye Brook (2.3 km north of the Proposed Mine) which discharge into the clay pans and samphire flats of the Coonderoo River (2 km west of the Existing Mine) (Saprolite, 2012). The Coonderoo River flows from north to south to join the Moore River, and only flows after heavy rainfall (Simcoa Operations Pty Ltd, 2018).

The principal groundwater aquifer in the region is hosted by the Noondine Chert which is extensively fractured and cavernous. High bore yields are common and local groundwater is used to supply the townships of Moora and Watheroo (Simcoa Operations Pty Ltd, 2018). Groundwater recharge generally occurs via limited infiltration of rainwater to a semi-confined aquifer at 20 m depth (Saprolite Pty Ltd, 2012).

4. Local Information

4.1 Current Land Use

The current land use at the Proposed Mine study area is predominately agricultural. Valleys between ridges are used as arable land, whereas the ridges tend to be undeveloped with a vegetation cover comprising trees and shrubs of varying density. The site is crossed by many light vehicle tracks, although no structures are visible in aerial imagery.

To the west of the study area is the north-south aligned Midlands Road, a sealed single carriageway state highway. A single track railway (Midlands Railway Line) is offset parallel to Midlands Road by approx. 35 m east. To the south, between the Proposed Mine and the Existing Mine is Kiaka Road, a west-east trending, sealed access road. The haul road starts near the intersection between Kiaka Road and Midlands Road. In the southwest, both Midlands Road and Kiaka Road pass over Kyaka Brook. The brook is a shallow northwest-southeast aligned stream and is lined with trees.

4.2 Topography

The study area contains a series of more or less parallel NNW-SSE trending ridges of bedrock, with small infilled valleys between them. The ridges are formed from the higher and more resistant to erosion parts of the Noondine Chert Formation, and reach topographic heights up to 65 m (spot height RL+ 281 m Australian Height Datum (mAHD)) above the adjacent valleys (Government of Western Australia, 2019). There is a larger valley just east of the study area and further chert ridges to the south (at the Existing Mine). The ridges vary in cross section, some having gentle slopes on both sides, and others (often narrower) having steeper slopes on one side. There are some steep rocky areas, but the slopes are mainly gentle to moderate, with a few being quite steep. (M.E. Trudgen & Associates, 2018). The infilling valleys have gentle slopes coalescing on a central point between ridge peaks.

Starting at Kiaka Road (RL+ 216 mAHD), the haul road follows the alignment in Figure 1 for approx. 316 m before encountering Kyaka Brook. The brook flows under the haul road route, Midlands Railway Line and Midlands Road. It is approximately 2 m deep. Approximately 684 m further along the alignment the footslope of the first ridge (RL+ 217 mAHD) is encountered. The ridge rises to 23 m height (RL+ 239 mAHD) over 364 m width before re-entering a valley at RL+ 228 mAHD; which is the proposed start location of the West Earthworks Pad. The width of the valley is approx. 640 m, with a central high point at RL+ 225 mAHD; with open ends gently sloping NNW-SSE to approx. RL+ 220 mAHD. The haul road connecting the West Earthworks Pad to the East Earthworks Pad is approx. 700 m long. It progresses gently upslope along an approx. 50 m wide, west-east aligned valley. The East Earthworks Pad is sited on a small valley between parallel ridges. The area is gently sloping west-east uphill from approx. RL+ 255 mAHD to RL+ 265 mAHD.

4.3 Site History

Historical aerial imagery is available in colour for the study area between 2000 and 2018 (Government of Western Australia, 2019), (Google Inc., 2019). The 2000 imagery shows the area in its current land use with agricultural crops in the valleys between ridges. In 2001 a palaeo-channel appears within the soil surface, which intersects the haul road alignment between Kiaka Road and the westernmost ridge. The stream course is next visible in 2006 and is variably obscured by crop thereafter. Over the span of available imagery, no structures were observed to have been placed within the haul road alignment or earthworks pads.

4.4 Geology

An extract of the 1:250,000 geological map of the site is presented in Figure 2. The site is underlain by Noondine Chert, which outcrops in NNW-SSE trending parallel ridges. Between the ridges are gentle sloping valleys infilled with Alluvium, where valleys are narrow, they may represent preferentially weathered Dolerite Dykes. The map does not differentiate between Colluvium derived from the ridges and Alluvium. However, sufficient site-specific information exists to confirm the presence of Colluvium. A conceptual geological model is presented in Figure 4.

Each geological unit is discussed in the following sub-sections.

4.4.1 Fill

Fill has not been mapped on the 1:250,000 geological map and no placement has been observed in historical aerial imagery. Fill may have been placed locally as part of access works for the 2007 exploratory drilling campaign and is likely to be limited in its lateral and vertical extent. Any Fill is likely to be variable in composition and derived from local sources such as Colluvium or waste rock from the Existing Mine.

4.4.2 Alluvium

The Alluvium is Quaternary (<2.58 Ma) in age and was deposited as a series of floodplain deposits by a large historical river, of which only Kyaka Brook and remnant palaeo-channels remain (Actis Environmental Services, 2011). The 1:250,000 geological map describes the Alluvium generically as “clay, silt, sand” (Geological Survey of Western Australia, 1982).

Site specific sources characterise the Alluvium as “loamy-earths, clays and minor sandy-earths” (Simcoa Operations Pty Ltd, 2018). Sources further suggest the Alluvium to comprise “clay and broken rock” (M.E. Trudgen & Associates, 2018). Agricultural practices, visible in aerial imagery, are likely to have disturbed the upper 300 mm of soil and increased the organic matter content.

No historical boreholes have been undertaken within the Alluvium therefore, the depth is not definitively known. Given that historical boreholes have encountered 2 to 4 m of Colluvium at the margin of ridges, it is possible that the soil – bedrock contact is in excess of 4 m depth. The depth is anticipated to increase towards the centre of the valley.

4.4.3 Colluvium

The Colluvium is Cainozoic (<66 Ma) in age and is currently being deposited by an ongoing combined process of chemical and physical erosion of the bedrock. The deposition is highly incremental and the unit is therefore, likely to vary in composition. Furthermore, the Colluvium’s lateral and vertical extents will vary significantly and may inter-finger with the Alluvium.

Site observations by others note that the soils on the chert ridges vary in depth from skeletal on the blocky outcropping chert, to gravelly, loamy sands lower down the slopes. The surface soil was often “pale grey, silty, fine sand” (M.E. Trudgen & Associates, 2018).

Within the Proposed Mine area, soil depths at the margin of ridges are noted in historical boreholes (MK 023, MK042, MK044 and MK046) to be up to 2 m thick. Elsewhere at the ridge margins, arisings from depths of typically 2 m to 4 m, up to 6 m (MK065, MK075, MK132 and MK153) show chert “chips” with ferruginous content (Simcoa Operations Pty Ltd). This suggests an intermittent presence of ferricrete. At the Existing Mine, boreholes MB02 and MB03 (located at a ridge margin), respectively encountered a 2 m and 4 m thick laterite overlying Noondine Chert. The laterite at MB02 was described as “Laterite/Quartz: Red-brown hard siliceous ferricrete, iron rich and iron stained; 30% light dark brown amorphous quartz, dark impurities, 20% light brown talc rich clay”, and in MB03 as “Laterite/Quartz: Red-brown hard siliceous ferricrete, iron-rich and iron stained; 20% grey and brown amorphous quartz; 10% light brown talc rich clay" (Saprolite Pty Ltd, 2012).

4.4.4 Noondine Chert

The Noondine Chert (previously Coomberdale Chert) is Middle Proterozoic (1600 – 1000 Ma) in age and is a member of the Coomberdale Sub-group of the Moora Group. The group lays unconformably over Archaean basement rocks at depth and is typically over 700 m thick (Geological Survey of Western Australia, 1982).

The chert was formed by the surface silicification of carbonate rocks (siliceous limestone/dolomite) which has been observed to a depth of 75 m below surface. The date of silicification is uncertain but is considered to be Tertiary (66 – 2.58 Ma) in age. The regional strike is generally between 10° and 20° west of north and dips are westwards at about 20° to 30° (Simcoa Operations Pty Ltd, 1992). The beds exhibit distinct sedimentary banding which has been strongly faulted (Simcoa Operations Pty Ltd, 2018).

The 1:250,000 geological map explanatory note describes the Noondine Chert as consisting of "bedded chert, chert breccia, orthoquartzite, silicified limestone and dolomite and contains significant siliceous siltstone and sandstone beds, and minor claystone" (Geological Survey of Western Australia, 1982). Lithological descriptions from boreholes (MB01, MB02 and MB03) within the Existing Mine typically describe it as light grey to grey amorphous quartz, variably translucent, massive, with occasional iron staining and minor dark impurities. The rock strength is given as moderately hard (Saprolite Pty Ltd, 2012).

Iron oxides, titanium oxides and clays occur in the chert in the near-surface zone, with significant quantities of kaolin at depths of 10 m, up to 40 m thick (MK010, MK018, MK021 and MK048) (Simcoa Operations Pty Ltd). These are thought to have been formed by strong weathering of other rock types. The zone includes clays and ferruginous material, which are concentrated along joints and cavities and contain iron, aluminium and titanium oxides (Parker, 2010).

Cavities occur throughout the deposit, which are sometimes empty and sometimes filled with quartz gravel. The gravel deposits are considered to be collapse breccias, which appear to have been washed and sorted by underground streams. The cavities, which appear to have been formed by faulting and possibly by leaching of carbonate rich chert have presented significant problems for open-hole exploratory drilling at the Proposed Mine (MK051, MK053, MK062 and MK064). The area is referred to as containing physiographic amphitheatres which are probably related to the collapse of limestone/chert into large underground caverns (Simcoa Operations Pty Ltd, 2019).

4.4.5 Dolerite Dykes

Dolerite Dykes of undetermined Precambrian (>541 Ma) age are shown within the bedrock on the 1:250,000 geological map. The dykes are steeply dipping, and generally between 1 m and 10 m thick with the largest up to 50 m thick or more. Some dykes approach 5 km in length, but the majority do not exceed 1 or 2 km (Geological Survey of Western Australia, 1982). The dykes have north and northwest trends, occasionally becoming east-west trending.

Boreholes MK142 to MK146 are arrayed within a narrow valley approximately 170 m to the north of the West Earthwork Pad. The recovered material was classified as "weathered dolerite" with comments that the boreholes recovered "red clay, no quartz" to depths of at least 18 m (Simcoa Operations Pty Ltd). This dyke may further extend south into the West Earthwork Pad.

Between the West and East Earthwork Pads, the haul road follows an alignment along a west-east trending valley. The trend is uncharacteristic for the NNW-SSE trending valleys, and may be the surface expression of a weathered dyke.

4.5 Groundwater

Extensive groundwater abstraction pumping trials have been undertaken at the Existing Mine therefore, a correspondingly large amount of monitoring data exists. No data is available for the Proposed Mine although due to the proximity and geological continuity of the two sites, only minimal changes in level are anticipated. Groundwater level is at approximately 20 m depth (Industrial Mineral Services Pty Ltd, 2001).

Monthly monitoring data for 2018 at the Existing Mine reveals that the groundwater levels vary annually between RL+ 210.94 mAHD to RL+ 214.24 mAHD (approx. 11 to 14 m depth at the West Earthworks Pad and 42 to 45 m depth at the East Earthworks Pad). The trend being for the level to fall between September to April, rising in May to August. This follows a pattern expected for aquifers directly affected by rainfall, with rising water levels over winter and falling water levels in summer (Saprolite Pty Ltd, 2019).

The salinity of groundwater ranges from fresh to brackish and groundwater pH is slightly alkaline (Saprolite Pty Ltd, 2012).

4.6 Acid Sulphate Soils

The Acid Sulfate Soil Risk Map indicates that where the site is located on the Coomberdale Sub-group, it is an area considered to be of “no known occurrence” of encountering Acid Sulphate Soils (ASS) (Australian Soil Resource Information System, 2019).

Areas mapped as Alluvium, are indicated to have a “low probability” of encountering ASS.

4.7 Geotechnical Parameters

No geotechnical parameters are available for any geological units.

4.8 Geotechnical Risks

4.8.1 Karst

The Noondine Chert is prone to karst cavities of varying scale. Many past boreholes at the Existing and Proposed Mines have been terminated at depths of between 10 m and 38 m due to cavities stopping drilling (Simcoa Operations Pty Ltd). Furthermore, these voids have been proven at the site to extend to 4 m in height (BH02, void encountered at 28 m depth, RL+ 188 mAHD) (Saprolite Pty Ltd, 2012). The voids are sometimes filled with quartz gravel which appear to have been washed and sorted by underground streams (Simcoa Operations Pty Ltd, 2019). Larger voids extending to the surface have been recorded in the Noondine Chert, such as at the Jingemia cave system and Devil’s Hole, located 27 km NNW of the site (Department of Parks and Wildlife, 2019). Of note, are references to the general site area being associated with surface depressions or ‘amphitheatres’ linked to the collapse of underground caverns (Simcoa Operations Pty Ltd, 2019).

Karst is most likely to pose a hazard to the bridge over Kiaka Brook, whereby relatively high loads are focussed at the bridge abutments. This may contribute to the collapse of any voids/caverns below the bridge and render the bridge inoperable.

At the East Earthworks Pad, several boreholes (MK050, MK051, MK053, MK062, MK063, MK064 and MK076) located on the ridges bordering the pad were terminated at depths of between 16 to 30 m due to cavities. The risk of karst collapse may be locally higher in this area.

4.8.2 Settlement

The Alluvium and to a lesser extent Colluvium, extend to an unknown depth with a poorly defined contact between soil and bedrock. Structures with foundations spread over areas of deep and shallow soil may experience differential settlement.

The soils may have undergone limited consolidation. The Alluvium is described as consisting predominantly of unsaturated sandy clay and may therefore, undergo a limited amount of settlement during the construction period, with potential for ongoing long-term settlement.

The Colluvium is described as being “gravelly loamy sand” and is therefore, likely to undergo limited amounts of settlement during the construction period, with minimal long-term settlement.

The presence of lateral concretions in the soil may contribute to a reduction in total settlement. Depending on the lateral extent of concretions relative to a structures foundations, differential settlement may occur.

4.8.3 Concrete and Steel Durability

Limited chemical laboratory test results (of unknown site location and strata origin) are available which may aid in assessing the exposure classification for buried concrete and steel components. In accordance with AS 2159-2009, the tests give a preliminary indication that the soil and water are likely to be classed as non-aggressive. No information is available for the Noondine Chert, although it is anticipated to also prove non-aggressive.

4.8.4 Near-surface Concretions

Laterites, as referred to in this report, consist of lateritic duricrusts or zones of iron oxide enrichment and cementation within the soil profile (Anand & Butt, 2003). The term laterite correctly refers to the complete weathering profile (including the weathered rock and in situ residual soils), but for the purpose of this report, laterite refers to ferricrete or the zone of iron oxide enrichment and cementation (Brink, 1985).

There are two recorded occurrences of laterite, both located at the boundary between ridge and valley in the Existing Mine. It is assumed that the lateritic soil identified is within the Colluvium. Boreholes MB02 and MB03, respectively encountered a 2 m and 4 m thick laterite overlying Noondine Chert. The laterite is typically described as a hard siliceous ferricrete with lesser amounts of quartz and clay (Saprolite Pty Ltd, 2012). Exploration boreholes at the margin of ridges in the Proposed Mine recovered chert “chips” with ferruginous content to depths of 6 m (Simcoa Operations Pty Ltd). This indicates that ferricretes may also be present at the Proposed Mine area.

Silcretes and ferricretes are noted on the 1:250,000 geological map to be present within the Phanerozoic soils approximately 4 km northeast of the site. Given the historical alluvial transportation and deposition across the site from east to west, there is potential for silcrete and ferricrete to be present not only in the Colluvium, but also within the Alluvium.

Calcretes are less likely to form as the original sedimentary rocks forming the Noondine Chert have been depleted in Calcium and Magnesium as part of the silicification process (Simcoa Operations Pty Ltd).

Dependant on the lateral extent of the concretions, standard techniques and methodologies (e.g. nominal 20 to 30 tonne capacity excavator) may prove sufficient for excavation. Where laterally extensive, the use of an excavator bucket with tiger teeth or a hydraulic breaker attachment may be necessary.

4.8.5 Pavement Sub-grade

Aerial imagery shows multiple unsealed vehicle tracks crossing the valleys and ridges at the Proposed Mine. It is not known if the tracks have been lined with gravel. The tracks infer that the sub-grade has good light vehicle trafficability and that therefore, subject to confirmatory insitu-density tests, limited treatment may be required for sustained heavy vehicle trafficking.

4.8.6 Rock Excavation & Cutting Stability

If the haul road is to maintain a shallow grade between the Bridge and the West Earthworks Pad, a cut within the Noondine Chert may be required. There is insufficient information available to assess whether blasting, ripping or to a lesser extent, excavation will be appropriate.

Once formed, the stability of the cutting will be highly dependent on a variety of factors, including how much soil cover is present and the presence of any faults, but principally the rock’s strength, weathering, joint set orientation and condition (aperture, infilling, saturation, Rock Quality Designation (RQD) etc.). The overall cutting design and support measures (if necessary) will require this data.

5. Recommended Site Investigation

5.1 Scope of Works

A geotechnical ground investigation is recommended to further characterise the site conditions by filling gaps within the existing data. The purpose of the investigation is to enable the refinement of:

- Geological Model, particularly in respect to the Alluvium under the Earthworks Pads;
- Geotechnical design parameters;
- Suitable siting locations for the development structures;
- Suitable foundation types and associated concrete/steel durability;
- Building settlement estimates; and
- Geotechnical risk levels:
  - Haul road sub-grade suitability;
  - Soil excavatability;
  - Rock excavatability and Support measures;
  - Karst collapse risk; and
  - Acid Sulphate Soils.

The recommended scope of the investigation is as follows:

- Four geotechnical boreholes to 30 m depth, minimum HQ size or larger (e.g. PQ size), with:
  - Standard Penetration Tests (SPTs) at 1.5 m centres and where cohesive, alternating with thin wall samplers of minimum diameter 63 mm (U63); and
  - Groundwater monitoring wells installed over the full depth of all boreholes.
- 20 No test pits to 3 m depth, including sub-sampling;
- Geotechnical logging of borehole core and test pit samples;
- 20 No Dynamic Cone Penetrometer (DCP) tests at the location of test pits, to 1.8 m depth;
- Four geophysical transects, including a combination of Multi-Channel Analysis of Surface Waves (MASW) and Seismic Refraction; and

A summary of each investigation location and the targeted development area is provided in

Table 2, overleaf. The locations are shown on Figure 5.

Table 2: Recommended Site Investigation

ID	Methodology	MGA50 Co-ordinates				Depth / Transect Length (m)	Secondary Feature	Investigation Target			
		Easting (m)	Northing (m)	Easting (m)	Northing (m)			Bridge	Haul Road	West Earthworks Pad	East Earthworks Pad
BH01	Borehole	407078	6625051	-	-	30.00	Monitoring Well	X	X		
BH02	Borehole	407094	6625149	-	-	30.00	Monitoring Well	X	X		
BH03	Borehole	408233	6625620	-	-	30.00	Monitoring Well		X	X	
BH04	Borehole	409002	6625950	-	-	30.00	Monitoring Well		X		X
TP01	Test Pit	407052	6624823	-	-	3.00	DCP		X		
TP02	Test Pit	407126	6625291	-	-	3.00	DCP		X		
TP03	Test Pit	407517	6625301	-	-	3.00	DCP		X		
TP04	Test Pit	407687	6625308	-	-	3.00	DCP		X		
TP05	Test Pit	407816	6625307	-	-	3.00	DCP		X		
TP06	Test Pit	407987	6625333	-	-	3.00	DCP		X	X	
TP07	Test Pit	407971	6625602	-	-	3.00	DCP		X	X*	
TP08	Test Pit	408149	6625615	-	-	3.00	DCP		X	X**	
TP09	Test Pit	408162	6625527	-	-	3.00	DCP		X	X	
TP10	Test Pit	408267	6625341	-	-	3.00	DCP		X	X	
TP11	Test Pit	408373	6625449	-	-	3.00	DCP		X	X	

ID	Methodology	MGA50 Co-ordinates				Depth / Transect Length (m)	Secondary Feature	Investigation Target			
		Easting (m)	Northing (m)	Easting (m)	Northing (m)			Bridge	Haul Road	West Earthworks Pad	East Earthworks Pad
TP12	Test Pit	408559	6625345	-	-	3.00	DCP		X	X	
TP13	Test Pit	408476	6625629	-	-	3.00	DCP		X	X	
TP14	Test Pit	408319	6625713	-	-	3.00	DCP		X	X	
TP15	Test Pit	408453	6625873	-	-	3.00	DCP		X		
TP16	Test Pit	408687	6625916	-	-	3.00	DCP		X		
TP17	Test Pit	408929	6625942	-	-	3.00	DCP		X		X
TP18	Test Pit	409013	6626056	-	-	3.00	DCP		X		X
TP19	Test Pit	408987	6625851	-	-	3.00	DCP		X		X
TP20	Test Pit	409057	6625946	-	-	3.00	DCP		X		X
GT01	Geophysical Transect	407072	6625024	407097	6625171	150.00	-	X	X		
GT02	Geophysical Transect	407958	6625305	408335	6625736	575.00	-		X	X	
GT03	Geophysical Transect	407945	6625606	408296	6625623	350.00	-		X	X***	
GT04	Geophysical Transect	408986	6625832	409016	6626081	250.00	-		X		X

Note: DCP = Dynamic Cone Penetrometer. (*) TP07 targeting administration buildings. (**) TP08 targeting weighbridge. (***) GT03 targeting administration buildings and weighbridge. All boreholes are to be placed on geophysical transect alignments to enable refinement of geophysical data. All drilling core will be retained for laboratory sub-sampling. Sub-samples will be taken by a Geotechnical Engineer/Engineering Geologist during the excavation of test pits.

5.2 Laboratory Testing

5.2.1 Geotechnical Laboratory Testing

Laboratory testing is to be undertaken at a NATA endorsed laboratory in accordance with current Australian Standards, or, where no Australian Standard test method exists, MRWA Materials Testing Manual standards may be used.

The following testing must be included as part of the laboratory testing implemented on samples recovered from boreholes and test pits:

- Liquid Limit, Plastic Limit, Plasticity Index – 9 tests;
- Linear Shrinkage – 9 tests;
- Moisture Content Test – 18 tests;
- Organic Matter Content – 6 tests;
- Particle Size Distribution (PSD) – 12 tests;
- Unconsolidated Undrained triaxial compression without measurement of porewater pressure, Set of 3 (AS 1289.6.4.1-2016) – 3 tests;
- One-dimensional consolidation tests (AS 1289.6.6.1-2016) – 3 tests;
- California Bearing Ratio (CBR), 95% Compaction, 4 Ring, 9 kg Surcharge, Soaked – 6 tests;
- Modified Maximum Dry Density (MMDD) – 6 tests;
- Point Load Strength Index tests on rock samples (uniaxial & diametric) – 12 tests;
- Uniaxial Compressive Strength (UCS) on rock samples – 8 tests;
- Durability Suite – Soil (pH, Sulphate (SO_4), Chloride, Electrical Resistivity) – 5 tests; and
- Durability Suite – Water (pH, Sulphate (SO_4), Chloride, Electrical Resistivity) – 4 tests.

5.2.2 Acid Sulphate Soil Laboratory Testing

Laboratory testing is to be undertaken at a NATA endorsed laboratory. Testing may include but not be limited to the following tests:

- pH_F – 20 tests; and
- pH_{FOX} – 20 tests.

6. References

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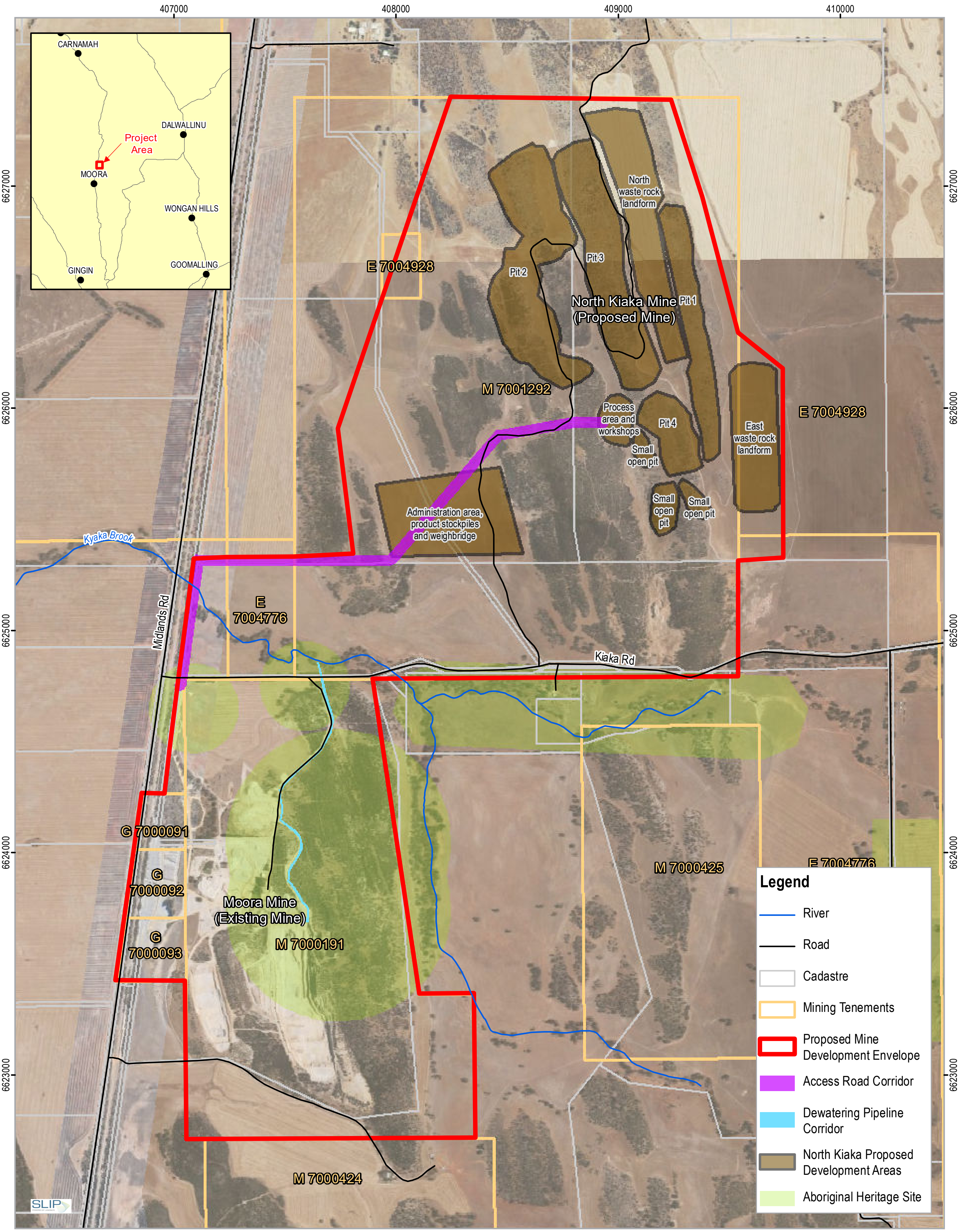
Figures



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Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

Simcoa Operations Pty Ltd
North Kiaka Approvals and Supporting Studies
Geotechnical Desktop Study

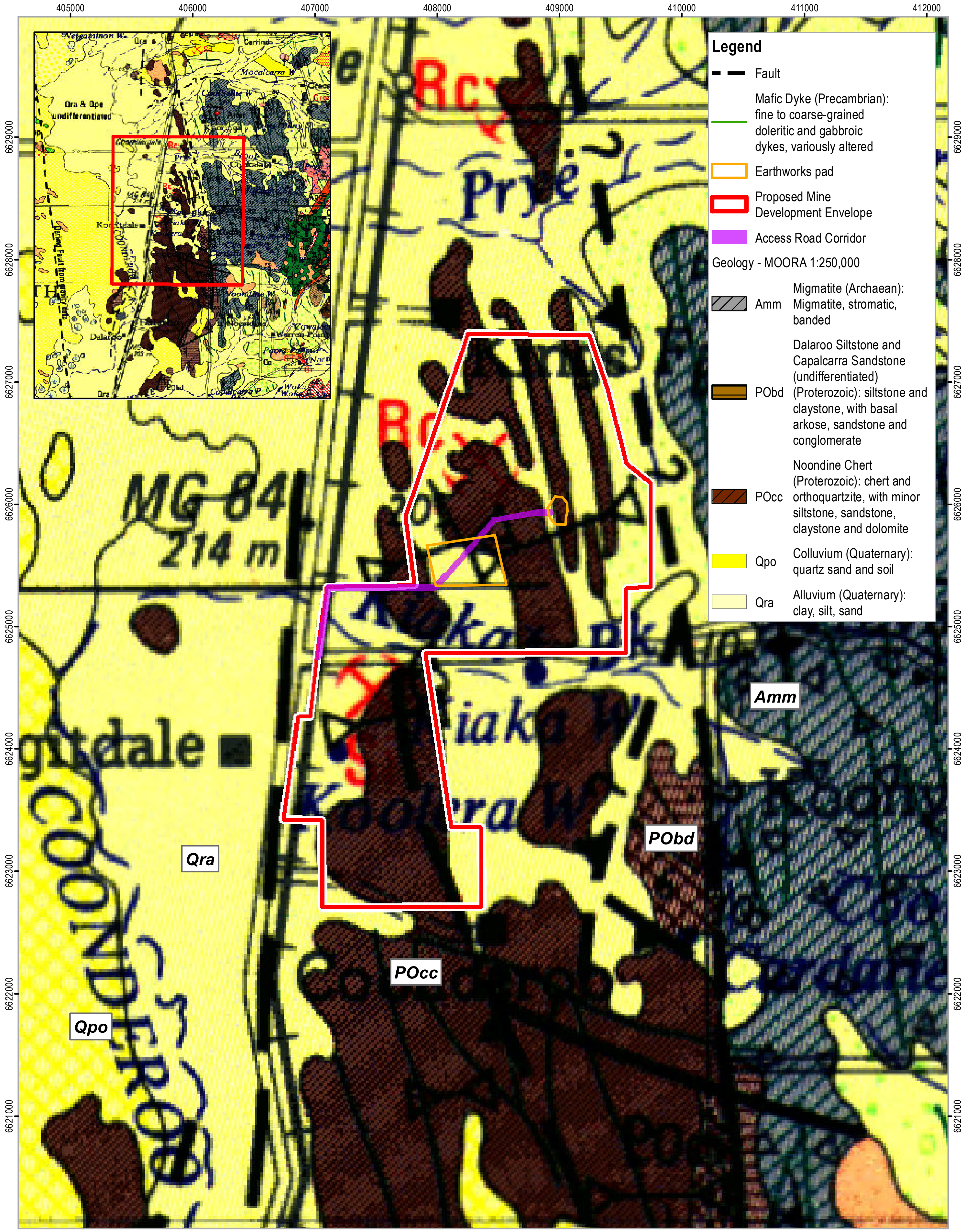
Site Locality Plan

Project No.	**61-37455**
Revision No.	**0**
Date	**30 Apr 2019**

FIGURE 1

G:\61\37455\GIS\Maps\Working\Geotech\6137455_001_SiteLocalityPlan_RevA.mxd
Print date: 30 Apr 2019 - 16:46

Data source: Simcoa: Mining Development Area - 2018; Landgate: Imagery, Cadastre, Road - 20180601; DMIRS: Mining Tenements - 20180601; Access Road Corridor - 20180601, Dewatering Pipeline Corridor - 20180627; Mine Development Emvelope - 20180627; DoW: River - 201108; DIA: Aboriginal Heritage Site - 201806. Created by: afeeney



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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

Simcoa Operations Pty Ltd
North Kiaka Approvals and Supporting Studies
Geotechnical Desktop Study

Site Geological Plan

Project No. 61-37455
Revision No. 0
Date 30 Apr 2019

FIGURE 2

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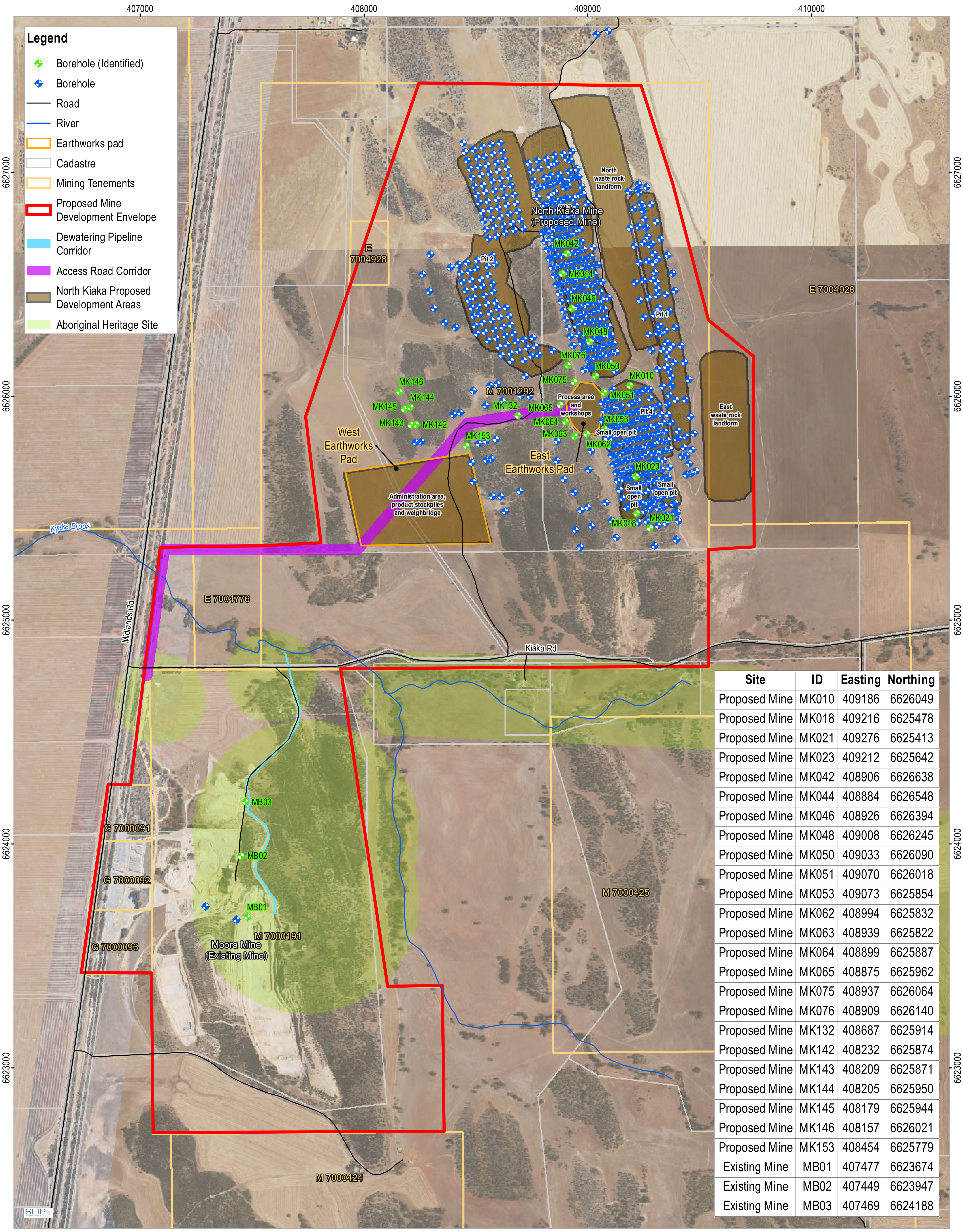
Data source: Simcoa: Mining Development Area - 2018; Geology: 1:250,000 Geological Series - MOORA, SHEET SH50-10, 1st Edition, Geological Survey of Western Australia, 1982. Created by: afeeney



Site	ID	Easting	Northing
Proposed Mine	MK010	409186	6626049
Proposed Mine	MK018	409216	6625478
Proposed Mine	MK021	409276	6625413
Proposed Mine	MK023	409212	6625642
Proposed Mine	MK042	408906	6626638
Proposed Mine	MK044	408884	6626548
Proposed Mine	MK046	408926	6626394
Proposed Mine	MK048	409008	6626245
Proposed Mine	MK050	409033	6626090
Proposed Mine	MK051	409070	6626018
Proposed Mine	MK053	409073	6625854
Proposed Mine	MK062	408994	6625832
Proposed Mine	MK063	408939	6625822
Proposed Mine	MK064	408899	6625887
Proposed Mine	MK065	408875	6625962
Proposed Mine	MK075	408937	6626064
Proposed Mine	MK076	408909	6626140
Proposed Mine	MK132	408687	6625914
Proposed Mine	MK142	408232	6625874
Proposed Mine	MK143	408209	6625871
Proposed Mine	MK144	408205	6625950
Proposed Mine	MK145	408179	6625944
Proposed Mine	MK146	408157	6626021
Proposed Mine	MK153	408454	6625779
Existing Mine	MB01	407477	6623674
Existing Mine	MB02	407449	6623947
Existing Mine	MB03	407469	6624188

Paper Size ISO A3

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

Simcoa Operations Pty Ltd
North Kiaka Approvals and Supporting Studies
Geotechnical Desktop Study

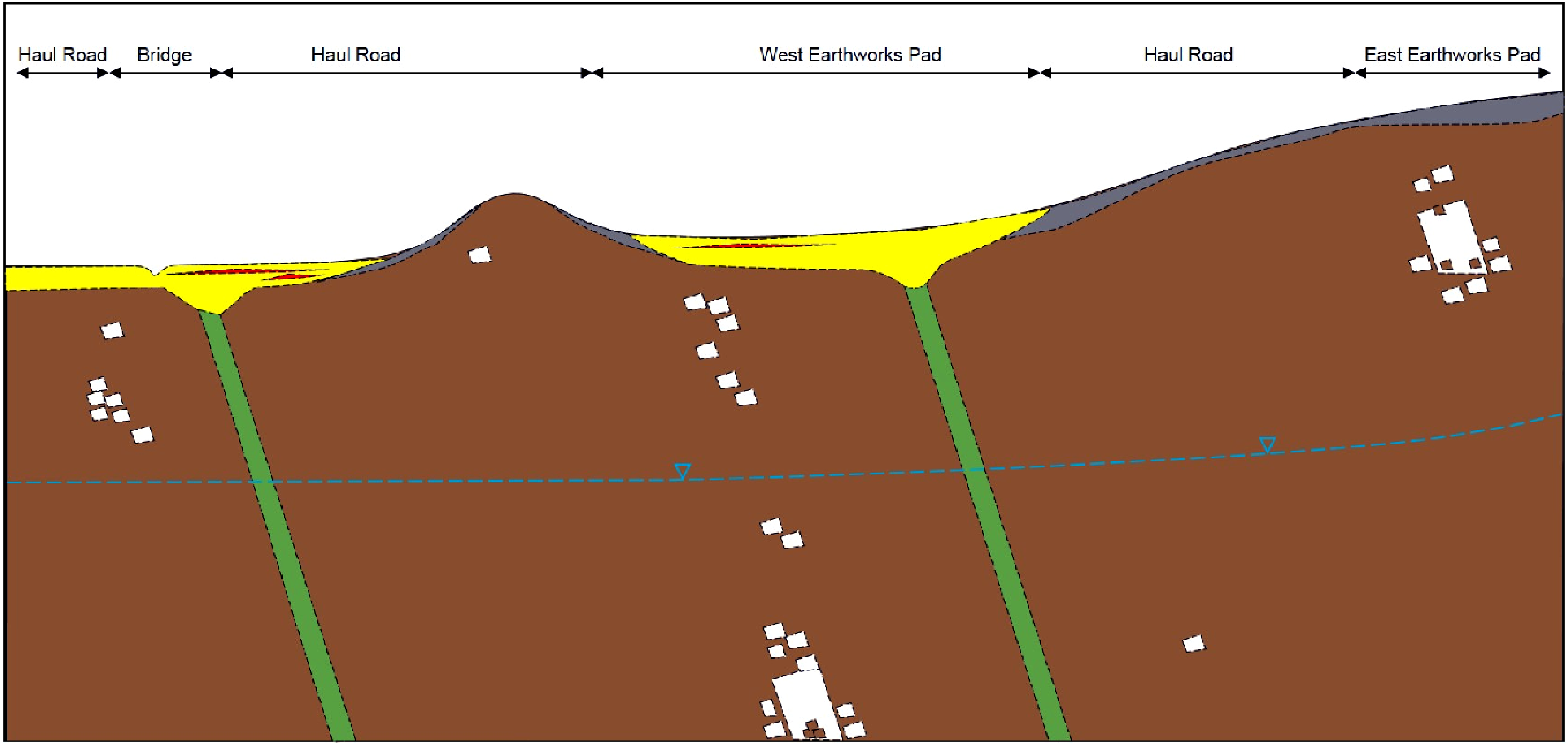
Existing Information Plan

Project No. **61-37455**
Revision No. **0**
Date **01 May 2019**

FIGURE 3

G:\61\37455\GIS\Maps\Working\Geotech\6137455_003_ExistingInformationPlan_RevA.mxd
Print date: 01 May 2019 - 09:02

Data source: Simcoa: Mining Development Area - 2018; GHD: Boreholes - 20190430; Landgate: Imagery, Cadastre, Road - 20180601; DMIRS: Mining Tenements - 20180601; Access Road Corridor - 20180601, Dewatering Pipeline Corridor - 20180627; Mine Development Emvelope - 20180627; DoW: River - 201108; DIA: Aboriginal Heritage Site - 201806. Created by: afeeney



Legend

▽ Groundwater table

🟨 Alluvium

🟥 Cementation

▨ Colluvium

🟩 Dolerite Dyke

🟫 Noondine Chert

☐ Karst

Geohazards:

1) Karst - Collapse under structure
2) Thick Unconsolidated Soil - Excessive structure settlement with long term creep
3) Cementation - Difficult Excavation / Variable pavement sub-grade suitability
4) Geo-environmental - Ground chemical aggressivity to buried concrete / steel
5) Rock Excavation - Strength and cutting stability

Paper Size ISO A4

Note: Not to scale

N

Simcoa Operations Pty Ltd
North Kiaka Approvals and Supporting Studies
Geotechnical Desktop Study

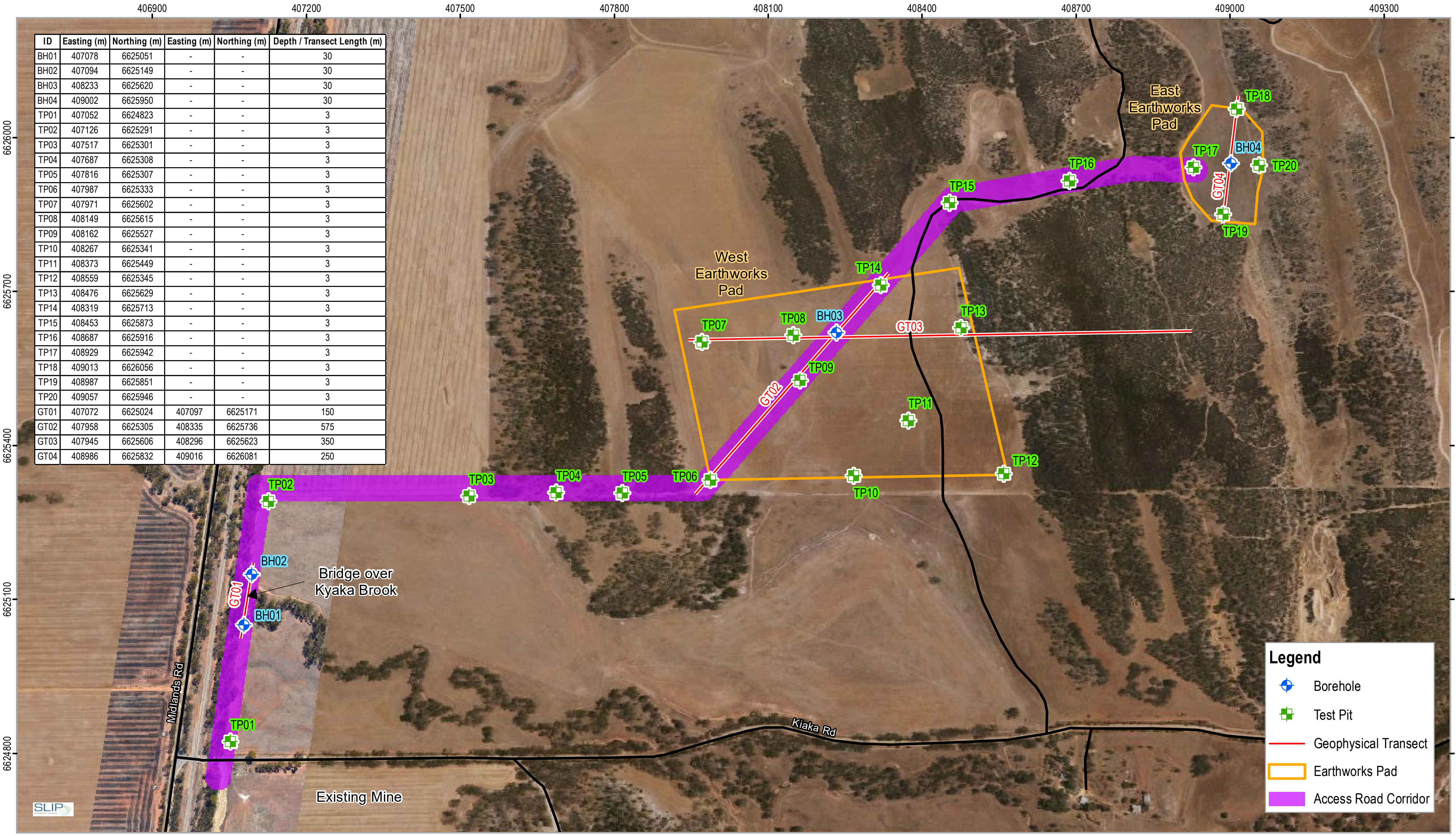
Project No. **61-37455**
Revision No. **0**
Date **30 Apr 2019**

Conceptual Geological Model

FIGURE 4

G:\61\37455\GIS\Maps\Working\Geotech\6137455_004_ConceptualGeologicalModel_RevA.mxd
Print date: 30 Apr 2019 - 15:55

Data source: GHD: Conceptual geological model - 20190430. Created by: afeeney



ID	Easting (m)	Northing (m)	Easting (m)	Northing (m)	Depth / Transect Length (m)
BH01	407078	6625051	-	-	30
BH02	407094	6625149	-	-	30
BH03	408233	6625620	-	-	30
BH04	409002	6625950	-	-	30
TP01	407052	6624823	-	-	3
TP02	407126	6625291	-	-	3
TP03	407517	6625301	-	-	3
TP04	407687	6625308	-	-	3
TP05	407816	6625307	-	-	3
TP06	407987	6625333	-	-	3
TP07	407971	6625602	-	-	3
TP08	408149	6625615	-	-	3
TP09	408162	6625527	-	-	3
TP10	408267	6625341	-	-	3
TP11	408373	6625449	-	-	3
TP12	408559	6625345	-	-	3
TP13	408476	6625629	-	-	3
TP14	408319	6625713	-	-	3
TP15	408453	6625873	-	-	3
TP16	408687	6625916	-	-	3
TP17	408929	6625942	-	-	3
TP18	409013	6626056	-	-	3
TP19	408987	6625851	-	-	3
TP20	409057	6625946	-	-	3
GT01	407072	6625024	407097	6625171	150
GT02	407958	6625305	408335	6625736	575
GT03	407945	6625606	408296	6625623	350
GT04	408986	6625832	409016	6626081	250

Paper Size ISO A4

0 100 200 300 400

Metres

N

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

Simcoa Operations Pty Ltd
North Kiaka Approvals and Supporting Studies
Geotechnical Desktop Study

Project No. **61-37455**
Revision No. **0**
Date **01 May 2019**

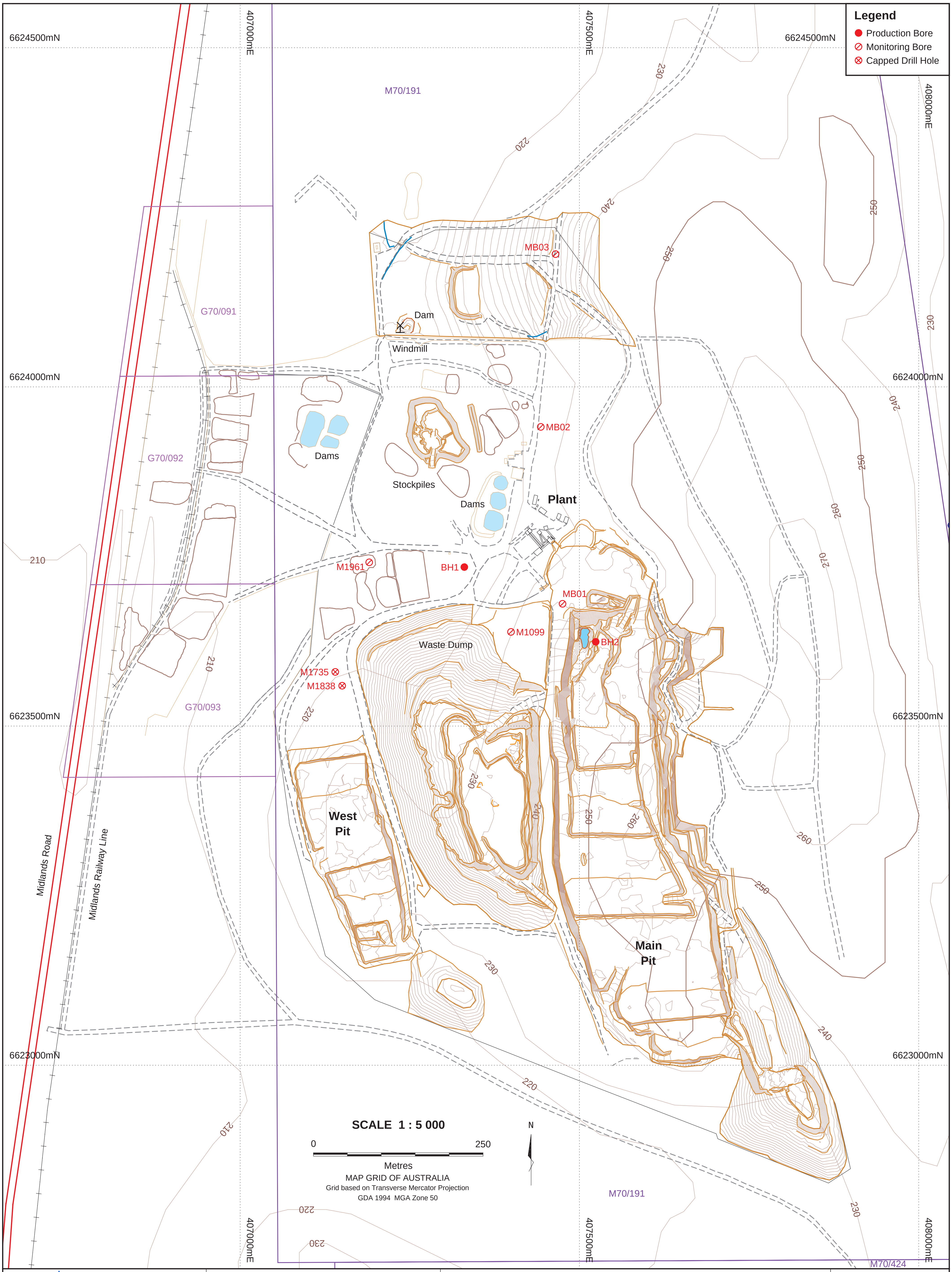
Recommended Investigation Plan

FIGURE 5

Data source: GHD: Boreholes, test pits, geophysical transects, earthworks pads - 20190430; Landgate: Roads - 20190128, Imagery. Created by: afeeney

Appendices

Appendix A – Existing Geotechnical Information



SAPROLITE ENVIRONMENTAL

Client: **SIMCOA OPERATIONS PTY LTD**

Project: **MOORA QUARTZ MINE**

MOORA QUARTZ MINE
MINE AREA

Author: Z.Scott
Checked: G.Richards
Drawn: S.Coleman
Approved: G.Richards

Date: January 2012
Scale: 1:5 000
Figure No. **4**
A3
Plan No. **E0200-006**

SAPROLITE ENVIRONMENTAL

52B Mornington Parkway
ELLENBROOK, WA, 6069
Phone: (08) 6296 7760
Fax: (08) 6296 7762
www.saprolite.com.au

COMPOSITE WELL LOG

Bore No: BH2

Client: Simcoa Operations Pty Ltd

Operation: Phase 2 Hydrogeological Investigations

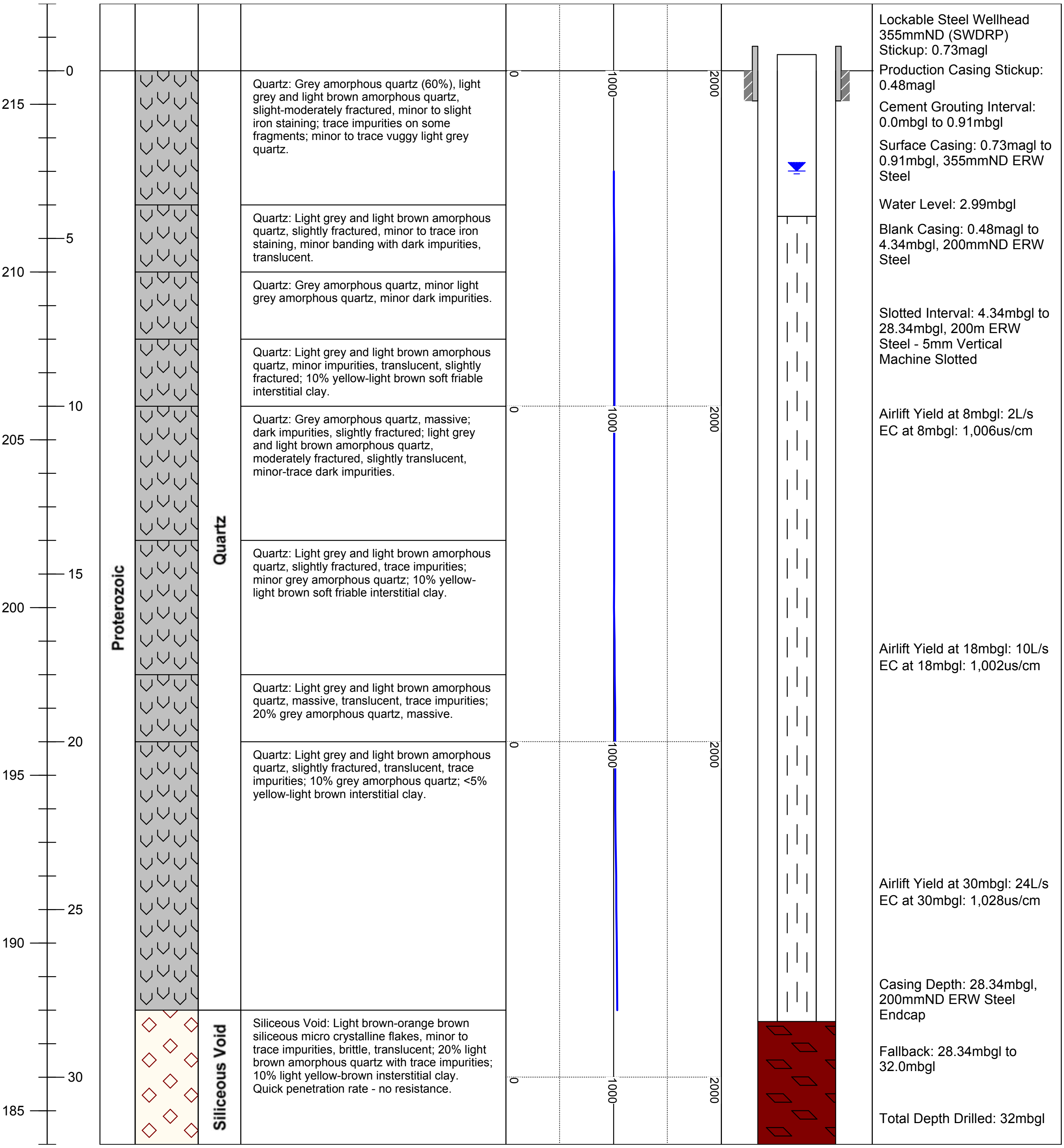
Commenced: 19/10/11
Completed: 21/10/11
Drilled: Austral Drilling
Logged By: Z.Scott

Method: Rotary Air Percussion
Fluid: N/A
Bit Record: 12" Hammer
Hole Purpose: Production Bore

Site: Moora Quartz Mine
East (MGA): 407526mE
North (MGA): 66236162mN
SRP RL: 216mAHD

Static Water Level: 3.72mbtoc
Date: 21/10/11

Elevation (mAHD)	Depth (mbgl)	Geology	Graphic Log	Strati-graphy	Lithological Description	EC Post-Purge (uS/cm)	Well Completion Diagram	Well Completion Notes



Quartz: Grey amorphous quartz (60%), light grey and light brown amorphous quartz, slight-moderately fractured, minor to slight iron staining; trace impurities on some fragments; minor to trace vuggy light grey quartz.

Quartz: Light grey and light brown amorphous quartz, slightly fractured, minor to trace iron staining, minor banding with dark impurities, translucent.

Quartz: Grey amorphous quartz, minor light grey amorphous quartz, minor dark impurities.

Quartz: Light grey and light brown amorphous quartz, minor impurities, translucent, slightly fractured; 10% yellow-light brown soft friable interstitial clay.

Quartz: Grey amorphous quartz, massive; dark impurities, slightly fractured; light grey and light brown amorphous quartz, moderately fractured, slightly translucent, minor-trace dark impurities.

Quartz: Light grey and light brown amorphous quartz, slightly fractured, trace impurities; minor grey amorphous quartz; 10% yellow-light brown soft friable interstitial clay.

Quartz: Light grey and light brown amorphous quartz, massive, translucent, trace impurities; 20% grey amorphous quartz, massive.

Quartz: Light grey and light brown amorphous quartz, slightly fractured, trace impurities; 10% grey amorphous quartz; <5% yellow-light brown interstitial clay.

Siliceous Void: Light brown-orange brown siliceous micro crystalline flakes, minor to trace impurities, brittle, translucent; 20% light brown amorphous quartz with trace impurities; 10% light yellow-brown insterstitial clay. Quick penetration rate - no resistance.

Lockable Steel Wellhead 355mmND (SWDRP) Stickup: 0.73magl

Production Casing Stickup: 0.48magl

Cement Grouting Interval: 0.0mbgl to 0.91mbgl

Surface Casing: 0.73magl to 0.91mbgl, 355mmND ERW Steel

Water Level: 2.99mbgl

Blank Casing: 0.48magl to 4.34mbgl, 200mmND ERW Steel

Slotted Interval: 4.34mbgl to 28.34mbgl, 200m ERW Steel - 5mm Vertical Machine Slotted

Airlift Yield at 8mbgl: 2L/s
EC at 8mbgl: 1,006us/cm

Airlift Yield at 18mbgl: 10L/s
EC at 18mbgl: 1,002us/cm

Airlift Yield at 30mbgl: 24L/s
EC at 30mbgl: 1,028us/cm

Casing Depth: 28.34mbgl, 200mmND ERW Steel Endcap

Fallback: 28.34mbgl to 32.0mbgl

Total Depth Drilled: 32mbgl

File Ref: E0201-02 Well No: BH2 Sheet 1 of 1

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52B Mornington Parkway
ELLENBROOK, WA, 6069
Phone: (08) 6296 7760
Fax: (08) 6296 7762
www.saprolite.com.au

COMPOSITE WELL LOG

Bore No: MB01

Client: Simcoa Operations Pty Ltd

Operation: Phase 2 Hydrogeological Investigations

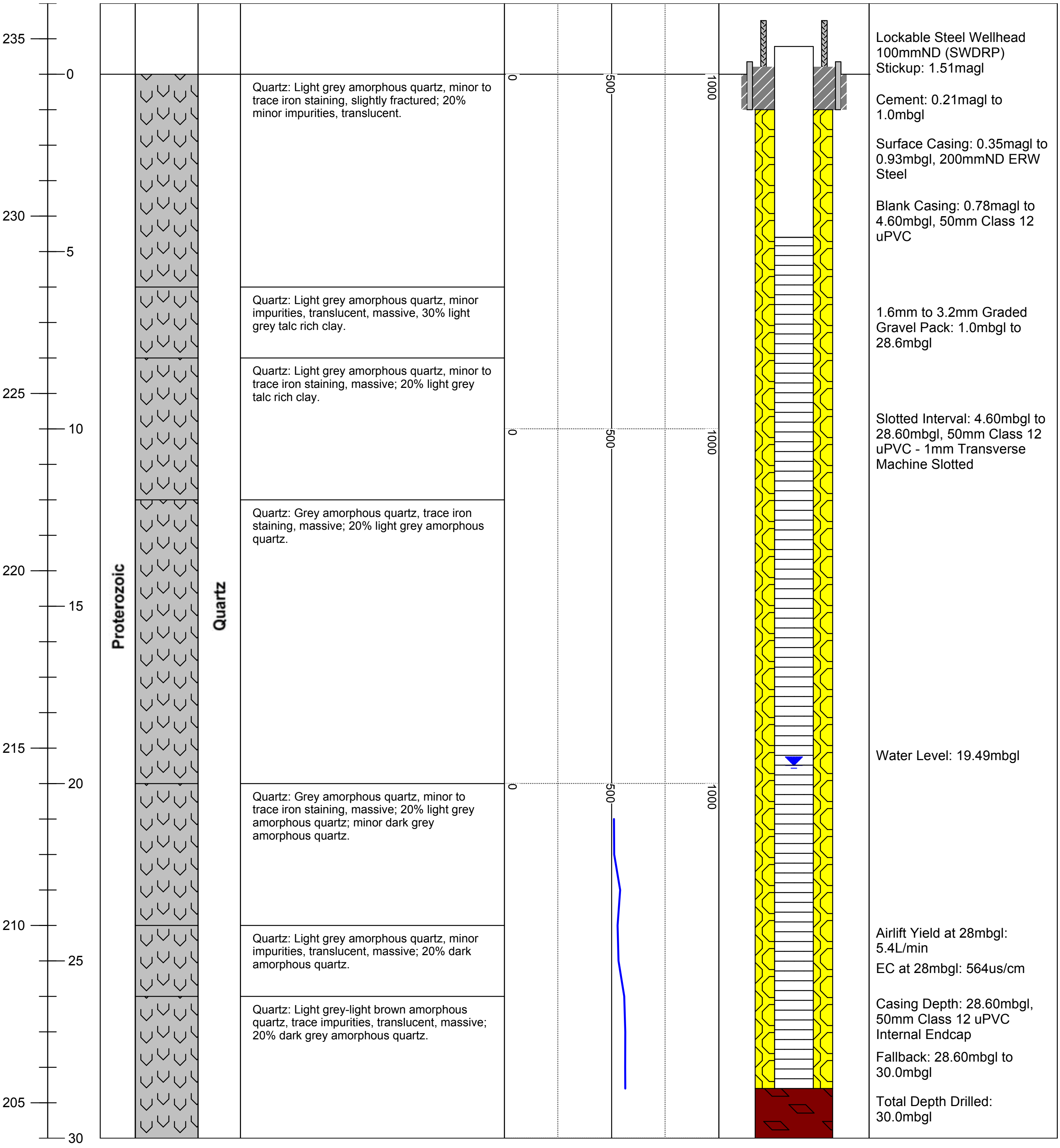
Commenced: 12/10/11
Completed: 14/10/11
Drilled: Austral Drilling
Logged By: Z.Scott

Method: Rotary Air Percussion
Fluid: N/A
Bit Record: 6" Hammer
Hole Purpose: Monitor Bore

Site: Moora Quartz Mine
East (MGA): 407477mE
North (MGA): 6623674mN
SRP RL: 234mAHD

Static Water Level: 21.00mbtoc
Date: 18/10/11

Elevation (mAHD)	Depth (mbgl)	Geology	Graphic Log	Strati-graphy	Lithological Description	EC Post-Purge (uS/cm)	Well Completion Diagram	Well Completion Notes



Quartz: Light grey amorphous quartz, minor to trace iron staining, slightly fractured; 20% minor impurities, translucent.

Quartz: Light grey amorphous quartz, minor impurities, translucent, massive, 30% light grey talc rich clay.

Quartz: Light grey amorphous quartz, minor to trace iron staining, massive; 20% light grey talc rich clay.

Quartz: Grey amorphous quartz, trace iron staining, massive; 20% light grey amorphous quartz.

Quartz: Grey amorphous quartz, minor to trace iron staining, massive; 20% light grey amorphous quartz; minor dark grey amorphous quartz.

Quartz: Light grey amorphous quartz, minor impurities, translucent, massive; 20% dark amorphous quartz.

Quartz: Light grey-light brown amorphous quartz, trace impurities, translucent, massive; 20% dark grey amorphous quartz.

Lockable Steel Wellhead 100mmND (SWDRP) Stickup: 1.51magl

Cement: 0.21magl to 1.0mbgl

Surface Casing: 0.35magl to 0.93mbgl, 200mmND ERW Steel

Blank Casing: 0.78magl to 4.60mbgl, 50mm Class 12 uPVC

1.6mm to 3.2mm Graded Gravel Pack: 1.0mbgl to 28.6mbgl

Slotted Interval: 4.60mbgl to 28.60mbgl, 50mm Class 12 uPVC - 1mm Transverse Machine Slotted

Water Level: 19.49mbgl

Airlift Yield at 28mbgl: 5.4L/min

EC at 28mbgl: 564us/cm

Casing Depth: 28.60mbgl, 50mm Class 12 uPVC Internal Endcap

Fallback: 28.60mbgl to 30.0mbgl

Total Depth Drilled: 30.0mbgl

SAPROLITE ENVIRONMENTAL
52B Mornington Parkway
ELLENBROOK, WA, 6069
Phone: (08) 6296 7760
Fax: (08) 6296 7762
www.saprolite.com.au

COMPOSITE WELL LOG

Bore No: MB02

Client: Simcoa Operations Pty Ltd

Operation: Phase 2 Hydrogeological Investigations

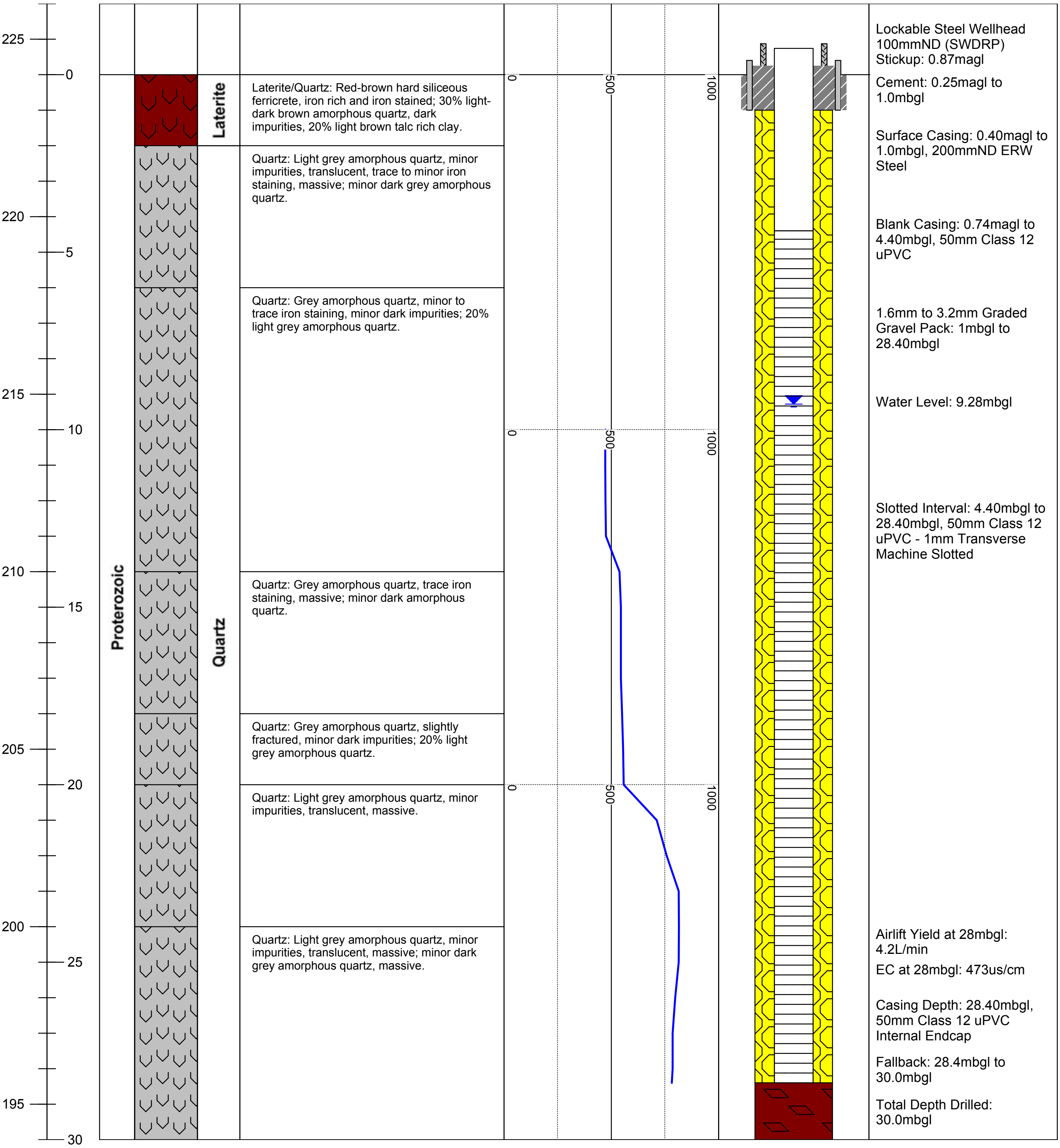
Commenced: 15/10/11
Completed: 15/10/11
Drilled: Austral Drilling
Logged By: Z.Scott

Method: Rotary Air Percussion
Fluid: N/A
Bit Record: 6" Hammer
Hole Purpose: Monitor Bore

Site: Moora Quartz Mine
East (MGA): 407446mE
North (MGA): 66239369mN
SRP RL: 224mAHD

Static Water Level: 10.15mbtoc
Date: 18/10/11

Elevation (mAHD)	**Depth** (mbgl)	**Geology**	**Graphic Log**	**Strati-graphy**	**Lithological Description**	**EC Post-Purge** (uS/cm)	**Well Completion** Diagram	Notes



Laterite/Quartz: Red-brown hard siliceous ferricrete, iron rich and iron stained; 30% light-dark brown amorphous quartz, dark impurities, 20% light brown talc rich clay.

Quartz: Light grey amorphous quartz, minor impurities, translucent, trace to minor iron staining, massive; minor dark grey amorphous quartz.

Quartz: Grey amorphous quartz, minor to trace iron staining, minor dark impurities; 20% light grey amorphous quartz.

Quartz: Grey amorphous quartz, trace iron staining, massive; minor dark amorphous quartz.

Quartz: Grey amorphous quartz, slightly fractured, minor dark impurities; 20% light grey amorphous quartz.

Quartz: Light grey amorphous quartz, minor impurities, translucent, massive.

Quartz: Light grey amorphous quartz, minor impurities, translucent, massive; minor dark grey amorphous quartz, massive.

Lockable Steel Wellhead 100mmND (SWDRP) Stickup: 0.87magl

Cement: 0.25magl to 1.0mbgl

Surface Casing: 0.40magl to 1.0mbgl, 200mmND ERW Steel

Blank Casing: 0.74magl to 4.40mbgl, 50mm Class 12 uPVC

1.6mm to 3.2mm Graded Gravel Pack: 1mbgl to 28.40mbgl

Water Level: 9.28mbgl

Slotted Interval: 4.40mbgl to 28.40mbgl, 50mm Class 12 uPVC - 1mm Transverse Machine Slotted

Airlift Yield at 28mbgl: 4.2L/min

EC at 28mbgl: 473us/cm

Casing Depth: 28.40mbgl, 50mm Class 12 uPVC Internal Endcap

Fallback: 28.4mbgl to 30.0mbgl

Total Depth Drilled: 30.0mbgl

SAPROLITE ENVIRONMENTAL

52B Mornington Parkway
ELLENBROOK, WA, 6069
Phone: (08) 6296 7760
Fax: (08) 6296 7762
www.saprolite.com.au

COMPOSITE WELL LOG

Bore No: MB03

Client: Simcoa Operations Pty Ltd
Operation: Phase 2 Hydrogeological Investigations

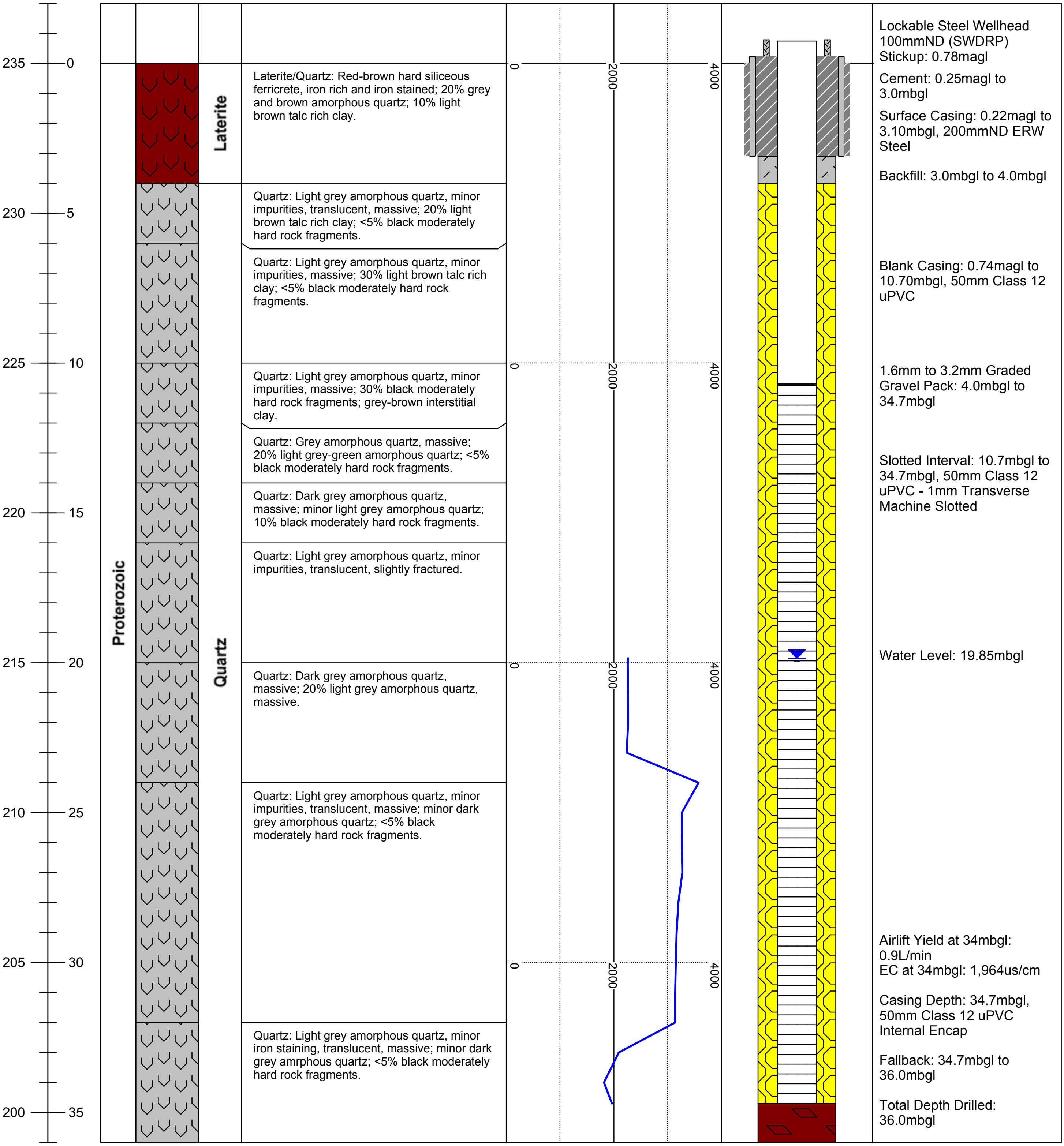
Commenced: 16/10/11
Completed: 17/10/11
Drilled: Austral Drilling
Logged By: Z.Scott

Method: Rotary Air Percussion
Fluid: N/A
Bit Record: 6" Hammer
Hole Purpose: Monitor Bore

Site: Moora Quartz Mine
East (MGA): 407469mE
North (MGA): 6624188mN
SRP RL: 235mAHD

Static Water Level: 20.63mbtoc
Date: 21/10/11

Elevation (mAHD)	Depth (mbgl)	Geology	Graphic Log	Strati-graphy	Lithological Description	EC Post-Purge (uS/cm)	Well Completion Diagram	Well Completion Notes



Laterite/Quartz: Red-brown hard siliceous ferricrete, iron rich and iron stained; 20% grey and brown amorphous quartz; 10% light brown talc rich clay.

Quartz: Light grey amorphous quartz, minor impurities, translucent, massive; 20% light brown talc rich clay; <5% black moderately hard rock fragments.

Quartz: Light grey amorphous quartz, minor impurities, massive; 30% light brown talc rich clay; <5% black moderately hard rock fragments.

Quartz: Light grey amorphous quartz, minor impurities, massive; 30% black moderately hard rock fragments; grey-brown interstitial clay.

Quartz: Grey amorphous quartz, massive; 20% light grey-green amorphous quartz; <5% black moderately hard rock fragments.

Quartz: Dark grey amorphous quartz, massive; minor light grey amorphous quartz; 10% black moderately hard rock fragments.

Quartz: Light grey amorphous quartz, minor impurities, translucent, slightly fractured.

Quartz: Dark grey amorphous quartz, massive; 20% light grey amorphous quartz, massive.

Quartz: Light grey amorphous quartz, minor impurities, translucent, massive; minor dark grey amorphous quartz; <5% black moderately hard rock fragments.

Quartz: Light grey amorphous quartz, minor iron staining, translucent, massive; minor dark grey amrphous quartz; <5% black moderately hard rock fragments.

Lockable Steel Wellhead 100mmND (SWDRP)
Stickup: 0.78magl

Cement: 0.25magl to 3.0mbgl

Surface Casing: 0.22magl to 3.10mbgl, 200mmND ERW Steel

Backfill: 3.0mbgl to 4.0mbgl

Blank Casing: 0.74magl to 10.70mbgl, 50mm Class 12 uPVC

1.6mm to 3.2mm Graded Gravel Pack: 4.0mbgl to 34.7mbgl

Slotted Interval: 10.7mbgl to 34.7mbgl, 50mm Class 12 uPVC - 1mm Transverse Machine Slotted

Water Level: 19.85mbgl

Airlift Yield at 34mbgl: 0.9L/min
EC at 34mbgl: 1,964us/cm

Casing Depth: 34.7mbgl, 50mm Class 12 uPVC Internal Encap

Fallback: 34.7mbgl to 36.0mbgl

Total Depth Drilled: 36.0mbgl

GHD

Level 10
999 Hay Street
T: 61 8 6222 8222   F: 61 8 6222 8555   E: permail@ghd.com

6137455-68145/https://projects.ghd.com/oc/WesternAustralia1/simcoankiakaapproval/Delivery/Documents/613745506-REP_Geotechnical Desktop Study.docx

Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	S Davidson	P Baker		Nick Houldsworth		13/09/2021

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Appendix F

Materials Characterisation Assessment (GHD 2020c and GHD 2023)

North Kiaka Quartzite Mine

Materials Characterisation Study

Simcoa Operations Pty Ltd

27 July 2023

→ **The Power of Commitment**

Project name	North Kiaka Quartzite Mine
Document title	North Kiaka Quartzite Mine | Materials Characterisation Study
Project number	12518217
File name	12518217 North Kiaka Silica Materials characterisation .docx

Status Code	**Revision**	**Author**	**Reviewer**		**Approved for issue**		
			Name	**Signature**	**Name**	**Signature**	**Date**
	A	Steff Bright	Paul Hamer	Paul	Fionnuala Hannon		

GHD Pty Ltd
999 Hay Street,
Perth, WA 6000, Australia
T 6222 8222

→ The Power of Commitment

Executive Summary

GHD Pty Ltd was engaged by Simcoa Operation Pty Ltd to undertake a waste materials characterisation of the proposed North Kiaka open-pit silica mine, located 15 km north of Moora, WA.

The assessment characterised **waste materials** above the water table to identify potential risks posed by acidic metalliferous drainage (AMD) and hazardous materials, to human health and the environment.

This report is subject to, and must be read in conjunction with, the limitations set out in section 1.4 and the assumptions and qualifications contained throughout the Report.

Due to limited waste rock drill hole samples, the original proposed scope of laboratory analysis was reduced and rationalised to the following analysis:

- Acid neutralising capacity (ANC): 17 samples
- Net acid generation (NAG): 17 samples
- Sulfur speciation: 4 samples
- Tailored metals suite: 1 sample
- Leach testing (major ions, pH, EC, metals): 1 sample
- Asbestos mineral fibres: 6 samples

Although limited wase rock samples were available, the findings herein also draw upon previous waste characterisation studies completed at the Moora Silica mine, located 2.5km to the south of North Kiaka, given the analogous geological conditions (strike/bedding and silica ore body).

Based on the laboratory testing and risk assessment, the following conclusions management requirements are presented to control and monitor the risk to human health and the environment:

Acid Metalliferous Drainage (AMD)

Based on the limited sampling results (herein) and drawing on previous waste characterisation studies at the Moora open pit mine (along geological strike), there is no evidence to indicate that the waste rock, situated above the water table poses a risk to human or environmental health with respect to metals mobilisation under acid conditions. As confirmation, a waste rock management plan should be developed and include follow-up sampling and analysis for AMD during resource drilling/blasting, and/or monitoring of surface and groundwater.

Hazardous materials

The results indicate that asbestos form minerals and radioactivity, inferred from the Moora mine (analogous geological setting), should not pose a risk to human health and are unlikely to require management.

However, exposure to silica dust during mining, stockpiling and transport of ore and waste rock should be managed under a suitable management plan to protect human health from dust inhalation (etc.)

Contents

Table index

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1. Introduction

Simcoa Operations Ltd Pty (Simcoa) engaged GHD Pty Ltd (GHD) to prepare environmental approvals under Part IV and Part V of the *Environmental Protection Act (WA) 1986 (EP Act)* and the *Mining Act (WA) 1978* for the North Kiaka Project (the Project).

As per the EPA's decision (29 July 2022) and subsequent Notice (15 August 2022), the proposed North Kiaka Project will be assessed as a "significant amendment to an existing approved proposal" meaning impacts are required to be assessed in context of both the existing approved proposal and the referred proposal.

Furthermore, prior to commencing mining activities (including clearing and construction) the Project must also be assessed and approved by the Department of Mines, Industry Regulation and Safety (DMIRS) in accordance with the *Mining Act (WA) 1978*.

To ensure the combined mining proposal and mine closure plan contain the requisite information (as per DMIRS guidance), the completion of a waste characterisation assessment (WCA) was recommended. Mining will take place above the water table at North Kiaka and the silica ore will be transferred to the Moora Mine for processing. Waste material will be stored in designated locations on site.

1.1 Project location

Simcoa's operations are 15 km north of the Moora township and approximately 180 km north of Perth in the Wheatbelt region of Western Australia. The proposed North Kiaka Mine is 2.5 km north of the existing Moora mining operations (Figure 1).

1.2 Purpose of this report

The aim of this report is to test and characterise the waste rock in the proposed pit envelope (located above the water table) and develop an understanding of the environmental and human health risks associated with mining, excavating, and storing waste rock material.

1.3 Scope of work

This scope of work provides "screening level" assessment of the waste material (discussed in detail in Section 3) and covers the following:

- Collection of drill spoils from existing / historical exploration drilling completed previously by Simcoa and submission to the laboratory (ALS) for the following analysis:
  - Acid neutralising capacity (ANC)
  - Net acid generation (NAG)
  - Sulfur speciation
  - Total metals
  - Leach testing ALSP and analysis for major ions, pH, EC, metals
  - Asbestos mineral fibres

1.4 Limitations

This report: has been prepared by GHD for Simcoa Operations Pty Ltd and may only be used and relied on by Simcoa Operations Pty Ltd for the purpose agreed between GHD and Simcoa Operations Pty Ltd as set out in section 1.2 of this report.

GHD otherwise disclaims responsibility to any person other than Simcoa Operations Pty Ltd arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report GHD disclaims liability arising from any of the assumptions being incorrect.

If this report is required to be accessible in any other format, this can be provided by GHD upon request and at an additional cost if necessary.

GHD has prepared this report on the basis of information provided by Simcoa and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

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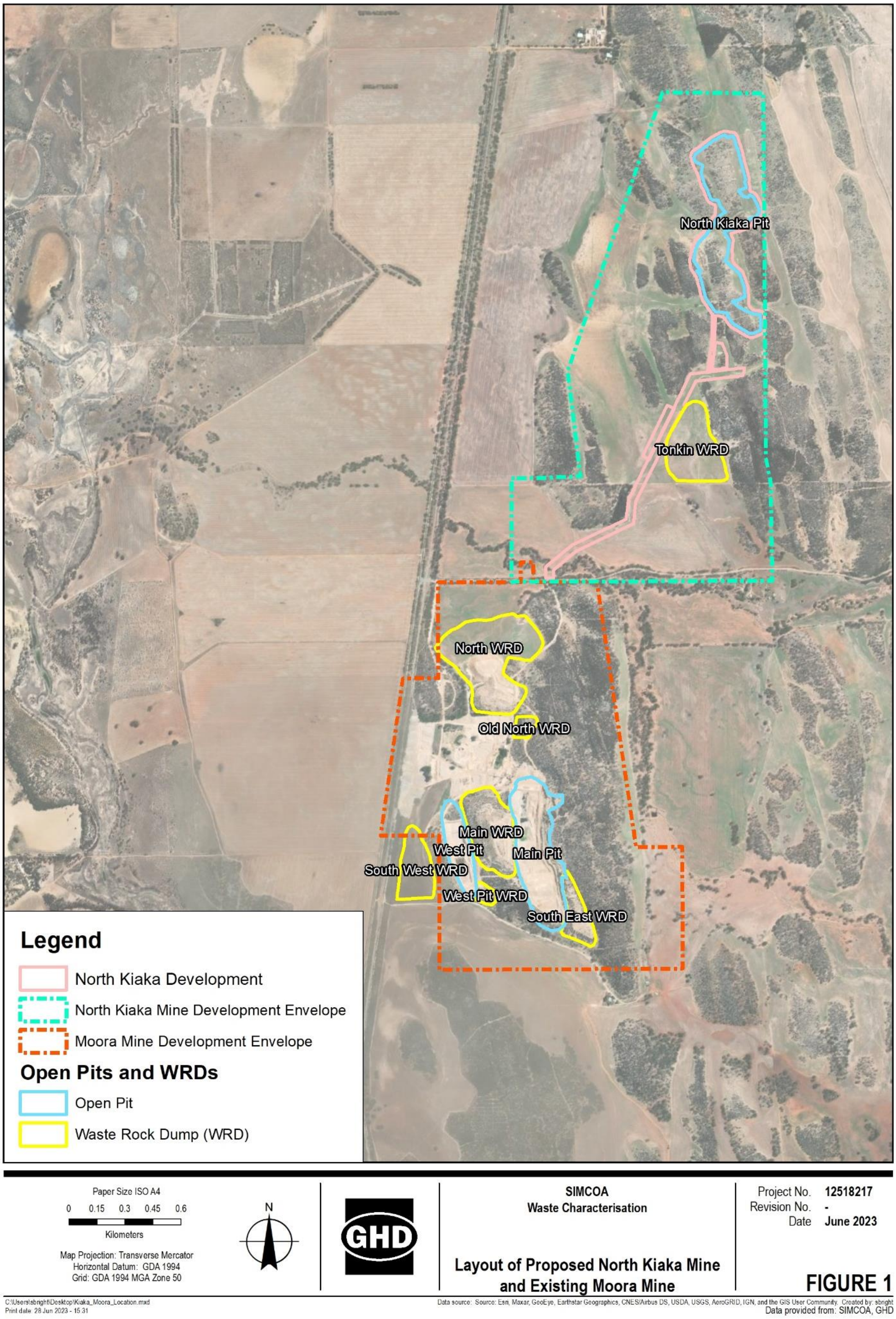

Figure 1 Location of North Kiaka and Moora

2. Site Setting and background

2.1 Previous studies

Previous material characterisation at the North Kiaka and Moora mines is included in the following relevant reports:

- ***GHD Pty Ltd, 2019 Simcoa – North Kiaka Mine Expansion Materials Characterisation Assessment Report (April 2019).***

This desktop assessment found that, although the site geological setting indicates that the risks of intersecting hazardous materials and leaching of metals under acidic conditions was considered low, confirmation is required though laboratory testing of the waste materials.

- ***GHD Pty Ltd, 2019 Simcoa – North Kiaka Mine, Hydrogeological Assessment (March 2023).***

This Report presents an initial understanding of the baseline groundwater levels and quality at the proposed North Kiaka Mine. The works included drilling and installing six groundwater monitoring bores, comprehensive analytical suite for groundwater quality and groundwater level monitoring.

- ***GHD Pty Ltd, 2020 Simcoa - Moora Mine: Waste rock materials characterisation.***

Laboratory testing, conducted on the waste-rock, included a “screening” assessment of the waste rock of samples taken from the floor and wall of the pit (by Simcoa), which were above the water table. Testing included 12 samples for Acid Metalliferous Drainage (AMD), metals leaching, radioactivity screen and asbestos.

The laboratory analysis indicated the following:

- Asbestos form minerals and radioactivity should not pose a risk to human health.
- The waste rock material is deemed not to pose an unacceptable risk through generation of acidic conditions (negligible acid production potential).
- Metals should not leach from the waste rock under acidic conditions at concentrations which may cause an impact to human health and the environment.
- The waste rock unlikely to leach readily dissolvable minerals at concentrations which will cause unacceptable increases in salinity.
- Exposure from silica should be managed to protect human health (dust during mining etc.).

- ***GHD Pty Ltd, 2022 Simcoa – Moora Quartzite Mine, Materials Characterisation Study (June 2022).***

The results indicated that asbestos form minerals and radioactivity levels are sufficiently low and should not pose a risk to human health or require management. An estimated 15-30% of the waste rock bulk from below the water table indicated the potential for acidic leaching at concentrations which could impact the receiving environment and a management plan should be developed.

2.2 Proposed waste rock landform

The North Kiaka development will consist of one mine pit, one waste dump, an easement linking to Moora Mine, internal access tracks, and associated infrastructure. A single waste dump landform is proposed to be located in areas which have been previously cleared of native vegetation, thereby minimising the disturbance to native vegetation.

2.3 Geological setting

The North Kiaka Mine is situated within the Noondine Chert stratigraphic unit, which is part of the Coomberdale Sub-Group of the Moora Group and is Middle Proterozoic in age. This Proterozoic Coomberdale Sub-Group comprises of consolidated and weakly metamorphosed sedimentary sequence of shelf carbonates and clastics (chert ie: Noondine chert (ore body), siltstones, quartzite). In addition, the Sub-Group is intruded by dolerite dykes and is broken up considerably by faulting (GSWA, 1982).

The Noondine chert (ore body) is a silicified, bedded carbonate (siliceous limestone/dolomite). The orebody appears to have been formed by the surface silicification of carbonate rocks. Silicification has been observed to a depth of 75 m. The age of the silicification is uncertain but is probably Tertiary in age (GSWA, 1982).

The chert (ore body) contains primary minerals such as chlorite, pyrite, apatite and minor remnant carbonates (calcite/dolomite). Iron oxides, titanium oxides and clays occur in the chert near the surface and are due to secondary weathering processes (Operations, 2010).

The chert strikes northerly and dips at 20 to 30 degrees to the west. Faulting is common and cavities occur which are usually filled with quartz gravel as collapse breccia (GSWA, 1982).

The geological map (not presented) indicates that the Moora and North Kiaka mining areas share an analogues geological setting, given the north-south strike of the chert bedding, and positioning of the open pits (along the strike).

2.4 Hydrogeological setting

Given the geological and topographical setting, groundwater occurrence at North Kiaka is constrained to fractured rock aquifers associated with the Proterozoic sedimentary units (The Perth Basin and associated sedimentary aquifers are located some 5 km to the east of the Moora quartzite mine (GSWA, 1982)).

There is little hydrogeological exploration at North Kiaka however, considering it is 2.5km north, along strike from the existing Moora mine site with similar geology and topography, it is expected that similar groundwater levels and groundwater quality will occur in North Kiaka.

Groundwater monitoring at the Moora mine (Saprolite Pty Ltd, 2022) indicates standing groundwater levels close to 210 to 215 mAHD (10 to 20 metres below natural ground level). Groundwater flow direction is likely to follow the regional topography and flow in a westerly direction towards the Coonderoo River (and wetlands), located some 2.5 km to the west of the western boundary of the Sites.

3. Methodology

3.1 Sample selection

Sample selection was limited to samples available in storage from previous exploration drilling completed by Simcoa. The saved samples were collected in labelled paper soil bags as 2m composites and stored in cardboard boxes in a designated storage shed. A map of sample locations selected for the WCA is presented in Figure 2

Samples were selected based on the following criteria:

- Samples available in the Simcoa storage shed
- Sampled deemed to be above the water table, taken as less than 12 meters below ground level
- Material characterised as waste; when the assay result exceeds the cut-off grades identified in section 3.3 (see Table 1)
- Within the North Kiaka pit outline
- Representative samples across the North Kiaka pit, where possible
- Representative sample from different geological formations where possible

Individual samples available in storage had a weight of approximately <50g per soil bag. In order to obtain enough sample for laboratory analysis, samples were composited up to 6m vertical depth within the same lithology.

3.2 Results analysis

Samples were selectively chosen for each individual analysis to ensure a representative analytical suite, therefore there was not enough sample to complete multiple analysis on each sample. As a result, the Net Acid Generation (NAG) tests which predicts the generation of acid rock drainage, and Acid Neutralising Capacity (ANC) which measures the overall buffering capacity, have been used as stand-alone tools to determine acid generation. The NAG analysis represents a direct measurement of the net amount of acid generated but does not estimate the neutralisation potential which would be obtained through a parallel analysis of Net Acid Production Potential (NAPP) and Sulfur Speciation. This means that a detailed classification of acid generation cannot be interpreted (Stewart W.A., 2006).

3.3 Definition of waste rock

The economic ore-grade material is based on cut-off grades for concentration of impurities as presented in Table 1. To define and categorise the waste material for the purposes of this report, Simcoa provided a database of drilling with laboratory assay results and GHD assigned waste to samples which exceeded these cut-off grades for one or more analyte.

It should be noted that ore estimates based on a three dimensional ore block model (Snowden, 2012) also include blending of materials with high impurities with materials of low impurities to achieve an average ore-grade volume. It is beyond the scope of this assessment to interrogate the ore-block model to define the distribution of ore and waste material (ore definition is subject to processing and economic considerations).

Table 1 North Kiaka Hills silica resource base cut-off grades according to SIMCOA 2012

Analyte	Cut-off grade*
Fe2O3	0.2
Al2O3	0.40
TiO2	0.05
CaO	na
MgO	na
P2O5	0.01

*Waste rock indicated when exceedance of cut-off grade

3.4 Laboratory analysis

Samples were submitted to ALS, which is a NATA (National Association of Testing Authorities) accredited laboratory, for a tailored analytical assessment.

Samples were submitted for the following analytical suites:

- Acid neutralising capacity (ANC): 17 samples
- Net acid generation (NAG): 17 samples
- Sulfur speciation: 4 samples
- Tailored metals suite: 1 sample
- Leach testing (major ions, pH, EC, metals): 1 sample
- Asbestos mineral fibres: 6 samples

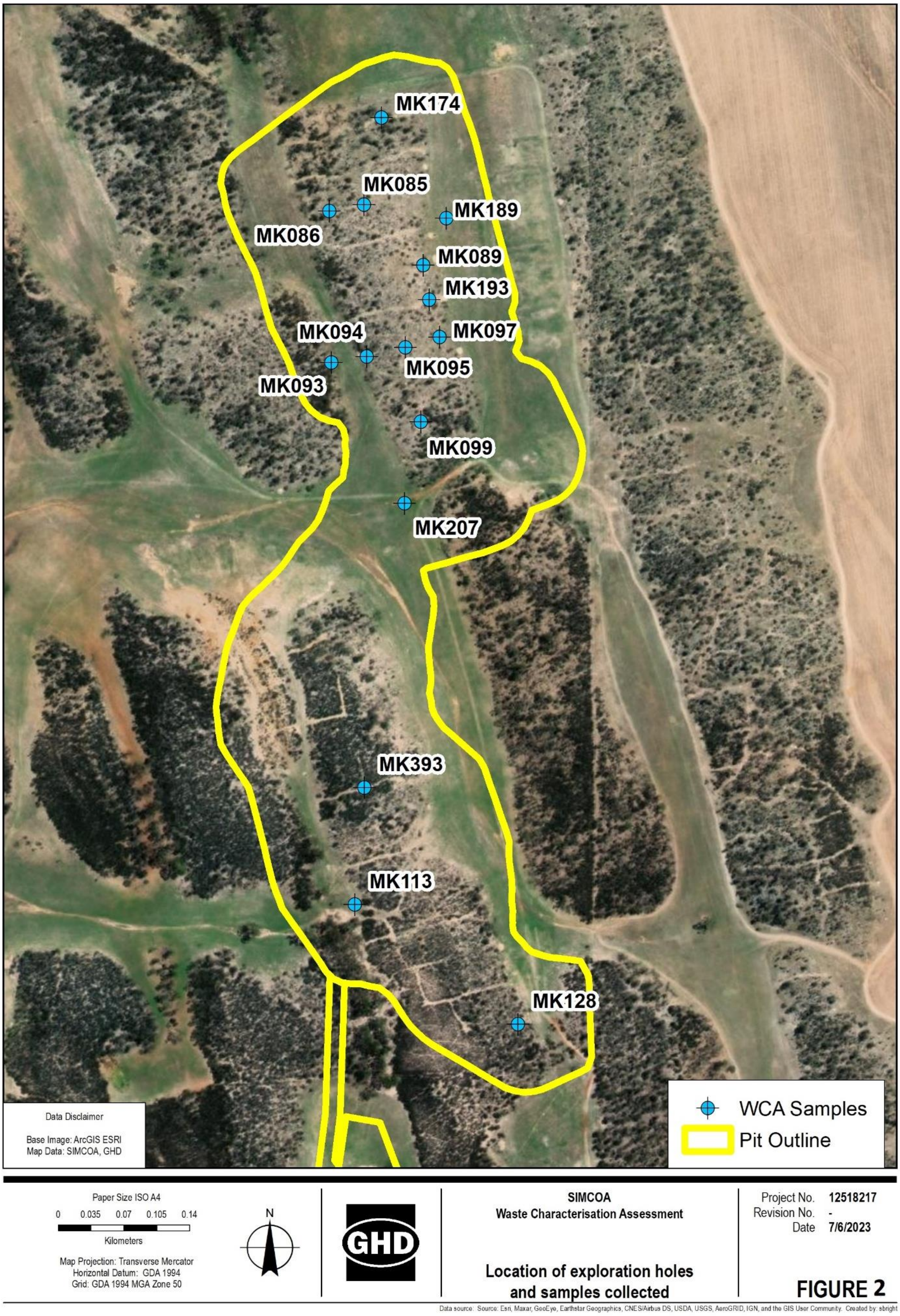

Figure 2 Sample locations for the WCA

4. Laboratory results

The laboratory results are discussed in the following sections and have been summarised and presented in Tables B1 to B4 in Appendix A, as follows:

- Table A1 Asbestos results
- Table A2 Total metals analysis
- Table A3 Leaching analysis results
- Table A4 Acid metalliferous drainage results

The following guidelines have been used to determine exceedances:

- Australian Drinking Water Guideline (ADWG) 2011 Health, V3.7 updated in 2022
- National Environment Protection Measures (NEPM), 2013, Guideline Investigation levels (GILs), Fresh Water
- The Geochemical Abundance Index (GAI). (INAP, 2009)

4.1.1 Hazardous materials:

The asbestos results (Appendix A, Table 1) indicate that fibrous asbestos material were not detected and supports the conclusion that exposure to the waste rock material will not result in an increased human exposure risk.

Although samples were not available for radioactivity analysis (gross beta and alpha), at the Moora Silica mine located 2.5 km to the south, previous radioactivity testing indicated negligible radiological activity (GHD, 2022). Given the similar geological conditions (strike/bedding/silica ore body) negligible concentrations are also anticipated at the North Kiaka mine, which supports the conclusion that exposure to the waste rock material will not result in an increased human radiation exposures risk

4.1.2 Total metals analysis:

The total metals analytical results (Appendix A, Table 2) have been compared to abundance of the elements in the earth's crust, as a screening tool to identify metals which may be relatively elevated and may require management if leached from the waste rock.

Table B2 indicates the metals that are elevated over the typical crustal average (TCA) and, if acidic conditions occur, these are metals that may leach from the geological profile. Any monitoring of groundwater and seepage derived from the mine site should include (but not be limited to) the following metals:

- Bismuth - Laboratory result: 0.04 ppm, TCA: 0.0085 ppm
- Molybdenum - Laboratory result: 2.97 ppm, TCA: 1.2 ppm
- Rhenium - Laboratory result: 0.002 ppm, TCA: 0.0007 ppm
- Antimony - Laboratory result: 0.26 ppm, TCA: 0.2 ppm
- Strontium - Laboratory result: 1.4 ppm, TCA: 0.037 ppm

4.1.3 Metals leaching analysis results:

The leaching results in Appendix A, Table 3 (ALSP under deionised water) indicate that no metals exceeded the drinking water guideline (ADWG 2011). The following metals leached at concentrations that exceed the fresh water guideline (NEPM, 2013):

- Aluminium – Laboratory result: 3.40 mg/L, Guideline: 0.055 mg/L
- Chromium (iii+iv) – Laboratory result:0.005 mg/L, Guideline: 0.001 mg/L
- Zinc - Laboratory result:0.054 mg/L, Guideline: 0.008 mg/L

The leaching of these metals occurs in the laboratory under neutral conditions (e.g: without the mobilisation effects of acidic conditions), and any monitoring of groundwater and seepage (under neutral conditions) derived from the mine site should include these metals.

4.1.4 Acid metalliferous drainage results:

The AMD analytical results, summarised in Appendix A, Table 4, were used to derive and calculate the net acid generation (NAG) and acid neutralising capacity (ANC) of the samples.

An average NAG and ANC is used to calculate maximum Potential Acidity (MPA) and Net Acid Producing Potential (NAPP). A positive NAPP value reflects the production of acid, while a negative value reflects the excess of buffering capacity (acid consumption).

Summary of results are displayed in Table 2 and Table 3. Notable observations are:

- The average NAG (pH 4.5) was <0.1 kg H2SO4/t (below the limit of reporting of 0.1 kg H2SO4/t) indicating negligible net acid generation in all samples.
- The average NAG (pH 7) was 10.2 H2SO4/t indicating little to no acid generation potential
- The average ANC (as H2SO4) was 0.83 kg H2SO4 equiv./t indicating weak acid neutralising capacity
- Sulfide concentrations were below the limit of reporting (<0.01%) rendering them negligible
- The calculated NAPP value is -0.64, the negative number indicating the waste rock material can be classified as non-acid forming (Amira , 2002).

Table 2 Key leachate results

Analyte Group	Unit	Limit of Reporting	Average (sample no.)
NAG (pH 4.5)	kg H2SO4/t	0.1	<0.1 (17)
NAG (pH 7.0)	kg H2SO4/t	0.1	10.2 (17)
ANC as H2SO4	kg H2SO4 equiv./t	0.5	0.83 (17)
Sulfide as S	%	0.01	<0.01 (4)

Table 3 Calculating NAPP results (average)

MPA	ANC	NAPP
0.15	0.8	-0.65

5. Interpretation of risk to human health and the environment

5.1 Understanding of source-pathway-receptor setting

A summary of the potential sources of impact, migration pathways (which may mobilise the sources) and receptors (which may be impacted by the sources) is summarised and discussed in sections 5.1.1 to 5.1.3.

5.1.1 Potential sources of impacts

The materials testing indicates the following with regard to the understanding of potential sources:

Asbestos and Radiological activity: The laboratory results indicate that asbestos fibres were not identified at North Kiaka.

Radiological activity in the Moora mine was identified as negligible (GHD, 2022) and are thus excluded from further consideration as the environmental and human health risks are considered negligible.

Silica: Although not tested, silica dust is deemed as a potential source given that silica has a potential to be mobilised during mining activities which poses a risk to human health through dust inhalation.

Metals leaching from waste rock: Waste rock was characterised to have little to no potential acid production and the potential for leaching of metals from the waste rock landform during rainfall infiltration under acid conditions is considered negligible. Three metals (Al, Cr and Zn) were identified as leaching from waste rock above freshwater aquatic guidelines (ALSP methods) and as a consequence are considered potential sources of impact.

5.1.2 Identified pathways (source mobilisation)

The potential source migration pathways are summarised as follows:

Surface water pathway: Leachate derived from the waste rock will migrate into the subsurface via rainfall infiltration, and/or discharge as seepage at the base of the waste rock dumps; expressed as surface water. Surface water flow will migrate towards and discharge into the creek lines associated with the mine area and migrate downstream to other tributaries.

Groundwater pathway: Where leachate derived from the waste rock (via rainfall infiltration) soaks into the subsurface, leachate will percolate downwards and impact groundwater quality. The impacted groundwater will migrate in the direction of the hydraulic gradient and may also discharge into creek lines and tributaries if hydraulically connected to groundwater.

Air dispersion: dust generation and migration during blasting, excavation, transportation of ore and waste material during mining and closure

5.1.3 Receptors (impacted by sources)

The potential receptors to impacts derived from the sources are as follows:

- The ecology of the creek lines and downgradient tributaries,
- Human exposure during operations and closure (drinking water, inhalation, or dermal contact).
- Stock exposure to drinking water.

Table 4 summarises the understanding of potential risks posed to human health and the environment from the waste-rock, where there is a complete linkage (source-pathway-receptors), and which will require management.

Table 4 Summary of Source Pathway Receptor linkage (environmental and human health risks for waste rock material)

Source	Pathway	Receptor	Potential Risk
Leaching metals from waste-rock above DWER fresh water guidelines (Al, Cr, Zn)	Seepage into the subsurface, mobilisation in the direction of groundwater flow, and potential discharge into receiving water bodies and creeks. Seepage and discharge to surface water environments	Ecology of creeks and receiving water bodies (where groundwater discharges into creek lines - not confirmed to occur through studies)	Yes
Silica (dust/particles generated from ore and waste rock)	Mobilisation into air/wind (generated through mining activities)	Human heath impacted through dust inhalation	Yes

5.2 Summary of risks and management requirements

Based on the scope of sampling, laboratory testing and risk assessment, the following conclusions can be drawn together with management requirements to control and monitor the risk to human health and the environment:

5.2.1 Acid Metalliferous Drainage (AMD)

Based on the limited sampling results (herein) and drawing on previous waste characterisation studies at the Moora open pit mine (along geological strike), there is no evidence to indicate that the waste rock, above the water table poses a risk to human or environmental health with respect to metals mobilisation under acid conditions. However, as confirmation, a waste rock management plan should be developed and include follow-up sampling and analysis for AMD during resource drilling/blasting, and/or monitoring of surface and groundwater.

5.2.2 Metalliferous Drainage (neutral conditions)

The preliminary leaching results (under neutral conditions, ALSP) support that the waste-rock may leach concentrations of some metals above the fresh-water guidelines (Al, Cr, Zn).

However, the leaching methods (ALSP) are recognised as likely over-estimating the leaching concentrations of metals, given that the sample media was supplied pre-prepared/ground rock, considered not reflective of the occurrence of waste-rock in the landform (samples tumbled with di-ionsied water)

Prior to understanding the management requirements, it is recommended that additional waste rock column leach tests, are undertaken with grain sizes reflective of the waste-rock landform (e.g.: gravels/clasts).

5.2.3 Hazardous materials

The results indicate that asbestos form minerals and radioactivity should not pose a risk to human health and are unlikely to require management.

However, exposure to silica dust during mining, stockpiling and transport of ore and waste rock should be managed under a suitable management plan to protect human health from dust inhalation (etc.)

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Appendix A

Laboratory summary results tables

Appendix A
Table 1
Asbestos Analytical Results

			Hole ID	MK086	MK089	MK093	MK113	MK128	MK207
			Depth (m)	6 - 8	6 - 8	10 - 12	4 - 6	8 - 10	4 - 6
		Unit	EQL						
Asbestos									
	Asbestos Fibres (g)	**g**	**0.1**	0	0	0	0	0	0
	Asbestos (Trace)	**Fibres**	**5**	0	0	0	0	0	0
	Asbestos Type	**-**		1	1	1	1	1	1
	weight of sample	**g**	**0.01**	57.1	70.6	77.4	44.9	47.6	73.1
	APPROVED IDENTIFIER:	**-**		1	1	1	1	1	1
	Organic Fibre	**g/kg**		0	0	0	0	0	0
	Synthetic Mineral Fibre	**g/kg**		0	0	0	0	0	0
	Description	**-**		1	1	1	1	1	1

		Unit
Asbestos		
	Asbestos Fibres (g)	**g**
	Asbestos (Trace)	**Fibres**
	Asbestos Type	**-**
	weight of sample	**g**
	APPROVED IDENTIFIER:	**-**
	Organic Fibre	**g/kg**
	Synthetic Mineral Fibre	**g/kg**
	Description	**-**

Appendix A

Table 2

Total Metals Analytical Results

Hole ID: MK095_6-8, 8-10 & 10-12

Sample ID: MK095_6-12

Material Classification: Waste Rock

Analyte	Abundance of elements in the earth's crust	Units	Value
Au	0.004	ppm	0.002
Ag	0.075	ppm	<0.01
Al	8.23	%	0.49
As	1.8	ppm	1.6
Ba	425	ppm	10
Be	2.8	ppm	0.08
Bi	0.0085	ppm	0.04
Ca	4.15	%	0.04
Cd	0.15	ppm	<0.02
Ce	66.5	ppm	1.9
Co	25	ppm	1.1
Cr	102	ppm	32
Cs	3	ppm	0.17
Cu	60	ppm	2.6
F	585	ppm	140
Fe	5.63	%	0.55
Ga	19	ppm	1.38
Ge	1.5	ppm	<0.05
Hf	3	ppm	0.2
Hg	0.085	ppm	0.029
In	0.25	ppm	0.016
K	2.09	%	0.04
La	39	ppm	0.8
Li	20	ppm	1.6
Mg	-	%	0.03
Mn	950	ppm	34
Mo	1.2	ppm	2.97
Na	2.36	%	0.01
Nb	20	ppm	0.8
Ni	84	ppm	3.3
P	1050	ppm	20
Pb	14	ppm	2.4
Rb	90	ppm	2.7
Re	0.0007	ppm	0.002
S	0.035	%	0.01
Sb	0.2	ppm	0.26
Sc	22	ppm	0.4
Se	0.05	ppm	<1*
Sn	2.3	ppm	2.3
Sr	0.037	ppm	1.4
Ta	2	ppm	0.05
Te	0.001	ppm	<0.05*
Th	9.6	ppm	0.85
Ti	0.56	%	0.026
Tl	0.85	ppm	0.1
U	2.7	ppm	0.2
V	120	ppm	10
W	1.25	ppm	0.3
Y	33	ppm	0.5
Zn	70	ppm	3
Zr	165	ppm	5.5

* The ME-ICP89 method was used for an analysis whose limit of reporting for Se and Te was 1 and 0.05, respectively.

Appendix A
Table 3
Leachate Metals Analytical Results

				Location Code	MK095	MK099	MK113	MK174	MK189
				Depth	6 - 12	4 - 10	6 - 12	2 - 8	2 - 8
	Unit	EQL	ADWG 2011 Health (leachable; v3.7 updated 2022)	NEPM 2013 Table 1C GILs, Fresh Waters (Leached)					
Major Ions									
Calcium	mg/L	1			<1	-	-	-	-
Magnesium	mg/L	1			<1	-	-	-	-
Potassium	mg/L	1			<1	-	-	-	-
Sodium	mg/L	1			2	-	-	-	-
Chloride	mg/L	1			1	-	-	-	-
Sulfate	mg/kg	100			-	<100	<100	<100	<100
Sulfate (filtered)	mg/L	1	500		2	-	-	-	-
Metals									
Niobium	mg/L	0.001			<0.001	-	-	-	-
Rhenium	mg/L	0.001			<0.001	-	-	-	-
Tantalum	mg/L	0.001			<0.001	-	-	-	-
Aluminium	mg/L	0.01		0.055	3.40	-	-	-	-
Antimony	mg/L	0.001	0.003		<0.001	-	-	-	-
Arsenic	mg/L	0.001	0.01		<0.001	-	-	-	-
Barium	mg/L	0.001	2		0.177	-	-	-	-
Beryllium	mg/L	0.001	0.06		<0.001	-	-	-	-
Boron	mg/L	0.05	4	0.37[#1]	0.08	-	-	-	-
Cadmium	mg/L	0.0001	0.002	0.0002[#2]	0.0002	-	-	-	-
Cerium	mg/L	0.001			0.002	-	-	-	-
Caesium	mg/L	0.001			<0.001	-	-	-	-
Chromium (III+VI)	mg/L	0.001		0.001[#1]	0.005	-	-	-	-
Cobalt	mg/L	0.001			<0.001	-	-	-	-
Copper	mg/L	0.001	2	0.0014[#2]	<0.001	-	-	-	-
Gallium	mg/L	0.001			<0.001	-	-	-	-
Germanium	mg/L	0.001			<0.001	-	-	-	-
Gold	mg/L	0.001			<0.001	-	-	-	-
Hafnium	mg/L	0.01			<0.01	-	-	-	-
Iron	mg/L	0.05			1.91	-	-	-	-
Lanthanum	mg/L	0.001	0.002		<0.001	-	-	-	-
Lead	mg/L	0.001	0.01	0.0034[#2]	0.002	-	-	-	-
Lithium	mg/L	0.001			0.002	-	-	-	-
Manganese	mg/L	0.001	0.5	1.9[#1]	<0.001	-	-	-	-
Mercury	mg/L	0.0001	0.001	0.00006[#3]	<0.0001	-	-	-	-
Molybdenum	mg/L	0.001	0.05		<0.001	-	-	-	-
Nickel	mg/L	0.001	0.02	0.011[#2]	<0.001	-	-	-	-
Rubidium	mg/L	0.001			<0.001	-	-	-	-
Strontium	mg/L	0.001			0.008	-	-	-	-
Selenium	mg/L	0.01	0.01	0.005[#3]	<0.01	-	-	-	-
tellurium	mg/L	0.005			<0.005	-	-	-	-
Silver	mg/L	0.001	0.1	0.00005	<0.001	-	-	-	-
Tungsten	mg/L	0.001			<0.001	-	-	-	-
Thorium	mg/L	0.001			0.002	-	-	-	-
Titanium	mg/L	0.01			0.02	-	-	-	-
Uranium	mg/L	0.001	0.02		<0.001	-	-	-	-
Tin	mg/L	0.001			<0.001	-	-	-	-
Vanadium	mg/L	0.01			<0.01	-	-	-	-
Yttrium	mg/L	0.001			<0.001	-	-	-	-
Zirconium	mg/L	0.005			<0.005	-	-	-	-
Zinc	mg/L	0.005		0.008[#2]	0.054	-	-	-	-

Comments
#1 Figure may not protect key species from chronic toxicity, refer to ANZECC & ARMCANZ (2000) for further guidance.
#2 Values calculated using hardness of 30 mg/L CaCO3. Refer ANZECC & ARMCANZ (2000) for site specific hardness guidance
#3 Chemical for which possible bioaccumulation and secondary poisoning effects should be considered, refer to ANZECC & ARMCANZ (2000) for further guidance.

Environmental Standards
National Health and Medical Research Council, January 2022, ADWG 2011 Health (leachable; v3.7 updated 2022)

Appendix A
Table 4
Acid Metaliferous Drainage Results

Hole ID			MK085	MK086		MK089				MK093				MK094	MK095	MK097	MK099	MK113				MK128		MK174		MK189	MK193	MK207		MK393
Depth (m)			8 - 10	4 - 6	6 - 8	2 - 4	4 - 6	6 - 8	8 - 10	4 - 6	6 - 8	8 - 10	10 - 12	8 - 10	6 - 12	4 - 6	4 - 10	0 - 2	2 - 4	4 - 6	6 - 12	8 - 10	10 - 12	0 - 2	2 - 8	2 - 8	2 - 4	2 - 4	4 - 6	4 - 6
	Unit	EQL																												
Inorganics																														
pH (Lab)	**pH units**	**0.01**	-	-	-	-	-	-	-	-	-	-	-	-	6.73	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Electrical conductivity (lab)	**µS/cm**	**1**	-	-	-	-	-	-	-	-	-	-	-	-	21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ASS - pH																														
pH-OX	**pH units**	**0.1**	5.2	5.3	-	5.3	5.4	-	5.4	5.4	5.4	5.1	-	5.5	-	5.6	-	5.5	5.7	-	-	-	5.3	5.4	-	-	5.8	5.7	-	5.1
ASS - ANC																														
Acid Neutralising Capacity	**% CaCO3**	**0.1**	<0.1	<0.1	-	0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	-	<0.1	-	<0.1	-	<0.1	<0.1	-	-	-	<0.1	<0.1	-	-	<0.1	<0.1	-	<0.1
ANC as H2SO4	**kg H2SO4/t**	**0.5**	0.6	1.0	-	1.2	<0.5	-	<0.5	<0.5	<0.5	<0.5	-	0.6	-	0.7	-	1.0	0.7	-	-	-	1.0	0.8	-	-	<0.5	<0.5	-	0.7
Fizz Rating	**Fizz Unit**	**0**	0	0	-	0	0	-	0	0	0	0	-	0	-	0	-	0	0	-	-	-	0	0	-	-	0	0	-	0
Minor Ions																														
Sulfide as S	**%**	**0.01**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.01	-	-	-	<0.01	-	-	-	<0.01	<0.01	-	-	-	-
Sulfur as S (%)	**%**	**0.01**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.01	-	-	-	<0.01	-	-	-	<0.01	<0.01	-	-	-	-
Net Acid Generation																														
NAG (pH 4.5)	**kg H2SO4/t**	**0.1**	<0.1	<0.1	-	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	-	<0.1	-	<0.1	-	<0.1	<0.1	-	-	-	<0.1	<0.1	-	-	<0.1	<0.1	-	<0.1
NAG (pH 7.0)	**kg H2SO4/t**	**0.1**	12.0	10.8	-	12.2	7.6	-	8.8	9.8	10.1	11.8	-	10.3	-	10.8	-	9.0	8.6	-	-	-	13.3	12.2	-	-	8.8	8.5	-	8.5

Appendix B

Laboratory Certificates of analysis

CERTIFICATE OF ANALYSIS

Work Order : **EP2305573**
Client : **GHD PTY LTD**
Contact : Steff Bright
Address : 999 HAY STREET
PERTH WA, AUSTRALIA 6000
Telephone : ----
Project : 12518217
Order number : 12518217/036
C-O-C number : ----
Sampler : SIMCOA
Site : ----
Quote number : EP/174/22
No. of samples received : 22
No. of samples analysed : 6

Page : 1 of 4
Laboratory : Environmental Division Perth
Contact : Peter Ravlic
Address : 26 Rigali Way Wangara WA Australia 6065
Telephone : +6138549 9645
Date Samples Received : 27-Apr-2023 12:00
Date Analysis Commenced : 05-May-2023
Issue Date : 05-May-2023 12:16

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted, unless the sampling was conducted by ALS. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Descriptive Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Alana Smylie	Team Leader - Asbestos	Newcastle - Asbestos, Mayfield West, NSW

General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contract for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- Asbestos conducted by ALS Newcastle, NATA accreditation no. 825, site no 1656.
- EA200 'Am' Amosite (brown asbestos)
- EA200 'Cr' Crocidolite (blue asbestos)
- EA200 'Trace' - Asbestos fibres ("Free Fibres") detected by trace analysis per AS4964. The result can be interpreted that the sample contains detectable 'respirable' asbestos fibres
- EA200: Asbestos Identification Samples were analysed by Polarised Light Microscopy including dispersion staining.
- EA200 Legend
- EA200 'Ch' Chrysotile (white asbestos)
- EA200: 'UMF' Unknown Mineral Fibres. "-" indicates fibres detected may or may not be asbestos fibres. Confirmation by alternative techniques is recommended.
- EA200: For samples larger than 30g, the <2mm fraction may be sub-sampled prior to trace analysis as outlined in ISO23909:2008(E) Sect 6.3.2-2
- EA200: 'Yes' - Asbestos detected by polarised light microscopy including dispersion staining.
- EA200: 'No*' - No asbestos found, at the reporting limit of 0.1g/kg, by polarised light microscopy including dispersion staining. Asbestos material was detected and positively identified at concentrations estimated to be below 0.1g/kg.
- EA200: 'No' - No asbestos found at the reporting limit 0.1g/kg, by polarised light microscopy including dispersion staining.

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	MK128_10	MK113_6	MK086_8	MK089_8	MK093_12
			Sampling date / time	14-Apr-2023 00:00	14-Apr-2023 00:00	14-Apr-2023 00:00	14-Apr-2023 00:00	14-Apr-2023 00:00
Compound	CAS Number	LOR	Unit	EP2305573-001	EP2305573-005	EP2305573-013	EP2305573-018	EP2305573-020
				Result	Result	Result	Result	Result
EA200: AS 4964 - 2004 Identification of Asbestos in Soils								
Asbestos Detected	1332-21-4	0.1	g/kg	**No**	**No**	**No**	**No**	**No**
Asbestos (Trace)	1332-21-4	5	Fibres	**No**	**No**	**No**	**No**	**No**
Asbestos Type	1332-21-4	-	--	**-**	**-**	**-**	**-**	**-**
Sample weight (dry)	----	0.01	g	**47.6**	**44.9**	**57.1**	**70.6**	**77.4**
APPROVED IDENTIFIER:	----	-	--	**A. SMYLIE**	**A. SMYLIE**	**A. SMYLIE**	**A. SMYLIE**	**A. SMYLIE**
Synthetic Mineral Fibre	----	-	--	**No**	**No**	**No**	**No**	**No**
Organic Fibre	----	-	--	**No**	**No**	**No**	**No**	**No**

Analytical Results

Sub-Matrix: **SOIL**
(Matrix: **SOIL**)

			Sample ID	**MK207_6**	----	----	----	----
			Sampling date / time	14-Apr-2023 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	**EP2305573-022**	--------	--------	--------	--------
				Result	----	----	----	----
EA200: AS 4964 - 2004 Identification of Asbestos in Soils								
Asbestos Detected	1332-21-4	0.1	g/kg	**No**	----	----	----	----
Asbestos (Trace)	1332-21-4	5	Fibres	**No**	----	----	----	----
Asbestos Type	1332-21-4	-	--	**-**	----	----	----	----
Sample weight (dry)	----	0.01	g	**73.1**	----	----	----	----
APPROVED IDENTIFIER:	----	-	--	**A. SMYLIE**	----	----	----	----
Synthetic Mineral Fibre	----	-	--	**No**	----	----	----	----
Organic Fibre	----	-	--	**No**	----	----	----	----

Analytical Results

Descriptive Results

Sub-Matrix: **SOIL**

Method: Compound	Sample ID - Sampling date / time	Analytical Results
EA200: AS 4964 - 2004 Identification of Asbestos in Soils		
EA200: Description	MK128_10 - 14-Apr-2023 00:00	Soil sample.
EA200: Description	MK113_6 - 14-Apr-2023 00:00	Soil sample.
EA200: Description	MK086_8 - 14-Apr-2023 00:00	Soil sample.
EA200: Description	MK089_8 - 14-Apr-2023 00:00	Soil sample.
EA200: Description	MK093_12 - 14-Apr-2023 00:00	Soil sample.
EA200: Description	MK207_6 - 14-Apr-2023 00:00	Soil sample.

Inter-Laboratory Testing

Analysis conducted by ALS Newcastle, NATA accreditation no. 825, site no. 1656 (Chemistry) 9854 (Biology).

(SOIL) EA200: AS 4964 - 2004 Identification of Asbestos in Soils

QUALITY CONTROL REPORT

Work Order	: **EP2305573**	Page	: 1 of 3
Client	: **GHD PTY LTD**	Laboratory	: Environmental Division Perth
Contact	: Steff Bright	Contact	: Peter Ravlic
Address	: 999 HAY STREET PERTH WA, AUSTRALIA 6000	Address	: 26 Rigali Way Wangara WA Australia 6065
Telephone	: ----	Telephone	: +6138549 9645
Project	: 12518217	Date Samples Received	: 27-Apr-2023
Order number	: 12518217/036	Date Analysis Commenced	: 05-May-2023
C-O-C number	: ----	Issue Date	: 05-May-2023
Sampler	: SIMCOA		
Site	: ----		
Quote number	: EP/174/22		
No. of samples received	: 22		
No. of samples analysed	: 6		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted, unless the sampling was conducted by ALS. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Alana Smylie	Team Leader - Asbestos	Newcastle - Asbestos, Mayfield West, NSW

General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis. Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Key :
Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR: 0% - 50%; Result > 20 times LOR: 0% - 20%.

- **No Laboratory Duplicate (DUP) Results are required to be reported.**

Method Blank (MB) and Laboratory Control Sample (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

- **No Method Blank (MB) or Laboratory Control Spike (LCS) Results are required to be reported.**

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

- **No Matrix Spike (MS) or Matrix Spike Duplicate (MSD) Results are required to be reported.**

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: **EP2305573**	Page	: 1 of 4
Client	: **GHD PTY LTD**	Laboratory	: Environmental Division Perth
Contact	: Steff Bright	Telephone	: +6138549 9645
Project	: 12518217	Date Samples Received	: 27-Apr-2023
Site	: ----	Issue Date	: 05-May-2023
Sampler	: SIMCOA	No. of samples received	: 22
Order number	: 12518217/036	No. of samples analysed	: 6

This report is automatically generated by the ALS LIMS through interpretation of the ALS Quality Control Report and several Quality Assurance parameters measured by ALS. This automated reporting highlights any non-conformances, facilitates faster and more accurate data validation and is designed to assist internal expert and external Auditor review. Many components of this report contribute to the overall DQO assessment and reporting for guideline compliance.

Brief method summaries and references are also provided to assist in traceability.

Summary of Outliers

Outliers : Quality Control Samples

This report highlights outliers flagged in the Quality Control (QC) Report.

- **NO Method Blank value outliers occur.**
- **NO Duplicate outliers occur.**
- **NO Laboratory Control outliers occur.**
- **NO Matrix Spike outliers occur.**
- **For all regular sample matrices, NO surrogate recovery outliers occur.**

Outliers : Analysis Holding Time Compliance

- **NO Analysis Holding Time Outliers exist.**

Outliers : Frequency of Quality Control Samples

- **NO Quality Control Sample Frequency Outliers exist.**

Analysis Holding Time Compliance

If samples are identified below as having been analysed or extracted outside of recommended holding times, this should be taken into consideration when interpreting results.

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times (referencing USEPA SW 846, APHA, AS and NEPM) based on the sample container provided. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. A listing of breaches (if any) is provided herein.

Holding time for leachate methods (e.g. TCLP) vary according to the analytes reported. Assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These are: organics 14 days, mercury 28 days & other metals 180 days. A recorded breach does not guarantee a breach for all non-volatile parameters.

Holding times for ***VOC in soils*** vary according to analytes of interest. Vinyl Chloride and Styrene holding time is 7 days; others 14 days. A recorded breach does not guarantee a breach for all VOC analytes and should be verified in case the reported breach is a false positive or Vinyl Chloride and Styrene are not key analytes of interest/concern.

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method	***Sample Date***	*Extraction / Preparation*			*Analysis*		
Container / Client Sample ID(s)		***Date extracted***	*Due for extraction*	*Evaluation*	***Date analysed***	*Due for analysis*	*Evaluation*
EA200: AS 4964 - 2004 Identification of Asbestos in Soils							
Pulp Bag (EA200) MK128_10, MK113_6, MK086_8, MK089_8, MK093_12, MK207_6	**14-Apr-2023**	**----**	----	----	**05-May-2023**	11-Oct-2023	✓

Quality Control Parameter Frequency Compliance

- **No Quality Control data available for this section.**

Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	*Method*	*Matrix*	*Method Descriptions*
Asbestos Identification in Soils	EA200	SOIL	AS 4964 Method for the qualitative identification of asbestos in bulk samples Analysis by Polarised Light Microscopy including dispersion staining

CHAIN OF CUSTODY RECORD
AND ANALYSIS REQUEST

GHD
Level 10, 999 Hay Street
Perth WA 6000

PO Box 3106
Perth WA 6832

Reception Ph: 08 6222 8222

Page 1 of 1

Project ID *(as per ESdat set up; no spaces)* 12518217	**PO Number (to be invoiced)** 12518217/036	Laboratory:	ALS Environmental
Laboratory Quote No. EP/174/22	**Turnaround Time** Standard	Address:	26 Rigali Way, Wangara WA 6065
Project Manager (Invoice) & GHD accounts Bronwyn Neville	**Email Address (Results)** steff.bright@ghd.com, GHD.LabReports@ghd.com paul.hamer@ghd.com	Laboratory Contact:	ALS Environmental

					Container			Analyses								
GHD Sample ID	**Lab Sample ID**	**Date**	**Time**	**Sample Matrix** S-Soil/ SL-Sludge/ W-Water/ A-Air	**Type** B-Bottle/J-Jar/V-Vial/Bag/G-Glass/P-Plastic	**Preservative** Unpreserved/ HCl/ H2SO4/HNO3/Other	**No**	ANC - (EA013)	NAG - (EA011)	Sulfur Speciation - (EK085T)	Sulfur Speciation - (ED042T)	Radioactivity - (EA250)	Asbestos - (EA200)	Metals Solid - (ME-MS61m) & (Au-ICP22) & (ME-ICP89) & (F-IC881)	Metals Leach - (NT-01D & 02) & (EG020W) & (EG035W) & (EA005P) & (EA010P)	**Remarks**
MK128_10	1	14/04/2023		S	Bag	N	1	x	x	x	x	x	x	x	x	
MK128_12	2	14/04/2023		S	Bag	N	1	x	x							
MK113_2	3	14/04/2023		S	Bag	N	1	x	x							
MK113_4	4	14/04/2023		S	Bag	N	1	x	x	x	x			x	x	
MK113_6	5	14/04/2023		S	Bag	N	1	x	x	x	x	x	x	x	x	
MK113_8	6	14/04/2023		S	Bag	N	1	x	x	x	x			x	x	
MK113_10	7	14/04/2023		S	Bag	N	1	x	x							
MK113_12	8	14/04/2023		S	Bag	N	1	x	x							
MK099_6	9	14/04/2023		S	Bag	N	1	x	x							
MK099_8	10	14/04/2023		S	Bag	N	1	x	x							
MK099_10	11	14/04/2023		S	Bag	N	1	x	x							
MK086_6	12	14/04/2023		S	Bag	N	1	x	x	x	x			x	x	
MK086_8	13	14/04/2023		S	Bag	N	1	x	x	x	x	x	x	x	x	
MK095_8	14	14/04/2023		S	Bag	N	1	x	x							
MK095_10	15	14/04/2023		S	Bag	N	1	x	x							
MK095_12	16	14/04/2023		S	Bag	N	1	x	x							
MK089_4	17	14/04/2023		S	Bag	N	1	x	x							
MK085_8	18	14/04/2023		S	Bag	N	1	x	x	x	x	x	x	x	x	
MK093_10	19	14/04/2023		S	Bag	N	1	x	x	x	x			x	x	
MK093_12	20	14/04/2023		S	Bag	N	1	x	x	x	x	x	x	x	x	
MK207_4	21	14/04/2023		S	Bag	N	1	x	x	x	x			x	x	
MK207_6	22	14/04/2023		S	Bag	N	1	x	x	x	x	x	x	x	x	

Sampled by: SIMCOA	Date/Time: UNK	Relinquished by: S.Bright	Date/Time: 14/4/2023
Received by: LS	Date/Time: 27/4 12:00	Relinquished by:	Date/Time:

Environmental Division
Perth
Work Order Reference
EP2305573

Telephone : 61-8-9406 1301

CERTIFICATE OF ANALYSIS

Work Order : **EP2306004**
Amendment : **1**
Client : **GHD PTY LTD**
Contact : Steff Bright
Address : 999 HAY STREET
PERTH WA, AUSTRALIA 6000
Telephone : ----
Project : 12518217
Order number : 12518217/036
C-O-C number : ----
Sampler : SIMCOA
Site : ----
Quote number : EP/174/22
No. of samples received : 38
No. of samples analysed : 22

Page : 1 of 9
Laboratory : Environmental Division Perth
Contact : Peter Ravlic
Address : 26 Rigali Way Wangara WA Australia 6065
Telephone : +6138549 9645
Date Samples Received : 27-Apr-2023 12:00
Date Analysis Commenced : 11-May-2023
Issue Date : 31-May-2023 15:34

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted, unless the sampling was conducted by ALS. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ankit Joshi	Senior Chemist - Inorganics	Sydney Inorganics, Smithfield, NSW
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Canhuang Ke	Inorganics Supervisor	Perth Inorganics, Wangara, WA
Chris Lemaitre	Laboratory Manager (Perth)	Perth Inorganics, Wangara, WA
Daniel Fisher	Inorganics Analyst	Perth ASS, Wangara, WA
Mark Hallas	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Satishkumar Trivedi	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD

General Comments

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Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contract for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- Particular samples have been crushed prior to preparation and analysis as per client request on the Chain of Custody. Please refer to SRN for further details.
- Moisture correction for this workorder has been disabled as samples were dried prior to analysis.
- Amendment (31/05/2023): This report has been amended and re-released as a result of the incorrect matrix selected for the lechate analysis for sample EP2306004_036 [MK095_8-12] which prevented the ESDAT EDD to be be uploaded. All analysis results are as per the previous report.
- ASS: EA013 (ANC) Fizz Rating: 0- None; 1- Slight; 2- Moderate; 3- Strong; 4- Very Strong; 5- Lime.
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

Analytical Results

Sub-Matrix: **DI WATER LEACHATE** (Matrix: **WATER**)			*Sample ID*	**MK095_8-12**	----	----	----	----
			Sampling date / time	05-May-2023 00:00	----	----	----	----
Compound	*CAS Number*	*LOR*	*Unit*	**EP2306004-036**	--------	--------	--------	--------
				Result	----	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**6.73**	----	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**21**	----	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	----	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	----	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**4**	----	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	**4**	----	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**2**	----	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**1**	----	----	----	----
ED093W: Water Leachable Major Cations								
Calcium	7440-70-2	1	mg/L	<1	----	----	----	----
Magnesium	7439-95-4	1	mg/L	<1	----	----	----	----
Sodium	7440-23-5	1	mg/L	**2**	----	----	----	----
Potassium	7440-09-7	1	mg/L	<1	----	----	----	----
EG020W: Water Leachable Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	**3.40**	----	----	----	----
ø **Germanium**	7440-56-4	0.001	mg/L	<0.001	----	----	----	----
Antimony	7440-36-0	0.001	mg/L	<0.001	----	----	----	----
ø **Niobium**	7440-03-1	0.001	mg/L	<0.001	----	----	----	----
Arsenic	7440-38-2	0.001	mg/L	<0.001	----	----	----	----
Beryllium	7440-41-7	0.001	mg/L	<0.001	----	----	----	----
Barium	7440-39-3	0.001	mg/L	**0.177**	----	----	----	----
ø **Rhenium**	7440-15-5	0.001	mg/L	<0.001	----	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	**0.0002**	----	----	----	----
Cerium	7440-45-1	0.001	mg/L	**0.002**	----	----	----	----
Caesium	7440-46-2	0.001	mg/L	<0.001	----	----	----	----
Chromium	7440-47-3	0.001	mg/L	**0.005**	----	----	----	----
Cobalt	7440-48-4	0.001	mg/L	<0.001	----	----	----	----
Copper	7440-50-8	0.001	mg/L	<0.001	----	----	----	----
Gallium	7440-55-3	0.001	mg/L	<0.001	----	----	----	----
Hafnium	7440-58-6	0.01	mg/L	<0.01	----	----	----	----

Analytical Results

Sub-Matrix: **DI WATER LEACHATE**
(Matrix: **WATER**)

			Sample ID	**MK095_8-12**	**----**	**----**	**----**	**----**
			Sampling date / time	05-May-2023 00:00	----	----	----	----
Compound	*CAS Number*	*LOR*	*Unit*	**EP2306004-036**	**--------**	**--------**	**--------**	**--------**
				Result	----	----	----	----
EG020W: Water Leachable Metals by ICP-MS - Continued								
Lanthanum	7439-91-0	0.001	mg/L	<0.001	----	----	----	----
Lead	7439-92-1	0.001	mg/L	**0.002**	----	----	----	----
Lithium	7439-93-2	0.001	mg/L	**0.002**	----	----	----	----
Manganese	7439-96-5	0.001	mg/L	<0.001	----	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	<0.001	----	----	----	----
Nickel	7440-02-0	0.001	mg/L	<0.001	----	----	----	----
Rubidium	7440-17-7	0.001	mg/L	<0.001	----	----	----	----
Selenium	7782-49-2	0.01	mg/L	<0.01	----	----	----	----
Silver	7440-22-4	0.001	mg/L	<0.001	----	----	----	----
Strontium	7440-24-6	0.001	mg/L	**0.008**	----	----	----	----
Tellurium	22541-49-7	0.005	mg/L	<0.005	----	----	----	----
Thorium	7440-29-1	0.001	mg/L	**0.002**	----	----	----	----
Tin	7440-31-5	0.001	mg/L	<0.001	----	----	----	----
Titanium	7440-32-6	0.01	mg/L	**0.02**	----	----	----	----
Uranium	7440-61-1	0.001	mg/L	<0.001	----	----	----	----
Vanadium	7440-62-2	0.01	mg/L	<0.01	----	----	----	----
Yttrium	7440-65-5	0.001	mg/L	<0.001	----	----	----	----
Zinc	7440-66-6	0.005	mg/L	**0.054**	----	----	----	----
Zirconium	7440-67-7	0.005	mg/L	<0.005	----	----	----	----
Boron	7440-42-8	0.05	mg/L	**0.08**	----	----	----	----
Iron	7439-89-6	0.05	mg/L	**1.91**	----	----	----	----
Gold	7440-57-5	0.001	mg/L	<0.001	----	----	----	----
Tungsten	7440-33-7	0.001	mg/L	<0.001	----	----	----	----
Tantalum	7440-25-7	0.001	mg/L	<0.001	----	----	----	----
EG035W: Water Leachable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	----	----	----	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	MK128_12	MK113_2	MK113_4	MK086_6	MK089_4
			Sampling date / time	05-May-2023 00:00	05-May-2023 00:00	05-May-2023 00:00	05-May-2023 00:00	05-May-2023 00:00
Compound	CAS Number	LOR	Unit	EP2306004-001	EP2306004-002	EP2306004-003	EP2306004-010	EP2306004-014
				Result	Result	Result	Result	Result
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	**5.3**	**5.5**	**5.7**	**5.3**	**5.3**
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	<0.1
NAG (pH 7.0)	----	0.1	kg H2SO4/t	**13.3**	**9.0**	**8.6**	**10.8**	**12.2**
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	**1.0**	**1.0**	**0.7**	**1.0**	**1.2**
ANC as CaCO3	----	0.1	% CaCO3	<0.1	<0.1	<0.1	<0.1	**0.1**
Fizz Rating	----	0	Fizz Unit	**0**	**0**	**0**	**0**	**0**

Analytical Results

Sub-Matrix: **SOIL** (Matrix: **SOIL**)			*Sample ID*	**MK089_6**	**MK089_10**	**MK085_10**	**MK093_6**	**MK093_8**
			Sampling date / time	05-May-2023 00:00	05-May-2023 00:00	05-May-2023 00:00	05-May-2023 00:00	05-May-2023 00:00
Compound	*CAS Number*	*LOR*	*Unit*	**EP2306004-015**	**EP2306004-016**	**EP2306004-017**	**EP2306004-018**	**EP2306004-019**
				Result	Result	Result	Result	Result
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	**5.4**	**5.4**	**5.2**	**5.4**	**5.4**
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	<0.1
NAG (pH 7.0)	----	0.1	kg H2SO4/t	**7.6**	**8.8**	**12.0**	**9.8**	**10.1**
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	<0.5	<0.5	**0.6**	<0.5	<0.5
ANC as CaCO3	----	0.1	% CaCO3	<0.1	<0.1	<0.1	<0.1	<0.1
Fizz Rating	----	0	Fizz Unit	**0**	**0**	**0**	**0**	**0**

Analytical Results

Sub-Matrix: **SOIL** (Matrix: **SOIL**)			Sample ID	**MK093_10**	**MK207_4**	**MK174_2**	**MK393_6**	**MK097_6**
			Sampling date / time	05-May-2023 00:00	05-May-2023 00:00	05-May-2023 00:00	05-May-2023 00:00	05-May-2023 00:00
Compound	CAS Number	LOR	Unit	**EP2306004-020**	**EP2306004-021**	**EP2306004-025**	**EP2306004-029**	**EP2306004-030**
				Result	Result	Result	Result	Result
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	**5.1**	**5.7**	**5.4**	**5.1**	**5.6**
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	<0.1
NAG (pH 7.0)	----	0.1	kg H2SO4/t	**11.8**	**8.5**	**12.2**	**8.5**	**10.8**
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	<0.5	<0.5	**0.8**	**0.7**	**0.7**
ANC as CaCO3	----	0.1	% CaCO3	<0.1	<0.1	<0.1	<0.1	<0.1
Fizz Rating	----	0	Fizz Unit	**0**	**0**	**0**	**0**	**0**

Analytical Results

Sub-Matrix: **SOIL** (Matrix: **SOIL**)			*Sample ID*	**MK094_10**	**MK193_4**	**MK113_8-12**	**MK099_6-10**	**MK095_8-12**
			Sampling date / time	05-May-2023 00:00	05-May-2023 00:00	05-May-2023 00:00	05-May-2023 00:00	05-May-2023 00:00
Compound	*CAS Number*	*LOR*	*Unit*	**EP2306004-031**	**EP2306004-032**	**EP2306004-034**	**EP2306004-035**	**EP2306004-036**
				Result	Result	Result	Result	Result
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	**5.5**	**5.8**	----	----	----
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	<0.1	----	----	----
NAG (pH 7.0)	----	0.1	kg H2SO4/t	**10.3**	**8.8**	----	----	----
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	**0.6**	<0.5	----	----	----
ANC as CaCO3	----	0.1	% CaCO3	<0.1	<0.1	----	----	----
Fizz Rating	----	0	Fizz Unit	**0**	**0**	----	----	----
ED040T : Total Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	100	mg/kg	----	----	<100	<100	----
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	----	----	<0.01	<0.01	----
EK085M: Sulfide as S2-								
Sulfide as S	----	0.01	%	----	----	<0.01	<0.01	----
EN60-DI: Bottle Leaching Procedure - Inorganics/Non-Volatile Organics (Glass Vessel)								
Final pH	----	0.1	pH Unit	----	----	----	----	**8.4**

Analytical Results

Sub-Matrix: **SOIL** (Matrix: **SOIL**)			*Sample ID*	**MK189_4-8**	**MK174_4-8**	**----**	**----**	**----**
			Sampling date / time	05-May-2023 00:00	05-May-2023 00:00	----	----	----
Compound	*CAS Number*	*LOR*	*Unit*	**EP2306004-037**	**EP2306004-038**	**--------**	**--------**	**--------**
				Result	Result	----	----	----
ED040T : Total Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	100	mg/kg	<100	<100	**----**	**----**	**----**
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	<0.01	<0.01	**----**	**----**	**----**
EK085M: Sulfide as S2-								
Sulfide as S	----	0.01	%	<0.01	<0.01	**----**	**----**	**----**

Inter-Laboratory Testing

Analysis conducted by ALS Brisbane, NATA accreditation no. 825, site no. 818 (Chemistry) 18958 (Biology).

(SOIL) EK085M: Sulfide as S2-

(SOIL) ED040T : Total Sulfate by ICPAES

(SOIL) ED042T: Total Sulfur by LECO

Analysis conducted by ALS Sydney, NATA accreditation no. 825, site no. 10911 (Chemistry) 14913 (Biology). Only applies to samples EP2306004 (036).

(WATER) EG020W: Water Leachable Metals by ICP-MS

QUALITY CONTROL REPORT

Work Order	: **EP2306004**	Page	: 1 of 7
Amendment	: **1**		
Client	: **GHD PTY LTD**	Laboratory	: Environmental Division Perth
Contact	: Steff Bright	Contact	: Peter Ravlic
Address	: 999 HAY STREET PERTH WA, AUSTRALIA 6000	Address	: 26 Rigali Way Wangara WA Australia 6065
Telephone	: ----	Telephone	: +6138549 9645
Project	: 12518217	Date Samples Received	: 27-Apr-2023
Order number	: 12518217/036	Date Analysis Commenced	: 11-May-2023
C-O-C number	: ----	Issue Date	: 31-May-2023
Sampler	: SIMCOA		
Site	: ----		
Quote number	: EP/174/22		
No. of samples received	: 38		
No. of samples analysed	: 22		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

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This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ankit Joshi	Senior Chemist - Inorganics	Sydney Inorganics, Smithfield, NSW
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Canhuang Ke	Inorganics Supervisor	Perth Inorganics, Wangara, WA
Chris Lemaitre	Laboratory Manager (Perth)	Perth Inorganics, Wangara, WA
Daniel Fisher	Inorganics Analyst	Perth ASS, Wangara, WA
Mark Hallas	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Satishkumar Trivedi	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD

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Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR: 0% - 50%; Result > 20 times LOR: 0% - 20%.

Sub-Matrix: **SOIL**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Acceptable RPD (%)*
EA011: Net Acid Generation (QC Lot: 5066781)									
EP2306004-001	MK128_12	EA011: NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	<0.1	0.0	No Limit
		EA011: NAG (pH 7.0)	----	0.1	kg H2SO4/t	13.3	13.3	0.0	0% - 20%
EP2306004-020	MK093_10	EA011: NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	<0.1	0.0	No Limit
		EA011: NAG (pH 7.0)	----	0.1	kg H2SO4/t	11.8	11.8	0.0	0% - 20%
EA013: Acid Neutralising Capacity (QC Lot: 5066782)									
EP2306004-001	MK128_12	EA013: ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	1.0	1.0	0.0	No Limit
EP2306004-020	MK093_10	EA013: ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	<0.5	<0.5	0.0	No Limit
ED040T : Total Sulfate by ICPAES (QC Lot: 5042935)									
EB2313695-001	Anonymous	ED040T: Sulfate as SO4 2-	14808-79-8	100	mg/kg	700	760	8.8	No Limit
ED042T: Total Sulfur by LECO (QC Lot: 5053295)									
EM2308097-004	Anonymous	ED042T: Sulfur - Total as S (LECO)	----	0.01	%	<0.01	<0.01	0.0	No Limit
EP2306004-038	MK174_4-8	ED042T: Sulfur - Total as S (LECO)	----	0.01	%	<0.01	<0.01	0.0	No Limit

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Acceptable RPD (%)*
EA005P: pH by PC Titrator (QC Lot: 5057204)									
EP2306150-003	Anonymous	EA005-P: pH Value	----	0.01	pH Unit	8.02	8.02	0.0	0% - 20%
EP2305855-048	Anonymous	EA005-P: pH Value	----	0.01	pH Unit	7.68	7.69	0.1	0% - 20%
EA010P: Conductivity by PC Titrator (QC Lot: 5057205)									
EP2305855-048	Anonymous	EA010-P: Electrical Conductivity @ 25°C	----	1	µS/cm	2400	2450	1.9	0% - 20%
ED037P: Alkalinity by PC Titrator (QC Lot: 5057206)									
EP2306150-003	Anonymous	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Acceptable RPD (%)*
ED037P: Alkalinity by PC Titrator (QC Lot: 5057206) - continued									
EP2306150-003	Anonymous	ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	122	123	0.0	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	122	123	0.0	0% - 20%
EP2305855-048	Anonymous	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	302	303	0.0	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	302	303	0.0	0% - 20%
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QC Lot: 5061043)									
EP2306004-036	MK095_8-12	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	2	2	0.0	No Limit
EP2306580-017	Anonymous	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	6	6	0.0	No Limit
ED045G: Chloride by Discrete Analyser (QC Lot: 5061042)									
EP2306004-036	MK095_8-12	ED045G: Chloride	16887-00-6	1	mg/L	1	1	0.0	No Limit
EP2306580-017	Anonymous	ED045G: Chloride	16887-00-6	1	mg/L	83	84	0.0	0% - 20%
ED093W: Water Leachable Major Cations (QC Lot: 5059482)									
EP2306004-036	MK095_8-12	ED093W: Calcium	7440-70-2	1	mg/L	<1	<1	0.0	No Limit
		ED093W: Magnesium	7439-95-4	1	mg/L	<1	<1	0.0	No Limit
		ED093W: Sodium	7440-23-5	1	mg/L	2	3	0.0	No Limit
		ED093W: Potassium	7440-09-7	1	mg/L	<1	<1	0.0	No Limit
EG020W: Water Leachable Metals by ICP-MS (QC Lot: 5059478)									
EP2306004-036	MK095_8-12	EG020B-W: Cerium	7440-45-1	0.001	mg/L	0.002	0.002	0.0	No Limit
		EG020B-W: Caesium	7440-46-2	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020B-W: Rubidium	7440-17-7	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020B-W: Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020B-W: Strontium	7440-24-6	0.001	mg/L	0.008	0.008	0.0	No Limit
		EG020B-W: Thorium	7440-29-1	0.001	mg/L	0.002	0.002	0.0	No Limit
		EG020B-W: Uranium	7440-61-1	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020B-W: Tellurium	22541-49-7	0.005	mg/L	<0.005	<0.005	0.0	No Limit
		EG020B-W: Titanium	7440-32-6	0.01	mg/L	0.02	0.03	54.7	No Limit
EG020W: Water Leachable Metals by ICP-MS (QC Lot: 5059479)									
EP2306004-036	MK095_8-12	EG020D-W: Gallium	7440-55-3	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020D-W: Lanthanum	7439-91-0	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020D-W: Yttrium	7440-65-5	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020D-W: Zirconium	7440-67-7	0.005	mg/L	<0.005	<0.005	0.0	No Limit
		EG020D-W: Hafnium	7440-58-6	0.01	mg/L	<0.01	<0.01	0.0	No Limit
EG020W: Water Leachable Metals by ICP-MS (QC Lot: 5059480)									
EP2306004-036	MK095_8-12	EG020E-W: Gold	7440-57-5	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020E-W: Tungsten	7440-33-7	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020E-W: Tantalum	7440-25-7	0.001	mg/L	<0.001	<0.001	0.0	No Limit
EG020W: Water Leachable Metals by ICP-MS (QC Lot: 5059481)									

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Acceptable RPD (%)*
EG020W: Water Leachable Metals by ICP-MS (QC Lot: 5059481) - continued									
EP2306004-036	MK095_8-12	EG020A-W: Cadmium	7440-43-9	0.0001	mg/L	0.0002	<0.0001	0.0	No Limit
		EG020A-W: Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-W: Arsenic	7440-38-2	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-W: Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-W: Barium	7440-39-3	0.001	mg/L	0.177	0.183	3.7	0% - 20%
		EG020A-W: Chromium	7440-47-3	0.001	mg/L	0.005	0.007	40.1	No Limit
		EG020A-W: Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-W: Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-W: Lead	7439-92-1	0.001	mg/L	0.002	0.002	0.0	No Limit
		EG020A-W: Lithium	7439-93-2	0.001	mg/L	0.002	0.002	0.0	No Limit
		EG020A-W: Manganese	7439-96-5	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-W: Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-W: Nickel	7440-02-0	0.001	mg/L	<0.001	0.001	0.0	No Limit
		EG020A-W: Tin	7440-31-5	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-W: Zinc	7440-66-6	0.005	mg/L	0.054	0.057	6.2	0% - 50%
		EG020A-W: Aluminium	7429-90-5	0.01	mg/L	3.40	3.45	1.5	0% - 20%
		EG020A-W: Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	0.0	No Limit
		EG020A-W: Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	0.0	No Limit
		EG020A-W: Boron	7440-42-8	0.05	mg/L	0.08	0.08	0.0	No Limit
		EG020A-W: Iron	7439-89-6	0.05	mg/L	1.91	1.78	7.2	0% - 20%
EG020W: Water Leachable Metals by ICP-MS (QC Lot: 5069545)									
ES2314317-002	Anonymous	EG020G-W: Germanium	7440-56-4	0.001	mg/L	<0.001	0.001	0.0	No Limit
		EG020G-W: Niobium	7440-03-1	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020G-W: Rhenium	7440-15-5	0.001	mg/L	<0.001	<0.001	0.0	No Limit
ES2314317-012	Anonymous	EG020G-W: Germanium	7440-56-4	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020G-W: Niobium	7440-03-1	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020G-W: Rhenium	7440-15-5	0.001	mg/L	<0.001	<0.001	0.0	No Limit
EG035W: Water Leachable Mercury by FIMS (QC Lot: 5059483)									
EP2306004-036	MK095_8-12	EG035W: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit

Method Blank (MB) and Laboratory Control Sample (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **SOIL**

				Method Blank (MB) Report	*Laboratory Control Spike (LCS) Report*			
					Spike	*Spike Recovery (%)*	*Acceptable Limits (%)*	
Method: Compound	*CAS Number*	*LOR*	*Unit*	*Result*	*Concentration*	*LCS*	*Low*	*High*
EA011: Net Acid Generation (QCLot: 5066781)								
EA011: NAG (pH 7.0)	----	----	kg H2SO4/t	----	24.084 kg H2SO4/t	100	87.6	110
EA013: Acid Neutralising Capacity (QCLot: 5066782)								
EA013: ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	<0.5	9.8 kg H2SO4 equiv./t	99.2	96.9	104
EA013: ANC as CaCO3	----	0.1	% CaCO3	<0.1	----	----	----	----
ED040T : Total Sulfate by ICPAES (QCLot: 5042935)								
ED040T: Sulfate as SO4 2-	14808-79-8	100	mg/kg	<100	579 mg/kg	92.1	79.0	121
ED042T: Total Sulfur by LECO (QCLot: 5053295)								
ED042T: Sulfur - Total as S (LECO)	----	0.01	%	<0.01	0.51 %	101	70.0	130

Sub-Matrix: **WATER**

				Method Blank (MB) Report	*Laboratory Control Spike (LCS) Report*			
					Spike	*Spike Recovery (%)*	*Acceptable Limits (%)*	
Method: Compound	*CAS Number*	*LOR*	*Unit*	*Result*	*Concentration*	*LCS*	*Low*	*High*
EA005P: pH by PC Titrator (QCLot: 5057204)								
EA005-P: pH Value	----	----	pH Unit	---- ----	4 pH Unit 7 pH Unit	100 99.8	98.5 98.5	102 102
EA010P: Conductivity by PC Titrator (QCLot: 5057205)								
EA010-P: Electrical Conductivity @ 25°C	----	1	µS/cm	<1	24800 µS/cm	97.8	92.1	105
ED037P: Alkalinity by PC Titrator (QCLot: 5057206)								
ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	----	----	----	----
ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	----	----	----	----
ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	<1	----	----	----	----
ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	<1 <1	20 mg/L 200 mg/L	93.4 101	87.8 87.8	118 118
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 5061043)								
ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	<1 <1	25 mg/L 500 mg/L	98.0 98.2	89.9 89.9	112 112
ED045G: Chloride by Discrete Analyser (QCLot: 5061042)								
ED045G: Chloride	16887-00-6	1	mg/L	<1 <1	10 mg/L 1000 mg/L	100 97.8	88.6 88.6	113 113
ED093W: Water Leachable Major Cations (QCLot: 5059482)								
ED093W: Calcium	7440-70-2	1	mg/L	<1	50 mg/L	96.4	88.7	109

Sub-Matrix: **WATER**

				Method Blank (MB) Report	*Laboratory Control Spike (LCS) Report*			
					Spike	*Spike Recovery (%)*	*Acceptable Limits (%)*	
Method: Compound	*CAS Number*	*LOR*	*Unit*	*Result*	*Concentration*	*LCS*	*Low*	*High*
ED093W: Water Leachable Major Cations (QCLot: 5059482) - continued								
ED093W: Magnesium	7439-95-4	1	mg/L	<1	50 mg/L	109	86.8	109
ED093W: Sodium	7440-23-5	1	mg/L	<1	50 mg/L	96.5	80.4	121
ED093W: Potassium	7440-09-7	1	mg/L	<1	50 mg/L	90.4	83.4	115
EG020W: Water Leachable Metals by ICP-MS (QCLot: 5059478)								
EG020B-W: Cerium	7440-45-1	0.001	mg/L	<0.001	0.12 mg/L	105	89.6	117
EG020B-W: Caesium	7440-46-2	0.001	mg/L	<0.001	0.1 mg/L	103	90.4	115
EG020B-W: Rubidium	7440-17-7	0.001	mg/L	<0.001	0.1 mg/L	101	93.4	116
EG020B-W: Silver	7440-22-4	0.001	mg/L	<0.001	0.02 mg/L	107	89.9	120
EG020B-W: Strontium	7440-24-6	0.001	mg/L	<0.001	0.1 mg/L	99.8	90.2	116
EG020B-W: Tellurium	22541-49-7	0.005	mg/L	<0.005	0.1 mg/L	110	82.6	120
EG020B-W: Thorium	7440-29-1	0.001	mg/L	<0.001	0.1 mg/L	115	82.2	120
EG020B-W: Titanium	7440-32-6	0.01	mg/L	<0.01	0.1 mg/L	111	81.2	121
EG020B-W: Uranium	7440-61-1	0.001	mg/L	<0.001	0.1 mg/L	106	90.5	115
EG020W: Water Leachable Metals by ICP-MS (QCLot: 5059479)								
EG020D-W: Gallium	7440-55-3	0.001	mg/L	<0.001	0.01 mg/L	103	98.1	117
EG020D-W: Hafnium	7440-58-6	0.01	mg/L	<0.01	0.01 mg/L	113	80.0	120
EG020D-W: Lanthanum	7439-91-0	0.001	mg/L	<0.001	0.01 mg/L	98.5	90.5	116
EG020D-W: Yttrium	7440-65-5	0.001	mg/L	<0.001	0.01 mg/L	100	95.3	120
EG020D-W: Zirconium	7440-67-7	0.005	mg/L	<0.005	0.01 mg/L	110	93.3	126
EG020W: Water Leachable Metals by ICP-MS (QCLot: 5059480)								
EG020E-W: Gold	7440-57-5	0.001	mg/L	<0.001	0.01 mg/L	90.8	80.0	120
EG020E-W: Tungsten	7440-33-7	0.001	mg/L	<0.001	0.01 mg/L	119	80.0	120
EG020E-W: Tantalum	7440-25-7	0.001	mg/L	<0.001	----	----	----	----
EG020W: Water Leachable Metals by ICP-MS (QCLot: 5059481)								
EG020A-W: Aluminium	7429-90-5	0.01	mg/L	<0.01	0.5 mg/L	105	91.8	114
EG020A-W: Antimony	7440-36-0	0.001	mg/L	<0.001	0.02 mg/L	132	65.7	162
EG020A-W: Arsenic	7440-38-2	0.001	mg/L	<0.001	0.1 mg/L	105	94.4	113
EG020A-W: Beryllium	7440-41-7	0.001	mg/L	<0.001	0.1 mg/L	109	85.8	127
EG020A-W: Barium	7440-39-3	0.001	mg/L	<0.001	0.1 mg/L	99.9	89.8	116
EG020A-W: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.1 mg/L	104	91.9	112
EG020A-W: Chromium	7440-47-3	0.001	mg/L	<0.001	0.1 mg/L	104	89.8	109
EG020A-W: Cobalt	7440-48-4	0.001	mg/L	<0.001	0.1 mg/L	101	91.0	111
EG020A-W: Copper	7440-50-8	0.001	mg/L	<0.001	0.1 mg/L	100	90.7	110
EG020A-W: Lead	7439-92-1	0.001	mg/L	<0.001	0.1 mg/L	102	90.8	110

Sub-Matrix: **WATER**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Acceptable Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result	Concentration	LCS	Low	High
EG020W: Water Leachable Metals by ICP-MS (QCLot: 5059481) - continued								
EG020A-W: Lithium	7439-93-2	0.001	mg/L	<0.001	0.1 mg/L	108	84.7	120
EG020A-W: Manganese	7439-96-5	0.001	mg/L	<0.001	0.1 mg/L	104	88.1	111
EG020A-W: Molybdenum	7439-98-7	0.001	mg/L	<0.001	0.1 mg/L	118	100	118
EG020A-W: Nickel	7440-02-0	0.001	mg/L	<0.001	0.1 mg/L	103	90.6	109
EG020A-W: Selenium	7782-49-2	0.01	mg/L	<0.01	0.1 mg/L	107	85.4	110
EG020A-W: Tin	7440-31-5	0.001	mg/L	<0.001	0.1 mg/L	108	89.5	117
EG020A-W: Vanadium	7440-62-2	0.01	mg/L	<0.01	0.1 mg/L	102	90.8	111
EG020A-W: Zinc	7440-66-6	0.005	mg/L	<0.005	0.1 mg/L	104	88.8	117
EG020A-W: Boron	7440-42-8	0.05	mg/L	<0.05	0.5 mg/L	111	83.1	132
EG020A-W: Iron	7439-89-6	0.05	mg/L	<0.05	0.5 mg/L	104	80.1	117
EG020W: Water Leachable Metals by ICP-MS (QCLot: 5069545)								
EG020G-W: Germanium	7440-56-4	0.001	mg/L	<0.001	0.1 mg/L	96.2	70.0	130
EG020G-W: Niobium	7440-03-1	0.001	mg/L	<0.001	0.1 mg/L	99.0	70.0	130
EG020G-W: Rhenium	7440-15-5	0.001	mg/L	<0.001	0.1 mg/L	98.8	70.0	130
EG035W: Water Leachable Mercury by FIMS (QCLot: 5059483)								
EG035W: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.005 mg/L	99.4	85.4	120

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **WATER**

				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Acceptable Limits (%)	
Laboratory sample ID	Sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 5061043)							
EP2306004-036	MK095_8-12	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	100 mg/L	104	70.4	130
ED045G: Chloride by Discrete Analyser (QCLot: 5061042)							
EP2306004-036	MK095_8-12	ED045G: Chloride	16887-00-6	1000 mg/L	101	70.0	130

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: **EP2306004**	Page	: 1 of 8
Amendment	: **1**		
Client	: **GHD PTY LTD**	Laboratory	: Environmental Division Perth
Contact	: Steff Bright	Telephone	: +6138549 9645
Project	: 12518217	Date Samples Received	: 27-Apr-2023
Site	: ----	Issue Date	: 31-May-2023
Sampler	: SIMCOA	No. of samples received	: 38
Order number	: 12518217/036	No. of samples analysed	: 22

This report is automatically generated by the ALS LIMS through interpretation of the ALS Quality Control Report and several Quality Assurance parameters measured by ALS. This automated reporting highlights any non-conformances, facilitates faster and more accurate data validation and is designed to assist internal expert and external Auditor review. Many components of this report contribute to the overall DQO assessment and reporting for guideline compliance.

Brief method summaries and references are also provided to assist in traceability.

Summary of Outliers

Outliers : Quality Control Samples

This report highlights outliers flagged in the Quality Control (QC) Report.

- **NO Method Blank value outliers occur.**
- **NO Duplicate outliers occur.**
- **NO Laboratory Control outliers occur.**
- **NO Matrix Spike outliers occur.**
- **For all regular sample matrices, NO surrogate recovery outliers occur.**

Outliers : Analysis Holding Time Compliance

- **Analysis Holding Time Outliers exist - please see following pages for full details.**

Outliers : Frequency of Quality Control Samples

- **Quality Control Sample Frequency Outliers exist - please see following pages for full details.**

Outliers : Analysis Holding Time Compliance

Matrix: **WATER**

Method **Container** / Client Sample ID(s)	*Extraction / Preparation* *Date extracted*	*Due for extraction*	***Days overdue***	*Analysis* *Date analysed*	*Due for analysis*	***Days overdue***
EA005P: pH by PC Titrator						
Clear Plastic Bottle - Natural						
MK095_8-12	----	----	----	18-May-2023	15-May-2023	**3**

Outliers : Frequency of Quality Control Samples

Matrix: **WATER**

Quality Control Sample Type Method	Count QC	 Regular	Rate (%) Actual	 Expected	Quality Control Specification
	0				
Matrix Spikes (MS)					
Water Leachable Mercury by FIMS	0	1	0.00	5.00	NEPM 2013 B3 & ALS QC Standard
Water Leachable Metals by ICP-MS - Suite A	0	1	0.00	5.00	NEPM 2013 B3 & ALS QC Standard
Water Leachable Metals by ICP-MS - Suite C	0	1	0.00	5.00	NEPM 2013 B3 & ALS QC Standard
Water Leachable Metals by ICP-MS - Suite E	0	1	0.00	5.00	NEPM 2013 B3 & ALS QC Standard

Analysis Holding Time Compliance

If samples are identified below as having been analysed or extracted outside of recommended holding times, this should be taken into consideration when interpreting results.

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times (referencing USEPA SW 846, APHA, AS and NEPM) based on the sample container provided. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. A listing of breaches (if any) is provided herein.

Holding time for leachate methods (e.g. TCLP) vary according to the analytes reported. Assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These are: organics 14 days, mercury 28 days & other metals 180 days. A recorded breach does not guarantee a breach for all non-volatile parameters.

Holding times for ***VOC in soils*** vary according to analytes of interest. Vinyl Chloride and Styrene holding time is 7 days; others 14 days. A recorded breach does not guarantee a breach for all VOC analytes and should be verified in case the reported breach is a false positive or Vinyl Chloride and Styrene are not key analytes of interest/concern.

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method ***Container*** */ Client Sample ID(s)*		***Sample Date***	*Extraction / Preparation* ***Date extracted***	*Due for extraction*	*Evaluation*	*Analysis* ***Date analysed***	*Due for analysis*	*Evaluation*
EA011: Net Acid Generation								
Pulp Bag (EA011)								
MK128_12, MK113_4, MK089_4, MK089_10, MK093_6, MK093_10, MK174_2, MK097_6, MK193_4	MK113_2, MK086_6, MK089_6, MK085_10, MK093_8, MK207_4, MK393_6, MK094_10,	**05-May-2023**	**11-May-2023**	04-May-2024	✓	**16-May-2023**	07-Nov-2023	✓

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method ***Container** / Client Sample ID(s)*	***Sample Date***	*Extraction / Preparation*			*Analysis*		
		Date extracted	*Due for extraction*	*Evaluation*	***Date analysed***	*Due for analysis*	*Evaluation*
EA013: Acid Neutralising Capacity							
Pulp Bag (EA013) MK128_12, MK113_2, MK113_4, MK086_6, MK089_4, MK089_6, MK089_10, MK085_10, MK093_6, MK093_8, MK093_10, MK207_4, MK174_2, MK393_6, MK097_6, MK094_10, MK193_4	**05-May-2023**	**11-May-2023**	04-May-2024	✓	**23-May-2023**	07-Nov-2023	✓
ED040T : Total Sulfate by ICPAES							
Pulp Bag (ED040T) MK113_8-12, MK099_6-10, MK189_4-8, MK174_4-8	**05-May-2023**	**12-May-2023**	02-Jun-2023	✓	**16-May-2023**	02-Jun-2023	✓
ED042T: Total Sulfur by LECO							
Pulp Bag (ED042T) MK113_8-12, MK099_6-10, MK189_4-8, MK174_4-8	**05-May-2023**	**17-May-2023**	01-Nov-2023	✓	**17-May-2023**	01-Nov-2023	✓
EN60-DI: Bottle Leaching Procedure - Inorganics/Non-Volatile Organics (Glass Vessel)							
Non-Volatile Leach: 14 day HT(e.g. SV organics) (EN60-DIa-G) MK095_8-12	**05-May-2023**	**15-May-2023**	19-May-2023	✓	**----**	----	----

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method ***Container** / Client Sample ID(s)*	***Sample Date***	*Extraction / Preparation*			*Analysis*		
		Date extracted	*Due for extraction*	*Evaluation*	***Date analysed***	*Due for analysis*	*Evaluation*
EA005P: pH by PC Titrator							
Clear Plastic Bottle - Natural (EA005-P) MK095_8-12	**15-May-2023**	**----**	----	----	**18-May-2023**	15-May-2023	×
EA010P: Conductivity by PC Titrator							
Clear Plastic Bottle - Natural (EA010-P) MK095_8-12	**15-May-2023**	**----**	----	----	**18-May-2023**	12-Jun-2023	✓
ED037P: Alkalinity by PC Titrator							
Clear Plastic Bottle - Natural (ED037-P) MK095_8-12	**15-May-2023**	**----**	----	----	**18-May-2023**	29-May-2023	✓
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA							
Clear Plastic Bottle - Natural (ED041G) MK095_8-12	**15-May-2023**	**----**	----	----	**25-May-2023**	12-Jun-2023	✓
ED045G: Chloride by Discrete Analyser							
Clear Plastic Bottle - Natural (ED045G) MK095_8-12	**15-May-2023**	**----**	----	----	**25-May-2023**	12-Jun-2023	✓

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method ***Container** / Client Sample ID(s)*	***Sample Date***	*Extraction / Preparation*			*Analysis*		
		Date extracted	*Due for extraction*	*Evaluation*	***Date analysed***	*Due for analysis*	*Evaluation*
ED093W: Water Leachable Major Cations							
Clear Plastic Bottle - Nitric Acid; Unfiltered (ED093W) MK095_8-12	**15-May-2023**	**19-May-2023**	12-Jun-2023	✓	**22-May-2023**	12-Jun-2023	✓
EG020W: Water Leachable Metals by ICP-MS							
Clear Plastic Bottle - Nitric Acid; Unfiltered (EG020E-W) MK095_8-12	**15-May-2023**	**19-May-2023**	11-Nov-2023	✓	**19-May-2023**	11-Nov-2023	✓
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG020G-W) MK095_8-12	**15-May-2023**	**24-May-2023**	11-Nov-2023	✓	**24-May-2023**	11-Nov-2023	✓
EG035W: Water Leachable Mercury by FIMS							
Clear Plastic Bottle - Nitric Acid; Unfiltered (EG035W) MK095_8-12	**15-May-2023**	**----**	----	----	**19-May-2023**	12-Jun-2023	✓

Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(were) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **SOIL**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		*Count*		*Rate (%)*			*Quality Control Specification*
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Duplicates (DUP)							
Acid Neutralising Capacity (ANC)	EA013	2	17	**11.76**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Net Acid Generation	EA011	2	17	**11.76**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate as SO4 2- Total	ED040T	1	6	**16.67**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Sulfur - Total as S (LECO)	ED042T	2	11	**18.18**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Acid Neutralising Capacity (ANC)	EA013	1	17	**5.88**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Net Acid Generation	EA011	1	17	**5.88**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate as SO4 2- Total	ED040T	1	6	**16.67**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Sulfur - Total as S (LECO)	ED042T	1	11	**9.09**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
Acid Neutralising Capacity (ANC)	EA013	1	17	**5.88**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate as SO4 2- Total	ED040T	1	6	**16.67**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Sulfur - Total as S (LECO)	ED042T	1	11	**9.09**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard

Matrix: **WATER**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		*Count*		*Rate (%)*			*Quality Control Specification*
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Duplicates (DUP)							
Alkalinity by Auto Titrator	ED037-P	2	14	**14.29**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Chloride by Discrete Analyser	ED045G	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Conductivity by Auto Titrator	EA010-P	1	10	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
pH by Auto Titrator	EA005-P	2	19	**10.53**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	2	18	**11.11**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Water Leachable Major Cations	ED093W	1	1	**100.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Water Leachable Mercury by FIMS	EG035W	1	1	**100.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Water Leachable Metals by ICP-MS - Suite A	EG020A-W	1	1	**100.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Water Leachable Metals by ICP-MS - Suite B	EG020B-W	1	1	**100.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Water Leachable Metals by ICP-MS - Suite C	EG020D-W	1	1	**100.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Water Leachable Metals by ICP-MS - Suite E	EG020E-W	1	1	**100.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Water Leachable Metals by ICP-MS - Suite G	EG020G-W	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Alkalinity by Auto Titrator	ED037-P	2	14	**14.29**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Chloride by Discrete Analyser	ED045G	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Conductivity by Auto Titrator	EA010-P	1	10	**10.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
pH by Auto Titrator	EA005-P	2	19	**10.53**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	2	18	**11.11**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard

Matrix: **WATER**

Evaluation: ✗ = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type *Analytical Methods*	*Method*	*Count*		*Rate (%)*			*Quality Control Specification*
		QC	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Control Samples (LCS) - Continued							
Water Leachable Major Cations	ED093W	1	1	**100.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Water Leachable Mercury by FIMS	EG035W	1	1	**100.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Water Leachable Metals by ICP-MS - Suite A	EG020A-W	1	1	**100.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Water Leachable Metals by ICP-MS - Suite B	EG020B-W	1	1	**100.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Water Leachable Metals by ICP-MS - Suite C	EG020D-W	1	1	**100.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Water Leachable Metals by ICP-MS - Suite E	EG020E-W	1	1	**100.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Water Leachable Metals by ICP-MS - Suite G	EG020G-W	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
Alkalinity by Auto Titrator	ED037-P	1	14	**7.14**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Chloride by Discrete Analyser	ED045G	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Conductivity by Auto Titrator	EA010-P	1	10	**10.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	18	**5.56**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Water Leachable Major Cations	ED093W	1	1	**100.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Water Leachable Mercury by FIMS	EG035W	1	1	**100.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Water Leachable Metals by ICP-MS - Suite A	EG020A-W	1	1	**100.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Water Leachable Metals by ICP-MS - Suite B	EG020B-W	1	1	**100.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Water Leachable Metals by ICP-MS - Suite C	EG020D-W	1	1	**100.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Water Leachable Metals by ICP-MS - Suite E	EG020E-W	1	1	**100.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Water Leachable Metals by ICP-MS - Suite G	EG020G-W	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)							
Chloride by Discrete Analyser	ED045G	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	18	**5.56**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Water Leachable Mercury by FIMS	EG035W	0	1	**0.00**	**5.00**	✗	NEPM 2013 B3 & ALS QC Standard
Water Leachable Metals by ICP-MS - Suite A	EG020A-W	0	1	**0.00**	**5.00**	✗	NEPM 2013 B3 & ALS QC Standard
Water Leachable Metals by ICP-MS - Suite C	EG020D-W	0	1	**0.00**	**5.00**	✗	NEPM 2013 B3 & ALS QC Standard
Water Leachable Metals by ICP-MS - Suite E	EG020E-W	0	1	**0.00**	**5.00**	✗	NEPM 2013 B3 & ALS QC Standard

Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	*Method*	*Matrix*	*Method Descriptions*
pH by Auto Titrator	EA005-P	SOIL	In house: Referenced to APHA 4500 H+ B. This procedure determines pH of water samples by automated ISE. This method is compliant with NEPM Schedule B(3)
Conductivity by Auto Titrator	EA010-P	SOIL	In house: Referenced to APHA 2510 B. This procedure determines conductivity by automated ISE. This method is compliant with NEPM Schedule B(3)
Net Acid Generation	EA011	SOIL	In house: Referenced to Miller (1998) Titremetric procedure determines net acidity in a soil following peroxide oxidation. Titrations to both pH 4.5 and pH 7 are reported.
Acid Neutralising Capacity (ANC)	EA013	SOIL	In house: Referenced to USEPA 600/2-78-054, I. Miller (2000). A fizz test is done to semiquanititatively estimate the likely reactivity. The soil is then reacted with an known excess quanitity of an appropriate acid. Titration determines the acid remaining, and the ANC can be calculated from comparison with a blank titration.
Alkalinity by Auto Titrator	ED037-P	SOIL	In house: Referenced to APHA 2320 B This procedure determines alkalinity by automated measurement (e.g. PC Titrate) on a settled supernatant aliquot of the sample using pH 4.5 for indicating the total alkalinity end-point. This method is compliant with NEPM Schedule B(3)
Sulfate as SO4 2- Total	ED040T	SOIL	In house: Total Sulfate is determined off a HCl digestion by ICPAES as S , and reported as SO4
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	SOIL	In house: Referenced to APHA 4500-SO4. Dissolved sulfate is determined in a 0.45um filtered sample. Sulfate ions are converted to a barium sulfate suspension in an acetic acid medium with barium chloride. Light absorbance of the BaSO4 suspension is measured by a photometer and the SO4-2 concentration is determined by comparison of the reading with a standard curve. This method is compliant with NEPM Schedule B(3)
Sulfur - Total as S (LECO)	ED042T	SOIL	In house: Dried and pulverised sample is combusted in a high temperature furnace in the presence of strong oxidants / catalysts. The evolved S (as SO2) is measured by infra-red detector
Chloride by Discrete Analyser	ED045G	SOIL	In house: Referenced to APHA 4500 Cl - G.The thiocyanate ion is liberated from mercuric thiocyanate through sequestration of mercury by the chloride ion to form non-ionised mercuric chloride. In the presence of ferric ions the liberated thiocynate forms highly-coloured ferric thiocynate which is measured at 480 nm.
Water Leachable Major Cations	ED093W	SOIL	In house: Referenced to APHA 3120; USEPA SW 846 - 6010; ALS QWI-EN/EG005, QWI-EN/ED093. The ICPAES technique quickly breaks the sample down into atoms and ions under extremely hot plasma. Atoms are then ionised, emitting a characteristic spectrum. The spectrometer then separates the wavelengths, prior to comparison of intensities against matrix matched standards for quantification.
Water Leachable Metals by ICP-MS - Suite A	EG020A-W	SOIL	In house: Referenced to APHA 3125; USEPA SW846 - 6020, AS 4439.3, ALS QWI-EN/EG020. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Water Leachable Metals by ICP-MS - Suite B	EG020B-W	SOIL	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.

Analytical Methods	*Method*	*Matrix*	*Method Descriptions*
Water Leachable Metals by ICP-MS - Suite C	EG020D-W	SOIL	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Water Leachable Metals by ICP-MS - Suite E	EG020E-W	SOIL	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Water Leachable Metals by ICP-MS - Suite G	* EG020G-W	SOIL	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Water Leachable Mercury by FIMS	EG035W	SOIL	In house: Referenced to APHA 3112 Hg - B (Flow-injection (SnCl2)(Cold Vapour generation) AAS) FIM-AAS is an automated flameless atomic absorption technique. A bromate/bromide reagent is used to oxidise any organic mercury compounds in the TCLP solution. The ionic mercury is reduced online to atomic mercury vapour by SnCl2 which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM Schedule B(3).
Sulfide as S	EK085T	SOIL	In-house. Sulfide in a soil is determined as the difference between Total Sulfur (Leco) and Sulfate.

Preparation Methods	*Method*	*Matrix*	*Method Descriptions*
Drying at 85 degrees, bagging and labelling (ASS)	EN020PR	SOIL	In house
HCl Digest	EN24	SOIL	1g of soil is digested in 30 ml of 30% HCl and the resultant digest bulked and filtered for analysis by ICP.
Digestion for Total Recoverable Metals in DI Water Leachate	EN25W	SOIL	In house: Referenced to USEPA SW846-3005. Method 3005 is a Nitric/Hydrochloric acid digestion procedure used to prepare surface and ground water samples for analysis by ICPAES or ICPMS. This method is compliant with NEPM Schedule B(3)
Deionised Water Leach - Glass Leaching Vessel	EN60-DIa-G	SOIL	In house QWI-EN/60 referenced to AS4439.3 Preparation of Leachates
Dry and Crush	* EN84	SOIL	In house
Dry and Pulverise (up to 100g)	GEO30	SOIL	#

CHAIN OF CUSTODY RECORD
AND ANALYSIS REQUEST

GHD
Level 10, 999 Hay Street
Perth WA 6000

PO Box 3106
Perth WA 6832

Reception Ph: 08 6222 8222

Page __1____ of ___1___

Project ID *(as per ESdat set up; no spaces)* 12518217	**PO Number** (to be invoiced) 12518217/036	Laboratory:	ALS Environmental
		Address:	26 Rigali Way, Wangara WA 6065
		Laboratory Contact:	ALS Environmental
Laboratory Quote No. EP/174/22	**Turnaround Time** Standard		
Project Manager (Invoice) & GHD accounts Bronwyn Neville	**Email Address (Results)** steff.bright@ghd.com, GHD.LabReports@ghd.com paul.hamer@ghd.com		

GHD Sample ID	Lab Sample ID	Date	Time	Sample Matrix S-Soil/ SL-Sludge/ W-Water/ A-Air	Container: Type B-Bottle/J-Jar/V-Vial/Bag/G-Glass/P-Plastic	Container: Preservative Unpreserved/ HCl/ H2SO4/HNO3/Other	Container: No	Analyses: ANC - (EA013)	NAG - (EA011)	Sulfur Speciation - (EK085T)	Sulfur Speciation - (ED042T)	Radioactivity - (EA250)	Asbestos - (EA200)	Metals Solid - (ME-MS61m) & (Au-ICP22) & (ME-ICP89) & (F-IC881)	Metals Leach - (NT-01D & 02) & (EG020W) & (EG035W) & (EA005P) & (EA010P)							Remarks
MK128_10		14/04/2023		S	Bag	N	1						x									Already submitted EP2305573
MK128_12	1	5/05/2023		S	Bag	N	1	x	x													
MK113_2	2	5/05/2023		S	Bag	N	1	x	x													
MK113_4	3	5/05/2023		S	Bag	N	1	x	x													
MK113_6		14/04/2023		S	Bag	N	1						x									Already submitted EP2305573
MK113_8	4	5/05/2023		S	Bag	N	1			x												Comp into one sample as: MK113_8-12 34
MK113_10	5	5/05/2023		S	Bag	N	1															
MK113_12	6	5/05/2023		S	Bag	N	1															
MK099_6	7	5/05/2023		S	Bag	N	1			x												Comp into one sample as: MK099_6-10 35
MK099_8	8	5/05/2023		S	Bag	N	1															
MK099_10	9	5/05/2023		S	Bag	N	1															
MK086_6	10	5/05/2023		S	Bag	N	1	x	x													
MK086_8		11/04/2023		S	Bag	N	1						x									Already submitted EP2305573
MK095_8	11	5/05/2023		S	Bag	N	1							x								Comp into one sample as: MK095_8-12 36
MK095_10	12	5/05/2023		S	Bag	N	1															
MK095_12	13	5/05/2023		S	Bag	N	1															
MK089_4	14	5/05/2023		S	Bag	N	1	x	x													
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MK093_12		14/04/2023		S	Bag	N	1						x									Already submitted EP2305573
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MK189_4	22	5/05/2023		S	Bag	N	1			x												Comp into one sample as: MK189_4-8 37
MK189_6	23	5/05/2023		S	Bag	N	1															
MK189_8	24	5/05/2023		S	Bag	N	1															
MK174_2	25	5/05/2023		S	Bag	N	1	x	x													
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MK174_6	27	5/05/2023		S	Bag	N	1															
MK174_8	28	5/05/2023		S	Bag	N	1															
MK393_6	29	5/05/2023		S	Bag	N	1	x	x													
MK097_6	30	5/05/2023		S	Bag	N	1	x	x													
MK094_10	31	5/05/2023		S	Bag	N	1	x	x													
MK193_4	32	5/05/2023		S	Bag	N	1	x	x													
MK192_8	33	5/05/2023		S	Bag	N	1															Sample submitted in error, please dispose of

Sampled by: SIMCOA	Date/Time: UNK	Relinquished by: S.Bright	Date/Time: 5/5/2023
Received by: 8/5 1300	Date/Time:	Relinquished by:	Date/Time:

Environmental Division
Perth
Work Order Reference
EP2306004

Telephone : -- 61-8-9406 1301

Simcoa Operations Pty. Ltd.

North Kiaka Proposed Mine Expansion
Materials Characterisation Assessment Report

Revision A

April 2019

Executive summary

Introduction

Simcoa Operations Pty Ltd (Simcoa) is proposing to expand operations for a new quartzite mine located approximately 15 km north of Moora in the Wheatbelt of Western Australia. Simcoa engaged GHD to undertake several studies to support the approvals process for the expansion.

This reports presents the outcomes of the desk-top Materials Characterisation assessment to understand the potential risks posed by Acid and Metalliferous Drainage (AMD), radioactivity and air-borne hazards (asbestos/silica) as a consequence of proposed mine expansion.

The Materials Characterisation is constrained to the waste-rock - which will remain on site, given that the ore-grade material will be transported, processed and managed off-site.

This report is subject to, and must be read in conjunction with, the limitations set out in section 1.3 and the assumptions and qualifications contained throughout the Report.

Key findings

Acid and Metalliferous Drainage: Although sufficient mineralogical and assay information is unavailable to characterise the acid leaching risks of the waste rock, the geological setting (silica-orebody) and anecdotal information supports that elevated concentrations of sulfide are not anticipated and that the likelihood of acidic leaching at elevated concentrations and increased rates, should be low.

Provided that the risk of acidic conditions remains low, and that metal numbers are constrained to the more commonly occurring metals associated with a silica style ore-body (eg: Fe, Al, Mn), conditions should not be conducive for leaching and mobilisation of metals at elevated concentrations.

The risk that waters with elevated salinity will leach from the waste rock and the pit-walls at concentrations which may cause adverse impacts is considered low, given that readily dissolvable minerals are likely not present at notable concentrations in the geological profile (ancient weathered and silicic geological profile).

Radioactivity: Although not characterised through former testing, the silicic mineralogy and lithology (predominantly chert) indicates that minerals which commonly exhibit elevated radioactivity (above that of background) are unlikely to be present.

The mining process should not concentrate any background radioactivity, given that the waste rock is not subject to processing (relocated to the waste rock landform), and that the ore and residual processed material will be managed off-site.

Air-borne hazards: Although not confirmed, the occurrence of asbestos is not anticipated within this style of silica based ore-body. However, the silicic mineralogy of the ore body indicates there is an elevated risk of exposure to human health from air-bore silica.

Recommendations: While the qualitative information indicates that the issues relating to the risk of acidic, metalliferous and saline drainage, radioactivity and asbestos appears to be low, confirmation is required given the lack of relevant data (as is required by DMIRS). As a consequence, laboratory testing is recommended to screen these issues within the waste-rock, as follows:

- Acid neutralising capacity (ANC): 12 samples
- Net acid generation (NAG) : 12 samples
- Sulfur speciation: 6 samples
- Metals comprehensive (full ICPMS scan, including U and Th): 6 samples
- Leach testing (major-ions, pH, EC, metals): 6 samples
- Radioactivity screen/gross alpha and beta: 4 samples
- Asbestos mineral fibres: 12 samples

Follow-up testing may be warranted, if the results of the laboratory testing do not confirm the assumptions that the Site, excluding air-borne silica, generally exhibits a low risk with respect to material characterisation.

Mining activities and waste-rock dumps should be managed to prevent the generation of air-bore silica at concentrations which may cause adverse impacts to human health.

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1. Introduction

1.1 Project background

Simcoa Operations Pty Ltd (Simcoa) operates the Moora Quartzite Mine (the Existing Mine) and the Kemerton Silicon Smelter (the Smelter). The Existing Mine is located 15 km north of Moora on tenements M70/191, G70/91, G70/92 and G70/93, in the Wheatbelt region of Western Australia (WA) (Figure 1). The Existing Mine produces high purity quartzite which is transported via truck to the Smelter located in the Kemerton Strategic Industrial Area approximately 17 km north-east of Bunbury in the South West of WA (Figure 1).

The Existing Mine and Smelter are governed by the provisions of the *Silicon (Kemerton) State Agreement Act 1987* (the State Agreement Act) in addition to environmental approvals issued in accordance with Parts IV and V of the *Environmental Protection Act 1986* (EP Act), the *Mining Act 1978* (Mining Act) and the *Rights in Water and Irrigation Act 1911* (RIWI Act).

Simcoa is considering developing a new greenfield quartzite mine at North Kiaka (the Proposed Mine) on M70/1292. The Proposed Mine is located approximately 2 km north of the Existing Mine. Development of the Proposed Mine is not currently explicitly covered by any of the approvals for the Existing Mine.

As part of development of the proposed mine at North Kiaka, several studies are required to support the approvals process. This reports documents the outcomes of the Material Characterisation assessment to understand the leaching potential and air-borne risks of the future waste rock dumps and mining void (walls).

1.2 Purpose of this report

The primary focus of this Material Characterisation relates to the assessment of the waste rock material given that the ore grade material is subject to processing and management off-site.

The purpose of this desk-top assessment was to collate and present the available information in relation to potential risks posed by leaching air-borne risks of the future waste rock and mining-void.

1.3 Limitations

This report has been prepared by GHD for Simcoa Operations Pty. Ltd. and may only be used and relied on by Simcoa Operations Pty. Ltd. for the purpose agreed between GHD and Simcoa client as set out in section 1.2 of this report.

GHD otherwise disclaims responsibility to any person other than Simcoa Operations Pty. Ltd. arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Simcoa Operations Pty. Ltd. and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

1.4 Information sources

In undertaking this desk-top assessment, in addition to the publically available information (*ie: GWSA 1:250,000 geology*), GHDs desk-top study and assessment was based on the following information sources, made available by Simcoa:

- ***Simcoa mineralogical and assay data base***, rationalised to selected data within the footprint of the pits, comprising:
    - A total of 424 drill holes, 20% with geological description, and 80% with no geological description
    - Survey and collar location details (holes drilled vertical holes to a maximum depth of 40 metres below ground level)
    - A total of 25,849 assays comprising: aluminium, iron, titanium, phosphorus, calcium, and magnesium.
- ***West Ridge Mining Development (IMS 2001).*** Reporting comprised a proposal and to the Department of Resource Development, to expand the existing Moora quartz mine (adjacent to the proposed Kiaka Mine).
- ***Mineralisation Report (Simcoa 2010).*** Reporting comprised the summary of exploration drilling, mineralisation and ore resource estimates/quartz grades at both Moora quartz mine and the proposed Kiaka Mine.
- ***Mine Development Plan (Snowden 2012).*** The scope of the Kiaka Mine Plan includes pit optimisation, pit design, estimation of mineral resource and reserves (3D models) and mine layout (roads and dumps).
- ***Moora Quartz Mine Phase 2 Hydrogeological Investigations (Saprolite Env. 2012).*** The scope of work comprised the drilling and installation of production bore and pump testing at the existing Moora quartz mine.
- ***Moora Project, Mineralisation Report (Simcoa Operations, 2010)***. Reporting comprised a summary of activities, drilling results, mineralisation and ore estimates to support an application for a mining lease, at the existing Moora quartz mine.

2. Site background and setting

2.1 Geological setting

The Moora Mine is situated within the Noondine Chert stratigraphic unit, which belongs to the Coomberdale Sub Group of the Moora Group and is Middle Proterozoic in age.

The Proterozoic Coomberdale Sub Group comprises consolidated and weakly metamorphosed sedimentary sequence of shelf carbonates and clastics (chert ie: Noondine chert , siltstones, quartzite). In addition, the Sub Group is intruded by dolerite dykes and is broken up considerably by strike and transverse faults (GSWA 1982).

The Noondine chert is a silicified, bedded carbonate (siliceous limestone/dolomite). The ore-body appears to have been formed by the surface silicification of carbonate rocks. Silicification has been observed to a depth of 75m.. The date of the silicification is uncertain but is probably Tertiary in age (GSWA 1982).

The chert (ore body) contains primary minerals such as chlorite, pyrite, apatite and minor remnant carbonates (calcite/dolomite). Iron oxides, titanium oxides and clays occur in the chert near the surface and are due to secondary weathering processes (Simcoa 2010).

The chert strikes northerly and dips at 20 to 30 degrees to the west. Faulting is common and cavities occur which are usually filled with quartz gravel as collapse breccia (GSWA 1982).

2.2 Hydrogeology and groundwater occurrence

Given the geological and topographical setting, groundwater occurrence at the Site is constrained to fractured rocks aquifers associated with the Proterozoic sediments. The Perth Basin and associated sedimentary aquifers are located some 5 km to the east of the proposed Kiaka Mine Site (GWSA 1982).

Groundwater bore testing in the existing and adjacent Moora Silica mine (Saprolite 2012), indicates a standing groundwater levels close to 215 mAHD (5 to 10 metres below ground level). During the testing, the pumping rates were between 15 to 33.5 L/sec with a maximum drawdown of close to 0.4 metres. Laboratory analysis of the groundwater undertaken during this bore testing indicates a groundwater salinity of 656 mg/L with major ion ratios as follows:

- Cations dominated by sodium (120 mg/L) and lesser magnesium (44 mg/L) and calcium (44 mg/L)
- Anions dominated equally by carbonate (240 mg/L) and chloride (240 mg/L) with relatively low sulphate (26 mg/L)

Given the similar geological setting and topography to that of the existing Moora mine site, it expected that similar groundwater levels and salinity and major-ion ratios occur within the proposed Kiaka Hills mining area.

The common occurrence of cavities observed within the geological logs of the drill holes at Kiaka Hills - at levels below the assumed water table height, indicates that the permeability and groundwater yields are likely to be relatively high.

Groundwater flow direction at the Kiaka Hills area is likely to follow the regional topography and flow in westerly direction towards the Coonderoo River (and wetlands), located some 2.5 km to the west of the western boundary of the Sites.

Given the shallow groundwater levels, and inferred westerly flow direction the groundwater is likely to discharge and be of beneficial use to the Coonderoo River and wetlands – identified as saline/hypersaline (Saprolite 2012).

2.3 Mine layout and ore/waste volumes

The mine plan and open pit design of the proposed Kiaka Hills mine is presented in Figure 2.

Mining is to be undertaken by drill and blast methods. The ore material will be temporarily stockpiled on site and transported to Kemerton for processing, and the waste material is to be excavated and disposed on the designated waste rock landforms (Figure 2).

The volumes of ore and waste material, provided within the Mine Development Plan (Snowden 2012) indicate a:total :

- "Mineral Inventory" of 8.98 million tonnes (Mt) within seven open pit designs; and
- insitu waste rock comprises 9.60 million tonnes (Mt)

At least 40% of the waste is to be backfilled within Pit 3, while the remaining 60% will be placed on the designated waste rock landforms (Figure 2).

Cross section through the open pits is presented in Figure 3 and shows a typical pit depth, some 20 to 30 metres below ground level.

2.4 Definition of waste rock

The economic ore-grade material is based on cut-off grades for concentration of impurities as presented in Table 1. For the purposes of this waste definition and separation of the data base into waste material and ore material, GHD has assigned waste as material which exceeds these cut-off grades.

However, it should be noted that ore estimates, based on a three dimensional ore block model (Snowden 2012), also include blending of material with high impurities with material with low impurities to achieve an average ore-grade volumes.

It is beyond the scope of this assessment to interrogate the methods ore- block model to define the distribution of the ore and waste material (ore definition is subject to processing and economic improvements).

Table 1 Kiaka Hills quartz resource base cut-off grade(s) specifications

Elements	% Fe_2O_3	% Al_2O_3	% TiO_2	% P_2O_5	% Ca	% Mg
Snowden, 2012:	*0.3*	*0.4*	*0.1*	*0.05*	*na*	*na*
Simcoa, 2010:	*0.2*	*0.4*	*0.05*	*0.01*	*na*	*na*

3. Materials Characterisation

3.1 Acidic leaching potential

The generalised understanding of the risk associated with acidic drainage (and secondary metals mobilisation) is based on the:

- total concentration of *sulfide* the waste rock and mining void walls which may produce acid and,
- *carbonate* content of the waste rock and mining void walls which has acid neutralising capacity.

Where sulfide (acid) is in excess to that of carbonate (buffer), potential exists for the material to leach acid and metals, which may impact the groundwater and surface water environments.

Table 1, shows the full list mineralogical assays undertaken on the waste rock and ore, and indicates that there are insufficient data relating to sulfide and carbonate concentrations.

Former reporting indicates that the chert contains primary minerals, including sulfide (Simcoa 2010). Tertiary leaching and development of the weathering profile during silica enrichment has the potential to deplete sulfides in the shallow profile (e.g: 20 metres depth), although, given silica's strong resistance to weathering (oxidation) sulfides may also be preserved. Secondary sulfide mineralisation is not anticipated, given that the ore material is not recognised as a hydro-thermal fluid style alteration of host rock.

The distribution and occurrence of carbonates within the waste rock and pits walls is not understood given the lack of identification within the geological drilling records/logs, and that carbonate is not identified with the assay results. Former reporting (Simcoa 2010) indicates that remnant carbonate minerals occur, (particularly at depth) and based on the calcium assay data (data not presented herein) there may be up to an average of 0.02% of carbonate minerals. Alternatively, the calcium may also reflect the presence of clays (clays noted in the geological logs – logs not presented herein).

Although confirmation is required, given that there is unlikely to be elevated concentrations of sulfide within the ore-body, the generation of acidic conditions should not occur at concentrations and rates which will be a cause for concern.

3.2 Metalliferous leaching potential

The generalised understanding of the risk associated with metalliferous drainage (which may impact groundwater or surface water environments) is based on the:;

- concentration, or enrichment of metals in the waste rock or pit walls, compared against a reference rock/soil type the Global Abundance Index *[(GAI = log index relative to the average crustal abundance)*];
- released concentrations of metals/elements leached from the waste rock over time,
- occurrence of acidic conditions, which may promote the dissolution and mobilisation of metals from the waste rock and mine void walls.

There are insufficient data available relating to metal occurrence and concentrations within the waste rock and pit walls (metals assay data limited to Table 1) to evaluate the metals which may be of concern.

Although metals which are common in the environment are likely to be present within the waste rock and pit walls (e.g.; aluminium, iron, manganese), given the silicic nature of the orebody and host rock (predominantly chert) the waste material is unlikely to comprise a large number of metallic elements.

The waste rock and pit walls will be subject to greater exposure (increased surface area) following mining/excavation and disposal of the material on to waste rock landform. However, given the silicic nature of the waste rock and resistance to weathering, leaching rates should be relatively low. Further, given that the risk of acidic conditions developing in the waste rock/pit walls is considered unlikely, conditions should not be conducive for leaching and mobilisation of metals.

3.3 Saline drainage potential

The generalised understanding of the risk associated with saline drainage is based on the mass of readily dissolvable minerals within the waste rock and walls of the pit-void. Dissolved solids leaching from the rock mass may cause an adverse impacts to the surrounding groundwater or surface water environments (if dissolved as elevated rates).

Although the detailed mineralogy of the waste rock is not available, the silicic mineralogy and lithological type of the of the ore body (predominantly chert) should preclude the presence of readily dissolvable minerals (eg: halite, gypsum, carbonate).

The elevated occurrence of one of the readily dissolved minerals - gypsum, common to the arid climates can be excluded, given that the calcium ion a major constituent of the gypsum ($CaSO_4$) is not identified at elevated concentrations in the assay data (data not presented herein). The calcium concentrations (CaO) exhibit an average of 0.02%, with 30 of the 5,170 samples above 0.1% CaO.

Given the likelihood that readily dissolvable minerals are likely not present at notable concentrations and the silicic nature of the waste rock (resistant to weathering), the risk of adverse impacts, derived from saline leaching from the waste rock and the pit-walls, is considered low.

3.4 Radioactivity

GHD is not aware of measurements or testing for naturally occurring radioactive materials within the subsurface of the Kiaka mining footprint.

The silicic mineralogy and lithological type of the ore body (predominantly chert) should support those minerals which commonly exhibit elevated radioactivity (above that of background) are unlikely to be present.

Although not defined, the exposure risk from radioactivity within the waste rock should not be increased, given that the waste rock will not be processed and the waste material will be relocated on the proposed waste rock landform. Any potential concentration of radioactive of minerals during ore processing (if present), will be managed off-site.

3.5 Air borne hazards

Asbestos: As far GHD is aware, the presence or absence of asbestos within the subsurface of the mining footprint has not been confirmed through testing, nor made mention within the former reporting and geological descriptions. Although not confirmed, the occurrence of asbestos is not anticipated within this style of silica based ore-body.

Silica: The silicic mineralogy and lithological type of the of the ore body (predominantly chert) indicates that mining activities and waste rock dumps should be managed to prevent the generation of air-bore silica at concentrations which may cause adverse impacts to human health.

4. Summary and recommendations

Characterisation of leaching impacts (AMD)

Although specific assay/laboratory data are unavailable, the desk-top assessment indicates that there is unlikely to be elevated concentrations of sulfide within the ore-body, and that the generation of acidic conditions is unlikely to occur at concentrations and rates which may be a cause for concern to human health and the environment.

Assuming that the risk of acidic conditions developing in the waste rock/pit walls is considered unlikely, and that metal occurrences are constrained to commonly occurring metals (eg: Fe, Al, Mn), conditions should not be conducive for leaching and mobilisation of metals at concentrations which may cause adverse impacts to human health and the environment.

The risk that waters with elevated salinity will leach from the waste rock and the pit-walls at concentrations which may cause adverse impacts is considered low, given that readily dissolvable minerals are likely not present at notable concentrations in the geological profile (ancient weathered and silicic geological profile).

Any adverse leaching impacts, derived from the waste rock and pit-walls (if any), and which seep into the relatively permeable subsurface, will migrate in the direction of groundwater flow, inferred in a westerly direction towards the Coonderoo River (and wetlands), located some 2.5 Km to the west of the western boundary of the Site.

Radioactivity:

The dominant silicic mineralogy and lithology (predominantly chert) support that minerals which commonly exhibit elevated radioactivity (above that of background), is unlikely to be present at this site.

The mining process should not concentrate background radioactivity which may be present given the waste rock is not subject to processing and will be relocated to the waste rock landform, and that the ore and residual processed material will be managed off-site.

Air-borne hazards:

Although not confirmed, the occurrence of asbestos is not anticipated within this style of silica based ore-body. However, the silicic mineralogy of the ore body indicates that there is an elevated risk of exposure to human health from air-bore silica.

Recommendations

While the qualitative information indicates that the issues relating to the risk of acidic, metalliferous and saline drainage, radioactivity and asbestos appears to be low, there are insufficient data to characterise the risk and likelihood of adverse impacts.

In particular, it is plausible that primary sulphides' (acidic production potential), which were anecdotally referenced within former reporting, may be remain and are preserved within the silicic material.

Given the paucity of relevant data and based on the recommendations with the DMP draft documentation regarding testing of materials (DMP 2016), specific laboratory testing is recommended to screen the issues within the waste rock, as follows:

- Acid neutralising capacity (ANC): 12 samples
- Net acid generation (NAG) : 12 samples

- Sulfur speciation: 6 samples
- Metals comprehensive: 6 samples
- Leach testing (major-ions, pH, EC, metals): 6 samples
- Radioactivity screen/gross alpha and beta: 4 samples
- Asbestos mineral fibres: 12 samples

Follow-up testing may be warranted, if the results of the laboratory testing do not confirm the assumptions that the Site - excluding air-borne silica - generally exhibits a low risk with respect to material characterisation.

Mining activities and waste rock dumps should be managed to prevent the generation of air-bore silica at concentrations which may cause adverse impacts to human health.

5. References

Snowden 2012, Simcoa: Moora Quartz District, Kiaka Hills Mine Development Plan Project No. 3545, 30 November 2012

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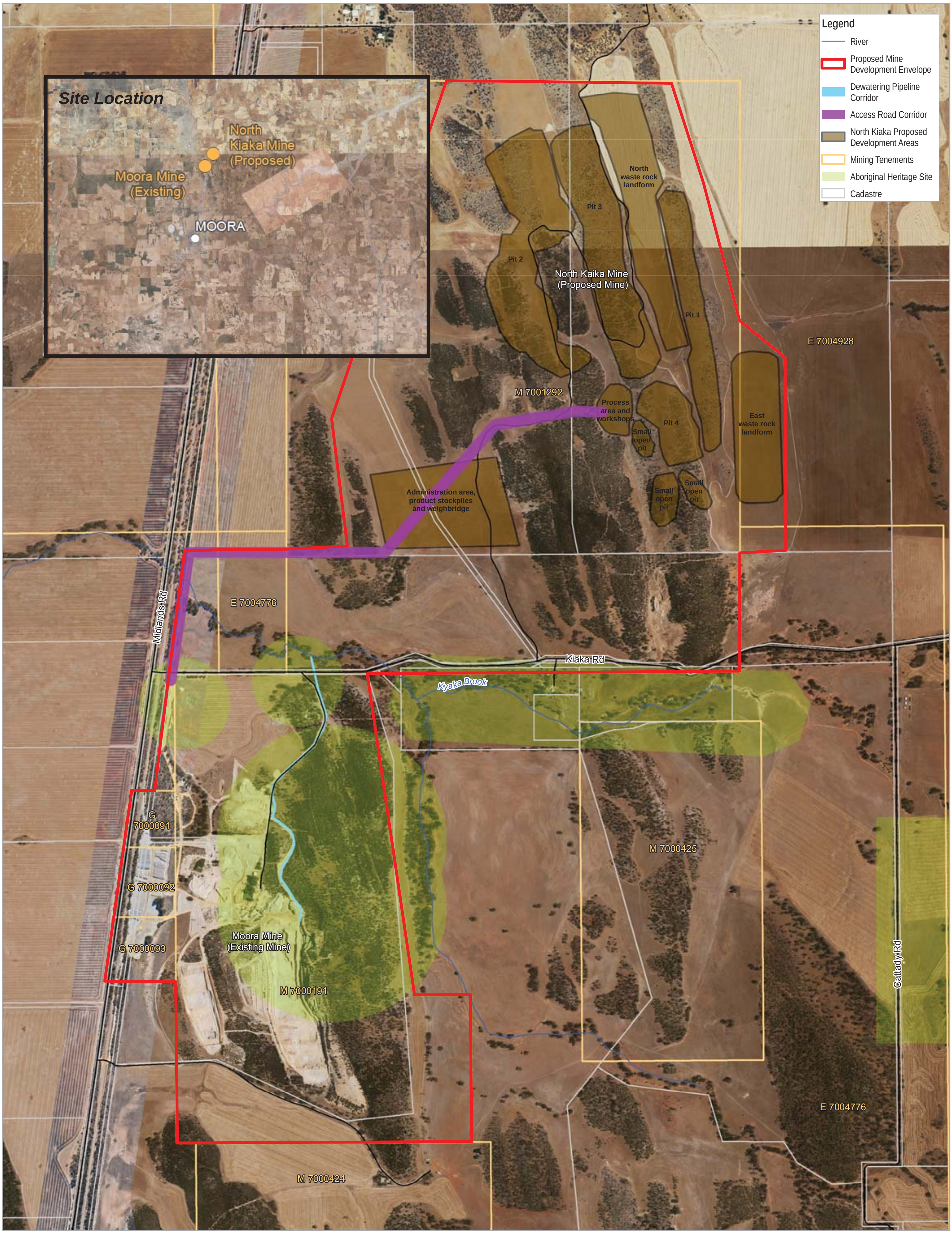
DMP , 2016, Draft Guidance, Materials Characterisation Baseline Data Requirements for Mining Proposal, March 2016, Government of Western Australia, Department of Mines an Petroleum, March 2016.

Figure List



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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

Simcoa Operations Pty Ltd
North Kiaka Mine Expansion

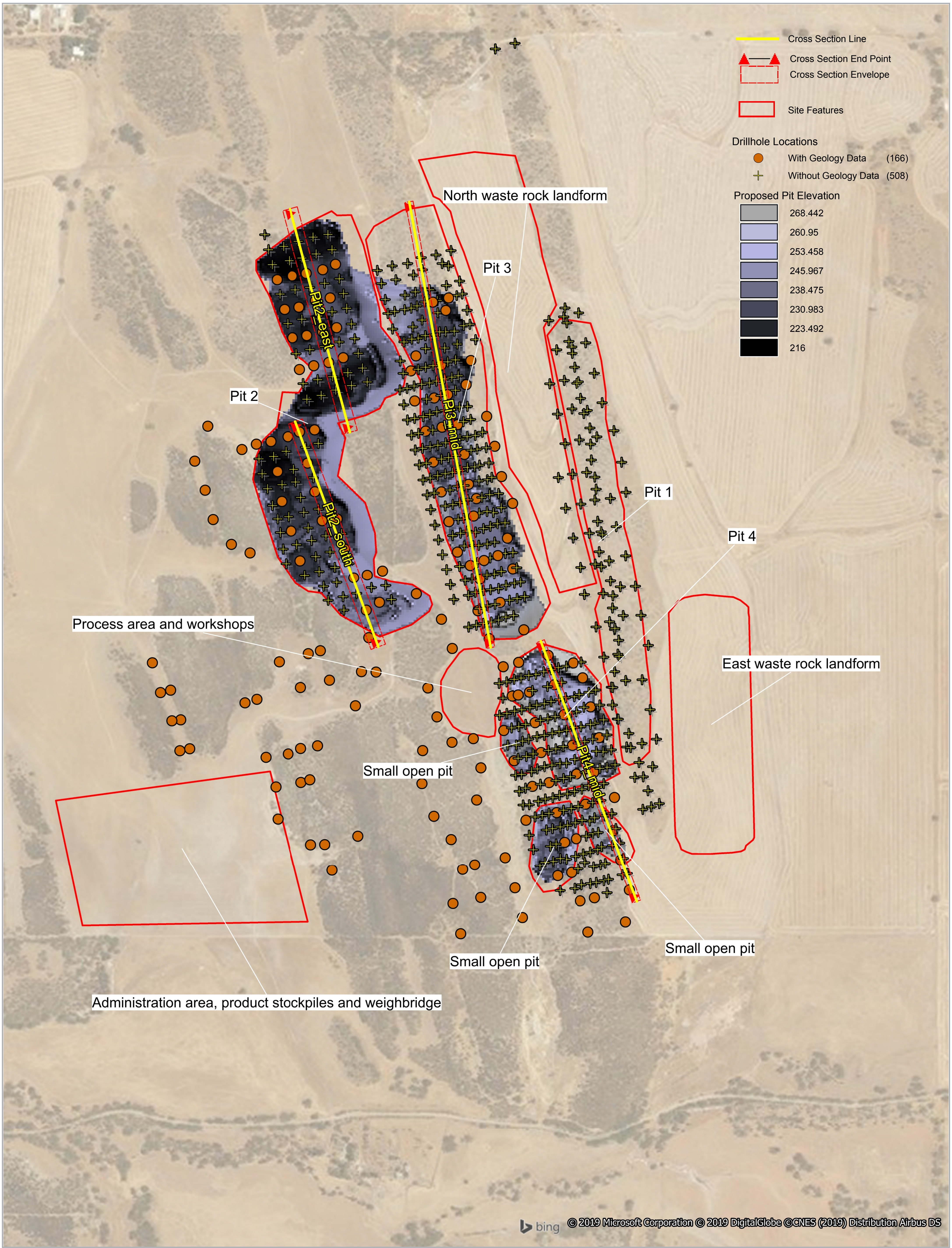
Simcoa Moora Mine and Proposed North Kiaka Mine

Project No.	61-37159
Revision No.	B
Date	05/06/2018

FIGURE 1

G:\61\37159\GIS\Maps\Working\6137159_007_SimcoaLayout_RevB.mxd
Print date: 04 Jul 2018 - 11:27

Data source: Simcoa: Mining Development Shape Areas is derived from client recieved 2018; Langate: Slip Imagery, Cadastre, Road - 20180601; DMIRS: Mining Tenements - 20180601; Access Road Corridor - 20180601, Access Road Corridor - 20180601, Dewatering Pipeline Corridor - 20180627, Mine Development Envelope - 20180627; DoW: River - 201108; DIA: Aboriginal Heritage Site - 201806. Created by: jwball



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metres

Paper Size A3

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 50

N

Simcoa Operations Pty Ltd
North Kiaka Mine Expansion

Kiaka mine drill-hole and
open pit locations

Project No. 6137455
Revision No. -
Date 21/03/2019

FIGURE 2

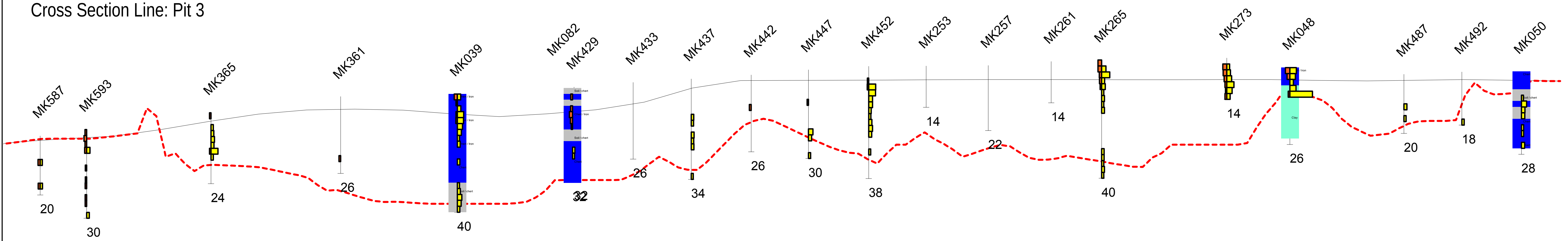
\ghdnet.internal\ghd\au\perth\projects\61\37117\Tech\Hydrogeo

Data source: GHD,. Created by: AO

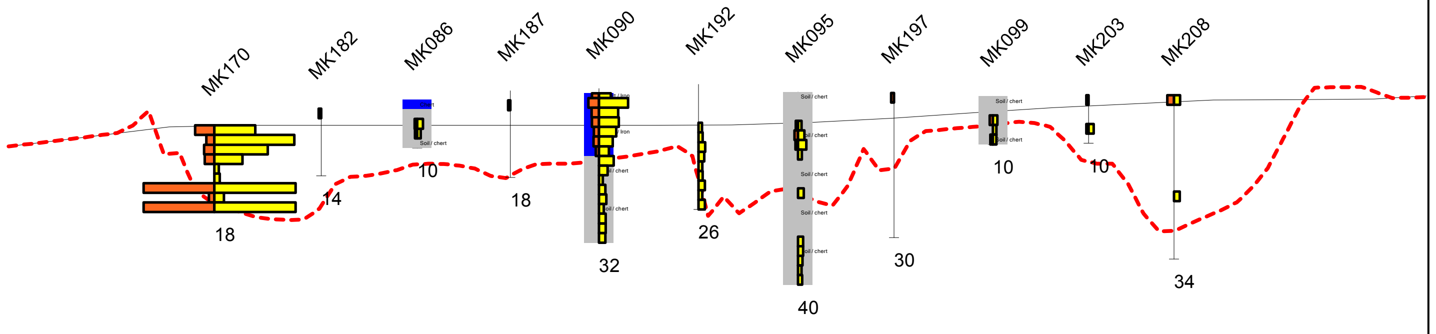
Simcoa Operations Pty Ltd
North Kiaka Mine Expansion

Figure 3
Cross sections through open pits

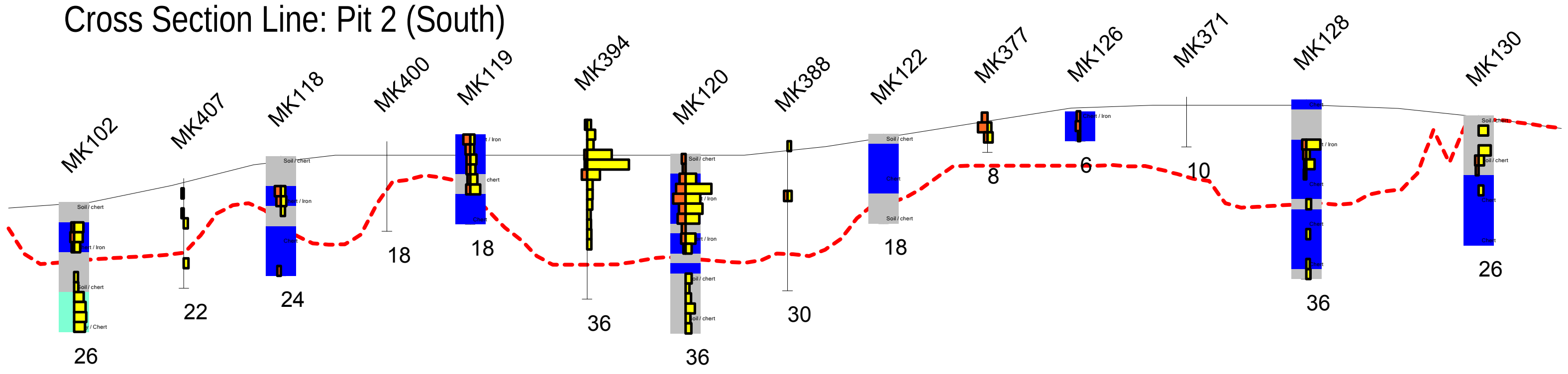
Cross Section Line: Pit 3



Cross Section Line: Pit 2 (East)



Cross Section Line: Pit 2 (South)



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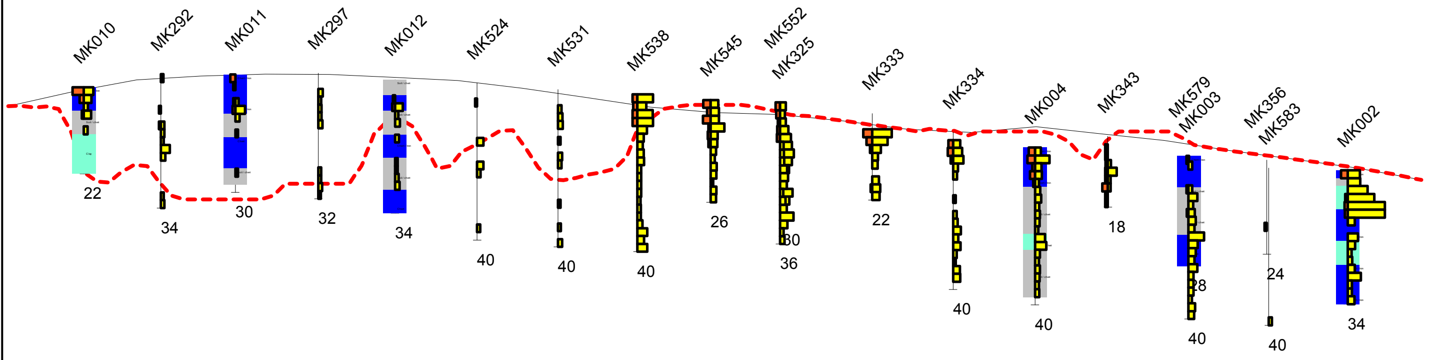

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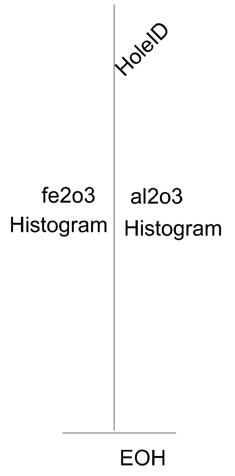

mm given at scale of 1:1200

Simplified Lithology

- 🟦 Chert
- ⬜ Soil
- 🟩 Clay
- 🟪 Chlorite
- 🟩 Dolerite
- no sample
- ⬜ Quartz

Fe2 O3 over 0.3%

🟧 0.3 - 20.55%

Al2 O3 0.4%

🟨 0.4 - 10%

GHD

1st Floor

10 Victoria Street

T: 61 8 9721 0700   F: 61 8 9721 0777   E: bunmail@ghd.com

6137455-97481/https://projects.ghd.com/oc/WesternAustralia1/simcoankiakaapproval/Delivery/Documents/613745505-doc-Nth Kiaka Approvals Materials Characterisation Assessment.docx

Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
Rev 1	Paul Hamer	Rob Virtue		Fionnuala Hannon	Fionnuala Hannon	6/05/2019

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Appendix G

Flora and Vegetation Report

GHD and Trudgen 2024

SIMCOA
Silicon Metal Company of Australia

Simcoa Operations Pty Ltd

North Kiaka

Flora and Vegetation Survey Report

M Trudgen and GHD

March 2024

Project name	North Kiaka Project Approval Support
Document title	Flora and Vegetation Survey Report | North Kiaka
Project number	12627587
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S4	0	B Harris	B Neville	BNeville	F Hannon		21/03/2024

GHD Pty Ltd | ABN 39 008 488 373
Contact: Bronwyn Neville, Environmental Scientist | GHD
10 Victoria Street, 1st Floor
Bunbury, Western Australia 6230, Australia
T +61 8 9721 0700 | **F** +61 8 9721 0777 | **E** bunmail@ghd.com | **ghd.com**

[Compliance statement]

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Executive Summary

SIMCOA Operations Pty Ltd (the **Proponent, (SIMCOA)**) currently operates the Moora Quartzite Mine (Moora Mine), approximately 15 km north of Moora, in the Wheatbelt of Western Australia (WA). Moora Mine has been operating for 30 years and is located on tenements M70/191, G70/91, G70/92, G70/93 and M70/1292 (with activities on M70/1292 limited to mine dewater discharge to Kyaka Brook). Quartzite ore from Moora Mine is currently transported via covered truck to SIMCOA's Kemerton Smelter (Kemerton Smelter) located in Kemerton Strategic Industrial Area (KSIA), approximately 17 km north-east of Bunbury in the South-West of WA. Existing activities at Moora Mine and Kemerton Smelter (the Approved Proposal) are approved under Part IV of the *Environmental Protection Act 1986* (EP Act) and Ministerial Statement 813 (MS 813). The Approved Proposal has been operating since 1989.

SIMCOA is proposing to establish a new quartzite mine, referred to as North Kiaka Mine (the Project), immediately north of Moora Mine (with the mine pit located approximately 1.5 to 2 km north of Kiaka Road). The proposed development of the North Kiaka mine is located within tenement M70/1292.

The flora and vegetation surveys and reporting for North Kiaka were undertaken over many years, beginning in 2012. The surveys have included the detailed survey (2012) and targeted surveys completed in 2016 and 2017. The dominant vegetation community is the Coomberdale Chert Threatened Ecological Community (TEC) The Coomberdale Chert is a distinctive vegetation type that is found on low rocky hills between Moora and Watheroo. This vegetation type is the predominant vegetation type both with the North Kiaka DE and the broader regional extent.

The North Kiaka DE consists of remnant vegetation on parts of parallel low chert ridges. The remnants surveyed as part of this survey effort are located on three ridges that trend from the north-north-west to the south-south-east. The southern end of the 1.4-kilometre-long area surveyed is 500 metres north of Kiaka Road and 2.2 kilometres east of the Midlands Road. The ridges are separated by narrow strips of cleared farmland and are part of a larger group of ridges located north of Kiaka Road.

Agriculture is the predominant landuse in the Proposal area, with the majority of the landscape cleared for broadacre agriculture. The landscape is very stable with no other land or industry development or activities occurring in the area other than farming and SIMCOA's mine operations. There are no records of bushfires having occurred in the areas of remnant vegetation and flora populations are stable and long established.

Key findings

Vegetation types and condition

The vegetation of the Critically Endangered Coomberdale Chert Threatened Ecological Community (TEC) vegetation and flora occurs between Dalaroo East Road and north of Kiaka Road.

The vegetation was classified into three levels. The lowest order units are defined near the *plant community* level with similar structure, dominance and floristics. The plant communities were grouped into 104 *vegetation associations* that have similar structure and dominant species and then into 31 *vegetation alliances* as a third level of classification.

Vegetation condition ranges from *Completely Degraded* (cleared farmland) to *Very Good* condition. The better condition areas north of Kiaka Road are mainly in the southern part of the main central ridge system.

Flora

The Flora surveys reported 102 species of native flowering plants, one native pine (*Actinostrobus arenarius*) and five species of native ferns. This is a significant subset of the 315 native flowering plants recorded for the area of the Coomberdale Chert TEC (2012) and the 192 native flowering plant species recorded north of Kiaka Road within that area. The survey area also reports 332 native flora species and 56 weeds.

Five threatened flora species occur in the survey area. Two of these were found north of Kiaka Rd and in the proposed impact area (*Acacia aristulata* and *Daviesia dielsii)*. Thirteen priority flora species have been recorded in the survey area with three recorded north of Kiaka Road and in the proposed impact area (*Regelia megacephala*, *Diuris recurva* and *Stylidium* sp. Moora.).

A post survey likelihood of occurrence assessment for all significant flora species identified in the desktop. Of the 69 species listed as potentially occurring within this table, five are listed as possibly occurring, 17 are known to occur and the remaining are listed are unlikely or highly unlikely.

This Report has been prepared to meet the Technical Guidance: Flora and Vegetation Surveys for Environmental Impact Assessment, 2016. This Report notes that the surveys were completed in 2012, 2016 and 2017 and while the currency of the data extend beyond five years, the findings can be confidently assessed for the following reasons:

- The experience of the Botanist. Malcolm Trudgen has been acknowledged by DBCA as a technical authority in the assessment in Coomberdale Chert vegetation community
- The survey extent and longitudinal data set
- The landscape is stable in terms of land and activity
- There have been no catastrophic events in the area that have impacted vegetation condition and flora populations within the 50 years, ie bushfire or cyclones.

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1. Introduction

SIMCOA Operations Pty Ltd (the **Proponent, (SIMCOA)**) currently operates the Moora Quartzite Mine (Moora Mine), approximately 15 km north of Moora, in the Wheatbelt of Western Australia (WA). Moora Mine has been operating for 30 years and is located on tenements M70/191, G70/91, G70/92, G70/93 and M70/1292 (with activities on M70/1292 limited to mine dewater discharge to Kyaka Brook). Quartzite ore from Moora Mine is currently transported via covered truck to SIMCOA's Kemerton Smelter (Kemerton Smelter) located in Kemerton Strategic Industrial Area (KSIA), approximately 17 km north-east of Bunbury in the South-West of WA. Existing activities at Moora Mine and Kemerton Smelter (the Approved Proposal) are approved under Part IV of the *Environmental Protection Act 1986* (EP Act) and Ministerial Statement 813 (MS 813). The Approved Proposal has been operating since 1989.

SIMCOA is proposing to establish a new quartzite mine, referred to as North Kiaka Mine (the Project), immediately north of Moora Mine (with the mine pit located approximately 1.5 to 2 km north of Kiaka Road) (Figure 1.1). The proposed development of the North Kiaka Mine is located within tenement M70/1292. The expansion covers an area of 216.42 hectares (ha) to the north of Kiaka Road which will be referred to as the North Kiaka Development Envelope (DE) as shown in Figure 2.1. The North Kiaka DE consists of remnant vegetation on parts of parallel low chert ridges. The dominant vegetation community is the Coomberdale Chert Threatened Ecological Community (TEC) The Coomberdale Chert is a distinctive vegetation type that is found on low rocky hills between Moora and Watheroo. This vegetation type is the predominant vegetation type both with the North Kiaka DE and the broader regional extent.

SIMCOA commissioned Consultant Botanist, Malcom Trudgen to complete a series of botanical investigations over a six-year timeframe to map the flora and vegetation in a survey area that included both the proposed expansion area and a wider regional extent (Trudgen, Griffin, & Morgan, 2012).

The remnants surveyed as part of this survey effort are located on three ridges that trend from the north-north-west to the south-south-east. The southern end of the 1.4-kilometre-long area surveyed is 500 metres north of Kiaka Road and 2.2 kilometres east of the Midlands Road. The ridges are separated by narrow strips of cleared farmland and are part of a larger group of ridges located north of Kiaka Road. Agriculture is the predominant landuse in the Proposal area, with most of the landscape cleared for broadacre agriculture.

The landscape is very stable with no other land or industry development or activities occurring in the area other than farming and SIMCOA's mine operations. There are no records of bushfires having occurred in the areas of remnant vegetation and flora populations are stable and long established.

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- The survey extent and longitudinal data set
- The landscape is stable in terms of land and activity
- There have been no catastrophic events in the area that have impacted vegetation condition and flora populations within the 50 years, ie bushfire or cyclones.

This Report has been prepared to meet the Technical Guidance: Flora and Vegetation Surveys for Environmental Impact Assessment (EPA, 2016).

1.1 Scope and limitations

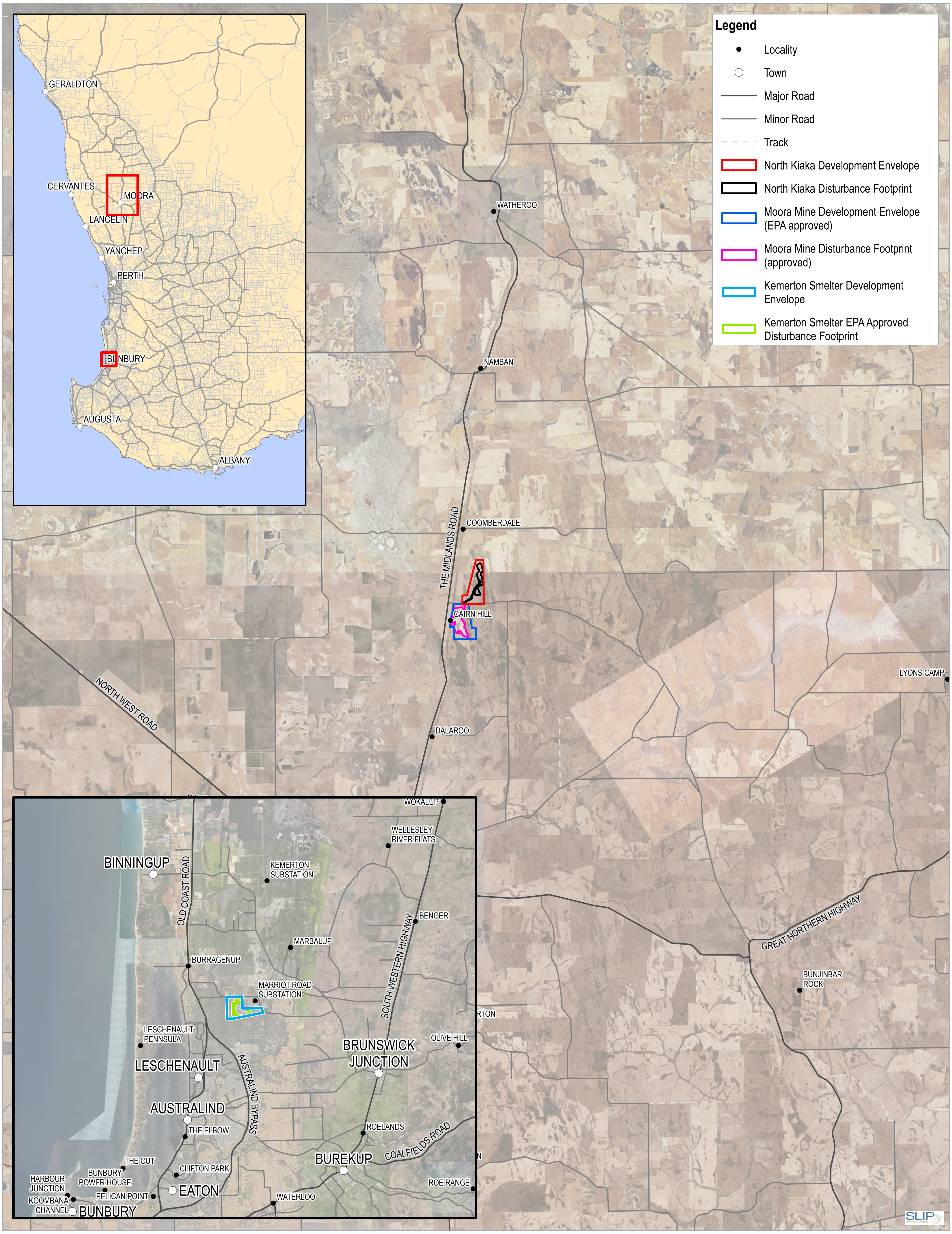
This report: has been prepared by GHD and M Trudgen for Simcoa Operations Pty Ltd and may only be used and relied on by Simcoa Operations Pty Ltd for the purpose agreed between GHD and Simcoa Operations Pty Ltd as set out in this report.

GHD otherwise disclaims responsibility to any person other than Simcoa Operations Pty Ltd arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.



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Simcoa Operations Pty Ltd
Flora and Vegetation Survey Report

Project Location

Project No.	**12518217**
Revision No.	**0**
Date	**14/ 03/ 2024**

FIGURE 1-1

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Data source: Simcoa: Mining Development Shape Areas is derived from client recieved 2020; Langate: Slip Imagery - April 2017 to November 2018 (accessed - 20191023), Cadastre, Road - 20180601; GA: Natmap Geodata Topo 250k Series 3. Created by: klabez

2. Legislative Background

2.1.1 Relevant legislation, conservation codes and background information

Flora and fauna in Western Australia (WA) are protected formally and informally by various legislative and non-legislative measures, including:

- *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) – Commonwealth;
- *Biodiversity Conservation Act 2016* (BC Act) – WA;
- *Environmental Protection Act 1986* (EP Act) – WA;
- *Biosecurity and Agriculture Management Act 2007* (BAM Act) – WA.
- WA Department of Biodiversity, Conservation and Attractions (DBCA) Priority lists for flora, ecological communities and fauna;
- Weeds of National Significance; and
- Recognition of locally significant populations by the DBCA.

A short description of each legislative measure is provided below. Other definitions, including species conservation categories, are provided in Appendix A.

2.1.2 *Environmental Protection and Biodiversity Conservation Act 1999*

The EPBC Act aims to protect Matters of National Environmental Significance (MNES), which are detailed in Appendix A. Under the EPBC Act, the Commonwealth Department of Agriculture, Water and Environment (DAWE) lists protected species and Threatened Ecological Communities (TECs) by criteria set out in the Act. Species are conservation significant if they are listed as Threatened (i.e. Critically Endangered, Endangered and Vulnerable) or Migratory.

Bird species protected as Migratory under the EPBC Act include those listed under international migratory bird agreements relating to the protection of birds which migrate between Australia and other countries, for which Australia has agreed. This includes the Japan-Australia Migratory Bird Agreement (JAMBA), the China-Australia Migratory Bird Agreement (CAMBA), the Republic of Korea Australia Migratory Bird Agreement (ROKAMBA) and the Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention).

Some marine fauna or terrestrial fauna that use marine habitats are listed as Marine under the EPBC Act. These species are only considered conservation significant when a proposed development occurs in a Commonwealth marine area (i.e. any Commonwealth Waters or Commonwealth Marine Protected Area). Outside of such areas, the EPBC Act does not consider these species to be matters of national environmental significance and therefore are not protected under the Act.

2.1.3 *Biodiversity Conservation Act 2016*

DBCA lists taxa (flora and fauna) under the provisions of the Biodiversity Conservation Act 2016 (BC Act), as protected and are classified as according to their need for protection (see Appendix A). The BC Act makes it an offence to ‘take’ threatened species without an appropriate licence. There are financial penalties for contravening the BC Act. Under the BC Act, DBCA lists species as Threatened (T) (Declared Rare) or Priority Flora (P1, P2, P3 or P4).

2.1.4 Environmental Protection Act 1986

Threatened flora, fauna (and significant habitat necessary for the maintenance of indigenous fauna) and TECs are given special consideration in environmental impact assessments and have special status as

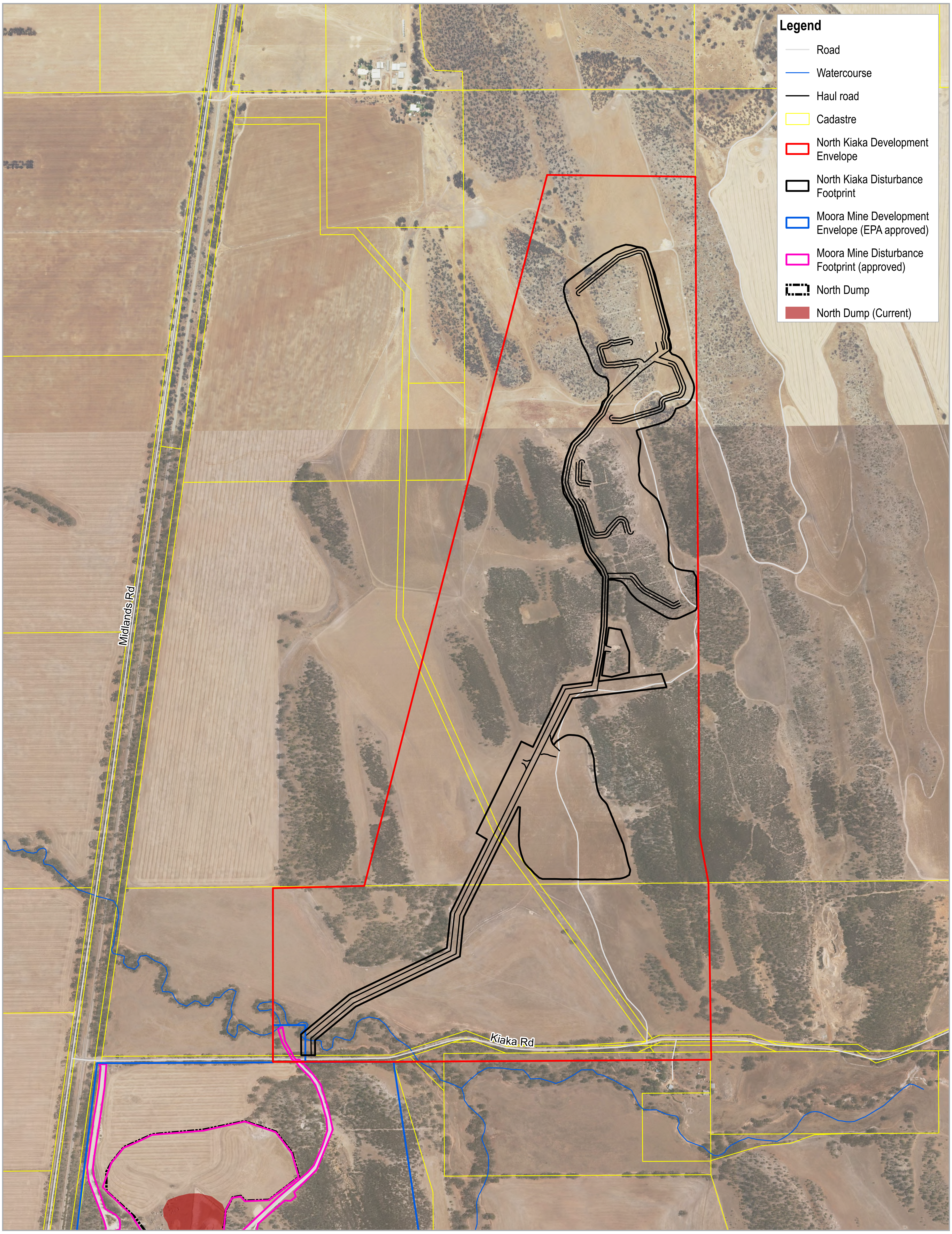
Environmentally Sensitive Areas (ESAs) under the EP Act and the Environmental Protection (Clearing of Native Vegetation) Regulations 2004. Exemptions for a clearing permit do not apply in, or within 50 m of, an ESA.

2.1.5 Biosecurity and Agriculture Management Act 2007

The *Biosecurity and Agriculture Management Act 2007* (BAM Act) provides for management and control of listed organisms, including introduced flora species (weeds). Species listed as declared pests under the BAM Act are classified under three categories:

- C1 Exclusion: Pests assigned under this category are not established in Western Australia, and control measures are to be taken to prevent them entering and establishing in the State.
- C2 Eradication: Pests assigned under this category are present in Western Australia in low enough numbers or in sufficiently limited areas that their eradication is still a possibility.
- C3 Management: Pests assigned under this category are established in Western Australia, but it is feasible, or desirable, to manage them in order to limit their damage. Control measures can prevent a C3 pest from increasing in population size or density or moving from an area in which it is established into an area that is currently free of that pest.

Under the BAM Act, land managers are required to manage populations of declared pests as outlined under the relevant category.



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Simcoa Operations Pty Ltd
Flora and Vegetation Report

North Kiaka DE
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Revision No.	**0**
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FIGURE 2.1

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Data source: Simcoa: Mining Development Shape Areas is derived from client recieved 2020; Langate: Slip Imagery - April 2017 to November 2018 (accessed - 20191023), Cadastre, Road - 20180601; DMIRS: Mining Tenements - 20180601; DoW: River - 201108. Created by: klabez

3. Methodology

The following methodology was undertaken to inform this flora and vegetation assessment.

1. Desktop assessment of vegetation mapping, vegetation condition mapping and flora survey reports, including Trudgen *et al*. (2001; 2006).
2. Detailed survey of vegetation and flora Trudgen *et* al (2012).
3. Targeted surveys of the survey area to map the occurrence of threated and priority flora (Trudgen, 2018).

3.1 Flora and Vegetation

3.1.1 Desktop assessment

A desktop assessment of the flora and vegetation was undertaken in accordance with current Environmental Protection Authority (EPA) guidance (EPA, 2016). A comprehensive review of contextual environmental information was undertaken including climate, biogeography, land systems, and pre-European vegetation. A search of available databases as listed in Table 3.1 was also undertaken (see Appendix D).

Table 3.1 Database searches conducted for the desktop assessment.

Custodian	Database	Taxonomic group	Buffer (km)
Department of Climate Change, Energy, Environment and Water (DCCEEW)	Protected Matters Search Tool	Flora, Vegetation	10
Department of Biodiversity, Conservation and Attractions (DBCA)	NatureMap	Flora	10
	West Australian Herbarium	Flora	10
	Threatened (Declared Rare) and Priority Flora (TPFL)	Flora	20
	Threatened and priority ecological communities (TEC/PEC)	Vegetation	20

3.1.2 Field assessment

The targeted surveys for threatened and priority flora accounted for the vegetation types and condition (including the level of weed invasion) within the area of the 2012 survey.

The 2016 targeted survey included transects at 30m intervals were used to maximise survey efficiency and were deemed appropriate to meet intensity required to recognise the species being targeted. A total of 72 transects were walked during the 2016 targeted survey.

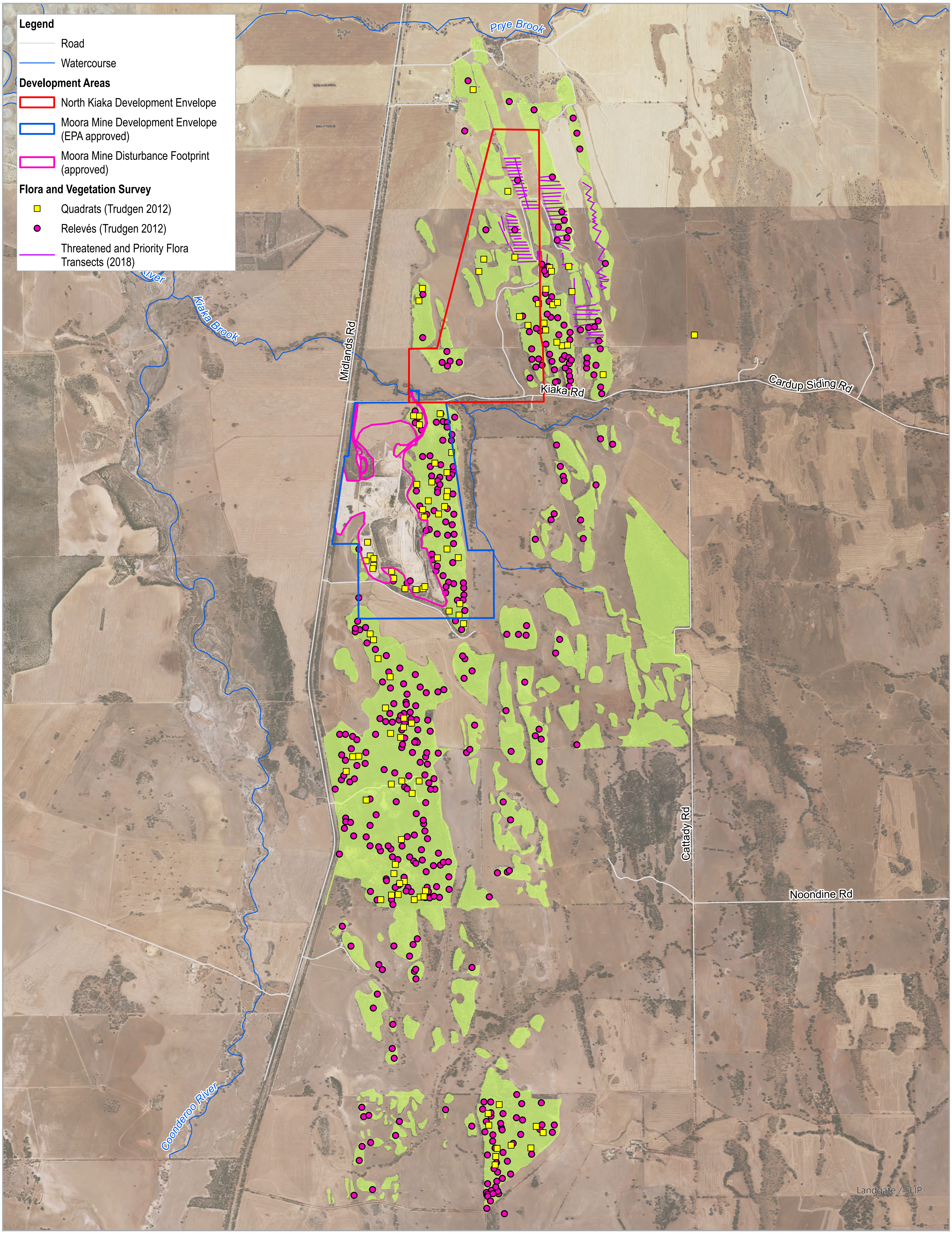
Where conservation significant flora species were recorded, population extents were defined to inform the understanding of significance of the species within the Coomberdale Chert TEC. The 2017 targeted survey included a targeted threatened and priority flora survey of surrounding areas for Cairn Hill Reserve, a targeted Banksia sphaerocarpa form survey on the Gardiner property and an assessment of haul road options for the proposed impact area. The extent of the survey effort is shown in Figure 3.1.

A summary of the flora and vegetation survey effort is shown in Table 3.1.

Table 3.2 Flora and Vegetation Survey effort

Survey year/ month		Season	Description of the survey including number of quadrats/ relevés
2000	September	Spring	40 quadrats
	October		
	November		
	December	Summer	
2002	October	Spring	40 quadrats
	November		
2003	March	Autumn	8 quadrats and 185 relevés
	April		
	August	Winter	
	October	Spring	
	November		
	December	Summer	
2004	January	Summer	169 relevés
	April	Autumn	
	November	Spring	
	December	Summer	
2005	February	Summer	29 relevés
2007	November	Spring	1 relevé
2010	September	Spring	11 quadrats and 13 relevés
	October		
	November		
2016	June	Winter	Targeted threatened and priority flora survey of proposed impact areas and adjacent vegetation – 72 transects Conservation significant flora; and Conservation significant ecological communities (TEC/PEC). **Threatened** *Acacia aristulata* *Daviesia dielsii*
	July		
	August		
	September	Spring	

Survey year/ month		Season	Description of the survey including number of quadrats/ relevés
			Eucalyptus pruiniramis *Goodenia arthrotricha* *Synaphea quartzitica* ***Priority*** P3 *Austrostipa nunaginensis* P3 *Babingtonia cherticola* P2 *Bossiaea moylei* P4 *Diuris recurva* P1 *Eremaea* sp. Cairn Hill P2 *Grevillea amplexans* subsp. semivestita P3 *Guichenotia tuberculata* P4 *Hemigenia conferta* P3 *Melaleuca sclerophylla* P4 *Regelia megacephala* P2 *Stylidium glabrifolium* P2 *Stylidium* sp. Moora P2 *Tricoryne* sp. Wongan Hills (B.H. Smith 794)
2017	July	Winter	Targeted threatened and priority flora survey of surrounding areas for Cairn Hill Reserve. Targeted *Banksia sphaerocarpa* form survey on the Gardiner property Assessment of haul road options for the proposed impact area Conservation significant flora; and Conservation significant ecological communities (TEC/PEC).
	November	Spring	
	December	Summer	



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Simcoa Operations Pty Ltd
Flora and Vegetation Survey Report

Survey Effort (Trudgen 2012 Flora and Vegetation Survey, Trudgen 2016 Targeted Threatened and Priority Transects)

Project No. **12518217**
Revision No. **0**
Date **21/03/2024**

FIGURE 3.1

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Data source: Simcoa: Mining Development Shape Areas is derived from client recieved 2020; Langate: Slip Imagery - April 2017 to November 2018 (accessed - 20191023), River, Road - 20180601. Created by: klabez

3.1.2.1 Field survey, floristic analysis, vegetation description and mapping

Prior to the flora and vegetation surveys detailed in the Trudgen *et al* (2012) report, aerial photographs were examined to assist in the selection of sites for the recording of quadrats. They were also used in the field for vegetation mapping. Nested quadrats measuring 10x10 m (ie. 100 m^2) within a 30 x 30 m area were used. The smaller is commonly used in regional surveys in the south-west of Western Australia (eg., Griffin (1992), Gibson et al (1994)) and its use would allow comparison of the data collected to previously collected data where appropriate. The 30x30 m (900 m2) quadrat surrounding the smaller quadrat was used as the vegetation in the TEC tends to be species poor. The larger size quadrats provided data less likely to have stochastic variation and therefore more rigorous floristic analyses. Species accumulation curves (Figure 3.2 and Figure 3.3) indicate that the quadrats recorded quite thoroughly sample the flora of the area surveyed by Trudgen *et al* (2012).

99 quadrat sites were selected to represent the range of the vegetation types present in the survey sub-areas sampled. The 10x10 m quadrats were pegged at all four corners with galvanised fence droppers. The geographic position of at least two diagonally opposite pegs was recorded with a hand-held GPS unit. The 30x30 m areas were defined around the smaller area with tape measures but were not pegged or locations recorded with the GPS, as location of the pegs for the 10x10 m quadrat would adequately locate the 30x30 m quadrat. Where it was not possible to fit the 30x30 m quadrat in exactly because of stand size or disturbance, the boundaries were modified to include 900 m^2 where possible.

At each of the quadrats, the structure and dominance of the vegetation was recorded using Aplin's (1979) modification of Specht's table. When a stratum was floristically diverse, only the most abundant species were included in the vegetation description. The quadrats were carefully searched to record as many of the species present as possible, all species observed were recorded for the site with an estimate of their height and cover. A "+" sign was used to indicate a cover assessment of significantly less than 1%. The quadrats were recorded twice to provide a comprehensive list of species.

The floristic (species list) data from the quadrats was used to provide a floristic analysis of the vegetation. The vegetation descriptions from the quadrats were used to define the vegetation of the vegetation mapping polygon they were recorded in. The vegetation in other polygons was described during the 2012 vegetation mapping field work.

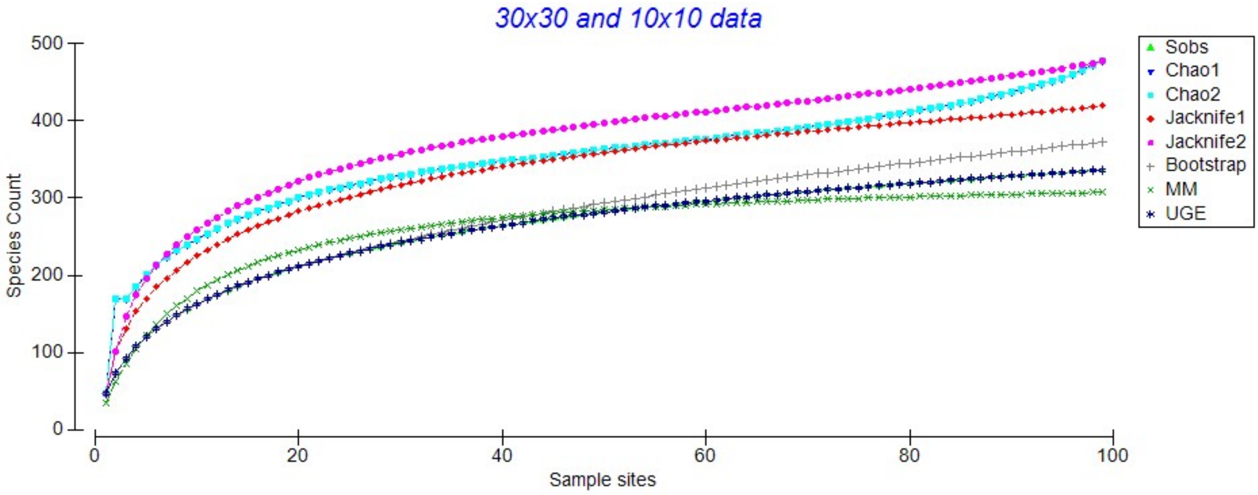


Figure 3.2 ***Species accumulation curves of combined 30x30m and 10x10m quadrats***

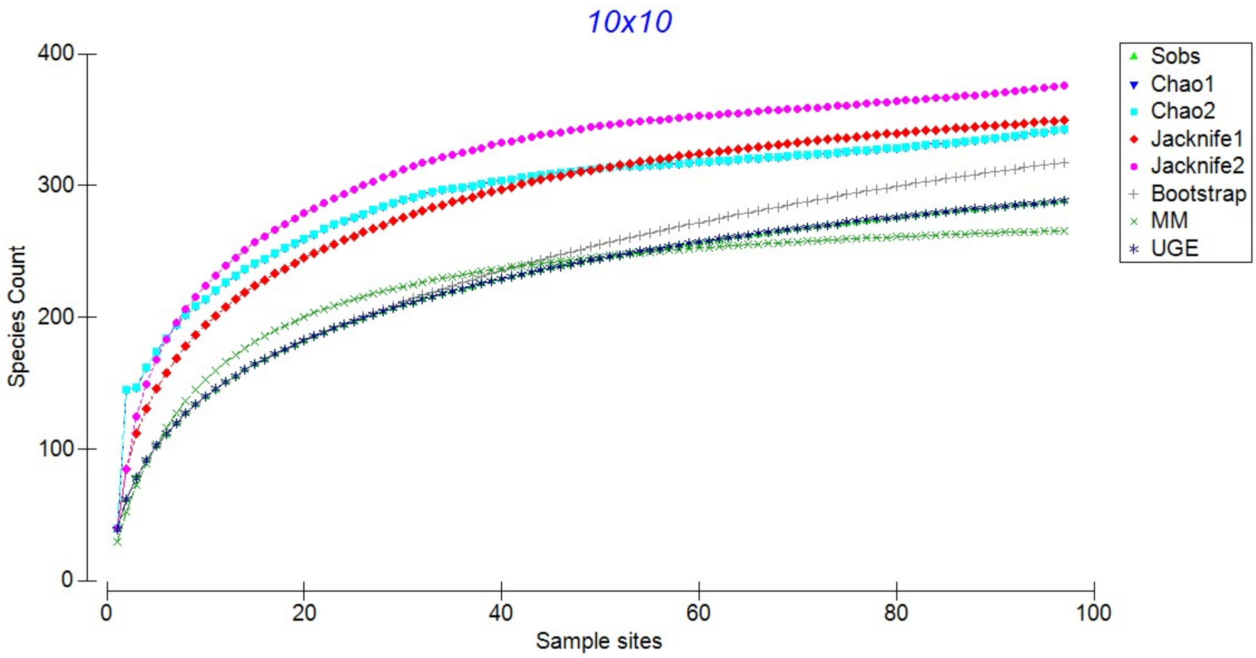


Figure 3.3 Species accumulation curves of 10x10m quadrats only

3.1.2.2 Targeted Threatened and Priority Flora survey

While much information on the distribution of conservation significant flora in the Trudgen *et al* (2012) survey area was available in that report, it was considered desirable to resurvey the proposed impact area for threatened and priority flora. A targeted search during Winter and Spring was undertaken 2016 (June, July, August, and September) as outlined in Trudgen (2018). Given the mostly open and poorer condition of the vegetation remnants, transects 30 metres apart were used. The transects were walked in a zig-zag manner rather than a straight line and were across the shorter dimension of the vegetation remnants searched (Figure 3.4). If conservation significant flora was encountered along the transect, then an area around the location was searched.

Prior to the survey, a list of conservation significant flora with the potential to occur was compiled. Field personnel familiarised themselves with photographs, reference samples and descriptions of these taxa before conducting the survey.

For occurrences of taxa of or possibly of conservation significant, a GPS location and a count of the individuals present were recorded. If there was any doubt as to the identification, a specimen was collected. However, no threatened or priority flora samples were collected during the 2016 search, as the species in the area are readily identifiable. During 2017 a further survey was undertaken during Winter and Spring, during which other flora species were also collected and some areas south of Kiaka Road were also searched for comparative data. Searches were undertaken to check surrounding areas for extent of populations of the *Banksia sphaerocarpa* form found in the proposed impact area during Summer of 2017.

The 72 transects walked in 2016 are shown in Figure 3.4, with alternate transects being searched twice during the survey.

All plants collected were taken under flora collecting permits, pursuant to Regulation 62 of the Biodiversity Conservation Regulations 2016 (or previous regulations). The vegetation mapping and floristic analysis used in Trudgen *et al.* (2012) are represented in this report to ensure comparability (**Error! Reference source not found.**).

3.1.2.2.1 Flora Identification and nomenclature

Species well known to the botanist were identified in the field; all other species were collected and assigned a unique collection number to facilitate tracking. Specimens collected during the field assessment were identified by comparison to previously identified reference specimens, or the use of taxonomic literature, electronic keys and online electronic databases.

The conservation status of all recorded flora was compared against the current lists available on *Florabase* (WA Herbarium, 1998-) and the EPBC Act Threatened species database provided by (DCCEEW, 2023b). Nomenclature used in this report follows that used by the Western Australian Herbarium as reported on *Florabase* (WA Herbarium, 1998-).

3.1.2.3 Vegetation types and condition

Trudgen *et al.* (2012) classified the vegetation of their survey area into three levels that go from low order to fairly high order of synthesis. The lowest order units are mostly defined near the *plant community* level.

This level of vegetation classification has units with very similar structure, species dominance and floristics. The next level of grouping was into 104 *vegetation associations*. This level still has stands with similar structure and dominant species, but more variation than the plant community level. The highest level of classification grouped the vegetation associations into 31 *vegetation alliances*.

Figure 5.6and Figure 5.7 show the vegetation alliances using different colours and vegetation associations and plant communities have used alpha numerical codes.

The alliances vary in the number of associations they contain, with some having only one association. Individual polygons show the distribution of one stand of a plant community. Vegetation alliances of the Coomberdale Chert TEC have been classified into Core and Buffer vegetation. Of the 8 alliances located within the Survey Area, 4 are Core and 2 are buffer (DPAW, 2013b). Further detail on the significance of these categories can be found in Trudgen et al. 2012 and shown in Figure 5.1.

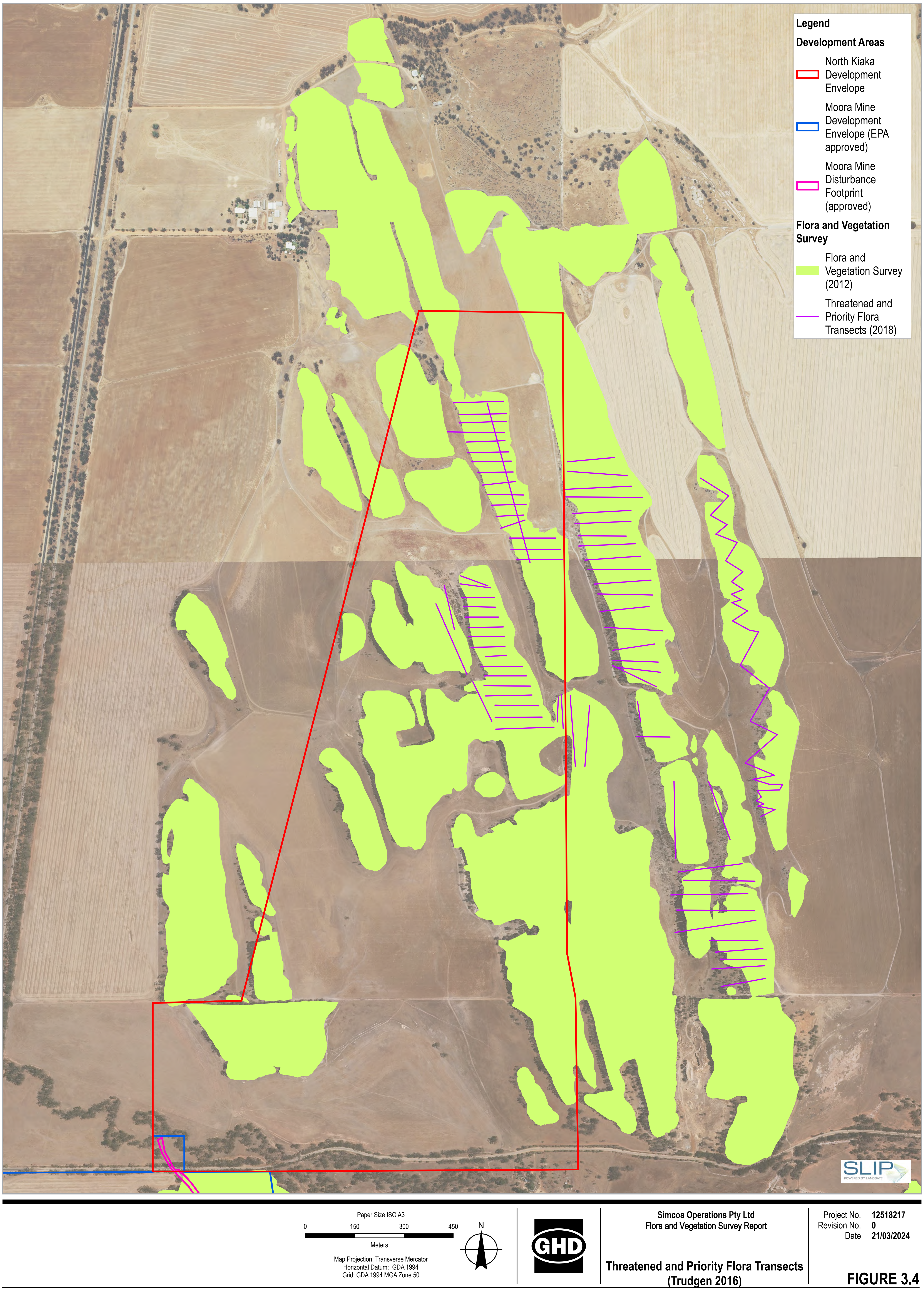
Trudgen *et al.* (2012) assessed the condition of the vegetation using the scale of Trudgen (1988) (Table 3.3). This information was used in conjunction with aerial photograph interpretation to produce a condition map of the remnant vegetation in the survey area. Table 3.3 shows the descriptors for vegetation condition .

Table 3.3 Vegetation Condition Scale for Southwest and Interzone Botanical Provinces (Trudgen M. E., 1988)

Vegetation Condition	Description
Excellent	Pristine or nearly so, no obvious signs of damage caused by the activities of European man.
Very Good	Some relatively slight signs of damage caused by the activities of European man. E.g. some signs of damage to tree trunks caused by repeated fire and the presence of some relatively nonaggressive weeds such as Ursinia anthemoides or Briza spp., or occasional vehicle tracks.
Good	More obvious signs of damage caused by the activities of European man, including some obvious impact on the vegetation structure such as caused by low levels of grazing or by selective logging. Weeds as above, possibly plus some more aggressive ones
Poor	Still retains basic vegetation structure or ability to regenerate to it after very obvious impacts of activities of European man such as grazing or partial clearing (chaining) or very frequent fires. Weeds as above, probably plus some more aggressive ones such as Ehrharta spp.
Very Poor	Severely impacted by grazing, fire, 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 including aggressive species
Completely Degraded	Areas that are completely or almost completely without native species in the structure of their vegetation. I.e. areas that are cleared or "parkland cleared" with their flora comprising weed or crop species with isolated native trees or shrubs.

The condition scale from Trudgen (1988) was modified so that ‘Completely Degraded’ areas included parkland cleared areas (areas with only scattered native plants in pasture) and areas where the vegetation had been removed to mine for gravel. Areas in the Cairn Hill reserve, which had been mined for gravel and consequently had some apparently spontaneous regrowth, were also included in the 'Completely Degraded' category. Post-mining regrowth, severely disturbed areas and areas with only scattered trees remaining were also classified as 'Completely Degraded'.

Levels of weed invasion and brief notes on the surface soil were recorded in the Survey Area at the time of recording of quadrats and of vegetation condition mapping (See Trudgen *et al.* (2012)).



Simcoa Operations Pty Ltd
Flora and Vegetation Survey Report

Threatened and Priority Flora Transects (Trudgen 2016)

Project No.	**12518217**
Revision No.	**0**
Date	**21/03/2024**

FIGURE 3.4

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3.1.3 Previous surveys

The vegetation and flora information in this report incorporates vegetation mapping, vegetation condition mapping and flora survey from Trudgen *et al* (2012). The 2012 report incorporates information from several earlier reports documenting the vegetation and flora of areas of the Coomberdale Chert Threatened Ecological Community (TEC) and covers a group of properties from north of Kiaka Road south to Dalaroo East Road. These reports have provided detailed vegetation mapping, a floristic analysis of the vegetation, the results of searches for threatened and priority flora and a flora inventory (Trudgen et al. 2012, 2006, 2001, and Trudgen 1985). The area surveyed is a polygon on the east side of the Midlands Road that varies from 3.5 to 4.95 kilometres wide and is 11.1 kilometres long. This information in the Trudgen *et al* (2012) report is supplemented for the proposed impact areas with searches for Threatened and Priority flora carried out in 2016 and 2017.

The series of studies of the Coomberdale Chert TEC area that has been previously surveyed for flora and vegetation mean that is one of the best known areas of its size in Western Australia for its vegetation and flora values. However, the earlier surveys did not focus the effort on the proposed impact areas. To ensure this area was adequately known for assessment of the proposed impact area, further survey work was carried out.

As the vegetation had been mapped in some detail by Trudgen *et al* (2012), the further work was largely targeted flora surveys on transects across the remnants of the TEC in the proposed impact area and a review of the knowledge of the flora of the Coomberdale TEC. This included reviewing the naming of specimens collected for the earlier surveys. Since the earlier work was carried out, more detailed information on the distribution of flora species has become available, and a greater understanding of the flora of the larger survey area is available to be considered in this assessment (see revised flora list in Appendix B).

The relevant points from this earlier work for the current assessment are:

1. The area surveyed in the earlier surveys is large in relation to the proposed impact area and the area north of Kiaka Road (which would have been a logical survey area if a new survey was required);
2. The number of quadrats is quite high for the size of the overall area surveyed and they have been recorded to a high standard;
3. The number of relevés is large, indicating the significant level of detail in the vegetation mapping (which has three classification layers);
4. The dominant species in the vegetation types have not changed since the surveys were carried out (there have been minor changes to scientific names, but these have been updated);
5. The floristic analyses carried out comparing parts of the TEC and parts of the survey area have been done by a person with significant experience in such analyses (Griffin, 1992) and new data and analyses would not change the results;
6. The standard for naming the flora in the earlier surveys is high and naming of most of the specimens from earlier surveys was checked to ensure correct determinations (see Appendix B);
7. The naming of native flora in the data has been updated where taxonomic changes have occurred, with an extensive review of the flora recorded for the overall survey area (see Appendix C).
8. Any structural and floristic change in the vegetation (except for some areas mined south of Kiaka Road) since the earlier surveys were carried out, is due to grazing, weed invasion, climate change or spray drift.
9. Some additional areas of the TEC south of Kiaka Road were mapped and searched for flora in 2017 to look for populations of species of conservation significance;
10. The earlier surveys were based on 111 person days in the field, indicating significant effort in the surveys. The initial recording of the quadrats was based on 49 field days.

As noted above, the current report will supplement Trudgen et al. (2012) by providing targeted flora searches of the proposed impact area, an updated flora list, and a comparison of the vegetation values of the proposed impact areas to the other parts of the Coomberdale Chert Threatened Ecological Community that have been surveyed.

Table 3.4 Field survey timing in the Moora Mine, proposed North Kiaka DE and proposed offset areas

Title	Survey extent	Survey year/ month		Season	Number of field survey days	Number of quadrats/ relevés
Comparison of the flora and vegetation of the proposed North Kiaka mine area to other parts of the Coomberdale Chert Threatened Ecological Community (Trudgen, 2018)	North Kiaka DE, adjacent areas	2016	June	Winter	1	Targeted threatened and priority flora and flora survey of proposed North Kiaka Mine impact areas and adjacent vegetation – 72 transects
			July		4	
			August		4	
			September	Spring	4	
		2017	July	Winter	2	Targeted *Banksia sphaerocarpa* form survey Threatened and Priority survey in 2017
			November	Spring	3	
			December	Summer	1	
Proposed Discharge Evaluation Conderoo River Wetlands (Actis, 2011)	Kyaka Brook	2011	November	Spring	1	Survey of vegetation fringing Kyaka Brook for Moora Mine
An extension of a flora survey, floristic analysis and vegetation survey of areas of the Coomberdale Chert TEC to include a further area (Trudgen, Griffin, & Morgan, 2012)	North Kiaka DE, Moora Mine DE, adjacent areas	2000	September	Spring	1	40 quadrats
			October		4	
			November		1	
			December	Summer	2	
		2002	October	Spring	9	40 quadrats
			November		1	
		2003	March	Autumn	1	8 quadrats and 185 relevés
			April		1	
			August	Winter	2	
			October	Spring	1	
			November		17	
			December	Summer	13	
		2004	January	Summer	14	169 relevés
			April	Autumn	1	
			November	Spring	4	
			December	Summer	7	
		2005	February	Summer	3	29 relevés
		2007	November	Spring	1	1 relevé
		2010	September	Spring	2	11 quadrats and 13 relevés
			October		2	
			November		5	

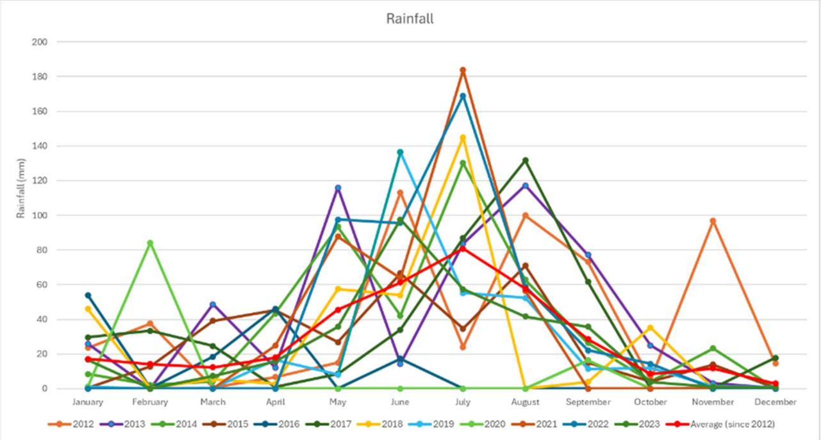
3.1.4 Survey limitations

There are possible limitations and constraints that can impinge on the adequacy of flora and vegetation surveys. The flora and vegetation survey was evaluated as part of this assessment, against a range of potential limitations (Table 3.5).

Table 3.5 Field survey limitations

Aspect	Constraint	Comment
Sources of information and availability of contextual information.	No constraint	The proposed North Kiaka Mine is located in the northern part of a large area of the Critically Endangered Coomberdale Chert Threatened Ecological Community that has been vegetation mapped at three levels, has vegetation condition mapping and detailed information for the flora of the area (Trudgen *et al* 2012). Information from this earlier work is incorporated in the current report and allows detailed comparison of the vegetation and flora of the proposed mine area to this larger area and to the part north of Kiaka Road where the project is located. The regional floristic survey (Griffin 1992) provided the floristic classification on which the TEC is based and places the TEC in a regional floristic context. The broad scale (1:250,000) mapping by Beard (1979) provides regional vegetation mapping context. Adequate information is available for the survey area including: – Broad scale (1:250,000) mapping by Beard 1979 – Previous flora surveys within and adjacent to the survey area – DBCA Threatened and Priority ecological community desktop information.
Proportion of flora collected and identified (based on sampling, timing and intensity)	No constraint	*Sampling timing* The vegetation and flora surveys collated in the Trudgen (2012) incorporates reports flora records from a multi-year, multi-season survey undertaken over 111 survey days (not person days) during Summer (45 days, these days vegetation mapping), Autumn (3 days), Winter (13 days) and Spring (50 days). The majority of survey days were in Spring which is considered the most optimal time to undertake vegetation surveys in the bioregion. Targeted surveys were undertaken during the flowering periods of the various species as per the likelihood of occurrence post survey assessment (Appendix D). The timing was considered appropriate for the purpose of the assessment. Specimens were collected at 99 quadrats, 397 vegetation mapping relevés and opportunistically. *Sampling intensity* For the Trudgen et al (2012 and earlier) report 3,715 flora collections were made for the identification of species occurring in the quadrats, approx. 1,500 collections were made during the vegetation mapping, on route between quadrats and relevés and during conservation flora searches. A further 266 collections were made while surveying M70/1292. This gives a total of about 5,460 collections made for the approximate 988 ha survey area covered by Trudgen *et al.* (2012). The resulting flora list also incorporates records from the original survey of Trudgen (1985) and data from Griffin (1992) from his sites located within the Trudgen *et al.* (2012) survey area. For the proposed North Kiaka Mine survey area the intensity of search would have found any flora taxon not previously recorded unless present in very small numbers. Given the above limitations, it is likely that the data from various surveys incorporated in this report has more than 95% of the flora of the areas of the TEC surveyed and more than 90% of the flora of the proposed North Kiaka Mine survey area.” The portion of flora collected and identified was considered suitable for the purposes of the assessment and the condition of the survey area.

Aspect	Constraint	Comment
Flora determination	Minor constraint	The flora specimens collected for the surveys included in Trudgen *et al* (2012) and for the current project have all been identified by Malcolm Trudgen who has extensive experience in identification of Western Australian flora specimens. Additionally, more than 200 specimens from the earlier surveys have been vouchered to the Western Australian Herbarium with current nomenclature available electronically to assist with updating names where taxonomic changes have occurred. Most specimens (except those donated to the Western Australian Herbarium as voucher specimens) collected for the earlier surveys were reviewed together to provide consistency of naming. The collection and vouchering of specimens has been undertaken in accordance with Western Australian Herbarium requirements at the time of collection, including: Specimens of new populations of threatened and priority flora. Specimens that appear to represent new species. Specimens representing range extensions, including introduced (weed) species. The taxonomy and conservation status of the WA flora is dynamic and the survey reports have been prepared with reliance on taxonomy and conservation status current at the time report development.
Completeness and further work which might be needed (e.g. was the relevant area fully surveyed)	Minor constraint	The areas of remnant vegetation of the Coomberdale TEC vegetation that the proposed North Kiaka Mine will remove for mining have been mapped at three levels, vegetation condition mapped, and included in floristic analyses of quadrat data as part of a larger area of the TEC (Trudgen *et al* 2012). This area has been extensively surveyed by M.E. Trudgen and Associates in 2000, 2002, 2003, 2004, 2010, 2016 and 2017 (Trudgen, Griffin, & Morgan, 2012; 2018). The vegetation and flora surveys collated in Trudgen *et al* 2012 and the current report provide a multi-year, multi-season survey undertaken over 111 survey days (not person days) during Summer (45 days), Autumn (3 days), Winter (13 days) and Spring (50 days) recording 99 quadrats (10 x 10 metre nested in 30 x 30 m; most recorded twice) and 397 relevés. Most of survey days were in Spring which is considered the optimal time to undertake vegetation and flora surveys in the bioregion. Targeted surveys were undertaken during the flowering periods of the various species as per the likelihood of occurrence post survey assessment (Appendix E). For the North Kiaka Mine targeted searches in 2016 and 2017 for threatened and priority flora of the then proposed mine area were carried out. A total of 73 traverses were walked at 30 m intervals within areas proposed to be disturbed in Winter (nine days over June, July and August). A subset of the transects in the Survey Area from 2016/2017 searched a second time in Spring (4 days in September). The impact area is smaller than the area searched in 2016 with 38 transects in this area. The vegetation mapping and description is detailed, with 217 plant communities identified in the broader 988-ha survey area. The 217 vegetation communities were grouped into 104 vegetation associations and those into 33 alliances (Trudgen, Griffin, & Morgan, 2012). The majority of the vegetation alliances were surveyed with a minimum three quadrats and/ or relevés however of the 33 alliances, due to a small area of a vegetation alliance/ community, nine were surveyed by only one or two quadrats and/ or relevés. Vegetation recording quadrats were placed in the larger areas of remnant vegetation as these are in better condition. The quadrat, relevé and conservation significant flora searches have all contributed to a comprehensive species list for the survey area and the larger area surveyed.

Aspect	Constraint	Comment
		It is considered the survey area was adequately surveyed at a detailed survey level as per EPA (2016) guidance for *Flora and Vegetation Surveys for Environmental Impact Assessment*. However, while most of the proposed impact areas were searched for conservation significant flora in 2016; some quite small areas of the TEC (9.8ha in total) within the impact area were not searched at that time. These will be included in any future flora and vegetation surveys of the area north of Kiaka Rd.
Mapping reliability	Minor constraint	The survey was conducted using aerial imagery, topographical features, previous vegetation mapping, and field data (Trudgen, Griffin, & Morgan, 2012). GPS locations of quadrats and relevés has been provided in the flora and vegetation reports (Appendix E). Data were recorded in the field using hand-held GPS tools. Certain atmospheric factors and other sources of error can affect the accuracy of GPS receivers. Therefore, the data points consisting of coordinates recorded from the GPS may contain minor inaccuracies.
Timing/ weather/ season/ cycle	No constraint	The field surveys were conducted during Summer, Autumn, Winter and Spring over 111 survey days (not person days) between 2000 and 2017 with the majority of survey days in undertaken in Spring and Summer (Trudgen *et al* 2012 and this report). Given that the majority of survey data was collated over seven years during a 17-year period it is considered that the weather conditions recorded during the survey periods are unlikely to have significantly impacted upon the vegetation and flora surveys. Rainfall levels appear to have been higher than average in 2012, 2017 and 2018, however were below average during 2016 and 2020 (refer to plate below) (BoM, 2023).  Plate 1: Monthly rainfall levels between 2012 and 2023compared to average monthly rainfall for the timeframe at Badgingarra Research Station (number 9037) (BoM, 2023).
Disturbances (e.g. fire, flood, accidental human intervention)	No constraint	The remnants of the TEC in the Trudgen (2012) survey area (including the current project area) are surrounded by cleared paddocks. They are subject to weed invasion, edge effects (increased wind speeds), grazing by stock, rabbits and kangaroos and herbicide drift. These all impact the vegetation and flora but have not affected the survey of the remnants. None of the remnants surveyed have been burnt either before or during the period of the surveys.
Intensity (in retrospect, was the intensity adequate)	Minor constraint	The intensity of survey of the Trudgen *et al* (2012) survey is quite high for the size of their survey area. The number of quadrats (99) and vegetation mapping relevés (397) reflects this. This was required because of the significant number of plant communities in this survey area, a result of the variation in the underlying soil, geology and topography.

Aspect	Constraint	Comment
		While the EPA Technical Guidance encourages a minimum of three quadrats per vegetation unit, the following statement from the EPA's Technical Guidance is highly pertinent: "the number of quadrats required within a vegetation unit is proportional to the area (hectares) of the unit". Many of the plant communities described have very small area and it would be of no significant value for environmental assessment to have recorded a greater number of quadrats. Therefore, the number of quadrats sampled by Trudgen *et al* is considered adequate to record floristic variation in their survey area and with the relevés to describe the vegetation. It is considered that the survey carried out by suitably qualified botanists during the field surveys and the vascular flora of the survey area was sampled in accordance with EPA (2016) Guidance. First searches of transects in the proposed impact area (and some adjoining areas, but not the eastern ridge on the J. Tonkin property) were searched on 30/6/2016, 1/7/2016, 6/7/2016, 7/7/2016, 13/7/2016, 7/7/2016, 1/8/2016, 1/8/2016 and 2/8/2016. The eastern ridge on the J. Tonkin property was added to the proposed mine area after the visits above were made, this area was searched on the 17/7/2017 and 18/7/2017. For additional information on species distribution in the Coomberdale Chert TEC searches were made of some areas south of Kiaka Road on 18/8/2016, 19/8/2016 (on the "Eastern Ridge" of Trudgen *et al.* 2012). Searches were made on Simcoa Block Two south of Kiaka Road to look for other populations of the *Banksia sphaerocarpa* form found in the Coomberdale Chert TEC on 10/11/2017 and 11/11/2017. On the 11/11/2017 and 12/11/2017 searches for rare flora were made on the two haul road options for the proposed impact area. On the 13/12/2017 the *Banksia sphaerocarpa* population on Phil Gardiner's property (east of Cairn Hill Reserve) was surveyed to document the population size and condition.
Resources	No constraint	Adequate resources were employed during the field survey. 111 survey days were spent by suitably qualified botanists undertaking the field survey in 2000, 2002, 2003, 2004, 2005, 2007, 2010, 2016 and 2017.
Access restrictions	No constraint	There were no access restrictions for the purpose of this assessment.
Experience levels	No constraint	Trudgen and Associates, who conducted the field surveys, are considered suitably qualified and experienced as they have worked on the flora and vegetation surveys in the TEC for SIMCOA since 2000.

3.1.5 Summary

This Flora and Vegetation Report is a culmination of data from the following data sets and reports.

- A Report on the Vegetation and Flora of the Proposed Moora Silica Minesite (Trudgen, 1985).
- A flora survey, floristic analysis and vegetation survey of the Coomberdale Chert TEC Trudgen *et al* (2001).
- A flora survey, floristic analysis and vegetation survey of the Coomberdale Chert TEC Trudgen *et al* (2006).
- An extension of a flora survey, floristic analysis and vegetation survey of areas of the Coomberdale Chert TEC to include a further area (Trudgen, Griffin, & Morgan, 2012).
- Collection of flora specimens during the 2012 and 2016 surveys
- Collection of flora specimens from 2012 relevés
- Opportunistic search areas around each flora species located during the 2016 transects
- Opportunistic collections of flora specimens between the quadrats and relevés during the 2012 surveys, especially of species not previously recorded;

- Collection of flora specimens during a systematic survey during 2016 of the distribution of threatened and priority flora within the area surveyed for vegetation during 2012.

4. Environmental Setting

This section provides the environmental setting of the Moora region and outlines the stable landscape of the area, with very minimal changes to the vegetation observed over time.

4.1 Climate

The region including the Survey Area has a Mediterranean climate, with a cool wet winter and summer drought. The summers are warm to hot, with average maxima of approximately 30° Celsius (°C) and extremes of over 40°C. The winters are cooler and milder with average maximum temperatures between 15° and 20°C and minimums of around 5°C.

The average annual rainfall is 463 mm, the majority of which falls from May to September. Figure 1 of Griffin (1992) shows rainfall and temperature graphs for the survey area and compares them with other regional centres.

4.2 Land systems and soils

These are two landscape divisions of the Moora Group. The first is the Coorow Landscape (Chert subsystem) this has gentle topography with low stripping of the soils by erosion. It occurs to the north of the current survey area and does include some chert outcrop (and has some smaller occurrences of the Coomberdale Chert TEC outside the areas mapped by Trudgen *et al* 2012). The second is the Coomberdale Landscape (Chert subsystem). This has gentle to moderate topography with moderate stripping of the soils by erosion. The 2012 survey area lies within areas of the Coomberdale Landscape (Chert subsystem). The surface in the Coomberdale Landscape (Chert subsystem) generally has outcropping chert on the higher parts and colluvium with chert gravel on the slopes. The Coomberdale Chert Threatened Ecological community mainly occurs on these ridges and the adjoining colluvium.

The key landform within 2012 survey area is the Noondine Chert Formation, which outcrops as north-north-west trending parallel ridges, elevated approximately 75 m above the adjacent valleys. The Noondine Chert (previously Coomberdale Chert), outcrops across a 150 km stretch between Moora and Three Springs.

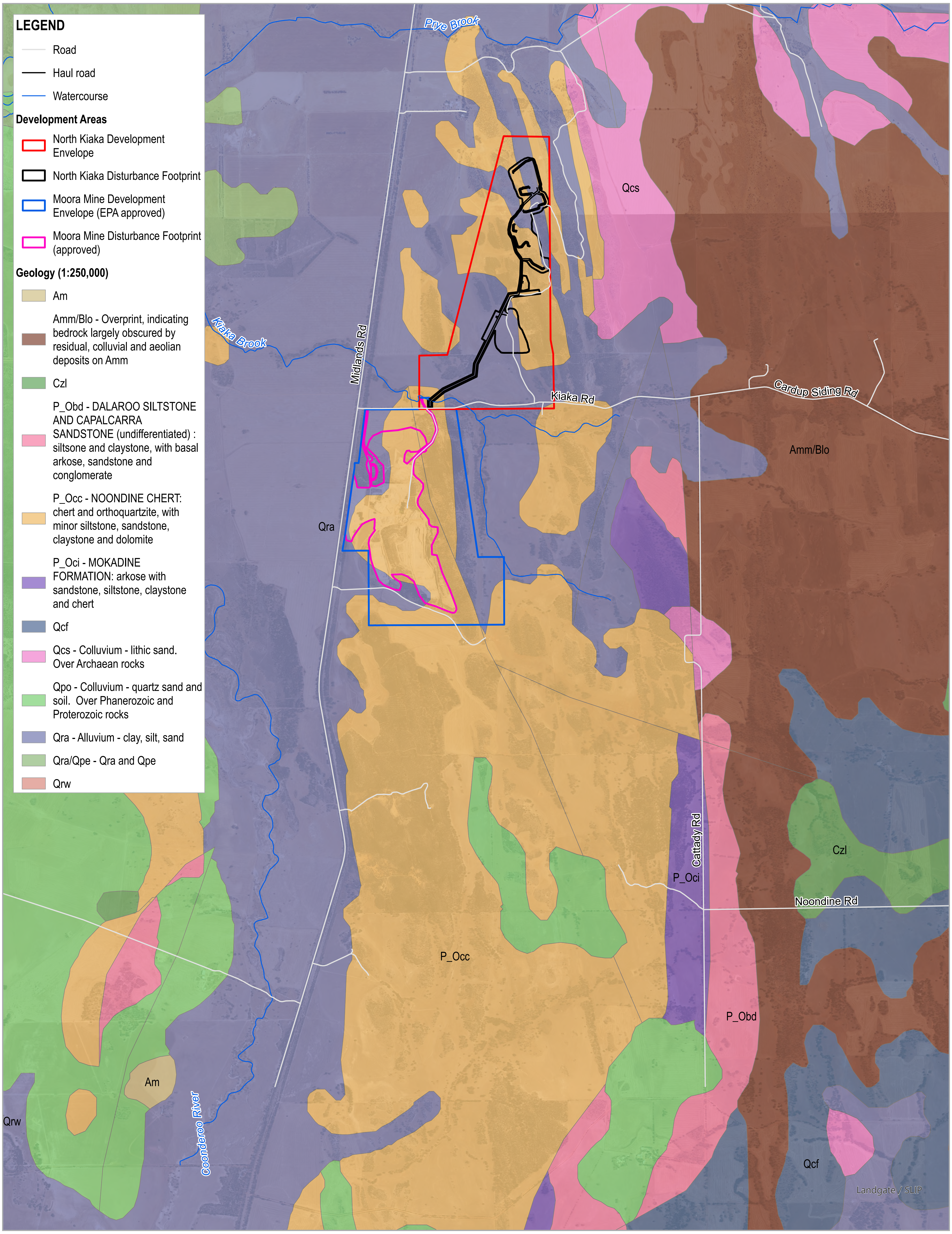
SIMCOA currently mines the quartzite mineral resource present in the Noondine Chert, which occurs as unweathered and massive dolerite/quartzite intrusions at Moora Mine and proposes to mine this resource in an area to the north of Kiaka Road.

The Noondine Chert Formation has a total extent of 14,586 ha.

4.2.1 Geology

The underlying rocks of the survey area belong to the Middle Proterozoic Moora Group These sedimentary rocks are separated from the Darling Plateau by a series of poorly defined faults (Griffin, 1992). The Noondine (Coomberdale) Chert Formation, which outcrops frequently in the survey area, is part of the Moora Group. "*It consists of bedded chert, chert breccia, orthoquartzite, silicified limestone and dolomite and contains significant siliceous siltstone and sandstone beds, and minor claystone*." (Carter and Lipple 1982 in (Griffin, 1992)).

The largest and most extensive area of outcrops of the Noondine Chert is between Dalaroo and Coomberdale and includes Cairn Hill, a highpoint approximately fifteen kilometres north of Moora. This area has several faults present, perhaps most notably the Kiaka Fault, which runs NW-NE near Kiaka Road south of the survey area for this report. Figure 4.1 shows the regional geology.



Paper Size ISO A3

0 300 600 900 1,200 1,500

Metres

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Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

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Regional Geology

FIGURE 4.1

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Data source: Simcoa: Mining Development Shape Areas is derived from client recieved 2020; Langate: Slip Imagery - April 2017 to November 2018 (accessed - 20191023), Cadastre, Road - 20180601; DoW: River - 201108. Created by: klabez

4.2.2 Topography

The survey area contains parts of a series of parallel northerly-southerly trending ridges of the Noondine Chert, with swales between them. The ridges are formed from the higher, more resistant to erosion, parts of the Noondine Chert Formation. There is a larger valley just east of the survey area and more chert ridges to the west. The ridges vary in cross section, some having gentle slopes on both sides, or steeper slopes on one side. There were some steep rocky areas, but the slopes are mainly gentle to moderate, with a few being quite steep.

4.2.3 Soils

The soils on the chert ridges vary in depth from skeletal on the blocky outcropping chert, to gravelly, loamy sands lower down the slopes (Griffin, 1992). The surface soil was often pale grey, silty, fine sand. The soils in the valleys between the ridges are deeper over clay and broken rock (A. Tonkin per. com. and personal observation).

Of particular interest is the existence of two soil-landscape mapping units in the region that both occur on the Noondine Chert. These are two landscape divisions of the Moora Group:

- Coorow Landscape (Chert subsystem). This has gentle topography with low stripping of the soils by erosion. It occurs to the north of the current survey area and does include some chert outcrop (and has some smaller occurrences of the Coomberdale Chert TEC outside the areas mapped by Trudgen *et al* 2012).
- Coomberdale Landscape (Chert subsystem). This has gentle to moderate topography with moderate stripping of the soils by erosion. The survey area lies within areas of the Coomberdale Landscape (Chert subsystem). The surface in the Coomberdale Landscape (Chert subsystem) generally has outcropping chert on the higher parts and colluvium with chert gravel on the slopes. The Coomberdale Chert Threatened Ecological community mainly occurs on these ridges and the adjoining colluvium.

Figure 4.2 gives a regional scale visual summary of the topography, distribution of soils-landscape mapping units and the extent of remnant vegetation in an area containing the current survey area. There is a set of adjoining sheets in Trudgen *et al.* (2012) showing variation along the extent of the Coomberdale Chert.

4.2.3.1 Soil types

Figure 4.2 shows the soil landscapes occurring across the area to the north of Kiaka Rd (GoWA, 2023).

The primary soil types are SMU 2 and SMU 3 as mapped by Soilwater Consultants (2019) as shown in Figure 4.3. Both SMU 2 and SMU 3 have three distinct soil horizons:

- Topsoil – friable sandy gravels, with minor organic accumulation (transported)
- Subsoil – friable sandy gravels, with negligible organic accumulation (transported)
- Overburden – granitic (mottled) saprolite (*in-situ*).

All soil horizons are slightly- to- moderately acidic, non-saline, and non-sodic. The sandy gravels (topsoil and subsoil) present in SMU 2 and SMU 3, are friable and structurally stable, with high saturated permeabilities. These materials are ideal for use in rehabilitation, particularly as an outer surface material on the WRD. The underlying granitic saprolite (fine fraction) is structurally unstable, dispersive and highly erodible.

It is noted the Moora Mine DE was not included in the Soilwater Consultants (2019) survey area which is shown in Figure 4.3.

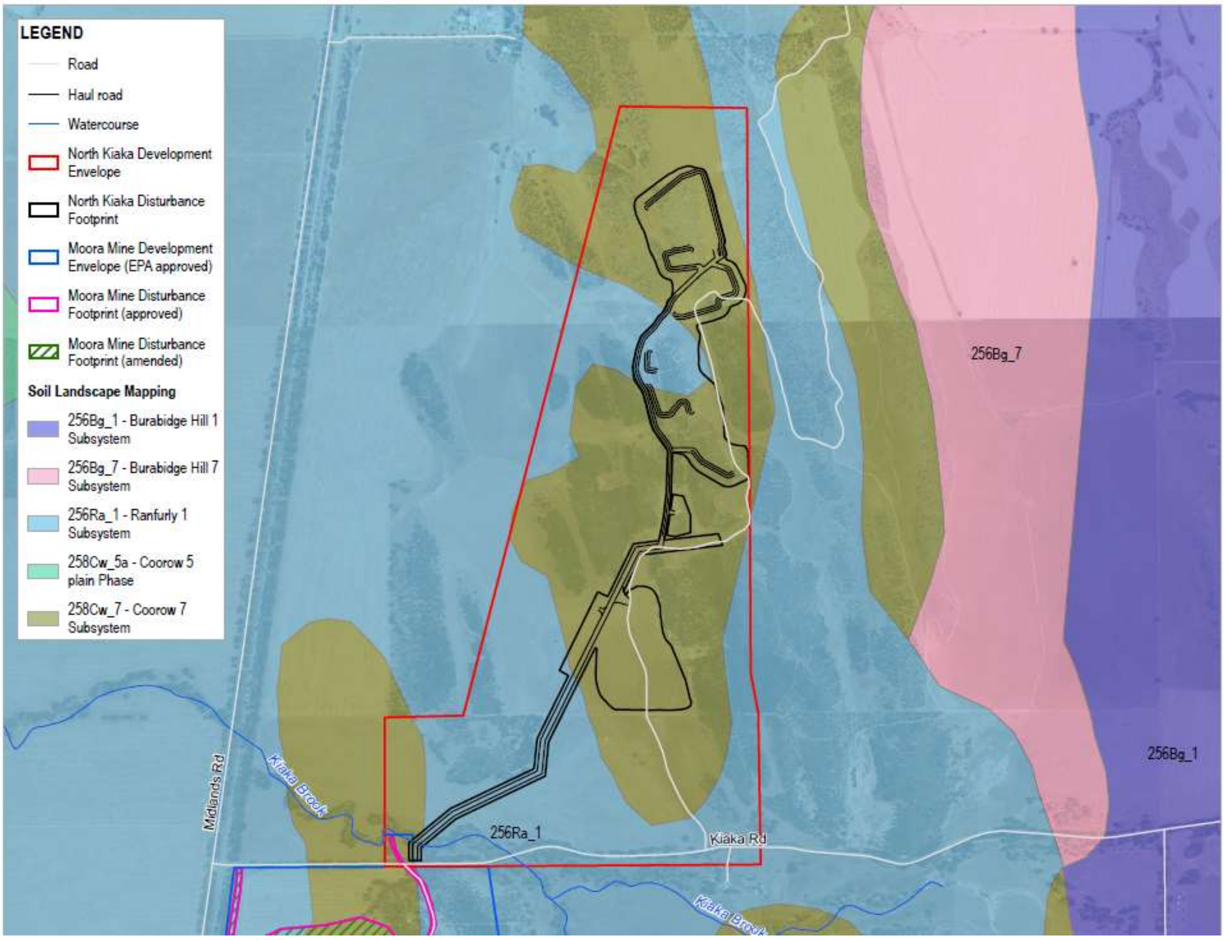


Figure 4.2 ***Soil landscapes for area north of Kiaka Rd***

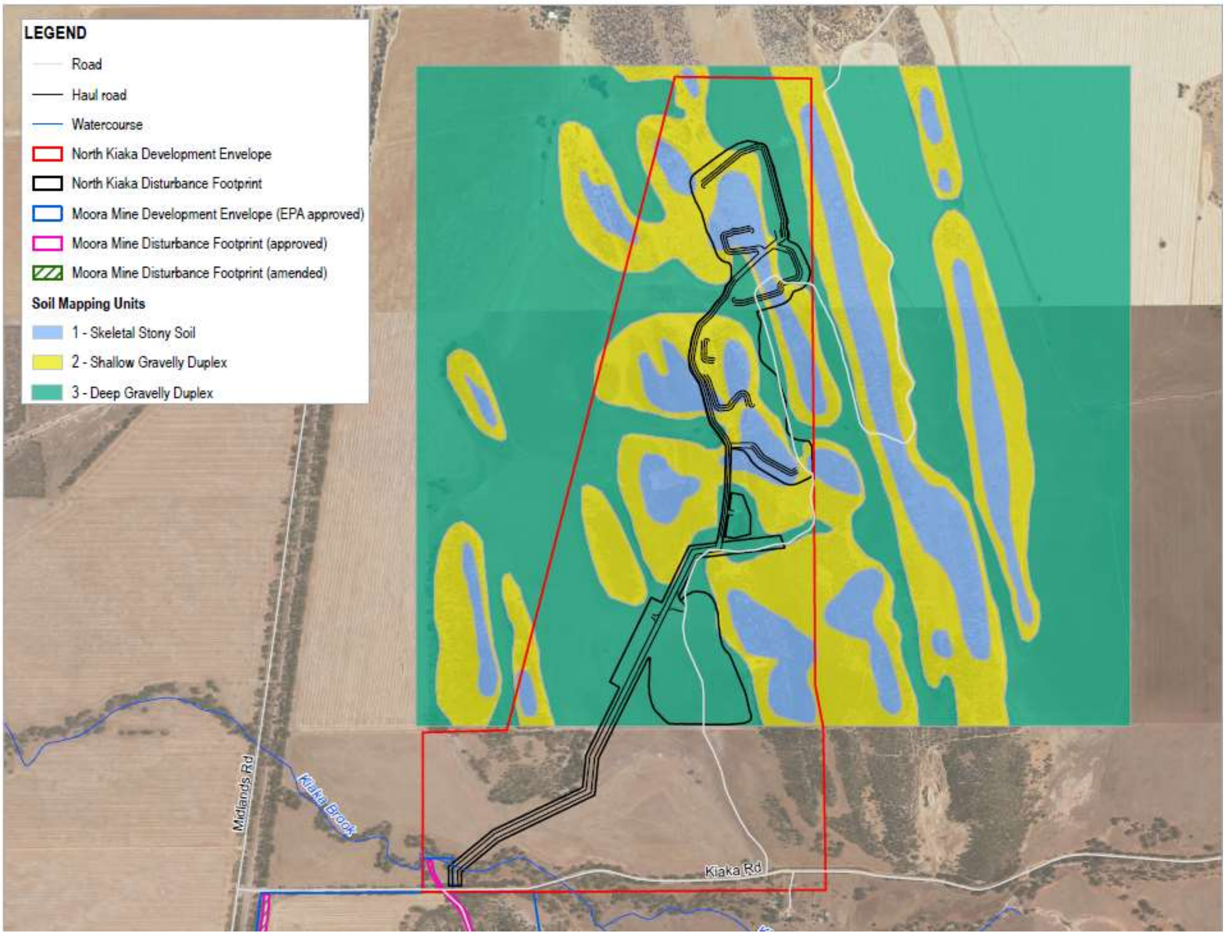


Figure 4.3 Soil units for area north of Kiaka Rd

4.3 Hydrology

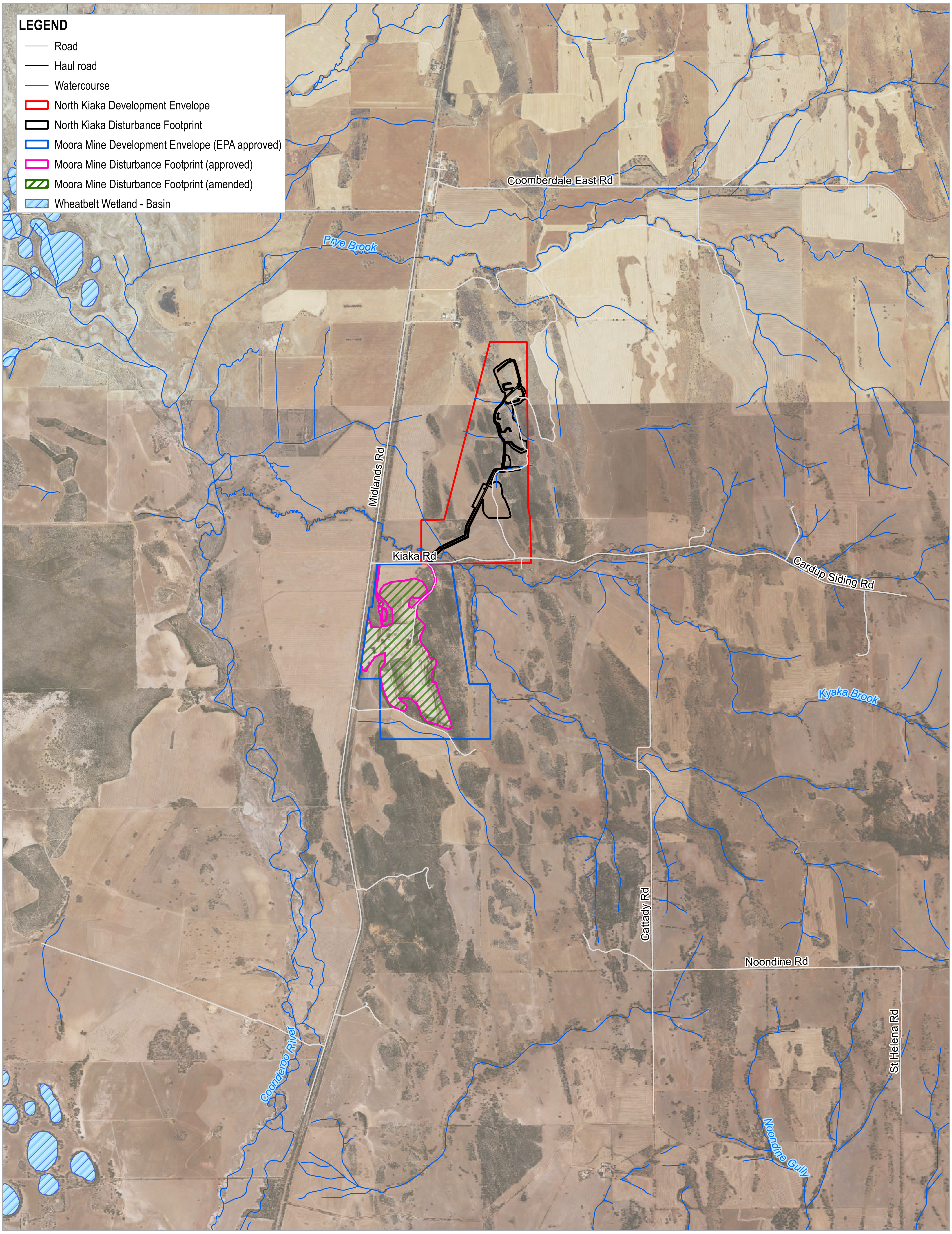
4.3.1 Surface water

The survey area is located within the Moore River catchment and Coonderoo / Marchagee sub-catchment (Figure 4.4). The Moora River catchment covers an area of 13,600 km^2. The major drainage lines within the catchment include the Moore River, the Coonderoo River and Gingin Brook (Department of Agriculture 2002). The Coonderoo / Marchagee sub-catchment covers an area of approximately 6,500 km^2 and in the vicinity of the North Kiaka DE drains from southeast to northwest. Drainage occurs via Pyre Brook Creek (approximately 4 km north of the North Kiaka DE), Kyaka Brook (located on the southern boundary of the North Kiaka DE) and their tributaries into the clay pans and samphire flats of the Coonderoo River (Saprolite Environmental, 2012).

Kyaka Brook extends east and north of the Kiaka Road, flowing in a north-west direction where it terminates in the Coonderoo River Wetlands. The Brook has a well-defined course with banks up to a meter deep. Water flows are seasonal and episodic, characterised by fast flowing water and short-lived pools (Actis, 2011).

4.3.2 Groundwater

The main groundwater aquifer in the region is hosted by the Noondine Chert, which is extensively fractured and cavernous, typically providing high bore yields. Local groundwater is used to supply the townships of Moora and Watheroo. Groundwater recharge occurs via infiltration of rainwater (GHD, 2019). The interpreted groundwater contours suggest a north-south groundwater flow direction consistent with the site topography with a water table between 6 and 9 m below ground level (mbgl).



Paper Size ISO A3

0 250 500 750 1,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

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Simcoa Flora and Vegetation report

Surface Hydrology

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FIGURE 4.4

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Data source: Simcoa: Mining Development Shape Areas is derived from client received 2020; DBCA: Wheatbelt wetland - 20191211; Landgate: Watercourses, Roads - 20190128, Imagery - 20171202 (accessed: 20190212). Created by: dchan3

4.3.3 Wetlands

Thera are no Ramsar listed or nationally important wetlands that occur within the survey area Trudgen et al (2012). The closest Ramsar wetland is Forrestdale and Thomson Lakes, located more than 200 km south and the closest nationally important wetland is Guraga Lake, located approximately 71 km south-west.

The Coonderoo River Wetlands is a historic saline wetland system located approximately 4.5 km north-west of Kiaka Road. The system is made up of a main channel as well as a series of periodic ponds and wetlands (Actis, 2011).

Based on the GHD (2023c) review of available data, none of the vegetation types recorded are considered to be groundwater dependent ecosystems reliant on the surface expression of groundwater or sub-surface presence of groundwater within the rooting depth of the ecosystem based on their species composition and location within the landscape. Most of the vegetation within the survey area (including the Coomberdale Chert TEC) occurs on ridges and upper slopes on shallow soils over chert. The depth of groundwater on these areas of ridges and slopes ranges from 16 to 20 mbgl (Saprolite Environmental 2016). Although there is limited to no data available on maximum root depths of these species, it is unlikely that they are accessing groundwater at this depth. Trudgen (2012) noted in the assessment of ridges that there were a number of deaths of *Regelia megacephala* at the time. This was attributed to a drier than average winter season, indicating that this species is not accessing the water table.

The zone of groundwater drawdown anticipated to occur as a result of mine dewatering operations is expected to be confined by the eastern and western ridges which are likely to form impenetrable barriers to groundwater movement (Saprolite Environmental 2016). To the north and south a maximum 1.5 km radius of influence would potentially extend, however remnant vegetation that occurs in these areas is also on hilltops and ridges, with the exception of the flow line to the north which is a seasonally inundated channel with narrow fringing band of vegetation (dominated by *Acacia acuminata*) within cleared farmland, the species composition of which indicates that it is unlikely to be reliant on ground water levels.

4.4 Land Use

The proposed impact area is located on mining tenements M70/1292 within a region with a long history of broad-acre agricultural use, primarily cropping and livestock (sheep) farming. Areas of remnant native vegetation within the survey area are generally not fenced off from paddocks where stock, predominantly sheep, graze. The lower lying areas have been cleared, with native vegetation replaced with introduced grasses. Native vegetation has been retained on areas of rocky outcrops and the surrounding area supports agricultural land uses.

The remnant vegetation has high conservation value (as noted above it is classified as a Threatened Ecological Community). The ongoing agricultural use of the cleared areas mean that the remnant vegetation of the TEC is exposed to herbicide drift, weed invasion and grazing. The closest rural residential dwelling is located approximately 0.01 km south of the North Kiaka DE (Figure 4.5).

4.4.1 Conservation estates and reserves

Most of the Coomberdale Chert TEC is located on privately owned farms. The only conservation area in the Trudgen et al (2012) survey area is Cairn Hill Nature Reserve (R47694, Class A). This nature reserve and Cairn Hill North is located approximately 3.5 km south of Kiaka Road and has some of the best quality vegetation of the TEC. The reserve was established to offset clearing of the Coomberdale TEC (including DBCA-listed Priority flora Regelia megacephala (P4)) associated with development of Moora Mine. No DBCA managed areas occur within the North Kiaka DE. Table lists the three DBCA managed lands located within approximately 20 km radius of the North Kiaka DE.

Table 4.1 DBCA managed lands within 20 km of the North Kiaka DE

ID	Classification	Name	Distance from North Kiaka DE boundary
R 47694	Class A nature Reserve	Cairn Hill Nature Reserve	1.5 km south
E 28674	Class A nature Reserve	Manaling Nature Reserve	10.9 km north-west
R 23316	Class A nature Reserve	Namban Nature Reserve	13.6 km north-west

4.4.2 Environmentally sensitive areas

The Trudgen et al (2012) survey area, the existing Moora Mine and proposed North Kiaka DE are all located within an Environmentally Sensitive Area (ESA). The ESA is associated with three TEC's including the Coomberdale TEC and known Threatened and Priority flora species (Figure 4.6). In the surrounding area there also two other TECs occurring within 2 km of the North Kiaka DE, these include:

- 'Eucalyptus Woodlands of the Western Australian Wheatbelt' TEC (also a WA State-listed PEC)
- 'Banksia Woodlands of the Swan Coastal Plain Community' TEC/ PEC (EN under the EPBC Act, Priority 3 State listed PEC)
- 'Vegetation alliances on ridges and slopes of the chert hills of the Coomberdale Floristic Region' (CR under the BC Act).

The assessment by Trudgen (2021) confirms isolated patches of Eucalypts such as *Eucalyptus salmonophloia, Eucalyptus loxophleba* and *Eucalyptus wandoo* persist within the regional mapped distribution of Coomberdale TEC, particularly where non-chert geologies are present within the region. *Eucalyptus loxophleba* is associated with the following vegetation communities in the survey area (Elo3 and El5).

The Commonwealth of Australia (2016) Guidance[1] '*Eucalypt Woodlands of the Western Australian Wheatbelt: a nationally protected ecological community'* includes criteria that would exclude a patch of Eucalyptus woodlands from being classified as 'Eucalypt Woodlands of the Western Australian Wheatbelt' TEC:

- *Non-eucalypt woodlands, e.g. with jam, sheoak, banksia*
- *Woodlands limited to granite or rock outcrops and higher elevations*
- *Vegetation with a sparse tree canopy cover, under 10%.*
- *Isolated paddock trees, very small remnants and patches that are degraded and in poor low condition*
- *Minimum patch size of 2 ha where vegetation understorey comprises <30% invasive species (i.e. high quality)*
- *Minimum patch size of 5 ha where vegetation understorey comprises >30% invasive species (i.e. low quality).*

Based on the above listed criteria, it is unlikely that plant communities Elo3 and El5 would represent 'Eucalypt Woodlands of the Western Australian Wheatbelt' PEC/ TEC particularly the given the community occurs on the chert outcrop (high elevation) and is in Poor condition.

Trudgen (2021) reported that the closest native vegetation with potential to represent 'Eucalyptus Woodlands of the Western Wheatbelt' TEC is a linear corridor of vegetation within the Midlands Road/ Rail reserve approximately 1 km west of the North Kiaka DE.

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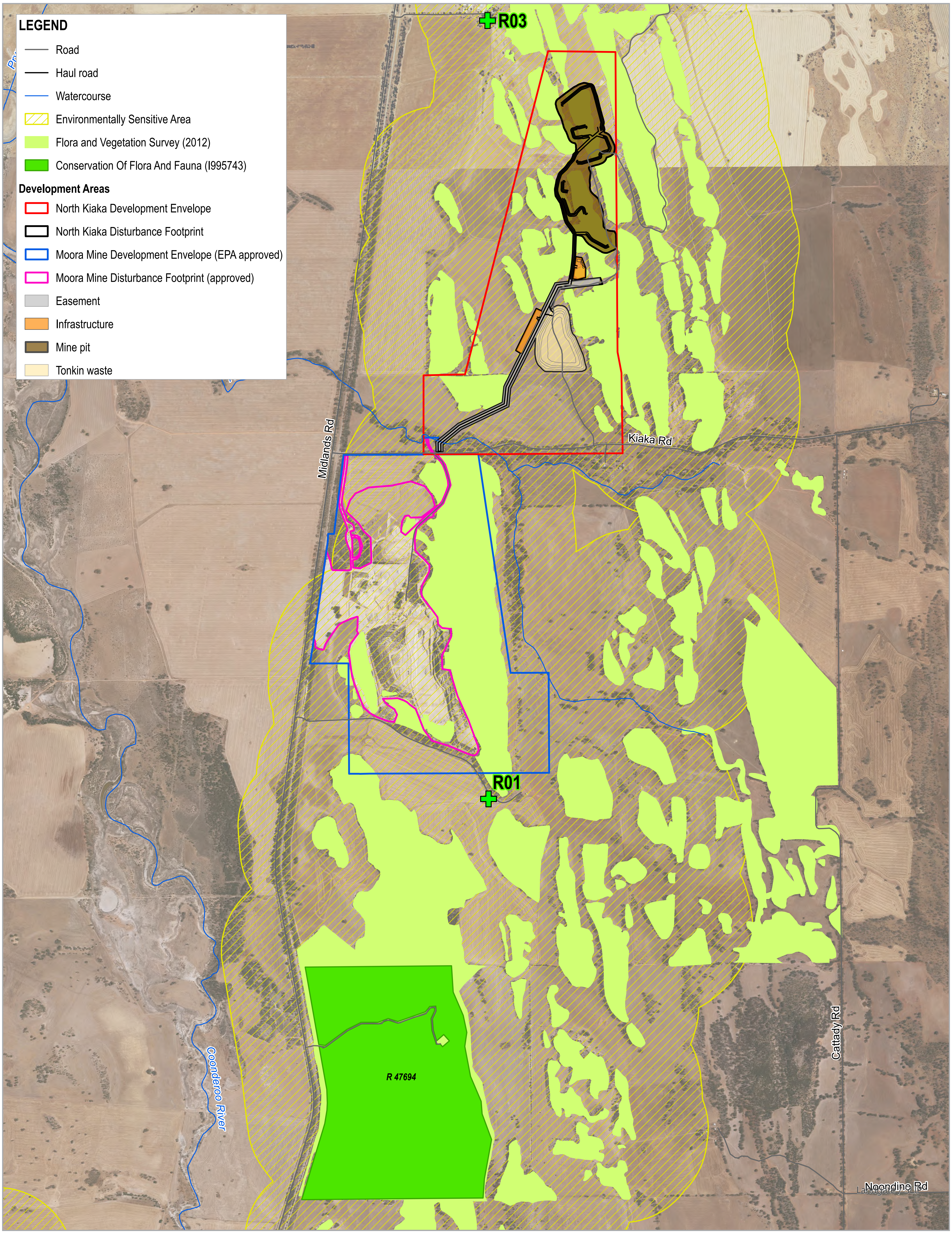
[1] Commonwealth of Australia (2016). Guidance: Eucalypt Woodlands of the Western Australian Wheatbelt: a nationally protected ecological community. Available online: **https://www.dcceew.gov.au/environment/biodiversity/threatened/publications/guide-eucalypt-woodlands-wa-wheatbelt**



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Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

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ESA and Conservation Reserves

Project No. **12518217**
Revision No. **0**
Date **21//03//2024**

FIGURE 4.5

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Data source: Simcoa: Mining Development Shape Areas is derived from client recieved 2020; DBCA: Legislated lands and waters - 2019; Langate: Slip Imagery - April 2017 to November 2018 (accessed - 20191023), Road - 20180601; DoW: River - 201108. Created by: klabez

4.5 Vegetation and flora

4.5.1 Regional vegetation

The vegetation of the Moora region has been mapped by Beard during the 1970s (1979) at a very broad scale (1:1 000 000). This work formed the basis of several regional mapping systems, including physiographic regions defined by John Beard in 1984, which led to the delineation of botanical districts as described in Beard (1990). It was also part of the basis of the biogeographical region dataset (Interim Biogeographic Regionalisation for Australia, IBRA) for Western Australia (Department of the Environment and Energy, 2018). As noted above there is also the floristic analysis of Griffin (1992) that surveyed a smaller area and that led to the identification of the vegetation of the Coomberdale (Noondine) Chert as a Threatened Ecological Community.

4.5.1.1 IBRA 7 biogeographic regions

The Interim Biogeographic Regionalisation of Australia (IBRA) describes a system of 89 'biogeographic regions' (bioregions) and 419 subregions covering the entirety of the Australian continent (Department of the Environment and Energy, 2018). Bioregions are defined on the basis of climate, geology, landforms, vegetation and fauna. The Project is situated in the Avon Wheatbelt (AVW) bioregion and is solely located in the Katanning subregion (AVW02) (DCCEEW, 2023d).

The Avon Wheatbelt bioregion is a dissected plateau of Tertiary laterite on the western edge of the Yilgarn Craton. This is a very old landscape that has not been glaciated for a very long time. This has led to its rich flora which includes many endemics, particularly in *Grevillea, Hakea, Verticordia, Eucalyptus, Acacia, Dryandra, Lhotskya, Eriostemon, Wehlia, Baeckea, Melaleuca, Chamelaucium, Micromyrtus, Thryptomene* and the Asteraceae family. Approximately 25 per cent of the Threatened flora in WA occurs in eucalypt woodlands in this region (Beecham, Avon Wheatbelt Bioregion, 2001).

The Katanning (AV2) subregion has an erosional surface of gently undulating rises to low hills with abrupt breakaways. The vegetation includes woodland of Wandoo, York Gum and Salmon Gum with Jam and Casuarina (Beecham, 2001b), with heath or shrublands less common.

4.5.1.2 Pre-European vegetation

Shepherd, Beeston, & Hopkins (2002) mapped the extent of the pre-European vegetation types of Western Australia using the work of Beard as a basis, with recent updates reflecting the National Vegetation Information System (NVIS) Standards. Two vegetation associations correspond with the Survey Area. The pre-European and current extent of each vegetation association is available from the State-wide Vegetation Statistics Dataset (GoWA, 2019) and is provided in Table 4.2.

Broad scale (1:250,000) vegetation mapping undertaken by Beard (1979) indicates two vegetation associations are associated with the area north of Kiaka Rd. The "*Low woodland; Allocasuarina huegeliana and Jam*" (association 1041) and "*Medium woodland; York gum and Salmon gum*" (association 142) in the south west of the area north of Kiaka Rd (GoWA, 2019). Whereas the south of Kiaka Rd would have comprised "*Low woodland; Allocasuarina huegeliana and Jam*" (association 1041) and "*Medium woodland; York gum and Salmon gum*" (association 142) (GoWA, 2019)

The remaining extent of these vegetation associations (last update March 2019 (GoWA, 2019)) is shown in Table 4.2 (GoWA, 2023). As shown in Table 4.2 there is less than 10% remaining at a IBRA subregional and local government authority (LGA) level and less than 30% at a State and IBRA regional level of the pre-European extent of vegetation association 142. There is less than 30% remaining at a IBRA subregional and LGA level for vegetation association 1041 (GoWA, 2019). It should be noted that these associations are very broadly defined and are not at a level to include the variation now recognised as the Coomberdale Chert TEC.

Table 4.2 Pre-European vegetation associations (GoWA, 2019)

Scale	Pre-European Extent (ha)	Current Extent (ha)	Remaining (%)	Remaining within DBCA Managed Lands (%)
Association 1041				
State: WA	4,781.12	1,507.46	31.53	6.66
Bioregion: Avon Wheatbelt	4,781.12	1,507.46	31.53	6.66
Sub-region: Katanning (AVW02)	2,545.46	729.06	28.64	3.03
LGA: Shire of Moora	2,274.88	688.62	29.39	2.10
Association 142				
State: WA	787,948.47	208,347.17	26.44	1.04
Bioregion: Avon Wheatbelt	637,707.53	79,309.95	12.44	0.37
Sub-region: Katanning (AVW02)	224,265.61	16,054.80	7.16	0.16
LGA: Shire of Moora	164,556.36	12,666.00	7.70	0.11

Note: orange indicates that less than 30% and red less than 10% of pre-European extent remains (EPA, 2000).

4.5.2 Conservation significant flora

Government spatial databases were queried to 10 and 20 km to identify conservation significant species and communities which might occur within the Survey Area. In conjunction with spatial records, habitat information, where described, was used to inform the likelihood of occurrence prior to attending the Survey Area. A total of 70 taxa of conservation significance were identified through the database searches as potentially occurring within the Survey Area (Table 8.1, Appendix G). Of these, 27 species are listed as Threatened under the BC Act and the EPBC Act (note that State and Federal rankings on individual taxa differ):

- Critically Endangered (CR) – 2 (EPBC Act) 11 (BC Act);
- Endangered (EN) – 21 (EPBC Act) 11 (BC Act); and
- Vulnerable (VU) – 4 (EPBC Act) 5 (BC Act).

The remaining 42 flora taxa identified are priority listed species under the BC Act:

- Priority 1 flora (P1) - 2 taxa;
- Priority 2 flora (P2) – 12 taxa;
- Priority 3 flora (P3) - 22 taxa; and
- Priority 4 flora (P4) – 6 taxa.

A likelihood of occurrence assessment has been reviewed for threatened and priority flora species potentially occurring within the Survey Area. The criteria listed in Of the 69 species listed as potentially occurring, 5 are listed as possibly occurring, 17 are known to occur in the 2012 survey area and the remaining are listed are unlikely or highly unlikely.

The likelihood of occurrence table can be found in Appendix D.

Table 4.3 were used to assess the likelihood of the occurrence of species and communities of conservation significance possibly in the proposed impact area identified as possibly or known to be in the surrounding area from the desktop surveys. Of the 69 species listed as potentially occurring, 5 are listed as possibly occurring, 17 are known to occur in the 2012 survey area and the remaining are listed are unlikely or highly unlikely.

The likelihood of occurrence table can be found in Appendix D.

Table 4.3 Likelihood of occurrence criteria

Likelihood	Criteria
Recorded	Species recorded in current survey and/or previous recorded from desktop review
Likely	Species previously recorded within the study area and large areas of suitable habitat occur in the project area.
Possible	Species previously recorded within the study area and areas of suitable habitat occur/may occur in the project area.
Unlikely	Species previously recorded within the study area, but suitable habitat does not occur in the project area.
Highly unlikely	Species not previously recorded within the study area, suitable habitat does not occur in the project area and/or the project area is outside the natural distribution of the species.
Other considerations	Intensity of survey, availability of access, growth form type, recorded flowering times, cryptic nature of species

Two species of Threatened Flora (see below) have previously been identified within or in proximity to the Survey Area:

– Acacia aristulata (T-EN);

– Daviesia dielsii (T-EN).

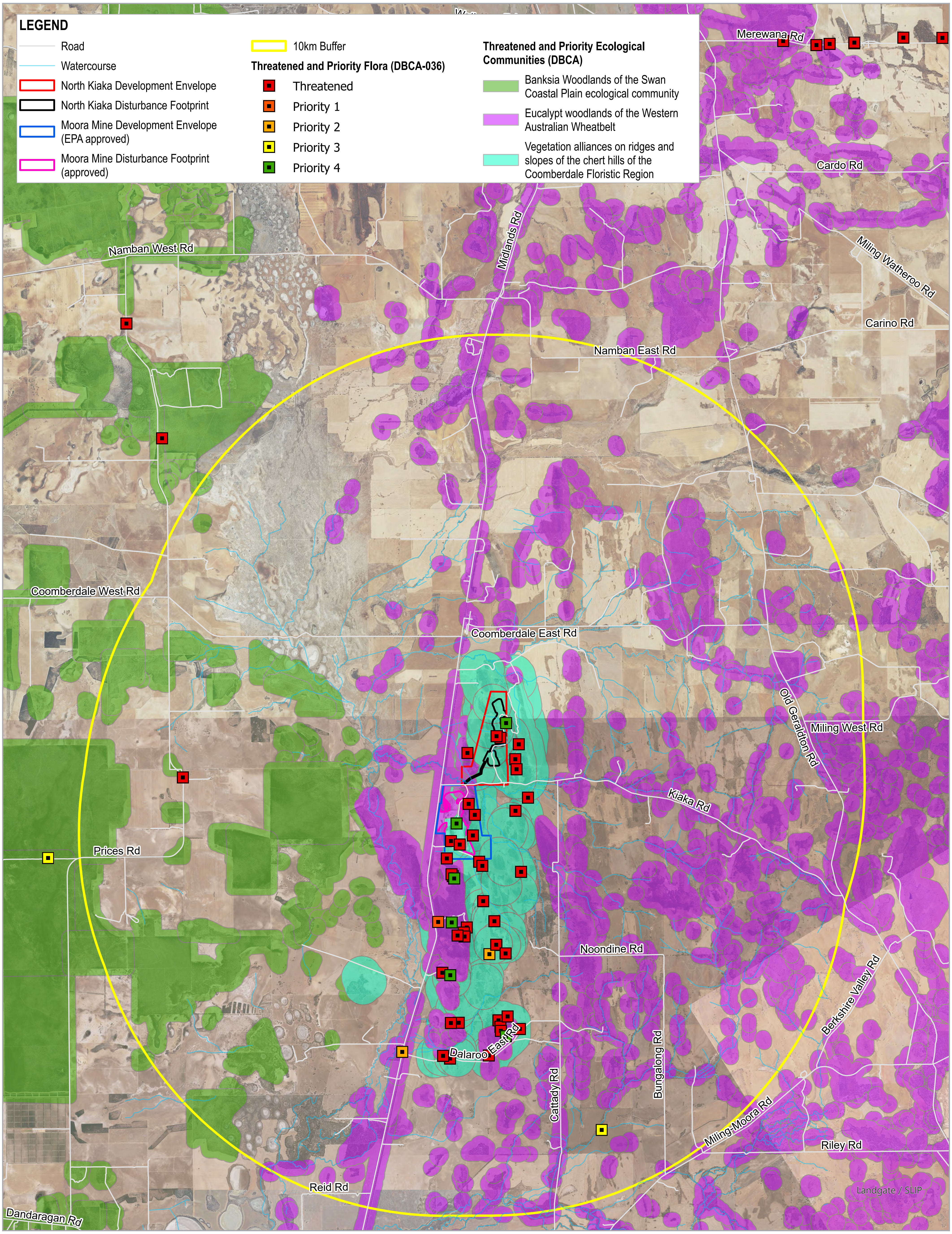
Of the priority species returned from the database searches, two have been previously recorded within (Appendix E) and 52 in proximity (Appendix G) to the Survey Area. A search using the Protected Matters Search Tool (PMST) of Matters of National Environmental Significance (MNES) identified 24 species that occur or may occur within the area (Appendix G). Of these, Table 4.4 lists the threatened and priority species historically recorded in proximity to the survey area.

Table 4.4 Historical threatened and priority species previously recorded within, or in proximity to the Survey Area

Taxon	Status	
	EPBC Act	WC Act /DBCA
Acacia aristulata	EN	EN
Acacia cochlocarpa subsp. cochlocarpa	EN	CR
Acacia congesta subsp. cliftoniana	-	P1
Acacia cummingiana	-	P3
Acacia flabellifolia	-	P3
Acacia splendens	EN	CR
Andersonia gracilis	EN	VU
Anigozanthos humilis subsp. Badgingarra (S.D. Hopper 7114)	-	P2
Austrostipa nunaginensis	-	P3
Babingtonia cherticola	-	P3
Babingtonia urbana	-	P3
Balaustion grande	-	P3
Banksia dallanneyi subsp. *pollosta*	-	P3
Banksia fuscobractea	CR	CR

Taxon	**Status**	
	EPBC Act	**WC Act /DBCA**
Beaufortia bicolor	-	P3
Boronia ericifolia	-	P2
Bossiaea moylei	-	P2
Caladenia drakeoides	EN	CR
Caladenia dundasiae	-	P1
Calothamnus accedens	-	P4
Chamelaucium lullfitzii	EN	VU
Chorizema humile	EN	CR
Conospermum densiflorum subsp. *unicephalatum*	EN	EN
Cryptandra glabriflora [Vouchers redetermined as C. myriantha]	-	P2
Dasymalla axillaris	CR	CR
Daviesia dielsii	EN	EN
Dicrastylis velutina	-	P3
Diuris recurva	-	P4
Eleocharis keigheryi	VU	VU
Eremaea sp. Cairn Hill (B. Morgan 532)	-	P2
Eremophila glabra subsp. *chlorella*	EN	EN
Eremophila scaberula	EN	CR
Eucalyptus absita	EN	CR
Eucalyptus crispata	VU	EN
Eucalyptus leprophloia	EN	EN
Eucalyptus macrocarpa x pyriformis	-	P3
Eucalyptus pruiniramis	EN	EN
Eucalyptus rhodantha var. rhodantha	VU	VU
Eucalyptus x carnabyi	-	P4
Frankenia conferta	EN	VU
Gastrolobium appressum	VU	EN
Gastrolobium hamulosum	EN	CR
Goodenia arthrotricha	EN	EN
Grevillea amplexans subsp. *semivestita*	-	P2
Grevillea christineae	EN	EN
Grevillea haplantha subsp. *recedens*	-	P3
Grevillea pythara	EN	CR
Grevillea saccata	-	P4
Guichenotia tuberculata	-	P3
Hemiandra gardneri	EN	CR
Hemigenia conferta	-	P4

Taxon	**Status**	
	EPBC Act	**WC Act /DBCA**
Hemigenia curvifolia	-	P2
Hydrocotyle spinulifera	-	P3
Isotropis cuneifolia subsp. glabra	-	P3
Melaleuca sclerophylla	-	P3
Persoonia chapmaniana	-	P3
Pertusaria trachyspora	-	P2
Petrophile biternata	-	P3
Regelia megacephala	-	P4
Stylidium glabrifolium	-	P2
Stylidium milleri	-	P2
Stylidium periscelianthum	-	P3
Stylidium sp. Moora (J.A. Wege 713)	-	P2
Styphelia allittii	-	P3
Styphelia tamminensis	-	P3
Synaphea quartzitica	EN	EN
Tricoryne sp. Wongan Hills (B.H. Smith 794)	-	P2
Verticordia insignis subsp*. eomagis*	-	P3
Verticordia muelleriana subsp*. muelleriana*	-	P3



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Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

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TEC/PEC locations from database searches and DBCA Threatened and Priority Flora records

Project No.	12518217
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FIGURE 4.6

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Data source: Simcoa: Mining Development Shape Areas is derived from client recieved 2020; Langate: Slip Imagery - April 2017 to November 2018 (accessed - 20191023), River, Road - 20180601. Created by: klabez

4.5.3 Weeds

Available data on the presence of weeds in the Avon Wheatbelt region and their inherent characteristics were compiled to provide a list to determine presence and absence within the Survey Area during earlier works by Trudgen et al. 2012. For the 2016 survey, that information was contextualised against the Ecological Impact and Invasiveness Ratings from the Department of Parks and Wildlife Wheatbelt Region Species Prioritisation Process (2014), specifically related to the Wheatbelt region (last updated 27th April 2023), the West Australian Organism List (BAM Act 2007), and the Weeds of National Significance Register (WoNS).

Of the 56 weed species with potential to occur, 34 were found in the 2012 Survey Area (Trudgen *et al.* 2012). Of those, eight have a high ecological impact and rapid invasiveness rating. All are common, with wide distribution and are not novel to the area. All weeds are permissible under Section 11 of the BAM Act 2007, and none were determined to be Weeds of National Significance. Rehabilitation monitoring of the Moora Mine rehabilitated areas in 2022 provides recent insight into weed presence in the vicinity of the Coomberdale Chert TEC and Survey Area, with only 12 out of the original 56 species being recorded, four of which have a high ecological impact and rapid invasiveness rating (Trudgen, 2022) (Table 4.6).

Table 4.5 BAM Act 2007 WAOL factor description

Factor	Description	Score code
Ecological Impact	Impact of species within the Region, from low impact (causes minimal disruption to ecological processes or loss of biodiversity) to high (causes acute disruption of ecological processes, dominates and/or significantly alters vegetation structure, composition and function of ecosystems).Examples of impact attributes to consider: – changed fire regime – changed nutrient conditions – changed hydrological patterns – changed soil erosion patterns – changed geomorphological processes – changed biomass distribution – changed light distribution – loss of biodiversity – substantially reduces regeneration opportunities of native plants – allelopathic effects	L – Low M – Medium H – High U - Unknown
Invasiveness	Rate of spread of a weed in native vegetation, encompassing factors of establishment, reproduction and long distance dispersal (>100m). Examples of establishment factors include: – ability to outcompete (light, moisture, nutrients, rapid root growth) – sexual or asexual establishment – need for disturbance to establish Examples of reproduction factors include: – time to seeding – seed production – vegetative reproduction Examples of long distance dispersal mechanisms include: – wind – water – flying/ground animals – deliberate/accidental human spread – vehicles – produce contaminant	S – Slow M - Moderate R - Rapid U - Unknown

Table 4.6 List of weeds with potential to occur in the Survey Area and presence/absence data (data sourced Trudgen et al. 2012)

Plant family	WAOL (BAM Act)	Taxa	Presence North of Kiaka Road	Presence proposed impact area	Ecological impact	Invasiveness	Present in Moora Rehab 2022
Poaceae	s11 - Permitted	Aira caryophyllea	Recorded	Recorded	H	R	No
Poaceae	s11 - Permitted	Avena barbata	Recorded	Recorded	H	R	Yes
Poaceae	s11 - Permitted	Brachypodium distachyon	Recorded	-	U	U	Yes
Poaceae	s11 - Permitted	Briza maxima	Recorded	Recorded	H	R	Yes
Poaceae	s11 - Permitted	Bromus diandrus	Recorded	Recorded	H	R	Yes
Poaceae	s11 - Permitted	Bromus madritensis	Recorded	Recorded	H	R	No
Poaceae	s11 - Permitted	Cynosurus echinatus	Recorded	-	-	-	No
Poaceae	s11 - Permitted	Ehrharta brevifolia var. cuspidata	Recorded	Recorded	U	U	No
Poaceae	s11 - Permitted	Ehrharta calycina	Recorded	-	H	M	No
Poaceae	s11 - Permitted	Ehrharta longiflora	Recorded	Recorded	U	M	Yes
Poaceae	s11 - Permitted	Hordeum leporinum	Recorded	Recorded	U	R	No
Poaceae	s11 - Permitted	Lamarckia aurea	Recorded	Recorded	U	M	No
Poaceae	s11 - Permitted	Lolium perenne	Recorded	Recorded	U	M	No
Poaceae	s11 - Permitted	Pentaschistis airoides	Recorded	Recorded	-	-	No
Poaceae	s11 - Permitted	Pentaschistis pallida	Recorded	Recorded	-	-	No
Poaceae	s11 - Permitted	*Pentaschistis sp.	-	-	-	-	No
Poaceae	-	Pentaschistis sp. Moora	Recorded	-	-	-	No
Poaceae	s11 - Permitted	Schismus barbatus	Recorded	Recorded	U	U	No

Plant family	WAOL (BAM Act)	Taxa	Presence North of Kiaka Road	Presence proposed impact area	Ecological impact	Invasiveness	Present in Moora Rehab 2022
Poaceae	s11 - Permitted	Vulpia myuros	Recorded	Recorded	U	R	No
Iridaceae	s11 - Permitted	Moraea setifolia	Recorded	Recorded	H	R	No
Iridaceae	s11 - Permitted	Romulea rosea	Recorded	Recorded	H	R	No
Polygonaceae	s11 - Permitted	Emex australis	Recorded	Recorded	-	-	No
Caryophyllaceae	s11 - Permitted	Petrorhagia dubia	Recorded	Recorded	U	R	No
Caryophyllaceae	-	Petrorhagia prolifera	Recorded	-	-	-	No
Caryophyllaceae	s11 - Permitted	Polycarpon tetraphyllum	Recorded	Recorded	U	M	No
Caryophyllaceae	s11 - Permitted	Silene gallica var. gallica	Recorded	Recorded	U	R	No
Caryophyllaceae	s11 - Permitted	Spergula arvensis	-	-	-	-	No
Brassicaceae	s11 - Permitted	Brassica barrelieri subsp. oxyrrhina	Recorded	-	U	U	No
Brassicaceae	s11 - Permitted	Lupinus angustifolius	Recorded	Recorded	L	S	No
Papilionaceae	s11 - Permitted	Trifolium arvense var. arvense	Recorded	-	U	U	Yes
Papilionaceae	s11 - Permitted	Trifolium campestre var. campestre	Recorded	-	U	U	No
Papilionaceae	s11 - Permitted	Trifolium hirtum	Recorded	Recorded	U	U	No
Papilionaceae	s11 - Permitted	Trifolium repens var. repens	-	-	-	-	No
Papilionaceae	s11 - Permitted	Trifolium subterraneum	Recorded	Recorded	U	U	No
Geraniaceae	s11 - Permitted	Erodium botrys	Recorded	Recorded	L	M	Yes

Plant family	WAOL (BAM Act)	Taxa	Presence North of Kiaka Road	Presence proposed impact area	Ecological impact	Invasiveness	Present in Moora Rehab 2022
Oxalidaceae	s11 - Permitted	Oxalis corniculata	-	-	H	S	No
Linaceae	s11 - Permitted	Linum trigynum	Recorded	-	-	-	No
Primulaceae	s11 - Permitted	Lysimachia arvensis	Recorded	Recorded	U	R	No
Gentianaceae	s11 - Permitted	Centaurium tenuiflorum	-	-	U	U	No
Solanaceae	s11 - Permitted	Solanum nigrum	Recorded	Recorded	U	R	No
Scrophulariaceae	s11 - Permitted	Dischisma capitatum	-	-	U	U	No
Scrophulariaceae	s11 - Permitted	Parentucellia latifolia	Recorded	-	U	R	No
Scrophulariaceae	s11 - Permitted	Zaluzianskya divaricata	-	-	U	R	No
Orobanchaceae	s11 - Permitted	Orobanche minor	-	-	M	R	No
Rubiaceae	s11 - Permitted	Galium murale	Recorded	-	U	U	No
Campanulaceae	s11 - Permitted	Wahlenbergia capensis	Recorded	Recorded	U	R	No
Asteraceae	s11 - Permitted	Arctotheca calendula	Recorded	Recorded	H	R	Yes
Asteraceae	s11 - Permitted	Cotula turbinata	Recorded	Recorded	-	-	No
Asteraceae	s11 - Permitted	Hedypnois rhagadioloides	-	-	U	U	No
Asteraceae	s11 - Permitted	Hypochaeris glabra	Recorded	Recorded	U	R	Yes
Asteraceae	-	Hypochaeris radiculata	-	-	U	R	No
Asteraceae	s11 - Permitted	Sonchus asper	Recorded	Recorded	U	R	No

Plant family	WAOL (BAM Act)	Taxa	Presence North of Kiaka Road	Presence proposed impact area	Ecological impact	Invasiveness	Present in Moora Rehab 2022
Asteraceae	s11 - Permitted	Sonchus oleraceus	Recorded	Recorded	U	R	No
Asteraceae	s11 - Permitted	Monoculus monstrosus	Recorded	Recorded	U	R	Yes
Asteraceae	s11 - Permitted	Urospermum picroides	Recorded	-	U	R	Yes
Asteraceae	s11 - Permitted	Ursinia anthemoides	Recorded	Recorded	U	R	Yes

4.5.4 Threatened and Priority Ecological Communities

Three Threatened Ecological Communities (TECs) were recorded as potentially occurring within proximity to the Survey Area (Figure 4.6). The data and consideration of the guidance available has allowed an assessment of likelihood of these being present in the survey area.

***The Eucalypt Woodlands of the Western Australian Wheatbelt* (Critically Endangered – EPBC Act only).**

The Eucalypt Woodlands are found on flatter landscapes and lower rises of the wheatbelt. The main trees are eucalypts that typically have a single trunk with a woodland crown cover of the canopy is less than 10%. The structure of the ecological community is a woodland in which the minimum crown cover of the tree canopy in a mature woodland is 10%. Native understorey is present but is of variable composition, being a combination of grasses, other herbs and shrubs. The nationally listed woodlands only include patches that are large and remain in good condition as outlined in the Commonwealth of Australia (2016) Guidance[2] '*Eucalypt Woodlands of the Western Australian Wheatbelt: a nationally protected ecological community'*. This community was identified as potentially occurring in the south-western portion of the search area through a DBCA database search. It was formerly extensive but now occurs as mostly small remnants, scattered across the wheatbelt with many patches being degraded.

Small pockets of isolated Eucalypts were recorded in Trudgen et al. 2012 in the Survey Area (plant communities Elo3 and El5), however were not of appropriate quality or size to be classified as this TEC, using the guidance from the Commonwealth Government.

Based upon the presence of underlying soils and landform, it is considered unlikely to occur within the Survey Area.

***The Banksia Woodlands of the Swan Coastal Plain Ecological Community* (Endangered – EPBC Act only)**.

The Banksia Woodlands typically occurs on well drained, low nutrient soils on sandplain landforms, particularly deep Bassendean and Spearwood sands and occasionally on Quindalup sands; it is also common on sandy colluvium and aeolian sands of the Ridge Hill Shelf, Whicher Scarp and Dandaragan Plateau. The Community canopy is dominated or co-dominated by Banksia attenuata and/or B. menziesii. Other Banksia species that can dominate in the community are B. prionotes or B. ilicifolia.

Based on underlying soils and landform, it is considered unlikely to occur within the Survey Area.

***The Vegetation alliances on ridges and slopes of the chert hills of the Coomberdale Floristic Region* (Critically Endangered – BC Act only).**

The community occurs on ridges and slopes of the chert hills of the Coomberdale floristic region. Noondine chert is a geological formation visible as a discontinuous, narrow band of low hills or outcroppings of the Moora group of Proterozoic rocks. The formation extends from near the town of Three Springs to Moora. It encompasses seven vegetation alliances including the core units and three vegetation alliances of the buffer units of the Coomberdale Chert community. Core vegetation alliances include *Allocasuarina campestris* (sheoak) shrubland, *Allocasuarina microstachya scrub*, *Regelia megacephala* (priority 4) shrubland, *Kunzea praestans* shrubland and scrub, *Melaleuca calyptroides* heath, *Hibbertia subvaginata* shrubland and *Xanthorrhoea drummondii* shrubland.

The community is restricted to exposed quartzite ridges of the Noondine chert geological formation and is known to occur within the impact area from previous survey work undertaken by Trudgen *et al. (*2012) and earlier works.

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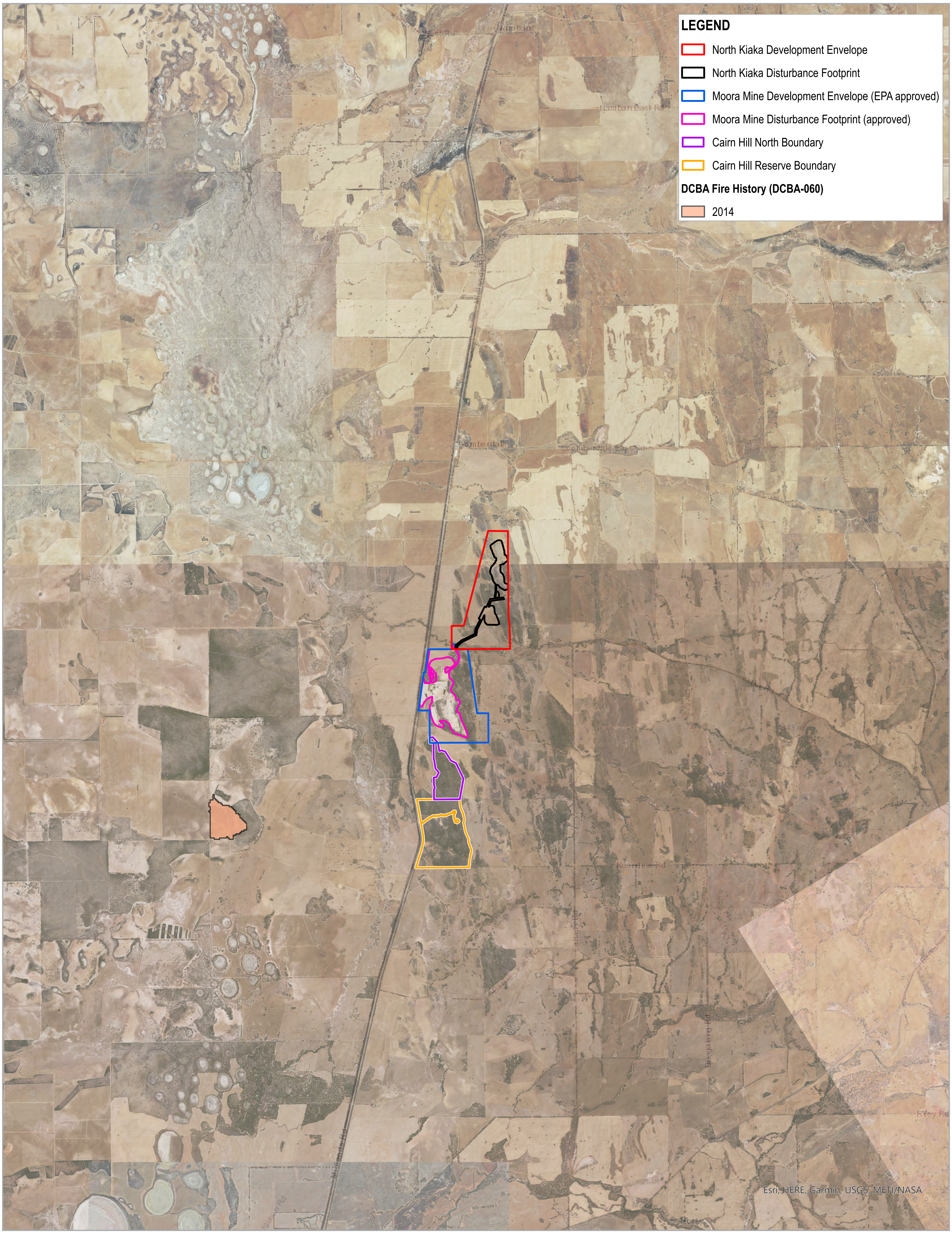
[2] Commonwealth of Australia (2016). Guidance: Eucalypt Woodlands of the Western Australian Wheatbelt: a nationally protected ecological community. Available online: **https://www.dcceew.gov.au/environment/biodiversity/threatened/publications/guide-eucalypt-woodlands-wa-wheatbelt**

4.6 Fire history

There have been no fire events in the area since 1981 (according to DBCA mapping and discussion with landowners located North of Kiaka Road) as shown in Figure 4.7.



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Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
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Fire events in the area since 2014

FIGURE 4.7

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Data source: Simcoa: Mining Development Shape Areas is derived from client recieved 2020; Langate: Slip Imagery - April 2017 to November 2018 (accessed - 20191023), Cadastre, Road - 20180601; DoW: River - 201108;. Created by: klabez

5. Results

A large area of the Coomberdale Chert TEC has been surveyed for flora and vegetation that extends from Dalaroo East Road to north of Kiaka Road. The southern end of the 1.4-kilometre-long area surveyed is 500 metres north of Kiaka Road and 2.2 kilometres east of the Midlands Road (Figure 3.1).

The survey in 2012 considered vegetation data collected in previous surveys. The flora list compiled and incorporated records from the original survey of the Moora Mine site (Trudgen, 1985) and data from Griffin (1992) from sites located within the survey area. During the 2012 survey a total of 5,460 collections were made for the survey area. The 2012 survey area has been shown to be different from areas of the TEC further north in floristic analyses.

There are three areas which contribute to the assessment of significance of flora and vegetation values for different areas of the TEC including:

- The flora and vegetation data collected during earlier surveys, updated with current flora names and nomenclature (See Figure 3.4).
- Data collected from the area north of Kiaka Road which was surveyed for Threatened and Priority flora in 2016 (Trudgen, 2018). This area has been found to have floristics from the area south of Kiaka Road (Trudgen *et al* 2012).
- The remnant vegetation found in the impact area. This is a subset of the area north of Kiaka Road and then of the area documented in Trudgen *et al* (2012). Additional survey work was carried out in this area in 2016 to further describe the threatened and priority flora species.

The survey results are outlined in the following sections.

5.1 Flora

Surveys by Trudgen *et al.* (2012) have recorded 315 species of native flowering plants, one native pine (*Actinostrobus arenarius*) and five species of native ferns (three *Cheilanthes* species, *Pleurosorus rutifolius* and *Ophioglossum lusitanicum*) within the Survey Area. Additionally, four of five native fern species recorded from the Coomberdale Chert TEC survey (Trudgen, Griffin, & Morgan, 2012) are common to the areas surveyed, while the fifth (*Ophioglossum lusitanicum*) has only been found in the TEC at one location within the proposed impact area.

The survey by Trudgen *et al* (2012) of the Coomberdale Chert TEC recorded 332 native flora species and 56 weeds. The area north of Kiaka Road, which includes the proposed North Kiaka Mine Development Envelope, has an intermediate sized flora of 192 native flowering plant species and 46 weed species. The proposed impact area recorded 102 native flora species and 53 weed species. See Table 5.2 for a comparison of the floras of these three areas and Appendix B for the flora list. This appendix also has comments for many of the species.

The composition of the native flora of the three areas is reasonably typical of the South West Botanical Province, with some minor deviation reflecting the TEC habitat, particularly few small shrub species recorded and five fern species present. The low number of small shrubs and number of ferns is unusual for the South West and is due to the fact that the TEC often has sub-outcrop of chert or outcrop. The families with most native species present groups represented in the Survey Area are *Asteraceae, Myrtaceae* and *Orchidaceae*. *Anthericaceae* (a Lily family), *Proteaceae, Cyperaceae* (sedges), *Mimosaceae* (Wattles), *Papilionaceae* and *Goodeniaceae* are also well represented and typical of the South West (Table 5.3).

A list of the native and introduced flora recorded in the survey area is given in Appendix B. To maintain consistency with earlier reports in documenting flora of the TEC, some changes in family boundaries (e.g. including *Mimosaceae* in *Papilionaceae* that have been proposed in recent years) have not been used in this report. Fewer monocotyledons than dicotyledons (a normal occurrence in south-western Australia) were recorded in the proposed impact area with 37 and 65 native species recorded, respectively. The ratio is similar for the numbers of species in these two groups recorded for the area north of Kiaka Road (58 and 134, respectively) and the area of the Coomberdale Chert TEC surveyed by Trudgen *et al.* (2012) (90 and 225, respectively) (Table 5.2).

Although the Coomberdale Chert has been extensively surveyed for flora, new records of flora species were found during the 2016 survey, but do not include any species of significance (Table 5.1).

Table 5.1 Species found during the 2016 survey (no records from historical surveys conducted by Trudgen et al.)

Species	Common form	Regional extent
Ophioglossum lusitanicum,	fern	Widespread
Isoetopsis graminifolia,	daisy	Widespread
Hyalosperma demissum,	daisy	Widespread
Diuris brumalis,	orchid	Modest (Perth to Geraldton)
Diuris tinkeri;	orchid	Modest (Mandurah to Eneabba)
Podolepis capillaris and	daisy	Widespread
Salsola australis.	herb	Widespread

The largest family groups represented in the area surveyed in 2016 are Asteraceae, Myrtaceae and Orchidaceae (Table 5.1). Only one perennial native Asteraceae has been recorded in the TEC (an *Olearia*), which was not recorded in the proposed impact area. *Pterostylis* was the predominant Orchidaceae genus (nine species) recorded for the TEC, five of which were recorded north of Kiaka Road and two in the proposed impact area.

Table 5.2 Number of species in higher groups recorded for the TEC area surveyed in 2012, north of Kiaka Road and proposed impact area (Trudgen et al., 2012)

Group of plants	Number of flora species recorded for TEC survey area of Trudgen *et al.* 2012	Number of flora species recorded north of Kiaka Road by Trudgen *et al.* 2012	Number of species recorded for proposed impact area
Ferns	5	5	5
Pines	1	1	1
Native monocotyledons	90	58	37
Native dicotyledons	225	134	65
Total native Angiosperm species	315	192	102
Total native species	321	198	108
Weed species	53	46	36

Except for the bias towards cryptophyte species and annual Asteraceae noted, the proportion of different families of angiosperms (Table 5.3) in the flora of the proposed impact area and the TEC is broadly similar to other areas in the south-west of Western Australia. However, there is also a relative paucity of smaller shrubs, reducing the numbers of some families such as Proteaceae, Mimosaceae and *Papilionaceae* that might otherwise be expected. It is noticeable in this respect that most of the 33 Myrtaceae (*Eucalyptus* and *Melaleuca* family) that are recorded for the Coomberdale Chert TEC are large shrubs or trees, with only seven being small shrubs (and even some of these get to over a metre tall). Ten species from the Myrtaceae family have been recorded in the proposed impact area and twelve recorded north of Kiaka Road.

Table 5.3 ***Number of native species in families recorded for the proposed North Kiaka Mine area, TEC area surveyed by Trudgen et al. (2012) and north of Kiaka Road***

Plant family	Number of species recorded for TEC survey area of Trudgen *et al.* 2012	Number of species recorded north of Kiaka Road by Trudgen *et al.* 2012	Number of species recorded for impact area (subset of North of Kiaka Road)
Pteridaceae	3	3	3
Ophioglossaceae	1	1	1
Aspleniaceae	1	1	1
Poaceae	20	10	7
Cyperaceae	11	4	2
Orchidaceae	24	16	10
Anthericaceae	14	10	5
Proteaceae	14	7	4
Amaranthaceae	7	4	2
Mimosaceae	15 (1 with 2 subspecies)	8	4
Papilionaceae	13	5	3
Myrtaceae	33 (1 with 2 forms)	12	10
Apiaceae	9	8	3
Goodeniaceae	11	2	1
Stylidiaceae	8	6	3
Asteraceae	35	23	20

The family *Anthericaceae* (part of the lilies group of monocotyledons) with fourteen species recorded for the TEC, ten for the area north of Kiaka Road and five for the proposed impact area is another family that has been suited by the harsh substrate of the Coomberdale Chert TEC, with six cryptophyte species and the remainder mostly herbs that can die back significantly and recover from the rootstocks or tubers. Changes in naming of native flora in the Coomberdale Chert TEC since Trudgen *et al.* (2012) are provided in Appendix C.

5.1.1 Threatened flora

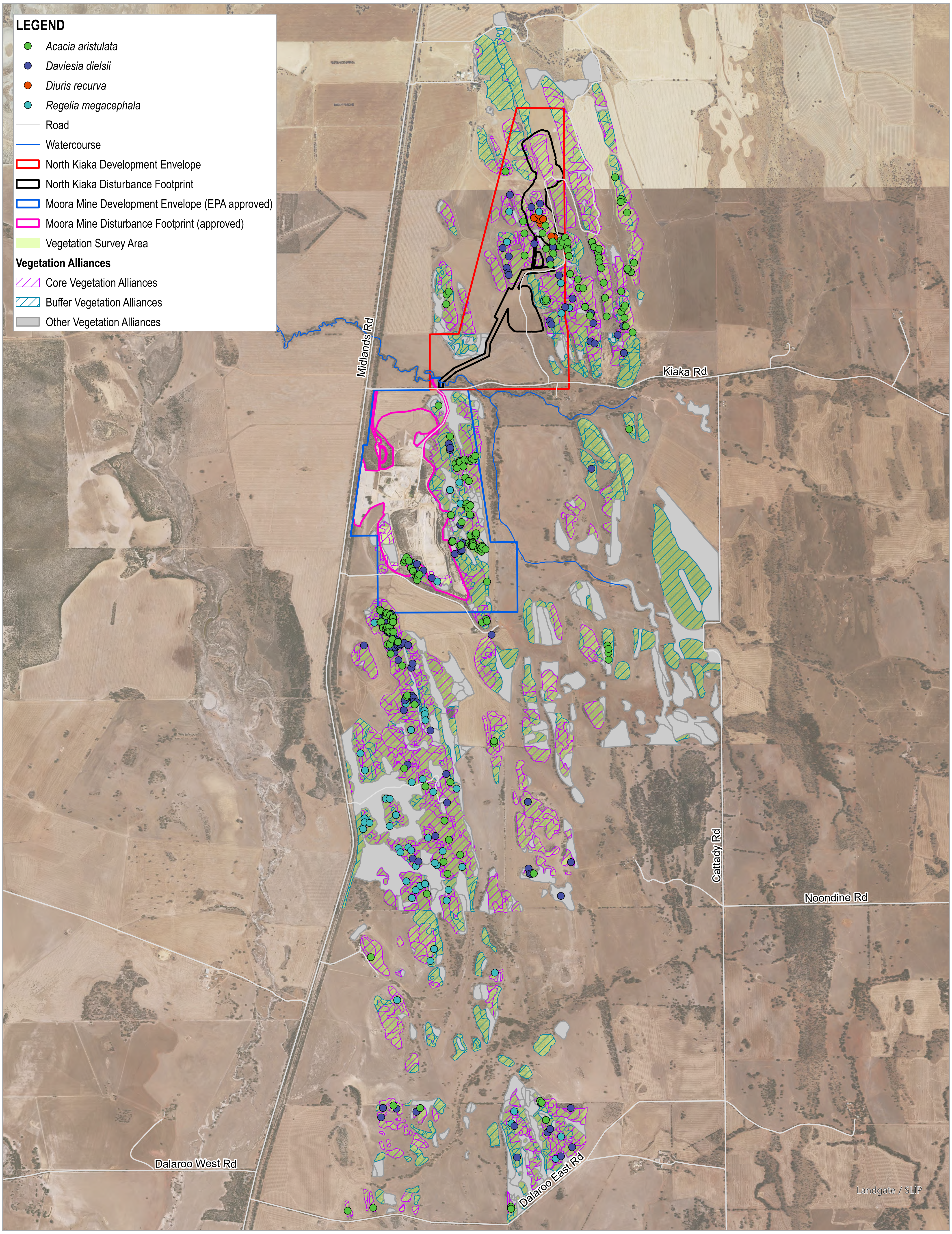
Five flowering plant species gazetted as Threatened Flora under the *Biodiversity Conservation Act 2016* have been recorded by Trudgen in 2012 (Table 5.4). Only the first two of these five species were recorded in the area north of Kiaka Road and proposed impact area. For the area north of Kiaka Road and the proposed impact area, details are provided in Table 5.4, including records from 2016.

Within the area north of Kiaka Road the listed occurrences include those on the easternmost ridge on the J. Tonkin property where a population of one hundred and eighty-five (185) *Acacia aristulata* plants was recorded in 2017 (within the 63 locations north of Kiaka Rd listed in Table 5.4).

Table 5.4 Number of occurrences of Threatened Flora species recorded in the Coomberdale Chert Threatened Ecological Community

Taxon	**Number of occurrences for TEC survey area of Trudgen *et al.* 2012**	**Number of occurrences north of Kiaka Road by Trudgen *et al.* 2012**	**Number of occurrences for proposed impact area**
Acacia aristulata	220	63	32[#]
Daviesia dielsii	135	27	3
Eucalyptus pruiniramis	3	0	0
Goodenia arthrotricha	11	0	0
Synaphea quartzitica	1	0	0

#The occurrences in the proposed impact area of *Acacia aristulata* include 2 clusters of significant numbers of plants.



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Conservation significant flora locations with Core and Buffer TEC vegetation alliances

FIGURE 5.1

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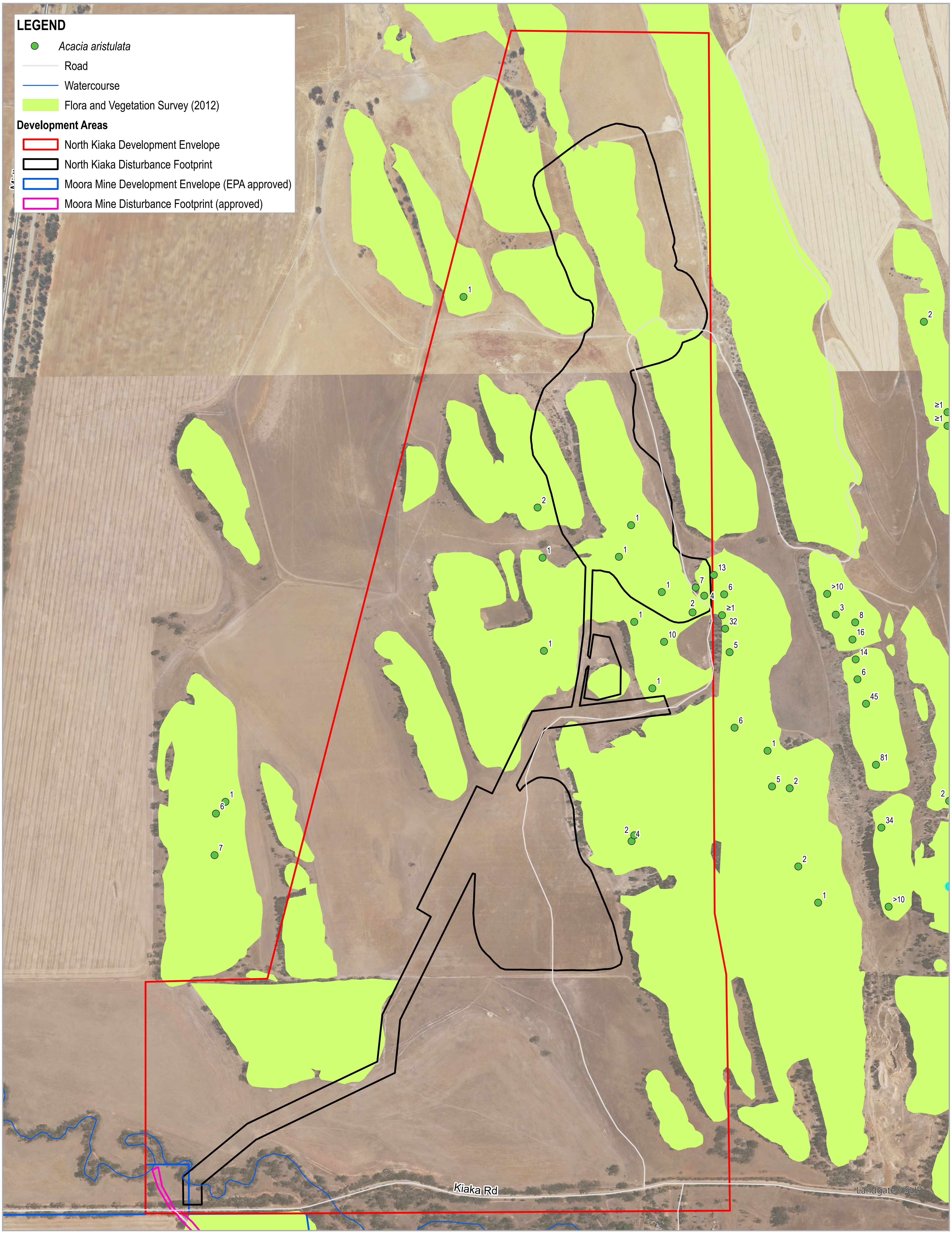

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***Acacia aristulata* Locations**

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FIGURE 5.2

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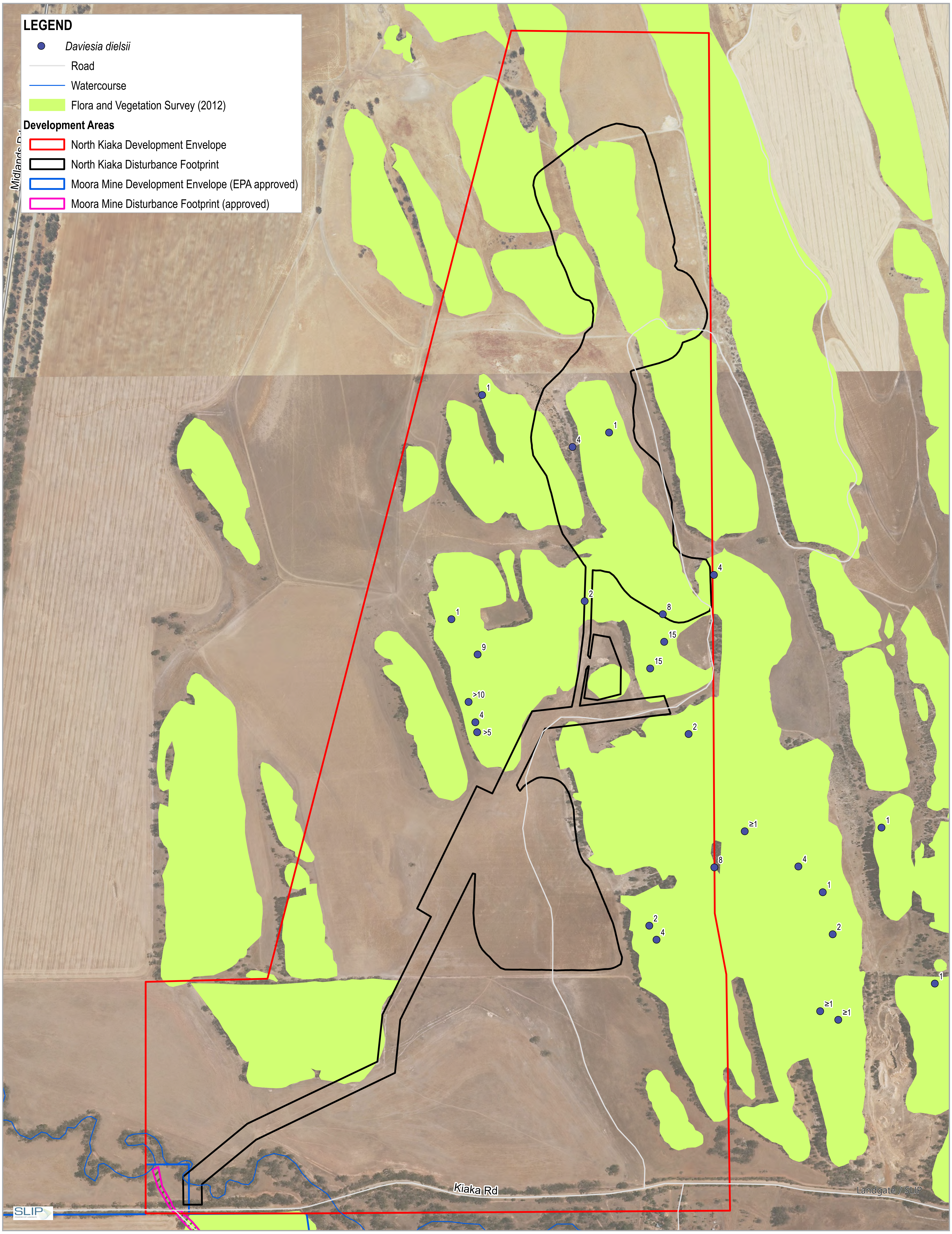

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***Daviesia dielsii* Locations**

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FIGURE 5.3

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5.1.2 Priority flora

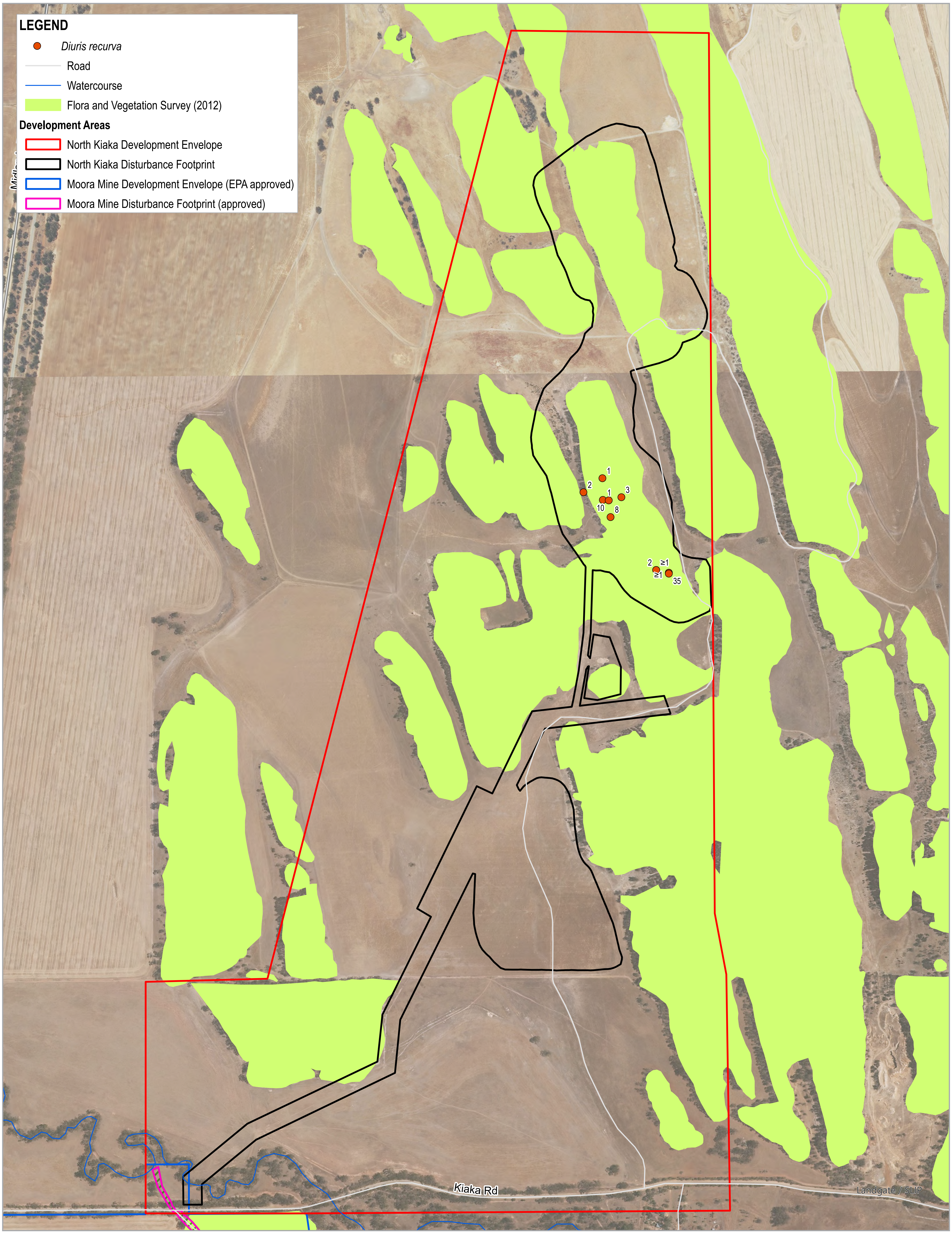
Thirteen priority flora species were recorded in the Trudgen *et al* (2012) survey area with three recorded in the area north of Kiaka Road and in the proposed impact area (Table 5.5). The three priority species recorded in the impact area are *Regelia megacephala*, *Diuris recurva* and *Stylidium* sp. Moora.

Regelia megacephala was recorded in 71 locations during the 2012 survey. At most of these sites the *Regelia* was dominant in a stand of *Regelia megacephala* vegetation type, although some stands are quite small. Of the 71 stands, eight are north of Kiaka Road and one is in the proposed impact area. The *Regelia megacephala* vegetation alliance has an area of about 75.39 hectares in the survey area of Trudgen *et al.* (2012). The stands in the impact area have a combined area of 2 hectares.

Diuris recurva has been recorded at 39 locations in the Trudgen *et al.* 2012 survey area. 10 of these occurrences are in the proposed impact area, with 65 flowering stems recorded between them. The concept of (and identifications of) *Diuris recurva* have changed significantly over the period of the surveys in the Trudgen *et al* (2012) survey area and it is likely that the high number of occurrences in the impact area compared to other parts of the 2012 area are due to this and possibly a good year for flowering of the species 2016.

Table 5.5 Priority flora species recorded

Taxon	Number of occurrences for TEC survey area of Trudgen *et al.* 2012	Number of occurrences north of Kiaka Road	Number of occurrences or counts for proposed impact area
P3 *Austrostipa nunaginensis*	1	0	0
P3 *Babingtonia cherticola*	77	0	0
P2 *Bossiaea moylei*	39 (including 4 from data of E.A. Griffin 1992)	0	0
P4 *Diuris recurva*	39	10 occurrences, 65 flowering stems	10 occurrences; 65 flowering stems
P1 *Eremaea* sp. Cairn Hill	1	0	0
P2 *Grevillea amplexans* subsp. semivestita	2	0	0
P3 *Guichenotia tuberculata*	1	0	0
P4 *Hemigenia conferta*	2 (& one roadside record just outside)	0	0
P3 *Melaleuca sclerophylla*	3	0	0
P4 *Regelia megacephala*	71 stands [75.39 hectares]	8 stands [14.07 hectares]	1 stand [2.00 hectares]
P2 *Stylidium glabrifolium*	3	0	0
P2 *Stylidium* sp. Moora	42	18	5 occurrences
P2 *Tricoryne* sp. Wongan Hills (B.H. Smith 794)	7	1	0



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Diuris recurva **locations nth of Kiaka Rd**

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FIGURE 5.4

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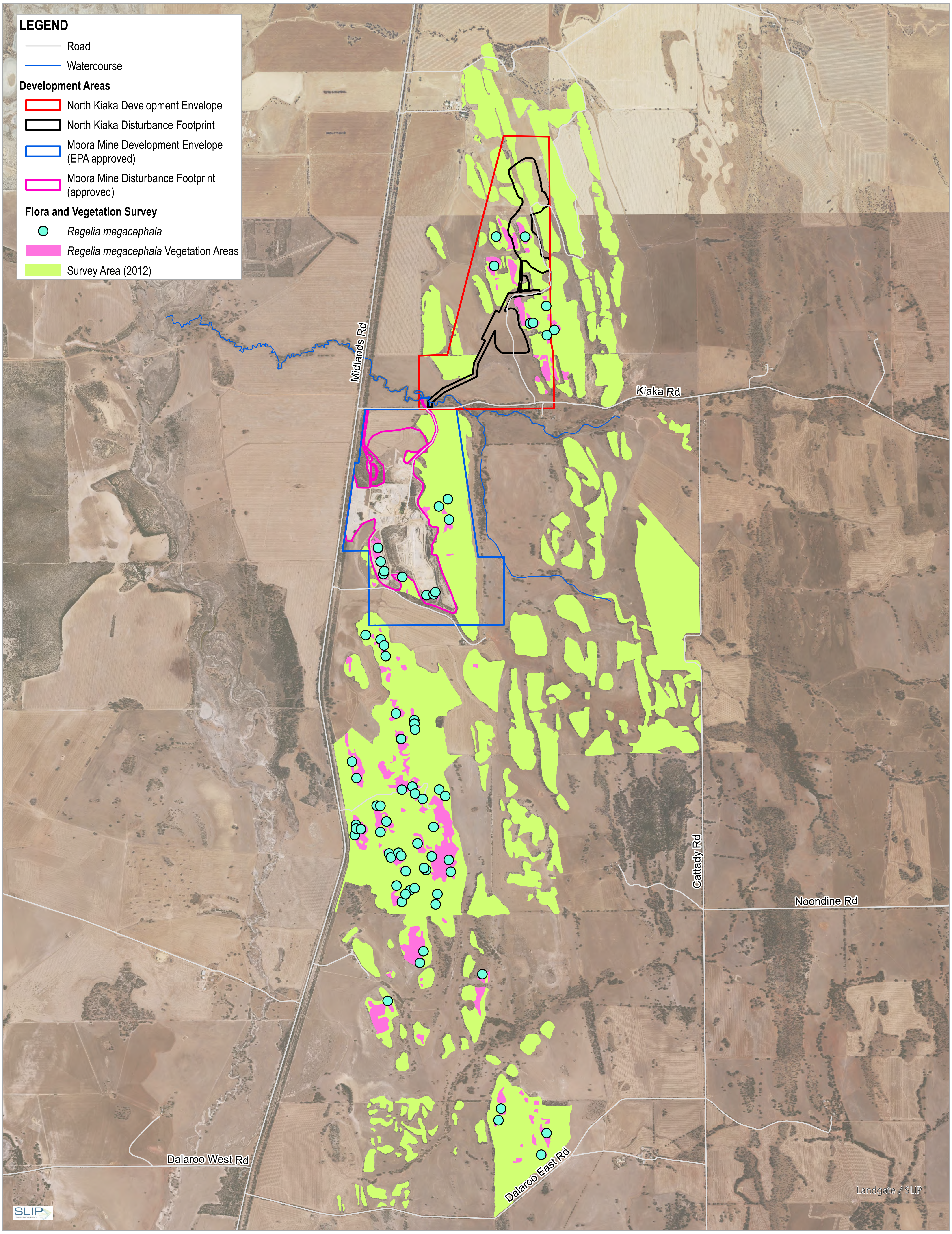

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Regelia megacephala **locations**
(as a component of vegetation alliances)

FIGURE 5.5

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5.1.3 Other flora of conservation interest

Some species may be of particular conservation interest while not on threatened flora or priority flora lists. Some examples are:

- newly discovered or very poorly known species;
- outlying populations of common species or of unrecognised taxa.

Several such species have been recorded in the 2012 survey area including:

- *Wurmbea drummondii;*
- *Stenanthemum tridentatum;*
- *Gastrolobium acutum;* and
- *Austrostipa exilis*

These species were priority species at the time of earlier reports but have subsequently been removed from these lists. The population of some species that have been removed from the priority list may still be significant. For example, while *Gastrolobium acutum* is no longer a priority species, the populations of this species observed in the 2012 survey area have significance because of they are at the northern extent of the known distribution.

Species of interest are listed in Table 5.6, including detail on distribution and significance of the population.

Table 5.6 ***Other flora of conservation interest recorded from the Coomberdale Chert TEC***

Taxon	Significance of TEC population of taxon	Occurrences in TEC survey area of Trudgen et al. 2012	Occurrences in north of Kiaka Road by Trudgen et al. 2012	Occurrences in the proposed impact area
Agrostocrinum scabrum aff. *ssp. scabrum*	TEC population disjunct from ssp. scabrum and specimen atypical.	3	0	0
Austrostipa exilis *(Previously P2 species)*	Near range limit in Western Australia, widespread but not common.	3	1	0
Banksia sphaerocarpa var. aff. *caesia*	Range edge, atypical habit & habitat if var. sphaerocarpa. Range extension and atypical habitat for var. caesia. Needs further study.	3	1	2 (6 plants)
*Calothamnus quadrifidus subsp. angustifolius (*Chert form*)*	Moderately geographically restricted, edaphically restricted not very common.	56 (Including 1 from data of E.A. Griffin)	9	2
Calytrix sp. Coomberdale (M.E. Trudgen MET 21184)	Geographically restricted, common in some habitats in the TEC. Not recognised as distinct in earlier surveys of the TEC. Common in the TEC and abundant in some vegetation types.	197 (Locally common)	34 (Locally common)	7
Cristonia stenophylla	TEC population outlying from main population by 60 km. Very uncommon in the 2012 TEC survey area. Needs taxonomic review.	3	3	1
Cyrtostylis huegelii	TEC population outlying by ca. 80 km from coastal part of population north of Perth.	3	0	0
Gastrolobium acutum *(Previously P3 species)*	Near northern limit, has disjunctions that may indicate unrecognised variation.	17	3	1
**Kunzea praestans* *(Previously a P3 species)*	More restricted than herbarium collections show (due to identification errors). May have unrecognised subspecies. The occurrences for this species are stands it occurs in.	219	47	10
Lepidosperma aff. leptostachyum (Moora: ERG18-7)	*Possibly restricted to the TEC. The status of this taxon is unclear due to the poor state of knowledge of Lepidosperma taxonomy.*	16	1	0

Taxon	Significance of TEC population of taxon	Occurrences in TEC survey area of Trudgen et al. 2012	Occurrences in north of Kiaka Road by Trudgen et al. 2012	Occurrences in the proposed impact area
Leptospermum aff. erubescens (Moora Chert; B. Morgan 133).	Apparently very rare (2 known collections) and very restricted.	2	0	0
Pauridia aff. occidentalis var. occidentalis	Probably an undescribed species, but the genus needs revision and the material needs further study. Locally common in parts of the Coomberdale Chert TEC.	40	4	0
Petrophile brevifolia (forma)	Possible new taxon. Not in impact area. Needs further study.	2	0	0
Pterostylis exserta	Known from less than ten locations.	3	1	1
Quoya (Pityrodia) dilatata	Has three centres of occurrence (may indicate subspecies), the southern one disjunct on current knowledge.	52	10	3
Stenanthemum tridentatum *(Previously a P3 species)*	Has disjunctions, possibly has subspecies.	6 (All in the Gardiner property adjacent to Dalaroo East Road.)	0	0
Trichocline sp.	Material sterile, if Trichocline (formerly Amblysperma) then undescribed.	1	0	0
Wurmbea drummondii *(Previously a P4 species)*	No longer a priority species, but not very common.	2	2	2
Xanthorrhoea sp. Coomberdale	Quite geographically restricted, only observed on the Coomberdale Chert south of Coomberdale and one location near Moora. Not recognised as distinct in earlier surveys of the TEC.	254 (Locally common)	36 (Locally common)	9 (Locally common; sample underestimates the population)
Agrostocrinum scabrum aff. ssp. scabrum	TEC population disjunct from ssp. scabrum and specimen atypical.	3	0	0
Austrostipa exilis *(Previously P2 species)*	Near range limit in Western Australia, widespread but not common.	3	1	0

Taxon	Significance of TEC population of taxon	Occurrences in TEC survey area of Trudgen et al. 2012	Occurrences in north of Kiaka Road by Trudgen et al. 2012	Occurrences in the proposed impact area
Banksia sphaerocarpa var. aff. caesia	Range edge, atypical habit & habitat if var. sphaerocarpa. Range extension and atypical habitat for var. caesia. Needs further study.	3	1	2 (6 plants)
Calothamnus quadrifidus subsp. angustifolius (Chert form)	Moderately geographically restricted, edaphically restricted not very common.	56 (Including 1 from data of E.A. Griffin)	9	2
Calytrix sp. Coomberdale (M.E. Trudgen MET 21184)	Geographically restricted, very common in some habitats in the TEC. Not recognised as distinct in earlier surveys of the TEC.	197 (Locally common)	34 (Locally common)	7 (Sample underestimates the large population in the proposed impact area.)
Cristonia stenophylla	TEC population outlying from main population by 60 km. Locally very uncommon. Only juvenile seen in 2016.	3	3	1

Notes: The numbers in the table are occurrences at vegetation recording sites in the data of Trudgen et al. (2012) and some other data, unless noted as numbers of plants. For *Kunzea praestans*, the number of “occurrences” represents stands of vegetation with the species often important in the structure

5.2 Vegetation Survey

5.2.1 Context of vegetation alliances found in the survey area

The proposed impact area is located in the northern part of a large area of the vegetation of the Critically Endangered Coomberdale Chert Threatened Ecological Community (TEC) vegetation and flora surveyed by Trudgen *et al* (2012) between Dalaroo East Road and north of Kiaka Road. The vegetation of that TEC in the 2012 survey area is in vegetation remnants found on low ridges of Chert that are separated by strips of cleared farmland. The Chert habitat (with small areas of other types) is very variable and has resulted in very diverse vegetation in numerous small stands. Trudgen *et al* (2012) provides a detailed description of the vegetation of the survey area. The Trudgen *et al* (2012) survey area is floristically different to areas of the TEC further north.

The description of vegetation units in this section is congruent with Trudgen *et al* (2012) mapping and data analysis. The DBCA Coomberdale Chert fact sheet classifies some of the vegetation types found within the TEC as "core" and others as "buffer" (2013) however, this division does not reflect the relative abundance of the different vegetation types in the TEC or their conservation status.

5.2.2 Vegetation classification of the Trudgen *et al* survey

Trudgen *et al.* (2012) classified the vegetation of the survey area into three levels that go from low order (grouping very similar vegetation) to fairly high order (grouping related but not very similar vegetation) of synthesis. Their lowest order units are mostly defined near the *plant community* level the sites in such units having very similar structure, dominance and floristics. Ther plant communities were grouped into 104 *vegetation associations* that have similar structure and dominant species and then into 31 *vegetation alliances* as a third level of classification. The mapping presented plant communities and vegetation associations with a combined code (see Table 5.7 for the vegetation alliances abbreviations).

The codes for the Trudgen *et al* (2012) vegetation units are alpha-numeric, with the names for dominant or subdominant species indicated by the codes for species in Table 5.7. These codes are used on the vegetation map and in tables in this report.

Table 5.7 Abbreviations used for the species in the vegetation association/plant community codes.

Code for species	Species	Code for species	Species
Aa	*Acacia acuminata*	Ep	*Eucalyptus pruiniramis*
Ac	*Allocasuarina campestris*	Es	*Eucalyptus salmonophloia*
Ah	*Allocasuarina huegeliana*	Ew	*Eucalyptus wandoo* subsp. *wandoo*
Ahu	*Allocasuarina humilis*	Ha	*Hypocalymma angustifolium*
Am	*Allocasuarina microstachya*	Hr	*Hakea recurva* subsp. *recurva*
As	*Acacia scirpifolia*	Hs	*Hibbertia subvaginata*
B	*Babingtonia cherticola* [Previously: *Baeckea* sp. *Moora* (R. Bone 1993/1)]	Id	*Isopogon divergens*
Bp	*Banksia prionotes*	Kp	*Kunzea praestans*
Cd	*Calytrix depressa*	Lp	*Lepidosperma pubisquameum*
Cl	*Calytrix* sp. *Coomberdale*	Mc	*Melaleuca calyptroides*
Cq	*Calothamnus quadrifidus* subsp. *angustifolius (Chert form)*	*Mco*	*Melaleuca concreta*

Code for species	Species	Code for species	Species
Co	*Casuarina obesa*	Mcor	*Melaleuca coronicarpa*
Df	*Dryandra fraseri*	Mr	*Melaleuca radula*
Di	*Dodonaea inaequifolia*	Ms	*Melaleuca sclerophylla*
Dp	*Dodonaea pinifolia*	Pd	*Quoya (Pityrodia) dilatata*
Ds	*Dryandra sessilis* var. *flabellifolia*	Rv	*Ricinocarpos velutinus*
Ec	*Eucalyptus camaldulensis*	Rm	*Regelia megacephala*
Ee	*Eucalyptus eudesmioides*	Rmu	*Ricinocarpos muricatus*
Eh	*Eucalyptus horistes*	Td	*Trymalium daphnifolium*
El, Elo	*Eucalyptus loxophleba* subsp. *loxophleba*	Tl	*Trymalium ledifolium* subsp. *rosmarinifolium*
Eo	*Eucalyptus obtusiflora*	Xd	*Xanthorrhoea* sp. *Coomberdale*

Note: The abbreviations are used on the vegetation map and in tables.

The vegetation of the proposed impact area is a subset of eight vegetation alliances (Table 5.8) of the 33 vegetation alliances described for the Coomberdale Chert TEC by Trudgen *et al.* (2012). Within the eight alliances there are 19 vegetation associations and 23 plant communities. Descriptions of the eight vegetation alliances can be found in Appendix J., including associated dendrograms.

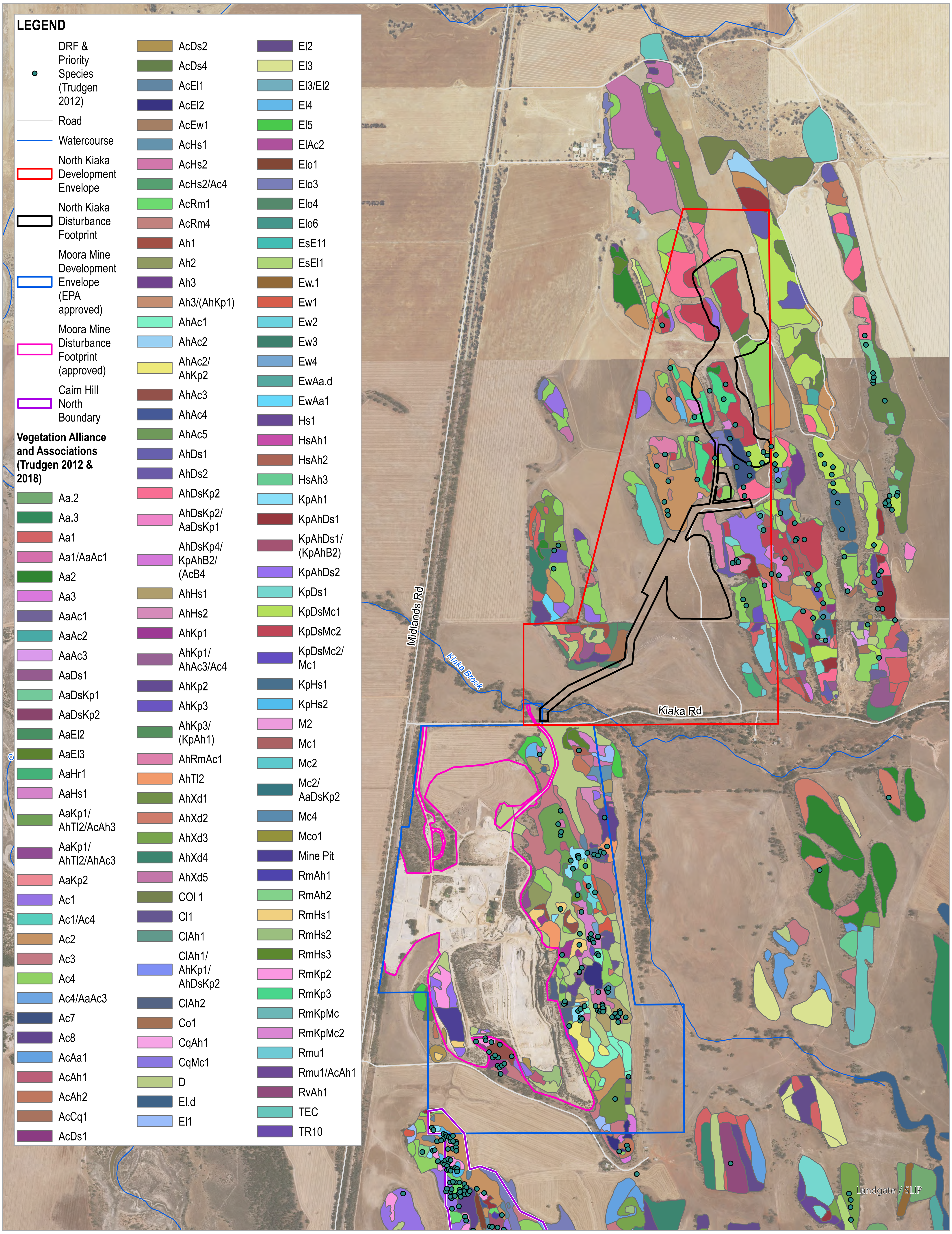
Kunzea praestans, and *Regelia megacephala* vegetation alliances are particularly relevant to the assessment of significance in a local or regional context. The *Regelia megacephala* vegetation is of particular importance, because the species is restricted to the Coomberdale Chert TEC. On the current application of the name *Kunzea praestans*, this species is less restricted in area, but there is some doubt over the proper application of the name (see Appendix B) and the form in the Coomberdale Chert TEC may be restricted in distribution.

Table 5.8 The vegetation alliances represented in the proposed impact area.

Vegetation alliances	Number of polygons	Number of vegetation associations in proposed impact area	Number of plant communities in proposed impact area
Kunzea praestans high shrubland to open and closed scrub	16	3	4
Allocasuarina campestris high shrublands to open and closed scrub	27	4	7
Allocasuarina huegeliana low woodlands to low open forests	10	4	4
Calothamnus quadrifidus subsp. *angustifolius* (Chert form) high shrubland	1	1	1
Acacia acuminata subsp. *acuminata* low woodlands	5	3	3
Eucalyptus loxophleba subsp. *loxophleba* low woodlands to low open forests	1	1	1
Melaleuca calyptroides open to closed heath	2	1	1
Regelia megacephala high shrubland to open and closed scrub	3	2	2

Table 5.9 Total area of the eight vegetation alliances found compared to total known areas in Trudgen 2012.

Vegetation alliances in the proposed North Kiaka Mine area	Area in proposed impact area (ha)	Total in the area mapped by Trudgen et al. 2012 (ha)
Kunzea praestans high shrubland to open and closed scrub	19.67	92.34
Allocasuarina campestris high shrublands to open and closed scrub	14.65	247.96
Allocasuarina huegeliana low woodlands to low open forests	3.88	128.71
Calothamnus quadrifidus subsp. *angustifolius* (Chert form) high shrubland	0.12	0.89
Acacia acuminata subsp. *acuminata* low woodlands	2.47	97.94
Eucalyptus loxophleba subsp. *loxophleba* low woodlands to low open forests	0.29	114.13
Melaleuca calyptroides open to closed heath	0.49	3.37
Regelia megacephala high shrubland to open and closed scrub	1.73	50.73



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Vegetation Type Mapping (Part 1)

FIGURE 5.6

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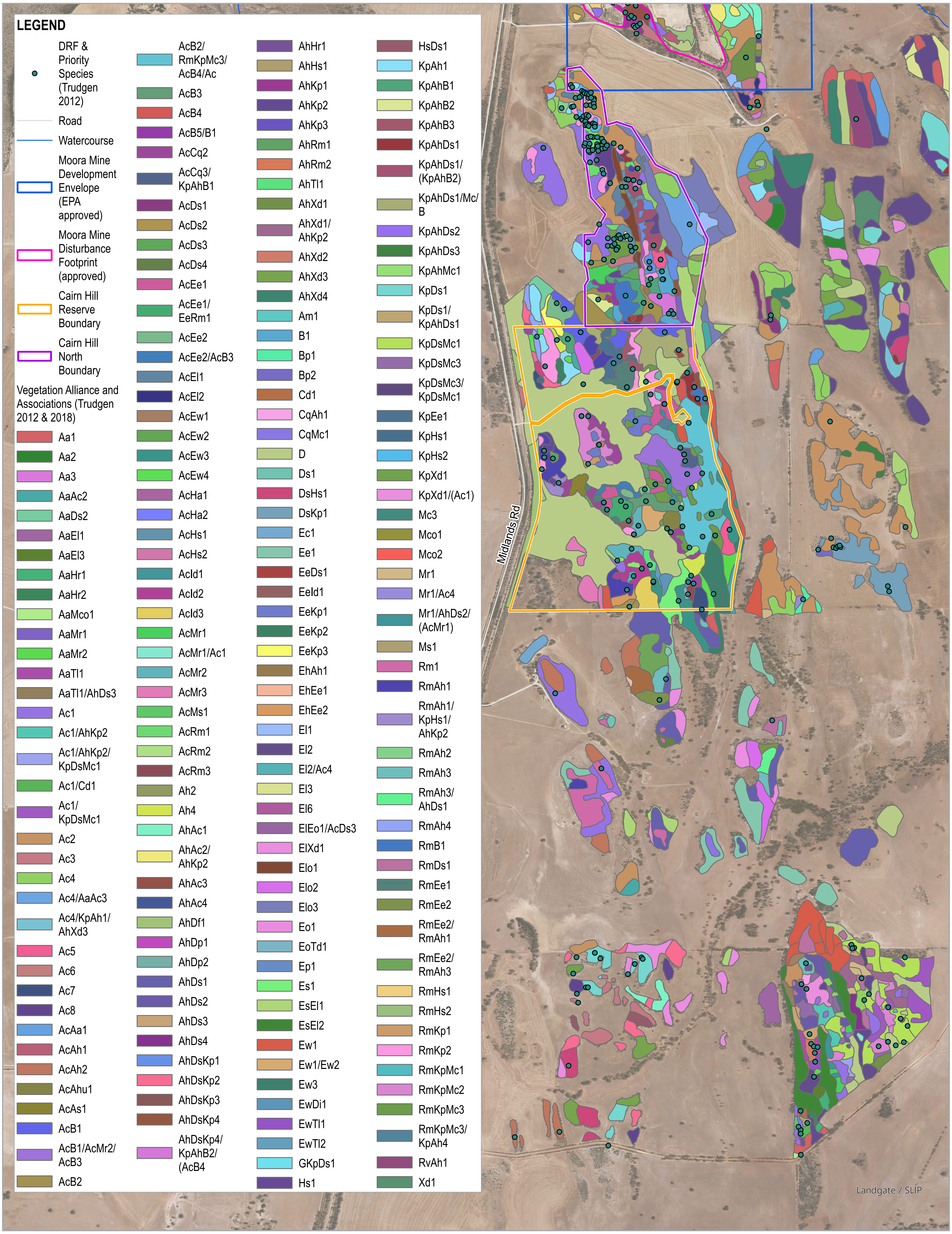

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Vegetation Type Mapping (Part 2)

FIGURE 5.7

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5.2.3 Vegetation condition in the Trudgen *et al* 2012 survey area

5.2.3.1 Vegetation condition mapping

The condition of the vegetation of the survey area was mapped by Trudgen *et al* (2012) using condition assessments recorded at quadrats and relevés in conjunction with aerial photograph interpretation (the field observations guiding the image interpretation). The condition mapped is shown in Figure 5.8. The condition was mapped using the scale of Trudgen 1998 (see **Error! Reference source not found.**). As would be expected with the Critically Endangered Coomberdale Chert Threatened Ecological Community (TEC) remnants being of different sizes and surrounded by farmland they have a range of condition varying from degraded to very good. Cairn Hill Nature Reserve has not been grazed and the parts of it which were not mined for gravel are in the best condition.

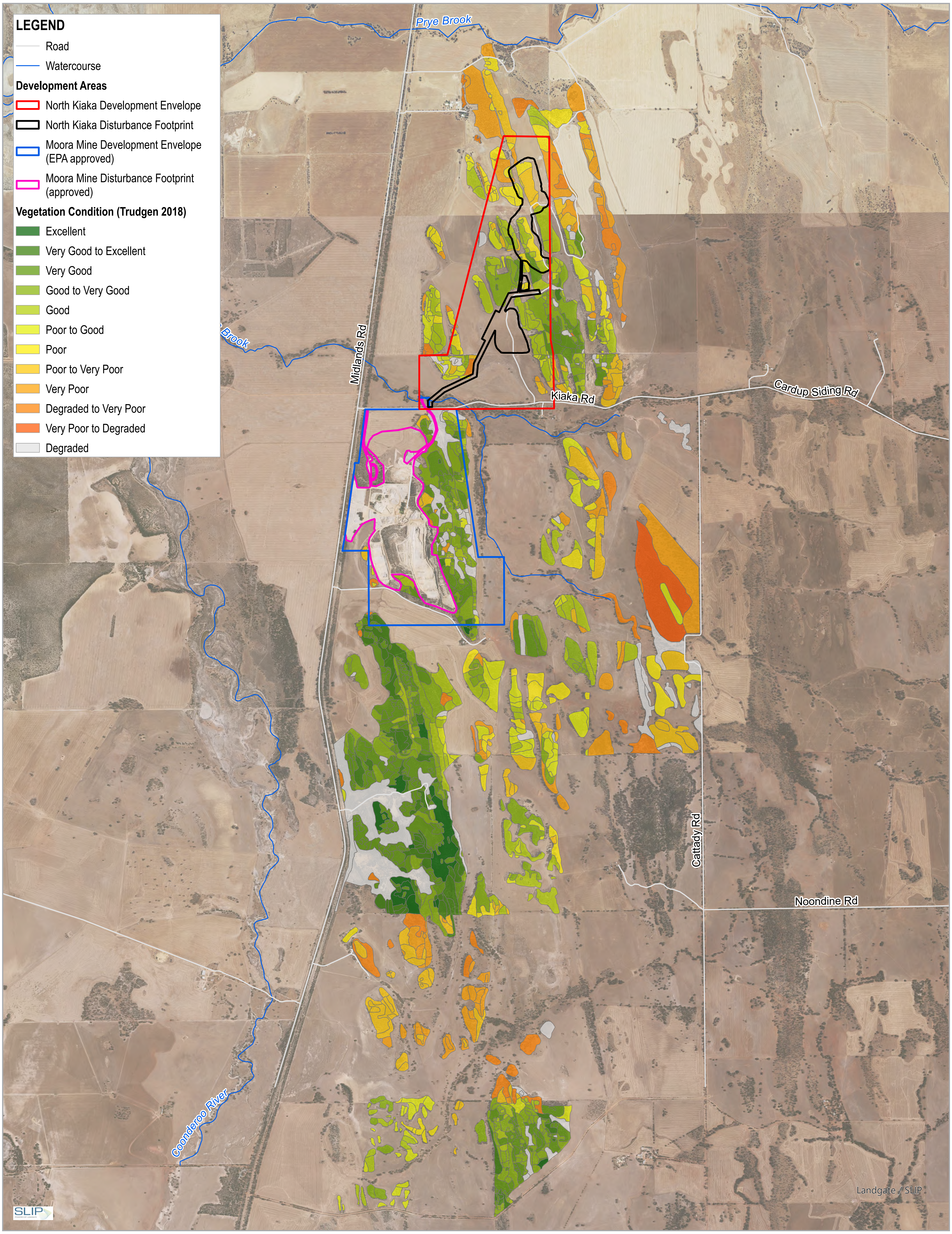
5.2.3.2 Changes in vegetation condition over time

The TEC remnants are subjected to ongoing changes in condition due to their size, farming activity and climate change. Increases in weed cover and changes in weed floristics have been recorded at some quadrats (Trudgen M. E., 2017) since they were originally recorded. However, field work in 2016 indicated that such changes did not affect the validity of the condition mapping of the Coomberdale Chert TEC to the extent that the mapping needed revision. Rather, a small decrease in condition can be assumed for areas with more open vegetation, while areas with denser vegetation are mostly not significantly changed at least in regard to weed invasion levels. In the longer term however, weed invasion, fertiliser drift and grazing are likely to continue to reduce the condition of areas of the TEC, particularly in areas that are not fenced off from stock.

One species in the Coomberdale Chert Threatened Ecological Community may be an indicator that change is more significant than is easily apparent. It was very noticeable during field work in 2016 that the adult population of *Xanthorrhoea* sp. Coomberdale is progressively dying and largely not being replaced. At some places ten or more dead plants (ranging from recently fallen plants to just the distinctive stumps with no stem remaining) were seen in areas with much fewer living plants. The obvious changes in the population structure of *Xanthorrhoea* sp. Coomberdale in the Coomberdale Chert TEC vegetation may be an indicator that there are other changes that are not so easily observed.

5.2.3.3 Condition of the TEC vegetation north of Kiaka Road

The vegetation of the TEC north of Kiaka Road (see Figure 5.8) varies from Completely Degraded (cleared farmland) to Very Good condition. Figure 5.8 shows that the better condition areas north of Kiaka Road are mainly in the southern part of the main central ridge system. Vegetation condition was generally better on rockier sites, steeper sites, and where *Regelia megacephala* or *Allocasuarina campestris* were denser. It is not clear how much some areas, especially on the property of A. & R. Tonkin have been affected by grazing, as they appeared (at the time of the condition mapping) to be in good or better condition but, have lower species numbers in quadrats than other areas.



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Vegetation Condition Mapping

FIGURE 5.8

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Data source: Simcoa: Mining Development Shape Areas is derived from client recieved 2020; Langate: Slip Imagery - April 2017 to November 2018 (accessed - 20191023), River, Road - 20180601. Created by: klabez

5.2.4 Other significant vegetation types

Kunzea praestans vegetation associations occurred in all the main bushland areas in the Trudgen *et al.* (2012) survey area, but were most extensive north of Kiaka Rd. While *Kunzea praestans* was often a minor component of vegetation associations, it was also prominent in 14 associations.

Vegetation types dominated by *Regelia megacephala* are geographically restricted to the Coomberdale TEC and were recorded in all the main sub-areas of bushland in the survey area, however there are significant structural differences between *Regelia megacephala* units across the survey area. For example, in the southern part of the survey area, some *Regelia megacephala* open scrub stands occurred under an overstorey of *Allocasuarina huegeliana* low open woodland to low open forest (Cairn Hill, Cairn Hill North and Gardener's Hill) and *Regelia megacephala* open scrub occurred under *Eucalyptus eudesmioides* scattered low trees to low open woodland (Cairn Hill Reserve). The scale of this variation is self-evident from the list of 10 vegetation associations from the survey area with *Regelia megacephala* dominant or sub-dominant.

6. Discussion

6.1 Flora

Native fern species recorded from the Coomberdale Chert TEC are found spread across the area surveyed by Trudgen *et al* (2012). One species (*Ophioglossum lusitanicum*) was only found in the TEC at one location within the impact area, north of Kiaka Road. While they are small plants, the three of five ferns found in the TEC to the north of Kiaka Road is fairly high for the small area, as ferns are a small part of the flora of the south-west of Western Australia. The number of ferns in the TEC reflects the fact that the harsh substrate there, thin soil over rock, suits species that have a cryptophyte life form (perennial rootstock of some form) and annual above ground parts. This habitat also inhibits smaller shrubs, lowering competition for the small cryptophytes and annuals. As with the small ferns, the same factors suit annual Asteraceae (Daisy family) and Orchids.

Callitris arenaria is the only native pine in the Coomberdale Chert TEC. It has been recorded by the Trudgen *et al* (2012) survey at one location within the proposed impact area north of Kiaka Road. During the 2016 threatened and priority searches, this small population (of six small trees) was extant, and one dead tree was observed nearby. This *Callitris* species is more commonly found on yellow sand than on chert and is common on that habitat west of the Midlands Road. This species was also recorded in the TEC to the south of Kiaka Road by Griffin (1992) but was not recorded there by Trudgen *et al* (2012).

The remnant vegetation observed in the areas north of Kiaka Road, particularly the subset potentially impacted, has flora populations recorded which represent 108 of the 321 species found in the Coomberdale Chert TEC (Trudgen, Griffin, & Morgan, 2012).

Within the Avon Botanical District land clearing for agriculture has removed large tracts of vegetation, with the remaining patches of vegetation providing important refuges for fauna and to support flora populations. Species such as *Regelia megacephala*, *Calytrix* sp. Coomberdale and *Xanthorrhoea* sp. Coomberdale are restricted to the Coomberdale Chert TEC or have most of their known population in it. Thus, the significance of these remaining populations is higher, given the flora populations of the survey area persist in a context where the original extent has been extensively reduced by clearing of native vegetation, largely for agriculture. Additionally the proportion of the original vegetation of the botanical district in secured conservation reserves is well below international and national objectives for secure reservation.

The overall assessment for the value of native flora in the areas of remnant vegetation in the proposed impact area is that it has moderate value for its size due to the flora present being of different composition to most other areas in the surrounding region. Note that the value is reduced somewhat because the vegetation has been degraded by grazing, weed invasion and spray drift.

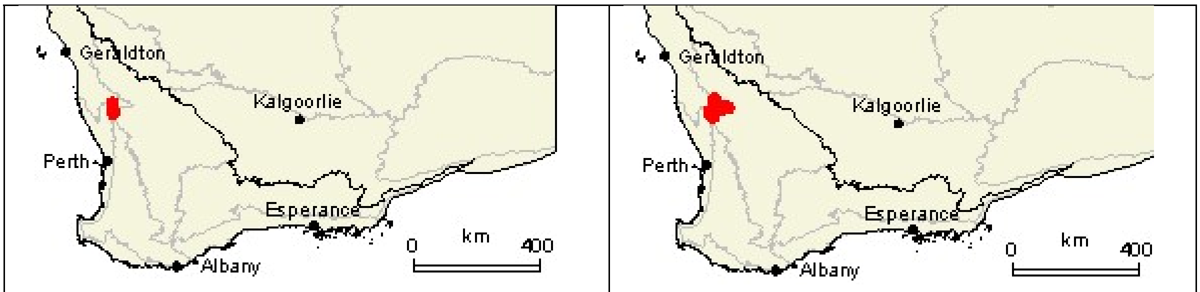
6.1.1 Threatened Flora

Of the 70 conservation significant species identified through DBCA and PMST database searches for areas surrounding the survey area, eighteen of these were recorded in the 2012 survey area (Table 5.4,Table 5.5). These recorded species include *Acacia aristulata* and *Daviesia dielsii* which are both listed as threatened.

There are less species and fewer records of threatened flora north of Kiaka Road compared to the larger area south of that road, can be attributed to a combination of factors other than just the size of the respective areas. Firstly, there seems to be some difference in flora distribution north of Kiaka Road compared to south (see detailed floristic analysis in Trudgen *et al.* 2012). Differences in floristics and grazing history are considered to be the primary reason. For a few species the apparent absence may partly reflect fire history (i.e. species may be present as seeds, requiring fire or other disturbance to appear), although fire has not been recorded since 1981 in the 2012 survey area. The very northern part of A. & R Tonkin's property (private property studied in Trudgen *et al.* 2012) has woodland of

Allocasuarina huegelii, which has fewer shrub species and herbs in the understorey than other vegetation types in the Coomberdale Chert TEC. Additionally, the area adjacent to the north side of Kiaka Road has areas of *Acacia acuminata* woodland that also has fewer shrub species. Some remnants of the TEC north of Kiaka Road (e.g. the easternmost ridge on J. Tonkin's property) are also quite degraded, reducing the available space for species and numbers of occurrences.

The threatened flora species *Acacia aristulata* is almost certainly a pyrosere species and the other threatened species recorded in the impact area *Daviesia dielsii*, may also be one. This means these species cycle between a seed storage stage in the absence of fire (or other disturbance that removes competition) and a shrub phase for a period after fire (with plants dying out over time, but seed being stored in the soil). An example of this may be the presence of a large population of *Acacia aristulata* on the very degraded easternmost ridge north of Kiaka Road in 2016. The population recorded in 2016 was much larger than that recorded in 2006. No such increase in population was observed in other areas during searches in 2016. It was also observed to be absent from a quadrat (JT011) north of Kiaka Road when that quadrat was revisited opportunistically, suggesting a limited life span (or possibly death due to the dry period up to 2016).



Restricted distribution of *Acacia aristulata*. (Map from the DEC site "Florabase").

Restricted distribution of *Daviesia dielsii* (Map from the DEC site "Florabase").

Figure 6.1 **Restricted distributions of *Acacia aristulata* and *Daviesia dielsii* (Florabase)**

Acacia aristulata appears to be most common in vegetation dominated by *Kunzea praestans* but is also often found with *Regelia megacephala* and was observed to be often grazed (Trudgen *et al*. 2012). *Acacia aristulata* has a very restricted distribution (north of Moora to near Watheroo and appears to be largely restricted to the Coomberdale Chert TEC). It has a fairly small population, within the Coomberdale Chert TEC area surveyed by Trudgen *et al.* (2012). Including records from the 2016 survey, it has been recorded at 220 locations in this area, significantly more locations than the other threatened species known for the TEC. Thirty-two of these locations fall within the impact areas north of Kiaka Road, while some of the older locations south of Kiaka Road have been lost due to mining activity.

Most locations where *Acacia aristulata* was recorded single-digit populations; however some were found with more than 20 plants and an estimated total of 1100 plants. Of these, some 230 plants occur in the proposed impact area. This is about 20.9% of the population known from the survey area of Trudgen *et al.* (2012) and their loss would be significant for the population of the species.

With 135 locations in the 2012 survey area *Daviesia dielsii* was the second most frequently recorded threatened species by Trudgen *et al.* (2012) of the threatened flora species found in the Coomberdale Chert TEC. This species has a wider geographic distribution than *Acacia aristulata (*Figure 6.1) but is still geographically restricted. It was mostly found at the ecotone between *Kunzea* and *Allocasuarina campestris* communities by Trudgen *et al.* (2012). More detailed distribution of the species north of Kiaka Road based on vegetation site data and threatened flora search data is shown in Figure 6.2. Outlying records of this species on The Australasian Virtual Herbarium are in eastern states herbaria and are probably mis-determined.

Of the three threatened flora species recorded for the 2012 Coomberdale Chert TEC survey area but not recorded in the proposed impact area (or north of Kiaka Road), two are very unlikely to occur. If *Eucalyptus pruiniramis* occurred there it would have been recorded, as it is a mallee eucalypt species and very obvious. *Synaphea quartzitica* is a small shrub, but is quite distinctive, and if present in any numbers it would have either been recorded by Trudgen *et al.* (2012), or by the targeted survey during 2016. In the 2012 survey area (Dalaroo East Road to 3.3 km north of Kiaka Road), *Synaphea quartzitica* has only been recorded in Cairn Hill Reserve. Both of these species have geographically restricted distributions as well as being very uncommon as shown in Figure 6.2.

Distribution of *Eucalyptus pruiniramis*. (Map from the site "Florabase").

Distribution of *Synaphea quartzitica.* (Map from the site "Florabase").

Distribution of *Goodenia arthrotricha.* (Map from the site "Florabase").

Figure 6.2 Restricted distributions of Eucalyptus pruiniramis, Synaphea quartzitica and Goodenia arthrotricha

Goodenia arthrotricha was possibly confused in the field with *Scaevola phlebopetala* at times during the Trudgen *et al.* (2012) survey and may be a little more common in the 2012 survey area than the records indicate. It was not recorded during field work in the proposed impact area in 2016. However, there is a possibility that it occurs there as seed. This is because of two factors, firstly it has been recorded just south of Kiaka Road and secondly it appears to be a pyrosere species and there has been no recent fire activity in the area north of Kiaka Road.

During field work in 2016, *Goodenia arthrotricha* was present in a vegetation quadrat on the Moora Mine Eastern Ridge (south of Kiaka Road). This quadrat was originally recorded in 2002 at which time *Goodenia arthrotricha* was not recorded. The dry years prior to 2016 had caused death of *Allocasuarina campestris*, opening the vegetation. In the gap in the (previously very dense) overstorey, several *Goodenia arthrotricha* had germinated and established (Trudgen M. E., 2017) as well as some seedlings of *Acacia aristulata*. Similar vegetation is present in the proposed impact area.

While records are available for the locations of *Acacia aristulata* and *Daviesia dielsii* have been recorded at from threatened searches and vegetation site data, there must be some uncertainty as to the populations of these species in the proposed impact area due to their long persistence as seeds and shorter persistence as shrubs.

The survey within the proposed impact area found *Acacia aristulata* which has significant conservation value and *Daviesia dielsii* which has minor value.

6.1.2 Priority flora

Fewer priority flora species have been recorded in the area surveyed north of Kiaka Road than south of it. This is partly due to the smaller size of the area north of Kiaka Road, but vegetation condition, grazing history and some difference in vegetation floristics are all relevant factors. Of the priority flora species recorded north of Kiaka Road, only three current priority flora species have been recorded in the proposed impact area, these are *Regelia megacephala, Diuris recurva* and *Stylidium* sp. Moora.

Unlike the other priority flora found in the Coomberdale Chert TEC, *Regelia megacephala* is a large shrub that dominates areas of the tall shrublands of the *Regelia megacephala* vegetation alliance. It is found in small to moderately large areas where it is locally abundant as the dominant in the stand. The size of these stands is an indication of the number of plants of this species in them.

Regelia megacephala is one of the defining species of the Coomberdale Chert TEC and is known to be restricted in habitat and distribution to the Coomberdale Chert. There are 77 records for *Regelia* *megacephala* in the Trudgen *et al.* (2012) survey area. The species is significantly geographically restricted, but usually dominant in the vegetation it occurs in. The distribution of this priority four species in the Trudgen *et al.* (2012) survey area is shown on Figure 5.1.

In contrast to *Regelia megacephala*, *Diuris recurva* is a small herb that is found as scattered individuals or small clusters of a few plants. It is a cryptophyte with a small basal rosette of leaves that when flowering also has a short stem with the flowers. *Diuris recurva* occurs sporadically in the Coomberdale Chert TEC. The distribution of this species has disjunctions that suggest it may have subspecies or varieties. Note, *Diuris recurva* was referred to *Diuris* aff. *recurva* in Trudgen *et al.* (2012), however the name *Diuris recurva* is now applied to material from the Moora area.

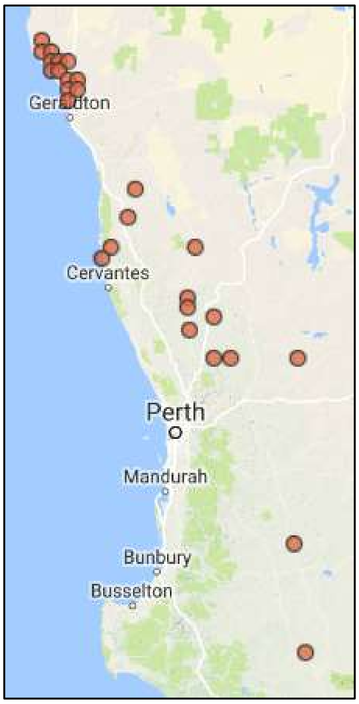


Figure 6.3 Distribution of Diuris recurva showing disjunct populations (Australasian Virtual Herbarium 3/2018)

The following priority species were not recorded during the survey, however may possibly be present seasonally (Table 6.1).

Table 6.1 Priority species not recorded but possibly present

Taxa	Cons Status	Comment
Goodenia arthrotricha	*T*	Recorded just south of Kiaka Road. A pyrosere species that possibly present as seed and germinate after fire or other disturbance. Possibility reduced by level of weed invasion.
Austrostipa nunaginensis (previously sp. Cairn Hill)	*P3*	The small size of this taxon and its similarity to other species when sterile may mean that it is present, but not recorded. However, the level of weed invasion in much of the proposed impact area reduces this possibly significantly. Recorded three times in the TEC south of Kiaka Road, but not restricted to it. The three records are one in Cairn Hill Nature Reserve and two in Moora Mine rehabilitation areas. The range of the species extends from near Geraldton to east of Perth, but there are only 11 eleven records on The Australasian Virtual Herbarium, indicating it is not a common species.
Tricoryne sp. Wongan Hills (previously *Tricoryne arenicola* MS)	*P2*	Recorded at three quadrats and three releves south of Kiaka Road in by Trudgen et al. (2012) in their survey area and appears to be uncommon there. However, as it was not known to be in the survey area prior to one of the earlier reports in this series (Trudgen et al. 2006), it was not searched for during the systematic rare flora surveys carried out at that time. It was not recorded during searches of the proposed North Kiaka Mine impact areas

Taxa	Cons Status	Comment
		carried out in 2016 although one occurrence was found north of Kiaka Road at that time.
Stylidium glabrifolium	*P2*	Recorded three times in the area of the Coomberdale Chert Threatened Ecological Community surveyed by Trudgen et al. (2012). Two were located on the Eastern Ridge, and the other in the remnant of native vegetation at the south end of the existing main mine (the Eastern Ore Body – note that some of this area has been mined since the collection was made). This species has not been recorded north of Kiaka Road.

The shrub priority species listed in Appendix B, except *Regelia megacephala*, can reasonably confidently be excluded from occurring in the proposed North Kiaka Mine area. None of them have been recorded north of Kiaka Road by Trudgen *et al* (2012) and they were not recorded in the proposed impact area during the 2016 threatened and priority flora searches.

The remaining three priority species are smaller and/or are available for collection less of the year. Therefore, there is a small possibility that the grass *Austrostipa* sp. Cairn Hill, the lily *Tricoryne* sp. Wongan Hills and the trigger-plant *Stylidium glabrifolium* are in the proposed impact area. However, if they were to be present the populations would be very small to have escaped notice given the intensity of botanical work carried out in that area.

6.1.3 Other flora of conservation interest

The Coomberdale Chert Threatened Ecological Community has a number of other flora species that are of particular conservation interest due to:

- Very small populations;
- Restricted distribution
- distribution suggesting potential undescribed subspecies; or
- The populations at extent of known ranges of the species.

Table 5.6 lists the species that occur in the Coomberdale Chert TEC and summarises the reason why they are of interest. As they are discussed individually in Appendix H, most will not be discussed in detail here, although brief comment will be made on the more significant species.

Xanthorrhoea sp. Coomberdale is a species restricted to the Coomberdale Chert Threatened Ecological Community except for a small occurrence near Moora where it occurs on sand over other siliceous rock. It is prominent in the Coomberdale Chert TEC, although its population is declining (see Section 5.1.3). The decline is likely to be due to climate change, grazing and weed invasion (the latter two factors reducing recruitment) but, other factors may be involved. There are 9 plants located within the impact area, with more than 250 observed in the TEC remnant vegetation during the 2012 survey. The population in the proposed impact area is of moderate size, but not disproportionate to other areas of the Coomberdale Chert TEC, so the conservation value of the population there is of note, but not significant in a regional context.

While the species *Banksia sphaerocarpa* var. aff. *caesia* needs further taxonomic study to define its status, it is at least a range extension of an unusual form of variety *caesia*. It is likely that the population on the Coomberdale Chert is part of a geographically restricted and uncommon taxon. The overall population seems likely to be quite small and the taxon needs additional surveys to define its population and probably needs special management. The value of the Coomberdale Chert TEC population, particularly the population on the Gardiner property is significant. Of less significance is the population recorded in the proposed impact area (six plants) and about 65 plants in the Gardiner property population.

Calytrix sp. Coomberdale (M.E. Trudgen MET 21184) is prominent in some vegetation types in the Coomberdale Chert TEC, to which it is largely restricted (it appears to have the same distribution as *Xanthorrhoea* sp. Coomberdale). The population does not seem to be declining significantly at present, but most plants observed during surveys were quite old (the species seems to be fairly long lived) and young plants were rarely seen during field work. The population in the proposed impact area is quite large and the species is more common there than in some many other parts of the Coomberdale Chert TEC. Consequently, the proposed North Kiaka Mine area has significant value for this species, although the population there is not a large part of the overall population.

6.2 Vegetation

6.2.1 Vegetation type

The vegetation alliances defined for the Trudgen *et al* (2012) survey area of the Coomberdale Chert TEC vary in the areas remaining. This partly reflects varying original extent, but is certainly affected by differential clearing for agriculture of different habitat types. As is common in much of the Western Australian Wheatbelt, areas not cleared are those largely not suitable for broad scale agriculture. Areas of the Coomberdale Chert TEC which still remain are those with chert at or near the surface making them unsuitable for agriculture. This has meant that communities on the lower slopes of the chert ridges tend to have been cleared and communities on the upper slopes and crests have remained uncleared. There is also substrate variation (such as fragmentation of the chert, depth of topsoil) that affects the areas of individual vegetation alliances and their constituent vegetation associations and plant communities.

The remnants of the Coomberdale Chert TEC reflect this clearing history. The alliances found in the proposed impact area are described by Trudgen *et al.* (2012). There is some variation, the most significant of which is that the '*Kunzea praestans* high shrubland to open and closed scrub vegetation' alliance has 31.5% of its known area in the proposed impact area. This is in the context that the 41.86 hectares of remnant vegetation of the TEC in the proposed impact area is 5.74% of the 728.81 hectares of remnants of the Coomberdale Chert TEC mapped by Trudgen *et al.* (2012).

The vegetation alliances dominated by *Calothamnus quadrifidus* subsp. *angustifolius* (Chert form) and *Melaleuca calyptroides* both have limited extent with overall areas of 0.89 hectares and 3.37 hectares respectively in the areas mapped by Trudgen *et al.* (2012).

The areas of these vegetation alliances in the proposed impact area are 0.12 hectares (13.5%) and 0.49 hectares (14.5%) respectively. The areas of these two vegetation alliances in the proposed impact area are roughly three times higher proportionally than their extent in the TEC overall. The two species these two vegetation alliances are named for are also present as the dominant (or co-dominant) of shrub layers in other vegetation types and as associated species in yet others.

6.2.2 Vegetation condition

There have been changes in the condition of some parts of the Coomberdale Chert TEC since the mapping was carried out. Trudgen (2017) noted when surveying to assess weed levels, increases in weed cover and changes in weed floristics have been recorded at some quadrats. However, there was no indication during the 2016 rare flora searches that such changes affected the validity of the condition mapping of the Coomberdale Chert TEC to the extent that the mapping needed revision. Rather, a small decrease in condition can be assumed for areas with more open vegetation, while areas with denser vegetation won't show changes in weed invasion levels. In the longer term however, weed invasion and grazing are likely to continue to reduce the condition of areas of the TEC, particularly in areas that are not fenced off from stock and at the edge of remnants.

The condition of different stands of vegetation in the Coomberdale Chert TEC varies significantly. This is largely because of grazing intensity of stock, rabbits and kangaroos, as well as weed encroachment. The vegetation of the area surveyed by Trudgen (2012) is shown in Figure 5.8 and ranges from *Completely Degraded* (cleared farmland) to *Very Good* condition. The better condition areas north of Kiaka Road are mainly in the southern part of the main central ridge system. The proposed impact area mainly avoids the better condition areas.

It is not clear how much some areas, especially on the property of A. & R. Tonkin (western portion of the area north of Kiaka Rd) have been affected by grazing, as they appeared (at the time of the condition mapping in 2012 and earlier) to be in good or better condition but have lower species numbers than other areas. It is likely that some of these areas naturally have lower species numbers and that the recording of quadrats on A. & R. Tonkin's during the 2010 drought accentuated this somewhat. Vegetation condition was generally better in the vegetation on rockier sites, steeper sites and where *Regelia megacephala* or *Allocasuarina campestris* was denser.

Table 6.2 Vegetation condition for native vegetation recorded (as mapped by Trudgen 2012)

Vegetation condition rating	Total area in Trudgen et al. 2012 survey area (ha.)	Impact area (subset of 2012 survey area)
Excellent	22.52	0
Very Good to Excellent	45.60	0
Very Good	137.68	2.63
Good – Very Good	146.13	1.15
Good	106.4	7.285
Poor – Good	63.63	3.86
Poor	56.97	4.29
Very Poor – Poor	71.08	7.41
Very Poor	68.08	12.07
Degraded – Very Poor	35.41	5.27
Degraded	94.13	1.53
Total native vegetation	**641.83**	**42.86**

6.2.3 Coomberdale Chert TEC

DBCA have calculated the known extent of the Coomberdale Chert TEC to cover an area of 785 ha (Threatened Ecological Community Fact Sheet: Vegetation alliances on ridges and slopes of the chert hills of the Coomberdale floristic region (DBCA, 2013)).The area of TEC which was surveyed by Trudgen *et al.* (2012) and subsequently totalled 728.85 ha.

Some of the area included in the TEC area (north of Coomberdale, in the Jingemia area). These areas have somewhat different floristics to the areas of the TEC surveyed by Trudgen *et al* as shown in their floristic analysis.

While it may seem unnecessary to discuss rarity in relation to a threatened ecological community such as the Coomberdale Chert TEC, it needs to be remembered that this is a composite unit that contains multiple vegetation alliances and within them vegetation associations and within these plant communities that have varying areas and numbers of occurrences and hence varying rarity.

The classification of the vegetation of the Coomberdale Chert as a critically endangered ecological community means that it has been accepted by Government as:

- A vegetation of restricted distribution that has a level of difference from other native vegetation and therefore is of conservation significance; and
- Vegetation which is subject to processes such as grazing, clearing, weed invasion and climate change that endanger its ongoing existence.

The fact that the Coomberdale Chert TEC is restricted in area means that all parts of it have high conservation value. The threatening processes noted above combined with the restricted area of occurrence are the rationale for giving this vegetation the status of endangered.

The high conservation value for vegetation of the Coomberdale Chert TEC does not mean that at a detailed level there are not differences in the conservation value of the different plant communities, or even of different stands of the same plant community, found in the TEC. This TEC has a very significant range of vegetation alliances, vegetation associations and plant communities that vary greatly in number of occurrences and size.

While some of the vegetation types found in the TEC are dominated by species that themselves have restricted occurrence, others are dominated by species that are more common but have different floristic composition to stands outside the TEC with the same species dominant. This difference in composition often includes species that are of restricted distribution. Such differences in composition mean that some stands will have somewhat higher conservation value than others, but the difference will not be great as all are part of an endangered ecological community.

The implication of floristic analysis conducted in Trudgen *et al.* 2012 is that the proposed impact area includes vegetation that is part of the Critically Endangered Coomberdale Chert TEC, but of floristic types only found north of Kiaka Road. Of importance here is that the floristic variation in the TEC vegetation north of Kiaka Road is not currently represented in the conservation estate.

The proposed impact area has conservation value for the area of the three levels of vegetation units found there which are not found in abundance elsewhere in the 2012 survey area. Currently the most significant threats in this area are grazing and climate change.

7. Conclusion

The flora and vegetation surveys and reporting for North Kiaka were undertaken over many years, beginning in 2012. The surveys have included the detailed survey (2012) and targeted surveys completed in 2016 and 2017. The dominant vegetation community is the Coomberdale Chert Threatened Ecological Community (TEC) The Coomberdale Chert is a distinctive vegetation type that is found on low rocky hills between Moora and Watheroo.

This vegetation type is the predominant vegetation type both with the North Kiaka DE and the broader regional extent. The North Kiaka DE consists of remnant vegetation on parts of parallel low chert ridges. The remnants surveyed as part of this survey effort are located on three ridges that trend from the north-north-west to the south-south-east. The southern end of the 1.4-kilometre-long area surveyed is 500 metres north of Kiaka Road and 2.2 kilometres east of the Midlands Road. The ridges are separated by narrow strips of cleared farmland and are part of a larger group of ridges located north of Kiaka Road.

Agriculture is the predominant landuse in the Proposal area, with most of the landscape cleared for broadacre agriculture. The landscape is very stable with no other land or industry development or activities occurring in the area other than farming and SIMCOA's mine operations. There are no records of bushfires having occurred in the areas of remnant vegetation and flora populations are stable and long established.

The vegetation was classified into three levels. The lowest order units are defined near the plant community level with similar structure, dominance and floristics. The plant communities were grouped into 104 vegetation associations that have similar structure and dominant species and then into 31 vegetation alliances as a third level of classification. It is floristically different from other vegetation in the region and has differences between the areas north and south of Kiaka Road and between these areas and areas of the TEC further north. This floristic difference is partly driven by species such as *Regelia megacephala*, *Xanthorrhoea* sp. Coomberdale, *Acacia aristulata* and *Calytrix* sp. Coomberdale which are restricted to or mostly restricted to the TEC. The TEC has a significant sized list of flora that includes populations of threatened flora (including *Acacia aristulata* and *Daviesia dielsii*), priority flora (including *Regelia megacephala* and *Bossiaea moylei*) as well as species that range from not very common to quite common.

Vegetation condition ranges from Completely Degraded (cleared farmland) to Very Good condition. The better condition areas north of Kiaka Road are mainly in the southern part of the main central ridge system.

The surveys reported 102 species of native flowering plants, one native pine (*Actinostrobus arenariu*s) and five species of native ferns. This is a significant subset of the 315 native flowering plants recorded for the area of the Coomberdale Chert TEC (2012) and the 192 native flowering plant species recorded north of Kiaka Road within that area. The survey area also reports 332 native flora species and 56 weeds.

Five threatened flora species occur in the survey area. Two of these were found north of Kiaka Rd and in the proposed impact area (Acacia aristulata and Daviesia dielsii). Thirteen priority flora species have been recorded in the survey area with three recorded north of Kiaka Road and in the proposed impact area (Regelia megacephala, Diuris recurva and Stylidium sp. Moora.).

A post survey likelihood of occurrence assessment for all significant flora species identified in the desktop. Of the 69 species listed as potentially occurring within this table, five are listed as possibly occurring, 17 are known to occur and the remaining are listed are unlikely or highly unlikely.

The significance of the vegetation and flora found in the Trudgen (2012) survey and transects (2016) compared to the remaining TEC is:

- **Flora** – The proposed impact area will affect the populations of all the flora species present in a region (the Avon Botanical District) where flora populations have been significantly reduced by clearing for agriculture;

- **Significant Flora** – The area has significant value for one threatened species *(Acacia aristulata),* moderate value for three priority species (*Regelia megacephala*, *Diuris recurva* and *Stylidium* sp. Moora) and minor value for one other threatened species (*Daviesia dielsii)*.
- **Vegetation type** – The area north of Kiaka Road is different floristically compared to south of Kiaka Road. This increases the significance of the loss of areas of the TEC, as there is limited area north of Kiaka Road and there is no representation in the conservation estate in this area.
- **Vegetation Condition** – Most of the vegetation on the TEC remnants within the impact area is in Poor to Degraded condition. This somewhat reduces the significance of that change in flora and vegetation condition on conservation values.
- **Coomberdale Chert TEC** – The impact area contains vegetation representing less than 2.5% of the 2012 TEC area surveyed.

This Report has been prepared to meet the Technical Guidance: Flora and Vegetation Surveys for Environmental Impact Assessment, 2016. This Report notes that the surveys were completed in 2012, 2016 and 2017 and while the currency of the data extend beyond five years, the findings can be confidently assessed for the following reasons:

- The experience of the Botanist. Malcolm Trudgen has been acknowledged by DBCA as a technical authority in the assessment in Coomberdale Chert vegetation community
- The survey extent and longitudinal data set
- The landscape is stable in terms of land and activity
- There have been no catastrophic events in the area that have impacted vegetation condition and flora populations within the 50 years, ie bushfire or cyclones.

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Appendices

Appendix A

Conservation codes and definitions

Threatened and Priority Flora Categories

Definition of CALM Threatened and Priority Flora categories (from Atkins 1998).

Threatened Flora – Extant Taxa

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

Threatened Flora – Presumed Extinct Flora

Taxa which have not been collected, or otherwise verified, over the past 50 years despite thorough searching, or of which all known wild populations have been destroyed more recently, and have been gazetted as such.

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, e.g. road verges, urban areas, farmland, active mineral leases, etc., or the plants are under threat, e.g. from disease, grazing by feral animals, etc. May include taxa with threatened populations on protected lands. Such taxa are under consideration for declaration as ‘rare flora’, but are in urgent need of further survey.

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 (ie. Not currently endangered). Such taxa are under consideration for declaration as “rare flora”, but are in urgent need of further survey.

Priority Three – Poorly Known Taxa.

Taxa which are known from several populations, and the taxa are not believed to 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 are in need of further study.

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.

Appendix B

Flora List (updated 2024)

Higher group or plant family	NAME [See distribution column for highlight coding]	Weed *	North Kiaka Mine and haul road	North of Kiaka Road	John Tonkin Property JT (12)	A & R Tonkin property ART (11)	Distribution, conservation status, comments Green highlight indicates a new record for the TEC. Light blue highlight indicates a conservation taxon light orange highlight indicates a taxon needing assessment for priority or rare flora status. Wsd = widespread. Grey highlight indicates inadequate material.	Cairn Hill Reserve CAH (20)	Cairn Hill North CHN (10)	Current mine [= E Ore Body] EOR (3)	Eastern Ridge ERG (23)	Gardiner's Hill GH (10)	Waste Dump Area WDM (3)	Western Ridge WOR (6)	Other areas surveyed
FERNS															
Adiantaceae	Cheilanthes adiantoides		Obs/16	Recorded	11q, 15r	4q	Wsd in WA W of Ravensthorpe, N of Perth to Shark B & some outlying records.	17q, 37r	9q, 21r	3q	23q, 40r	8q, 21r	3q, 1r	6q, 1r	32r
Adiantaceae	Cheilanthes austrotenuifolia		1q	Recorded		5q, 1o	Wsd in SW WA, some outlying records, disjunct to SA, NSW, Vict. & Tas.								
Adiantaceae	Cheilanthes distans			Recorded	1q	3q, 3r	Wsd in SW, Eastern States & NZ!	1q		1q					
Aspleniaceae	Pleurosorus rutifolius			Recorded	1q		Wsd in Aust. S of tropics			1q	2q	1q			
Ophioglossaceae	Ophioglossum lusitanicum		Coll/16	Recorded	o		Wsd in Aust. mainly S of tropics with some disjunctions. Also in NZ.								
PINES															
Cupressaceae	Callitris arenaria		Obs/16 (dead)	Recorded	1q		Small population (six plants) on the Chert at quadrat JT010. One dead tree seen nearby. Griffin record from North Cairn Hill not refound during surveys. Population apparently in decline.								
ANGIOSPERMS Monocotyledons															
Poaceae	Aira elegantissima	*		Recorded	5q			10q			5q	1q			
Poaceae	Amphipogon caricinus var. caricinus						Wsd in Aust. S of tropics.	5q, 2r	1r		4q	1q, 3r		2q	
Poaceae	Aristida contorta						Occurs over most of Aust.	1q						1q	
Poaceae	Aristida holathera var?						Occurs over much of Aust. The species needs revision (there are undescribed varieties).						1q		
Poaceae	Austrostipa compressa						Coastal from Geraldton area to Perth, then scattered in far SW. TEC record small inland range extension.		8q						
Poaceae	Austrostipa elegantissima		Obs/16	Recorded	2q	1q, 1r,	Wsd in SW WA & nearby Eremaean, also SA, NSW & Vict.	8q, 5r	2q	1q	8q	6q, 5r	2q	2q	2r
Poaceae	Austrostipa eremophila						Wsd in southern Aust.	1r							
Poaceae	Austrostipa exilis						Sporadic in SW WA, also in SA, Vict.	2r							
Poaceae	Austrostipa hemipogon			Recorded	1q	1q	Wsd in SW WA, also SA, Vict, 1 record Tas.				1q	2q	1q	3q	
Poaceae	Austrostipa macalpinei						Common in a band from N of Geraldton to Perth, disjunct to S coast & disjunct to SA & Vict.					2q			
Poaceae	Austrostipa mollis						Wsd in SW WA, disjunct to SE Aust. & Tas.				1r				1r
Poaceae	Austrostipa nitida			Recorded	5q		Wsd in southern Aust.	2q			4q, 3r	2q			3r
Poaceae	Austrostipa scabra			Recorded	1q		Wsd in southern Aust. & Tas.	3q				4q			1r
Poaceae	Austrostipa sp.			Recorded	1q, 2r			1q	1q		1q				
Poaceae	Austrostipa nunaginensis						Priority 3 species. Sporadic from Geraldton area to Perth & E of Perth. (formerly Austrostipa sp. Cairn Hill (M.E. Trudgen 21176))	1q							
Poaceae	Austrostipa tenuifolia						Wsd in SW WA & nearby Eremaean, also near coastal SA & 2 records in Vict.			1q	1q		1q		
Poaceae	Austrostipa trichophylla		3q	Recorded	1q	8q, 1r	Wsd in SW WA & nearby Eremaean, also NT, SA, NSW & Vict., 1 record in Q.	8q	5q	1q	12q	3q, 2r	2q	5q	
Poaceae	Austrostipa variabilis			Recorded	3q, 2r		Wsd in SW WA & nearby Eremaean, few records in SA, NSW.	4q		1q	3q	6q		1q	
Poaceae	Avellina micheli	*		Recorded	3q			1q			2q				
Poaceae	Avena barbata	*	3q	Recorded	11q, 20r	9q, 7r		8q	5q	3q	23q, 17r	9q, 10r	2q	6q	67r
Poaceae	Brachypodium distachyon	*	1q	Recorded		3q									
Poaceae	Briza maxima	*	1q	Recorded	12q, 6r	7q		10q	8q	3q	23q, 8r	8q, 35r	3q	6q	17r
Poaceae	Bromus diandrus	*		Recorded	9q, 2r	5q, 1o		3q	2q	3q	12q, 5r	4q, 1r	1q	5q	9r
Poaceae	Bromus madritensis	*		Recorded											
Poaceae	Cynosurus echinatus	*	1r	Recorded	f	1q, 1r									
Poaceae	Ehrharta brevifolia var. cuspidata	*	1q	Recorded		1q									
Poaceae	Ehrharta calycina	*													2r
Poaceae	Ehrharta longiflora	*	2q	Recorded	9q, 5r	10q, 3r		12q	6q	3q	19q,6r	7q, 5r	1q	6q	1q,25r
Poaceae	Eriachne ovata						Wsd in WA W of Esperance, disjunct to SA, NT & Q.	1q							
Poaceae	Hordeum leporinum	*	2q	Recorded		1q									
Poaceae	Lamarckia aurea	*	1q	Recorded		1q									

Higher group or plant family	NAME [See distribution column for highlight coding]	Weed *	North Kiaka Mine and haul road	North of Kiaka Road	John Tonkin Property JT (12)	A & R Tonkin property ART (11)	Distribution, conservation status, comments Green highlight indicates a new record for the TEC. Light blue highlight indicates a conservation taxon light orange highlight indicates a taxon needing assessment for priority or rare flora status. Wsd = widespread. Grey highlight indicates inadequate material.	Cairn Hill Reserve CAH (20)	Cairn Hill North CHN (10)	Current mine [= E Ore Body] EOR (3)	Eastern Ridge ERG (23)	Gardiner's Hill GH (10)	Waste Dump Area WDM (3)	Western Ridge WOR (6)	Other areas surveyed
Poaceae	Lolium perenne	*		Recorded	1q	2q		1q				1q			1r
Poaceae	Neurachne alopecuroidea		2q	Recorded	12q, 10r	7q, 4r	Wsd in SW WA disjunct to SA & Vict.	16q, 55r	10q, 34r	2q, 1r	20q, 38r	10q, 33r	3q, 2r	6q, 1r	1q, 21r
Poaceae	Pentameris airoides subsp. airoides	*	2q	Recorded		8q, 1r	Formerly Pentaschistis airoides	3q	7q	3q	15q		3q	5q	2r
Poaceae	Pentameris pallida	*		Recorded	7q, 6r		Formerly Pentaschistis pallida	1q			3q	7q, 6r		1q	11r
Poaceae	Pentameris sp.	*				2q					1q	1q			
Poaceae	Polypogon monspeliensis	*	1r			1r									
Poaceae	Rytidosperma acerosum		1q	Recorded	3q	2q	Wsd in SW WA. But not common..	4q,2r			2q, 4r	4q, 1r	2q	4q	1r
Poaceae	Rytidosperma caespitosum			Recorded		1q, 1o	Wsd in SW WA, continuous to SA, Vict, NSW & Tas. Also NZ.	5q	1q		8q, 7r	3q, 3r		1q	4r
Poaceae	Rytidosperma setaceum			Recorded	2q, 1r		Wsd in S Aust. TEC population somewhat isolated..	7q, 3r	7q	3q	10q, 4r	3q, 1r	1q	4q	2r
Poaceae	Rytidosperma sp.			Recorded	1q	1r,		1q				2q			7r
Poaceae	Schismus barbatus	*	1q	Recorded		1q 1o									
Poaceae	Vulpia myuros	*	3q	Recorded	11q, 7r	11q, 3r		17q, 1r	8q	2q	5q	9q, 3r	3q	5q	
Cyperaceae	Gahnia drummondii						Moderate distribution in SW W.A.								1r
Cyperaceae	Lepidosperma aff. leptostachyum (Moora: ERG18-7)			Recorded	1q		Probably a restricted species. The genus is in need of detailed revision.	5q	1q		4q	5q		1q	
Cyperaceae	Lepidosperma costale						Wsd in SW WA W of Ravensthorpe.	4q, 1r			2q	1q, 2r			
Cyperaceae	Lepidosperma leptostachyum						Wsd in SW WA S of Gingin. The Moora area records are disjunct from the main population. The TEC records are on unusual habitat. Three other records from surrounding areas are on different soils, or are very old collections with poor localisation. Genus needs revision.	4q, 14r	4r	2q	13q, 3r	2q, 1r	1q	4q	5r
Cyperaceae	Lepidosperma pubisquameum			Recorded		1o	Moderately Wsd in SW WA S of Lancelin. The TEC records are part of a disjunct population that extends to near Coorow (3 records on The AVH).		1r		1q	1r			
Cyperaceae	Lepidosperma sp.			Recorded	2r			1q	1q, 1r		1q	1r	1q		
Cyperaceae	Lepidosperma sp. P1 small head (M.D. Tindale 166A)						Moderately Wsd in SW WA south of Cervantes, 6 records N of there.	2r							
Cyperaceae	Lepidosperma tenue			Recorded	3r	1q, 1r	Wsd in SW WA.	8q, 10r	1q, 4r		5q, 35r	8r	1r	2q, 1r	7r
Cyperaceae	Schoenus brevisetis						Wsd in SW WA.	1q, 4r	1q						
Cyperaceae	Schoenus clandestinus		Obs/16	Recorded	5q, 8r	1o	Wsd from Mandurah to S of Shark B.	4q, 13r	1q, 9r		3q, 7r	28r	2q, 1r	1q, 1r	
Cyperaceae	Schoenus nanus						Wsd in SW WA, disjunct to SA & Vict.	1r	1q						
Cyperaceae	Schoenus pleiostemoneus						Moderately Wsd in SW WA.	1q						1q	
Restionaceae	Desmocladus asper		2q	Recorded	11q, 24r	8q, 2r, 1o	Wsd in SW WA W of Ravensthorpe. (TEC material referred to D. flexuosus in earlier reports)	14q, 39r	7q, 15r	1q, 1r	5q, 10r	9q, 19r	2q, 1r	4q, 1r	17r
Restionaceae	Lepidobolus chaetocephalus		Obs/16	Recorded	2r		Moderately Wsd in SW WA.	4q, 8r	1q, 1r			4r	1q		
Centrolepidaceae	Centrolepis drummondiana						Wsd in SW WA mainly near the coast. TEC population shortly disjunct.	2q	1q						
Centrolepidaceae	Centrolepis pilosa						Wsd in SW WA W of Bremer Bay. TEC population shortly disjunct.	1q		1q			1q		
Centrolepidaceae	Centrolepis sp.								1q						
Dasypogonaceae	Lomandra sp. (Moora twisty)			Recorded	2q	2q	May be the same as *Lomandra micrantha.*	1q			4q	1q			
Dasypogonaceae	Lomandra aff. micrantha subsp. micrantha			Recorded		1q	Wsd in SW W.A. also in eastern states.	3q			3q	1q	1q		
Dasypogonaceae	Lomandra effusa			Recorded			Wsd in SW & SE Aust.	1q, 5r	1q			3q, 5r			1r
Dasypogonaceae	Lomandra sp.							1q							1r
Xanthorrhoeaceae	Xanthorrhoea sp. Coomberdale		2q	Recorded	10q, 15r	7q, 4r	Geographically restricted. Population declining significantly. Referred to X. drummondii in earlier reports.	16q, 39r	9q, 22r	2q, 1r	10q, 27r	8q, 20r	3q	6q, 1r	1q
Phormiaceae	Dianella revoluta var. divaricata			Recorded		1o	Wsd in southern WA and in SA.	6q, 2r	3q, 1r		2r	3q, 2r	2q	3q	
Phormiaceae	Stypandra glauca		Coll/16	Recorded	4q, 2r	5q, 2r	Common in SW WA, NSW and Vict, few records in SA.	12q, 39r	5q, 15r	3q	17q, 19r	3q, 5r	2q, 1r	5q	
Anthericaceae	Agrostocrinum scabrum aff. subsp. scabrum			Recorded		1q	Agrostocrinum scabrum subsp. scabrum has clusters of occurrence in the SW of WA that suggests variation. Needs review. TEC material atypical.	1q				2q			

Higher group or plant family	NAME [See distribution column for highlight coding]	Weed *	North Kiaka Mine and haul road	North of Kiaka Road	John Tonkin Property JT (12)	A & R Tonkin property ART (11)	Distribution, conservation status, comments Green highlight indicates a new record for the TEC. Light blue highlight indicates a conservation taxon light orange highlight indicates a taxon needing assessment for priority or rare flora status. Wsd = widespread. Grey highlight indicates inadequate material.	Cairn Hill Reserve CAH (20)	Cairn Hill North CHN (10)	Current mine [= E Ore Body] EOR (3)	Eastern Ridge ERG (23)	Gardiner's Hill GH (10)	Waste Dump Area WDM (3)	Western Ridge WOR (6)	Other areas surveyed
Anthericaceae	Dichopogon preissii			Recorded	5q		Called *Caesia* sp. Moora & *Caesia* (Moora hairy stem) in Trudgen *et al.* (2012). Common in proposed mine area.	4q	1q		1q			1q	
Anthericaceae	Caesia sp. Wongan (K.F. Kenneally 8820)			Recorded	1q		This species (complex?) has disjunct southern and norther populations, the TEC population is a small range extension for the southern population. It is also disjunct. Called *Caesia alfordii* [MS] in earlier reports.	1q, 1r			5q	2q			
Anthericaceae	Chamaescilla versicolor		Obs/16	Recorded	11q, 4r		Patchy distribution from Geraldton area to east of Perth. Specimens referred to *C. corymbosa* in earlier reports.	15q, 13r	9q, 10r	1q, 1r	22q, 15r	10q, 4r	3q	6q	7r
Anthericaceae	Dichopogon capillipes			Recorded	9q, 2r	7q, 1r	Has a moderate distribution in the west of SW W.A. with some disjunctions.	17q, 42r	7q, 16r	3q	22q, 28r	10q, 10r	3q, 1r	6q	1q,22r
Anthericaceae	Laxmannia omnifertilis						On NE edge of range.	1q							
Anthericaceae	Laxmannia ramosa subsp. ramosa		Coll/16	Recorded	2q	1q	Small disjunction within range.								
Anthericaceae	Sowerbaea laxiflora						Wsd in SW W.A., but with disjunctions, the TEC population is at the N end of the main area. Needs revision.		1q		5q, 1r	5q			
Anthericaceae	Thysanotus dichotomus			Recorded		1o	Wsd in SW W.A, but with disjunctions. TEC population part of a small disjunct group of records. Needs revision.	1q			2q, 3r	1q, 1r			1o
Anthericaceae	Thysanotus manglesianus			Recorded	11q	3q, 1r	Wsd, common in W.A. west of Kalgoorlie and south of Pilbara.	18q, 5r	9q, 9r	3q	20q, 2r	8q, 1r	3q	4q	
Anthericaceae	Thysanotus multiflorus			Recorded	1q		Disjunct population, needs taxonomic study.	1q							
Anthericaceae	Thysanotus patersonii						Wsd, common in SW W.A. disjunct to eastern states.				1q				
Anthericaceae	Thysanotus sp.							1q			1q				
Anthericaceae	Tricoryne sp. Wongan Hills (B.H. Smith 794)			Recorded			Priority 2 species [Referred to Tricoryne arenicola (MS) previously.] Sporadic, moderate distribution in SW W.A.	1q	1q, 3r				1q		
Anthericaceae	Tricoryne elatior			Recorded		2o	Wsd in SW WA, E Aust., also CA Kimb., & northern NT. Needs revision.		3q, 2r		3q, 2r	1q			
Colchicaceae	Burchardia bairdiae [Probably B. congesta.]						Determination unlikely on habitat grounds. One collection from the Eastern Ridge [specimen not refound in 2016].				1q				
Colchicaceae	Burchardia congesta		Obs/16	Recorded	7q, 1r	2q	TEC population at the edge of the main population, small disjunction, unusual habitat.	15q, 21r	9q, 8r	3q, 1r	18q, 16r	8q, 6r	1q	6q	3r
Colchicaceae	Wurmbea drummondii		Coll/16	Recorded	2q		Previously P4, moderately Wsd in SW WA.								
Boryaceae	Borya laciniata			Recorded		3q, 1o	Genus needs review.	1q	1q						
Boryaceae	Borya sphaerocephala		Obs/16	Recorded	7q, 1r	1r,	Genus needs review.	10q, 29r	5q, 15r	1r	7q, 19r	76q, 35r	3q, 1r	1q	15r
Haemodoraceae	Conostylis androstemma						TEC population has short disjunction from main population.	1q							
Haemodoraceae	Haemodorum paniculatum		Obs/16	Recorded	1q		Sporadic from Green Head to forests E of Bunbury, one record near Geraldton. TEC population outlying.	2q	1q				1q		
Haemodoraceae	Haemodorum simulans			Recorded	2q	1o	Occurs in a band from S of Shark B to N of Albany.	4q	2q				1q	1q	1r
Hypoxidaceae	Pauridia aff. occidentalis var. occidentalis		Obs/16	Recorded	5q		Genus needs review in W.A. Appears to be undescribed, but the taxonomy of the group needs significant work.	5q	5q	1q	20q	9q	4q	1q	1q
Dioscoreaceae	Dioscorea hastifolia		1q	Recorded	4q, 3r	9q, 4r	Occurs in a band parallel to the coast from Shark B to south of Perth.	15q 19r	7q, 5r	3q	23q, 24r	7q, 4r	2q	6q	1q, 8r
Iridaceae	Moraea setifolia	*	1q	Recorded		1q, 1o									
Iridaceae	Orthrosanthus laxus var. gramineus						Occurs in a band from S of Geraldton to S of Perth. Species needs review.	1r,1q				4q, 2r		2q	
Iridaceae	Romulea rosea	*		Recorded	1q				1q	2q	7q		3q	2q	
Orchidaceae	Caladenia denticulata subsp. denticulata			Recorded	6q		Moderately Wsd, but records sporadic.			1q	9q		2q	1q	
Orchidaceae	Caladenia flava subsp. flava		Obs/16	Recorded	9q	3q	Wsd in SW W.A. Common in the Coomberdale Chert TEC.	9q	9q	3q	17q	9q	1q	4q	
Orchidaceae	Caladenia paradoxa						Moderately Wsd, outlying record.	1q					1q		
Orchidaceae	Caladenia sp.						These records are of sterile specimens (leaves).		3r						
Orchidaceae	Caladenia vulgata			Recorded		1q	Very Wsd in SW W.A.				1q	1q			
Orchidaceae	Cyanicula gemmata		Coll/16	Recorded	4q		Very Wsd in SW W.A.		1q		1q				
Orchidaceae	Cyrtostylis huegelii						Moderately Wsd in SW W.A. but sporadic occurrence north of Perth.	1q		1q	1q				
Orchidaceae	Diuris brumalis		Coll/16	Recorded	o		Moderate distribution from the Eneabba area to east of Bunbury.								
Orchidaceae	Diuris recurva		Coll/16	Recorded	3q		A priority 4 species. Moderate distribution, but of disjunct small areas and a few outlying records. Called *Diuris* aff. *recurva* in earlier reports.	5q	6q		6q	5q	1q	1q	
Orchidaceae	Diuris tinkeri		Coll/16	Recorded	o		Fairly small distribution from north of Kalbarri to north of Perth. TEC records a small range extension to the east.								

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Orchidaceae	Elythranthera brunonis			Recorded	1q		Moderately Wsd in SW W.A.		1q					2q	
Orchidaceae	Eriochilus dilatatus subsp. undulatus		Obs/16	Recorded			Wsd in SW W.A. One plant seen in North Kiaka Mine area.	1q		1q	2q		3q	1q	
Orchidaceae	Eriochilus helonomos			Recorded			Moderate distribution in SW W.A. but not common north of Perth. Small range extension.	7q	4q		1q	4q			
Orchidaceae	Leporella fimbriata						Fairly Wsd in SW W.A.	1q	1q			2q	1q		
Orchidaceae	Paracaleana hortiorum			Recorded	1q		Specimen not refound. Would be a long range extension. Not recorded during 2016 field work. On geography possibly *P. nigrita*.								
Orchidaceae	Pheladenia deformis			Recorded	10q		Very Wsd in SW W.A. with a large disjunction to the eastern states.	3q	9q	3q	17q	8q	3q	1q	
Orchidaceae	Prasophyllum gracile						Very Wsd in SW W.A. extending into adjacent Eremaean.				1q	1q			
Orchidaceae	Pterostylis aff. nana								2q		1q				
Orchidaceae	Pterostylis exserta			Recorded	1q		Small range extension.	1q				1q			
Orchidaceae	Pterostylis recurva			Recorded	1q			6q	2q	1q				1q	
Orchidaceae	Pterostylis sanguinea		Coll/16	Recorded	4q			12q		2q	9q	8q	2q	1q	
Orchidaceae	Pterostylis sargentii						Small range extension.					1q			
Orchidaceae	Pterostylis scabra							3q		1q	1q				
Orchidaceae	Pterostylis setulosa		Coll/16	Recorded	2q			5q	8q	3q	7q	1q	2q		
Orchidaceae	Pterostylis sp.			Recorded	2q		These records are of sterile specimens (leaves).	1q, 2r	1q		1q				
Orchidaceae	Pterostylis spathulata			Recorded		1o		1q							
Orchidaceae	Pterostylis vittata								1q					2q	
ANGIOSPERMS Dicotyledons															
Casuarinaceae	Allocasuarina campestris		2q	Recorded	8q, 18r	3q, 6r	Wsd.	15q, 62r	9q, 33r	2q, 1r	17q, 40r	1q, 22r	3q, 1r	4q, 1r	40r
Casuarinaceae	Allocasuarina huegeliana		1q	Recorded	8q, 25r	6q, 6r	Wsd.	10q, 51r	7q, 29r	3q, 1r	19q, 48r	9q, 26r	2q, 1r	3q, 1r	59r
Casuarinaceae	Allocasuarina humilis			Recorded		2q	Wsd.	1q, 5r							
Casuarinaceae	Allocasuarina microstachya						Wsd.					1r			
Casuarinaceae	Casuarina obesa		1r	Recorded		3r	Wsd.								3r
Urticaceae	Parietaria debilis						Wsd.	2q							
Proteaceae	Banksia prionotes														2r
Proteaceae	Banksia sphaerocarpa var. aff. caesia		1r, Coll/16	Recorded		1r, 1o	The material needs expert determination, it may represent a new taxon, a range extension of var. caesia (but atypical) or atypical var. sphaerocarpa. The species has five varieties and needs revision.								1r
Proteaceae	Banksia fraseri var. fraseri		Obs/16	Recorded	1q	1o	Wsd	1q, 5r				1q, 3r			1o
Proteaceae	Banksia nivea subsp. nivea						Wsd in SW W.A.								1r
Proteaceae	Banksia sessilis var. flabellifolia		1q, 1r	Recorded	6q, 19r	2q, 1r	Wsd [A complex?]	5q, 17r	3q, 14r	1r	4q, 2r	6q, 9r	1q	5q, 1r	33r
Proteaceae	Grevillea amplexans subsp. semivestita						Priority 2 taxon.								2r
Proteaceae	Grevillea biternata						Wsd				1q				1o
Proteaceae	Hakea incrassata						Wsd	4q, 6r							
Proteaceae	Hakea lissocarpha		Coll/16	Recorded			Wsd.	5r	1r		4r	3r			1r
Proteaceae	Hakea preissii			Recorded		1r	Wsd.								
Proteaceae	Hakea recurva subsp. recurva			Recorded		1o	Wsd.		1r			7r			1r, 1o
Proteaceae	Isopogon divergens			Recorded	1r		Wsd	7q, 7r	1q			2q, 3r			1o
Proteaceae	Petrophile brevifolia						Material atypical. The distribution of this Wsd suggests more than 1 taxon..								1r
Proteaceae	Synaphea quartzitica						Threatened (Declared rare) flora. Very restricted. Known for TEC, but not in the North Kiaka Mine area.								
Santalaceae	Leptomeria preissiana						Wsd. Distribution suggests variation	1r							
Santalaceae	Santalum acuminatum			Recorded		4o	Extremely Wsd	1q, 2r	1r						1o
Santalaceae	Santalum spicatum			Recorded		1o	Very Wsd				1q				

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Loranthaceae	Amyema miraculosa subsp. miraculosa			Recorded		1r, 1o	Wsd				1q				
Loranthaceae	Amyema preissii		2q	Recorded		2q, 1r, 1o	Extremely Wsd				2q, 1o				1o
Loranthaceae	Lysiana casuarinae						Wsd				1q				
Loranthaceae	Nuytsia floribunda		1q, 1r	Recorded	1q, 1r	2q, 1r	Wsd	5r	2q			2r		1q	6r
Polygonaceae	Emex australis	*	1q	Recorded		1q									
Polygonaceae	Muehlenbeckia adpressa			Recorded	1q		Very Wsd			1q	1q				
Chenopodiaceae	Atriplex suberecta		1q	Recorded		1q, 1r	Very scattered records in WA, but very Wsd					1r			
Chenopodiaceae	Dysphania melanocarpa forma melanocarpa		1q	Recorded		1q	Very Wsd. The record is a small range extension.								
Chenopodiaceae	Enchylaena tomentosa var. tomentosa		1q	Recorded		2q	Extremely Wsd, on the SW edge of distribution.	1r							
Chenopodiaceae	Maireana brevifolia			Recorded		1r	Wsd in WA, disjunct to ES					1r			
Chenopodiaceae	Maireana enchylaenoides						Moderate distribution in WA; disjunct to ES Small range extension.					2r			
Chenopodiaceae	Maireana marginata		1q	Recorded		1q	Moderate to large distribution in WA	2q				2r			
Chenopodiaceae	Rhagodia drummondii						Large distribution in WA South of Shark Bay, just into SA.	3q, 1r							
Chenopodiaceae	Rhagodia preissii subsp. preissii			Recorded			Wsd WA & SA [Recorded on JT property 2017.]	2q, 1r	1q						
Chenopodiaceae	Salsola australis	*?		Recorded	o	o	At edge of remnant. Probably weedy.								
Amaranthaceae	Ptilotus declinatus			Recorded		1o	Moderate distribution in WA	2r							
Amaranthaceae	Ptilotus divaricatus						Large distribution in WA	2q, 1r	2r			2r			1o
Amaranthaceae	Ptilotus drummondii var. drummondii			Recorded		1q, 2o	Large distribution in WA	2r	1r			1r			
Amaranthaceae	Ptilotus gaudichaudii			Recorded		1q	Wsd across Australia, except tropics and southern ES.				1q				
Amaranthaceae	Ptilotus holosericeus						Moderate to large distribution in WA.		1q						
Amaranthaceae	Ptilotus manglesii						Moderate to large distribution in WA.	1r							
Amaranthaceae	Ptilotus polystachyus		1r	Recorded	1q	1q, 1r	Extremely Wsd, all mainland states.	1r			1q, 2r			1q	
Amaranthaceae	Ptilotus spathulatus		1q	Recorded		1q, 1r	Moderate to large distribution in WA.		1q			1q			
Nyctaginaceae	Boerhavia coccinea			Recorded		1o	Extremely Wsd, all mainland states. A complex.								
Gyrostemonaceae	Gyrostemon ramulosus						Very Wsd, WA, SA, NT & Q.								1o
Portulacaceae	Calandrinia calyptrata		1q	Recorded	3q	5q, 1o	Wsd, WA to NSW, but disjunct in WA.	4q			5q	5q			
Portulacaceae	Calandrinia eremaea			Recorded	1q		Extremely Wsd, all mainland states & Tasmania.	1q	1q						
Portulacaceae	Calandrinia remota			Recorded		1q	Fairly large distribution in WA, disjunction to NT & SA, another to Q.		1q						
Portulacaceae	Calandrinia sp.						Inadequate material, mostly seedlings.	5q, 1r	4q	1q	8q	2q, 3r	1q	1q	1r
Portulacaceae	Calandrinia baccata			Recorded	1q		Moderate distribution in WA, scattered records.								
Caryophyllaceae	Petrorhagia dubia	*	1q	Recorded	8q	3q, 1r,			1q		10q	1q	1q	1q	
Caryophyllaceae	Petrorhagia velutina	*		Recorded		6q									
Caryophyllaceae	Polycarpon tetraphyllum	*	1q	Recorded		1q									
Caryophyllaceae	Silene gallica var. gallica	*	1q	Recorded	9q	5q			3q		5q	4q		1q	1q
Caryophyllaceae	Spergula arvensis	*												1q	
Lauraceae	Cassytha pomiformis			Recorded		1o		3q	1q			1q, 1r			
Brassicaceae	Brassica barrelieri subsp. oxyrrhina	*		Recorded	1q						1q				
Brassicaceae	Lepidium rotundum						Wsd in southern WA, extends to SA.	1r							
Droseraceae	Drosera aff. macrantha			Recorded	6q	4q	Fairly Wsd?	13q	5q	2q	3q	6q	2q	6q	
Droseraceae	Drosera sp. Branched styles (S.C. Coffey 193)			Recorded	6q	1q	Very widespread.	8q	4q		1q	6q	2q		
Droseraceae	Drosera hirsuta			Recorded	7q		Large distribution in SW WA, disjunct to SA & Vict.	10q	4q	1q	20q	9q	2q	2q	1q
Droseraceae	Drosera macrophylla		Obs/16	Recorded	6q	1q		8q	4q		1q	6q	2q		
Droseraceae	Drosera pallida						Moderate to large near coastal distribution Geraldton area to E of Albany.	1q	5q	1q	3q				

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Crassulaceae	Crassula colorata (ssp. indet.)			Recorded	2r	1q		1r							6r
Crassulaceae	Crassula colorata var. acuminata		1q	Recorded		3q, 1r	Extremely Wsd, all mainland states.								
Crassulaceae	Crassula colorata var. colorata			Recorded	11q	2q	Very Wsd, WA, SA, NT, NSW.	7q, 4r	4q	3q	9q	5q, 3r		1q	2r
Crassulaceae	Crassula decumbens var. decumbens			Recorded	1q		Very Wsd, WA, SA, NSW, Tas.	1q							
Crassulaceae	Crassula exserta			Recorded	5q	3q	Quite Wsd, WA, SA, Vict.	3q	3q	1q	7q	2q	2q	2q	
Pittosporaceae	Billardiera heterophylla						Wsd in southern WA, also in SA, Vict, NSW & Tas. Range extension in TEC. Formerly in Sollya.	2r				1q, 1r			1o
Surianaceae	Stylobasium australe						Common from south of Shark B to east of Perth.	3r							1o
Mimosaceae	Acacia acuminata		2r	Recorded	10q, 20r	6q, 5r, 3o	Wsd in SW WA.	5q, 33r	3q, 31r		20q, 40r	7q, 22r	1q	2q	72r
Mimosaceae	Acacia aestivalis						Moderate range in SW WA.		1q						
Mimosaceae	Acacia aristulata		DRS/06	Recorded	5q, 3r	1o	Threatened (Declared Rare) Flora. Very limited range from just N of Moora to NW of Watheroo.	9q, 9r	4q	2q	6q, 3r	4q, 2r	1q	5q	
Mimosaceae	Acacia congesta subsp. congesta			Recorded	1q	1o	Patchy distribution between Geraldton and E of Perth. Species distribution suggests needs review	5q, 10r	1q, 1r	3q, 1r	5q, 8r		1q	2q	1r
Mimosaceae	Acacia daphnifolia										1o				
Mimosaceae	Acacia ericksoniae						Patchy distribution between Geraldton and E of Perth.					1r			
Mimosaceae	Acacia erinacea			Recorded		1r,	Wsd in SW WA.	2q, 2r	1q, 1r			1r			2o
Mimosaceae	Acacia hemiteles			Recorded	2q		Wsd in SW WA.								1o
Mimosaceae	Acacia lasiocarpa var. aff. sedifolia						There are two forms of Acacia lasiocarpa var. sedifolia in the collections for the survey area, both have been determined as this by B. Maslin, the authority for the group. The records for this form are mixed with the records for var. sedifolia.								
Mimosaceae	Acacia lasiocarpa var. sedifolia						Wsd in SW WA.	1q	1q, 1r	1q, 1r	2q, 2r	1q, 1r	1q	2q	1r
Mimosaceae	Acacia ligustrina		1q	Recorded		1q, 1r	Moderate distribution from SW of Geraldton to E of Perth.	1q							
Mimosaceae	Acacia microbotrya			Recorded		1o	Wsd in SW WA.	1q, 2r			1o	1r			1r
Mimosaceae	Acacia pulchella var. glaberrima						Wsd in SW WA. Needs review.								1r
Mimosaceae	Acacia pulchella var. goadbyi						Wsd in SW WA. Needs review.	1q, 1r							
Mimosaceae	Acacia restiacea		Obs/16	Recorded	2q, 3r	1o	Wsd in SW WA north of Perth. Needs review.	3r					1q		1r
Mimosaceae	Acacia saligna (ssp?)						Very Wsd in SW WA & in ES. P	1r							
Mimosaceae	Acacia scirpifolia						Common from Geraldton area to E of Perth.	1r							1o
Mimosaceae	Acacia stenoptera						Common from Geraldton area to Albany.			2q	1q			5q	
Papilionaceae	Bossiaea moylei						Very restricted, only known from the Coomberdale Chert TEC.	6q, 13r	4q, 2r		2q			6q	1r
Papilionaceae	Cristonia stenophylla			Recorded	3q		Disjunct, possibly a restricted form, needs investigation.								
Papilionaceae	Daviesia benthamii						Moderately Wsd, needs review.	1q							
Papilionaceae	Daviesia dielsii			Recorded	2q, 1r	1o	Threatened (Declared Rare). Quite restricted	7q, 6r	1q	1r	1q	3r	1q		5r
Papilionaceae	Daviesia hakeoides subsp. subnuda			Recorded	1q		Wsd in a band from Kalbarri to Albany.	1r							1o
Papilionaceae	Gastrolobium acutum			Recorded	2q, 1r		The Coomberdale Chert TEC population is disjunct from the main population, not large and likely to be a variety or subspecies.	6q, 1r	1q	1q [Since mined]		3q, 1r	1q		1r
Papilionaceae	Gastrolobium obovatum						Fairly Wsd in SW WA.					4r			
Papilionaceae	Gompholobium glutinosum						Moderately localised with two populations.	2r							1o
Papilionaceae	Isotropis drummondii						Wsd in SW WA.								1o
Papilionaceae	Jacksonia floribunda						Common between Geraldton & SE of Perth.								1r
Papilionaceae	Jacksonia foliosa						Modest range, Mingenew to Goomalling.								1r
Papilionaceae	Kennedia prostrata			Recorded		1q	Wsd in SW WA & SE Australia.			1q	7q	1q			2r
Papilionaceae	Lupinus angustifolius	*		Recorded					3q		2q				
Papilionaceae	Templetonia smithiana						Small range extension, Gairdner's Property.					1r			

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Papilionaceae	Trifolium arvense var. arvense	*		Recorded	1q	2q			2q	2q	3q		3q	3q	
Papilionaceae	Trifolium campestre var. campestre	*		Recorded		1q									
Papilionaceae	Trifolium hirtum	*		Recorded	8q	1q			1q		1q	1q			
Papilionaceae	Trifolium repens var. repens	*								1q	6q			1q	
Papilionaceae	Trifolium subterraneum	*		Recorded	2q				2q		11q			1q	1q
Geraniaceae	Erodium botrys	*	2q, 1r	Recorded	5q	4q, 1r					5q	3q			3r
Geraniaceae	Erodium cygnorum		Obs/16	Recorded	1q		Very Wsd, all mainland states.	4q	2q	1q	4q	1q		1q	1q
Geraniaceae	Pelargonium littorale						Wsd in a band // to the coast from Cervantes to Cape Arid, then disjunct to ES. TEC population disjunct.				1o				
Oxalidaceae	Oxalis corniculata	*						1q	1q			1q			
Linaceae	Linum trigynum	*		Recorded		1q					4q	1q			1r
Rutaceae	Cyanothamnus coerulescens subsp. spinescens						Wsd in SW WA.		2r		2q				1o
Rutaceae	Cyanothamnus ramosa subsp. anethifolius						Wsd in SW WA.	1q	3q					3q	
Polygalaceae	Comesperma integerrimum			Recorded	3q	1q, 1o	Wsd in SW WA, also SA & NSW.	7q, 1q	1q, 1r	2q	8q	3q	3q	6q	1r
Euphorbiaceae	Beyeria lechenaultii		Coll/16				Fairly common SW WA, also SA, Vict, NSW & Tas. Near NW range end.								1o
Euphorbiaceae	Euphorbia drummondii subsp. drummondii			Recorded	1q	1q	Wsd WA.								
Euphorbiaceae	Phyllanthus calycinus			Recorded			Wsd SW WA, also in SA.				4r				1o
Euphorbiaceae	Poranthera microphylla			Recorded	1q		Very Wsd in Aust., except Eremaean	1q			2q				
Euphorbiaceae	Ricinocarpos muricatus		1r	Recorded		1q, 5r, 1o	Moderate distribution. Small range extension.								
Euphorbiaceae	Ricinocarpos velutinus						Only recorded at vegetation releve RM2								1r
Stackhousiaceae	Stackhousia monogyna			Recorded	3q		Wsd in SW WA & in ES.	2q				3q, 1r			
Stackhousiaceae	Tripterococcus brunonis			Recorded	1q		Wsd in SW WA.	5q	4q		1q	3q		2q	
Sapindaceae	Diplopeltis huegelii subsp. lehmannii		1q,1r	Recorded	4q, 1r	4q, 1r, 1o	TEC record isolated from other records. Moderate distribution. Species needs review.								
Sapindaceae	Dodonaea inaequifolia			Recorded		1o	Wsd SW WA No f Perth.	4q, 19r							1o
Sapindaceae	Dodonaea pinifolia						Wsd SW WA.	1q,7r	1r			2r			
Rhamnaceae	Cryptandra myriantha						Wsd SW WA. [Vouchers redetermined as C. myriantha]	3q, 1r			1q		1q	2q	
Rhamnaceae	Stenanthemum tridentatum						Moderate distribution in SW WA.					1q, 5r			
Rhamnaceae	Trymalium daphnifolium						Moderate distribution in SW WA.	2q	1q, 1r						
Rhamnaceae	Trymalium ledifolium var. rosmarinifolium			Recorded	2r	1q, 1r, 1o	Wsd from Hill River to E of Albany.	3q, 6r			4q, 4r	3q, 6r			
Malvaceae	Alyogyne hakeifolia			Recorded		1o	Wsd in SW WA & SA, rare Vict.		1o						1o
Malvaceae	Alyogyne sp. Hutt River (B.J.Lepschi & T.R.Lally 2310							1r							
Sterculiaceae	Guichenotia micrantha						Wsd in SW WA.		1q		1o				
Sterculiaceae	Guichenotia sarotes						Wsd in SW WA.				1q				
Sterculiaceae	Guichenotia tuberculata						Priority 3 species. Known from Morawa to inland from Lancelin, sporadic.								1o
Sterculiaceae	Thomasia grandiflora						Fairly Wsd in SW WA. TEC population disjunct.	2q, 3r		1q	1r			2q	
Dilleniaceae	Hibbertia acerosa						Wsd in SW WA.	1q							
Dilleniaceae	Hibbertia subvaginata		1q, 2r	Recorded	8q, 18r	6q, 6r	Fairly Wsd in SW WA. TEC population disjunct.	14q, 33r	8q, 13r	3q, 1r	19q, 6r	7q, 8r	2q, 1r	6q	24r
Thymelaeaceae	Pimelea imbricata var. piligera						Wsd in SW WA.	1q, 1r	3q						
Myrtaceae	Babingtonia cherticola						Priority 3. Restricted habitat and restricted to a small area inland from Jurien Bay & Cervantes.	8q, 28r	5q, 12r						

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Myrtaceae	Calothamnus quadrifidus subsp. angustifolia (Chert form)		Obs/16	Recorded	3q, 4r	1o	Included in Calothamnus quadrifidus ssp. angustifolius in a recent treatment, but a distinct taxon associated with chert from Moora to Watheroo.	8q, 23r	1q		1r	4q, 7r			3r
Myrtaceae	Calothamnus sanguineus			Recorded	1q	1o	Wsd in SW WA.	3q, 6r	2q			2q, 2r			
Myrtaceae	Calytrix depressa		Obs/16	Recorded			Wsd in SW WA.	2r	1q, 2r		1q	3r			
Myrtaceae	Calytrix sp. Coomberdale (M.E. Trudgen 21184)		1q, 2r	Recorded	10q, 15r	2q, 2r,	A geographically restricted species that is common in the Coomberdale Chert TEC, favouring more open areas. Old plants in more weedy areas. May regenerate mostly after fire.	14q, 34r	9q, 22r	1q, 1r	7q, 22r	9q, 23r	2q, 1r	4q	17r
Myrtaceae	Calytrix strigosa						Common from Shark B to SE of Perth.								1r
Myrtaceae	Eremaea beaufortioides var. lachnosanthe						Restricted to an area between Geraldton and Cervantes. TEC record is disjunct.								1r
Myrtaceae	Eremaea sp. Cairn Hill (B. Morgan BMor 351)						Priority 1 species. Very restricted distribution.								1o
Myrtaceae	Ericomyrtus serpyllifolia						A complex. Widespread in SW WA. One record from a very degraded area near Cairn Hill.								
Myrtaceae	Ericomyrtus tenuior						Moderately Wsd in SW WA, north of Perth.	5r			2r	2r			3r
Myrtaceae	Eucalyptus camaldulensis (forma)						The “forma” common from the Kalbarri area to E of Lancelin. The species extremely widespread.	1o							1r
Myrtaceae	Eucalyptus eudesmioides						Common from the Shark B area to E of Lancelin.	3q, 16r							3r
Myrtaceae	Eucalyptus horistes						Wsd in SW WA & nearby Eremaean.	1r	1r,2o						1r
Myrtaceae	Eucalyptus loxophleba subsp. loxophleba		1q	Recorded	1r	1q, 2r,	Common in a broad band from S of Shark B to near Albany.	6r	1q, 12r	1q	7q, 16r	1q, 8r	1q		21r
Myrtaceae	Eucalyptus obtusiflora						Common in a broad band from Carnarvon to E of Perth.	1q, 1r	1r						1o
Myrtaceae	Eucalyptus pruiniramis						Threatened (Declared Rare). Restricted to a few localities between Three Springs & Mogumber.								1r, 4o
Myrtaceae	Eucalyptus salmonophloia			Recorded		1o	Wsd in SW WA S of Geraldton.	1r				3r			1r
Myrtaceae	Eucalyptus wandoo subsp. pulverea			Recorded		1q, 1r	Wsd in the western part of the SW of WA.	5q, 12r			2q, 3r	2q, 3r			3r
Myrtaceae	Hypocalymma angustifolium						Common in the western half of the SW of WA. A complex.					4r			
Myrtaceae	Kunzea praestans		1q, 2r	Recorded	11q, 21r	4q, 3r	Limited distribution that suggests not one taxon. Needs review.	13q, 42r	8q, 16r	1r	7q, 15r	5q, 10r	1q, 1r	6q	25r
Myrtaceae	Leptospermum aff. erubescens (Moora Chert; B. Morgan 133)						Recorded for the TEC, but not in the North Kiaka Mine area. Very limited distribution. Specimen vouchered but taxon not on FloraBase.					1o			1o
Myrtaceae	Leptospermum erubescens						See: Leptospermum aff. erubescens (Moora Chert; B. Morgan 133)								3r. 1o
Myrtaceae	Melaleuca leuropoma		1q, 2r	Recorded	9q, 8r	2q, 3r,	Wsd in about half of the SW of WA. Distribution suggests needs review.	10q, 31r	5q			5q, 7r	1q		5r
Myrtaceae	Melaleuca concreta		1q	Recorded		1q	Common in a band from Shark B to near Perth.	1r	1q, 1r			1r			1o
Myrtaceae	Melaleuca coronicarpa						Common in a band from Shark B to Esperance. Needs review.					1r			1r
Myrtaceae	Melaleuca lateriflora						Wsd in SW of WA.		1o						
Myrtaceae	Melaleuca radula		Coll/16	Recorded		1o	Common in the N half of the SW, scattered otherwise.	6q, 16r	1q, 7r		1r	1q, 11r			1r
Myrtaceae	Melaleuca sclerophylla						Priority 3 species. Restricted to an area from Three Springs to E of Lancelin.					3r			
Myrtaceae	Melaleuca sp.			Recorded	1q										
Myrtaceae	Regelia megacephala		1r	Recorded	1q	2q, 5r	Priority 4 species. Very restricted range N of Moora.	9q, 26r	5q, 5r	3q	2q, 1r	3q, 1r	1q	4q	
Myrtaceae	Tetrapora preissiana						A complex, Wsd in W.A.								1r
Myrtaceae	Verticordia chrysanthella						Wsd in SW WA.	1q							
Myrtaceae	Verticordia densiflora var. densiflora						Wsd in SW WA.	1r				1r			1o
Myrtaceae	Verticordia huegelii var. stylosa						Fairly Wsd S of Moora, uncommon N of Moora.	1r							
Myrtaceae	Verticordia pennigera						Wsd from Kalbarri area to south of Perth and E of Albany.								1o
Haloragaceae	Glischrocaryon flavescens						Wsd in southern WA, also in SA.	1r				1q			1o
Haloragaceae	Gonocarpus nodulosus		Coll/16	Recorded	1q		Wsd in WA S of Carnarvon & E of Cape Arid.		1q		1q				
Apiaceae	Apium annuum			Recorded	1q		WA S of Shark B in a band then along coast to SA, Vic & Tas.	3q		2q	2q				
Apiaceae	Daucus glochidiatus			Recorded		3q	Wsd in Australia south of tropics.	2q			7q	3q		1q	

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Apiaceae	Homalosciadium homalocarpum			Recorded	1q		Common in a broad band from S of Shark B to near Albany and to cost.								
Apiaceae	Platysace cirrosa			Recorded	2q		From near Geraldton to E of Perth in a widening band, not common.	10q	6q	1q	14q	2q	1q	1q	
Apiaceae	Trachymene cyanopetala		1q	Recorded	9q	5q	Wsd in WA S of Shark B & E of Cape Arid, also in SA, Vict & NSW.	5q, 14r	7q, 5r		10q, 1r	5q, 1r	2q	2q	
Apiaceae	Trachymene ornata			Recorded	7q, 1r	6q	Wsd in WA S of Carnarvon & E of Cape Arid, also in SA, Vict & NSW.	14q, 6r	6q, 2r	3q	19q, 1r		3q	4q	1q
Apiaceae	Trachymene pilosa		Obs/16	Recorded	5q, 1r		Wsd in SW WA, also in SA, Vict & NSW	12q, 21r	1q, 7r		7q, 4r	7q, 6r		3q	
Apiaceae	Trachymene sp.							2q			1q	1q			
Apiaceae	Xanthosia fruticulosa						Sporadic from Green Head to S of Perth, uncommon.	14q, 33r	7q, 7r						
Epacridaceae	Styphelia serratifolia			Recorded	2q, 1r		Wsd in a broad band from Geraldton to Albany & Esperance.	4q, 8r	1r			3q, 2r	1q		
Epacridaceae	Styphelia retrorsa						Restricted distribution. TEC record an outlying record, but not greatly.								
Primulaceae	Lysimachia arvensis	*		Recorded		1q		5q	4q	3q	4q	5q	1q	3q	
Loganiaceae	Phyllangium sulcatum			Recorded	4q		Wsd in SW WA, disjunct to SA, Vict, NSW.	2q	3q		13q	2q			
Gentianaceae	Centaurium tenuiflorum	*												1q	
Asclepiadaceae	Rhyncharrhena linearis						Found over much of Australia.					1q			
Convolvulaceae	Convolvulus angustissimus subsp. angustissimus			Recorded		1q	Uncommon in SW WA, but common in ES. Needs review.								
Chloanthaceae	Quoya dilatata		1r	Recorded	5q, 2r	2q, 1r	Uncommon in a band from Three Springs to Wannamal, with 4 outlying records (2 in ES Herbaria need checking). Needs review.	6q, 4r	4q, 1r	1q, 1r	9q, 7r	3r	1q	5q	
Lamiaceae	Hemiandra incana						Sporadic distribution from E of Cervantes to E of Margaret River. Needs review.	1q							1o
Lamiaceae	Hemigenia conferta						Priority 4 species. Restricted to a very small area in the TEC (Cairn Hill NR and nearby).								
Solanaceae	Lycium australe						Wsd in S WA, SA, also in Vict & NSW.		1o						
Solanaceae	Solanum nigrum	*	1q	Recorded		1q						1q			
Solanaceae	Solanum oldfieldii			Recorded		1o	Common in a broad band from Shark B to N of Albany, some coastal records.				1q, 2r				
Scrophulariaceae	Dischisma capitatum	*									1o				
Scrophulariaceae	Parentucellia latifolia	*		Recorded	6q	2q		3q	4q	1q	17q	4q	3q	4q	1r
Scrophulariaceae	Zaluzianskya divaricata	*									1q				
Orobanchaceae	Orobanche minor	*												1q	
Myoporaceae	Eremophila lehmanniana						Occurs in an irregular broad band from S of Geraldton to N of Albany, some coast records. Needs review.	1q							
Plantaginaceae	Plantago debilis						Wsd in S WA, disjunct to CA & ES.	2q	1q				1q		
Rubiaceae	Galium murale	*		Recorded	1q						2q	1q			1q
Rubiaceae	Opercularia vaginata		1q	Recorded	6q, 2r	1q	Wsd in SW WA. A complex?	5q, 7r	6q, 1r		4q, 1r	5q, 14r		2q	7r
Campanulaceae	Wahlenbergia capensis	*		Recorded	1q			1q			1q				
Campanulaceae	Wahlenbergia gracilenta		Obs/16	Recorded	1q	1r	Wsd in the W of WA S of Carnarvon. Disjunct to SA, Vict, NSW, Tas.	6q		1q	1q			1q	
Lobeliaceae	Isotoma hypocrateriformis						Wsd in SW WA.	1q							
Lobeliaceae	Lobelia cleistogamoides						Sporadic in SW WA and nearby	3q			1q	3q			
Goodeniaceae	Brunonia australis						Wsd over Australia, a complex.				4q				1r
Goodeniaceae	Dampiera lavandulacea						Wsd in SW WA & nearby, uncommon in SA.	2q, 3r	1q			1q, 3r			
Goodeniaceae	Goodenia arthrotricha						Threatened (Declared Rare) Flora. Geographically restricted. Probably a pyrosere species.	1q	1q		1q	3q, 2r			1r
Goodeniaceae	Goodenia berardiana		Coll/16	Recorded	2q	1q	Common W WA, disjunct to NT, SA, NSW, Q.	4q	5q, 1r		13q, 3r	3q	1q	1q	
Goodeniaceae	Goodenia glareicola						Wsd in a broad band from Geraldton to Cape Arid. Needs review.	1r							
Goodeniaceae	Goodenia hassallii						Moderate occurrence from Kalbarri to Wannamal & Wongan Hills. Needs review.	1q, 1r	1q, 3r			1q, 3r			
Goodeniaceae	Goodenia sp.											2q	1q		
Goodeniaceae	Lechenaultia biloba						Wsd in SW WA.	2q				1q			
Goodeniaceae	Scaevola anchusifolia						Coastal from Carnarvon to Albany, with some inland records. Needs review.		1q						
Goodeniaceae	Scaevola glandulifera						Occurs in a broad band // to the coast from Geraldton to E of Albany.	1q			1r				

Higher group or plant family	NAME [See distribution column for highlight coding]	Weed *	North Kiaka Mine and haul road	North of Kiaka Road	John Tonkin Property JT (12)	A & R Tonkin property ART (11)	Distribution, conservation status, comments Green highlight indicates a new record for the TEC. Light blue highlight indicates a conservation taxon light orange highlight indicates a taxon needing assessment for priority or rare flora status. Wsd = widespread. Grey highlight indicates inadequate material.	Cairn Hill Reserve CAH (20)	Cairn Hill North CHN (10)	Current mine [= E Ore Body] EOR (3)	Eastern Ridge ERG (23)	Gardiner's Hill GH (10)	Waste Dump Area WDM (3)	Western Ridge WOR (6)	Other areas surveyed
Goodeniaceae	Scaevola phlebopetala			Recorded	1q		Occurs in a broad band // to the coast from Geraldton to Perth.	3q	4q					1q	
Goodeniaceae	Velleia cycnopotamica						Wsd in SW WA and nearby, disjunct to SA.	1r			1q				
Stylidiaceae	Levenhookia stipitata			Recorded	1q		Wsd in SW WA and nearby, disjunct to SA.	2q	1q						
Stylidiaceae	Stylidium calcaratum		Coll/16	Recorded			Wsd in SW WA and nearby, disjunct to SA.	1q	1q				1q		
Stylidiaceae	Stylidium caricifolium			Recorded	3q		Wsd in a widening belt from Geraldton to N of Stirling Range.	1q, 1r				2q		3q	
Stylidiaceae	Stylidium glabrifolium						Priority 2 species. Specimen sterile.			1q	2q				
Stylidiaceae	Stylidium miniatum						Moderate distribution from S of Geraldton to N & NE of Perth.	2q				1q			
Stylidiaceae	Stylidium repens			Recorded	6q	1r	Wsd in SW WA					3q			
Stylidiaceae	Stylidium sp. Moora (J.A. Wege 713)		Coll/16	Recorded	9q, 1r	2q	Priority 2. Sporadic from N or Geraldton to NE of Perth, needs review.	13q, 28r	9q, 7r		1q, 2r	6r		1q	
Asteraceae	Actinobole uliginosum					1o	Wsd in the southern 2/3 of Australia. A complex?								
Asteraceae	Arctotheca calendula	*	2q	Recorded	11q	6q		6q	8q	1q	15q	3q	3q+	1q	
Asteraceae	Blennospora drummondii			Recorded	1q. 1r		Wsd in SW WA, disjunct to SA & Vict.	7q, 11r	9q, 2r	2q	8q, 2r	2q, 4r		1q	
Asteraceae	Brachyscome perpusilla		1q	Recorded		1q	Wsd in SW WA, disjunct to SA, NSW & Vict.		1q						
Asteraceae	Calotis hispidula						Wsd over Aust. S of the tropics.		1q		1q				
Asteraceae	Cotula turbinata	*	1q	Recorded		1q									
Asteraceae	Erymophyllum tenellum						Wsd in SW WA & a few Eremaean records.		1r						
Asteraceae	Gilberta tenuifolia			Recorded	1q, 1r	1q, 1o	Wsd in SW WA & nearby Eremaean.	2q	1q, 5r		9q, 20r	4q, 3r	3q		13r
Asteraceae	Hedypnois rhagadioloides	*									3q	1q			
Asteraceae	Hyalosperma cotula			Recorded	1q	1o	Wsd Geraldton to Albany // to the coast, scattered records in NSW & Vict.		2q		2q	9q, 2r	2q	1q	4r
Asteraceae	Hyalosperma demissum			Recorded	1o										
Asteraceae	Hyalosperma glutinosum subsp. glutinosum			Recorded	1q		Wsd in SW WA, disjunct to SA, NSW & Q.		1r		1q				2r
Asteraceae	Hypochaeris glabra	*	2q	Recorded	12q, 13r	10q, 1r		17q	9q	3q	22q, 2r	7q, 4r	3q	4q	1q,10r
Asteraceae	Hypochaeris radicata	*						3q							
Asteraceae	Isoetopsis graminifolia			Recorded	Coll/16										1o
Asteraceae	Lagenophora huegelii						Wsd in W SW WA, disjunct to SA, NSW & Tas.	1q				3q			
Asteraceae	Lawrencella rosea			Recorded		1r	Wsd in SW WA, adjacent Eremaean.	8q, 19r	8q, 10r		9q, 5r	1q, 4r		1q	1r
Asteraceae	Millotia aff. tenuifolia (Moora: CH20-11)							1q							
Asteraceae	Millotia myosotidifolia			Recorded	2q	2q	Wsd in SW WA, disjunct to SA, NSW & Vict.					1q			
Asteraceae	Millotia tenuifolia var. tenuifolia			Recorded	2q, 1r	1q, 1r	Wsd in SW WA, disjunct to SA, Tas. & Vict.	4q, 5r		1q	4q	1q		1q	2r
Asteraceae	Olearia sp. Eremicola (Diels & Pritzel s.n. PERTH 00449628)			Recorded	1q, 1r	1o	Wsd in SW WA.				9q, 9r	6q, 11r			4r
Asteraceae	Podolepis canescens			Recorded	1q	1q, 1r, 2o	Wsd in Aust. S of tropics.	3q, 5r	2q		2q	5q, 20r			
Asteraceae	Podolepis capillaris			Recorded	o		Wsd in Aust. S of tropics, except far ES.								
Asteraceae	Podolepis gracilis						Wsd from Geraldton to Albany in a band // to the coast, scattered records to E.							1q	
Asteraceae	Podolepis lessonii			Recorded	10q, 14r	2q, 1r	Wsd in WA S of Carnarvon & E of Cape Arid, one SA record.	5q, 9r	8q, 11r		19q, 31r	8q, 15r	3q, 2r	6q	1q
Asteraceae	Podotheca aff. gnaphalioides (Moora WDM1-65)						Not uncommon, fairly Wsd (not restricted to TEC).						3q		
Asteraceae	Podotheca angustifolia		Coll/16	Recorded	4q, 3r		Wsd in SW WA, disjunct to SA, NSW & Vict, 1 record from Tas.	3q, 6r	6q, 3r		11q, 1r	7q, 5r	3q	1q	
Asteraceae	Podotheca gnaphalioides			Recorded	2q	1q	Wsd in WA S of Carnarvon & W of Ravensthorpe								
Asteraceae	Pterochaeta paniculata						Wsd in SW WA.	1q							
Asteraceae	Quinetia urvillei			Recorded	Coll/16		Wsd in SW WA, disjunct to SA, & Vict.		2q		4q				
Asteraceae	Rhodanthe laevis			Recorded	4q		Wsd in SW WA, disjunct to SA, NSW & Vict & 2 records each in Q & NT.				3q		1q		
Asteraceae	Rhodanthe manglesii			Recorded	1q		Wsd in SW WA, also in adjacent Eremaean.		1q						

Higher group or plant family	NAME [See distribution column for highlight coding]	Weed *	North Kiaka Mine and haul road	North of Kiaka Road	John Tonkin Property JT (12)	A & R Tonkin property ART (11)	Distribution, conservation status, comments Green highlight indicates a new record for the TEC. Light blue highlight indicates a conservation taxon light orange highlight indicates a taxon needing assessment for priority or rare flora status. Wsd = widespread. Grey highlight indicates inadequate material.	Cairn Hill Reserve CAH (20)	Cairn Hill North CHN (10)	Current mine [= E Ore Body] EOR (3)	Eastern Ridge ERG (23)	Gardiner's Hill GH (10)	Waste Dump Area WDM (3)	Western Ridge WOR (6)	Other areas surveyed
Asteraceae	Rhodanthe polycephala			Recorded		2q	Wsd in a band from Shark B to N of Albany, with a few records to the E.	5q, 3r	1q, 3r		1r	1r			
Asteraceae	Rhodanthe pygmaea			Recorded			Wsd in S WA & SA, Wsd in Vict & NSW		1q						
Asteraceae	Schoenia cassiniana			Recorded	1q	4q	Wsd in WA, S NT & SA.	3q			3q	3q		1q	
Asteraceae	Senecio glossanthus		1q	Recorded		1q	Wsd in Aust. S of Tropics.								
Asteraceae	Siloxerus humifusus						Wsd in a band parallel to coast from S of Geraldton to Cape Arid area.				1q				
Asteraceae	Sonchus asper	*		Recorded		1q									
Asteraceae	Sonchus oleraceus	*		Recorded	1q, 1r			1		1q	2q	1q	2q		
Asteraceae	Trichocline [Amblysperma] sp. Moora (GH7-57)						Specimen sterile. If Trichocline undescribed. Needs recollection.					1q			
Asteraceae	Monoculus monstrosus	*		Recorded	8q	1q		5q	2q	2q	7q	2q	1q	1q	1q
Asteraceae	Urospermum picroides	*	1q	Recorded	3q	8q, 1r		2q		2q	5q	4q		2q	1q
Asteraceae	Ursinia anthemoides subsp. anthemoides	*	1q, 1r	Recorded	12q, 2r	10q, 6r		18q, 1r	9q	3q	23q, 2r	10q, 4r	3q	6q	1q
Asteraceae	Waitzia acuminata						Wsd in Aust. S of tropics.					1q			
Asteraceae	Waitzia nitida			Recorded	5q	1q	Wsd in SW WA.	1q, 7r	1q, 4r		13q, 8r	4q, 9r			

Appendix C

Taxonomic name changes

Taxonomic name changes

This appendix has changes to botanical names used in Trudgen *et al.* 2012 and earlier reports where specimens have been redetermined, there have been nomenclatural changes published in taxonomic papers, or specimens previously referred to by an informal (geographic name) have been described in such papers.

Name used in earlier reports, particularly Trudgen *et al.* (2012)	**Name used in the current report**
Acacia lasiocarpa var. sedifolia *[This name still applied to some specimens, there are two forms]*	*Acacia lasiocarpa var. sedifolia* *AND* *Acacia lasiocarpa var. aff. sedifolia*
Aira caryophyllea	*Aira elegantissima*
Alyogyne huegeliana	*Alyogyne sp. Hutt River (B.J. Lepschi & T.R. Lally 2310)*
Baeckea crispiflora	*Ericomyrtus serpyllifolia*
Baeckea crispiflora (smaller leaf form) *Baeckea crispiflora var. tenuior*	*Ericomyrtus tenuior*
Baeckea preissiana	*Tetrapora preissiana*
Baeckea sp. Moora (R. Bone 1993/1)]	*Babingtonia cherticola*
Boronia ramosa ssp. anethifolia	*Cyanothamnus ramosus subsp. anethifolius*
Boronia coerulescens subsp. spinescens	*Cyanothamnus coerulescens subsp. spinescens*
Caesia alfordii [MS]	*Caesia sp. Wongan*
Caesia sp. (Moora hairy stem) & *Caesia (Moora hairy stem)*	*Dichopogon preissii*
Caladenia flaccida subsp. flaccida	*Caladenia paradoxa*
Chamaescilla corymbosa var. corymbosa	*Chamaescilla versicolor*
Comesperma virgatum	*Comesperma integerrimum*
Comesperma volubile	*Comesperma integerrimum*
Corynotheca micrantha var. micrantha	*Thysanotus dichotomus*
Cryptandra glabriflora	[Vouchers redetermined as C. myriantha]
Desmocladus flexuosus	*Desmocladus asper*
Diuris aff. recurva	*Diuris recurva*
Drosera erythrorhiza subsp. erythrorhiza *Drosera macrophylla subsp. macrophylla*	*Drosera macrophylla*
Drosera macrantha	*Drosera hirsuta*
Hemigenia sp.	*Hemigenia conferta*
Leucopogon sp. Moora *Leucopogon sp. Yanchep* *Leucopogon sp. Northern Scarp.*	*Styphelia retrorsa*
Lobelia sp. small flowers (K.F. Kenneally 7705)	*Lobelia cleistogamoides*
Melaleuca calyptroides	*Melaleuca leuropoma*

Name used in earlier reports, particularly Trudgen *et al*. (2012)	**Name used in the current report**
Olearia dampieri subsp. eremicola	*Olearia sp. Eremicola (Diels & Pritzel s.n. PERTH 00449628)*
Paracaleana carinata	*Paracaleana hortiorum*
Pterostylis aff. rufa	*Pterostylis exserta*
Schoenus clandestinus	*Schoenus latitans*
Stylidium septentrionale	*Stylidium sp. Moora (J.A. Wege 713)*
Tricoryne arenicola (MS)	*Tricoryne sp. Wongan Hills (B.H. Smith 794)*

Appendix D

Likelihood of Occurrence (Pre/Post Survey)

Likelihood of Occurrence (Pre/Post Survey)

Flora likelihood of occurrence assessment guidelines

Likelihood of occurrence	Guideline
Recorded	Species recorded in current survey and/or previous recorded from desktop review
Likely	Species previously recorded within the study area and large areas of suitable habitat occur in the project area.
Possible	Species previously recorded within the study area and areas of suitable habitat occur/may occur in the project area.
Unlikely	Species previously recorded within the study area, but suitable habitat does not occur in the project area.
Highly unlikely	Species not previously recorded within the study area, suitable habitat does not occur in the project area and/or the project area is outside the natural distribution of the species.
Other considerations	Intensity of survey, availability of access, growth form type, recorded flowering times, cryptic nature of species

Source information - desktop searches
PMST – DEE Protected Matters Search Tool (PMST) to identify flora listed under the EPBC Act potentially occurring within the study area
TPFL and WAHERB – records of threatened flora from TPFL and WAHERB database searches within the study area
NM – DBCA *NatureMap* (accessed February 2023)

Flora likelihood of occurrence assessment of conservation significant flora identified in the desktop assessment as potentially occurring in the survey area

Table 8.1 Likelihood of Occurrence – Pre and Post survey

Family	Taxon	Status		Description	Survey efficacy	Likelihood of occurrence		Source
		EPBC Act	WC Act /DBCA			Pre-Survey	Post-Survey	
Araliaceae	*Hydrocotyle spinulifera*	-	P3	Annual herbs consisting of a basal rosette of leaves and branched stems bearing leaves and umbellate inflorescences, 1–4 cm high. This species is a winter annual, with flowering and	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and Rare/Priority search transects.	Highly unlikely, no suitable habitat within the survey area. Area surveyed during flowering period.	Highly unlikely to occur.	WAHerb

Family	Taxon	Status		Description	Survey efficacy	Likelihood of occurrence		Source
		EPBC Act	WC Act /DBCA			Pre-Survey	Post-Survey	
				fruiting occurring from August to November (Perkins, 2018). Extends from near Moora north to Three Springs and further north-east to beyond Morawa. Plants grow along moist margins of seasonal wetlands, freshwater and saline lakes in this region (Perkins, 2018).				
Ericaceae	*Andersonia gracilis*	EN	VU	Slender erect or open straggly shrub, 0.1-0.5(-1) m high. Flowers: white-pink-purple, September to November. White/grey sand, sandy clay, gravelly loam. Winter-wet areas, near swamps (Trudgen, Morgan, & Griffin, A flora survey, floristic analysis and vegetation survey of the Coomberdale Chert TEC, 2006).	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and Rare/Priority search transects.	Unlikely, no suitable habitat within the survey area. Area surveyed during flowering period.	Highly unlikely to occur.	PMST
Ericaceae	*Styphelia allittii*	-	P3	Distribution: Gingin, Regans Ford, Boonanarring,	High coverage of all habitats in 2012 survey area with 99	Unlikely, area surveyed during flowering period. Little if any suitable habitat.	Highly unlikely to occur.	WAHerb

Family	Taxon	Status		Description	Survey efficacy	Likelihood of occurrence		Source
		EPBC Act	WC Act /DBCA			Pre-Survey	Post-Survey	
				Moora, Ajan, Yuna. Flowering period: April to June (State of Western Australia, 2022). One record approx. 15 km south within the Moora townsite (DBCA, 2023).	quadrats, 398 releves and Rare/Priority search transects.			
Ericaceae	*Styphelia tamminensis*	-	P3	Distribution: Wongan Hills, Marchagee, Watheroo, Moora, Tammin. Flowering period: June, October to December (State of Western Australia, 2022). One record approx. 15 km south within the Moora townsite in sandy soil (DBCA, 2023).	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and Rare/Priority search transects.	Unlikely, area surveyed during flowering period.	Highly unlikely to occur.	WAHerb
Fabaceae	*Acacia aristulata*	EN	EN	Erect or scrambling shrub, 0.25-1 m high. Flowers: cream-white, September to December. Loamy or clayey sand over chert. Low rocky ridges and hills, outcrops (Trudgen, Morgan, & Griffin, A flora survey, floristic analysis and	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and Rare/Priority search transects.	Recorded, suitable habitat known to occur within the survey area. Area surveyed during flowering period.	Known to occur, population well defined. After fire or disturbance <u>may</u> appear from soil stored seed at <u>additional</u> locations to those already known.	PMST, NatureMap, TPLF, WAHerb

Family	Taxon	Status		Description	Survey efficacy	Likelihood of occurrence		Source
		EPBC Act	WC Act /DBCA			Pre-Survey	Post-Survey	
				vegetation survey of the Coomberdale Chert TEC, 2006).				
Fabaceae	*Acacia cochlocarpa subsp. cochlocarpa*	EN	CR	Glabrous, sprawling shrub, 0.3-0.7(-1.5) m high. Flowers: yellow. Clayey, sandy, often gravelly soils (Trudgen, Morgan, & Griffin, A flora survey, floristic analysis and vegetation survey of the Coomberdale Chert TEC, 2006). Flowering period June to July (State of Western Australia, 2022). One record approx. 15 km south within the Moora townsite (DBCA, 2023).	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and Rare/Priority search transects.	Unlikely, limited suitable habitat within the survey area. Area surveyed during flowering period.	Highly unlikely to occur.	PMST, WAHerb
Fabaceae	*Acacia congesta subsp. cliftoniana*	-	P1	Spreading shrub, 0.5-1 m high. Flowers: yellow, August to September. Rocky or lateritic loam (Trudgen, Morgan, & Griffin, A flora survey, floristic analysis and vegetation survey of the Coomberdale Chert TEC, 2006).	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and Rare/Priority search transects.	Possible, suitable habitat known to occur within the survey area. Area surveyed during flowering period. There is one record in the TEC, but it is an outlier for the range of the taxon.	Highly unlikely to occur.. The putative record at Cairn Hill is likely to be mis-determined. All other records of *Acacia congesta* from Cairn Hill or the TEC area (including 4 determined by B. Maslin) are considered to be subspecies *congesta*.	NatureMap, TPLF, WAHerb

<table>
<thead>
<tr><th rowspan="2">Family</th><th rowspan="2">Taxon</th><th colspan="2">Status</th><th rowspan="2">Description</th><th rowspan="2">Survey efficacy</th><th colspan="2">Likelihood of occurrence</th><th rowspan="2">Source</th></tr>
<tr><th>EPBC Act</th><th>WC Act /DBCA</th><th>Pre-Survey</th><th>Post-Survey</th></tr>
</thead>
<tbody>
<tr><td></td><td></td><td></td><td></td><td>One record at Cairn Hill (DBCA, 2023).</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Fabaceae</td><td>Acacia cummingiana</td><td>-</td><td>P3</td><td>Sprawling, straggly, rush-like shrub, 0.3-0.5 m high. Flowers: yellow, May to June or August. Grey or yellow sand, lateritic gravel. Sandplains, lateritic breakaways (Trudgen, Morgan, & Griffin, A flora survey, floristic analysis and vegetation survey of the Coomberdale Chert TEC, 2006). One record approx. 15 km southwest on the margin of lake/ wetland (DBCA, 2023).</td><td>High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and Rare/Priority search transects.</td><td>Unlikely, limited suitable habitat within the survey area. Survey conducted during flowering period.</td><td>Highly unlikely to occur.</td><td>TPLF, WAHerb</td></tr>
<tr><td>Fabaceae</td><td>Acacia flabellifolia</td><td>-</td><td>P3</td><td>Erect, spreading, pungent shrub, 0.4-1 m high. Rocky loam, lateritic gravelly soils. Low hills and ridges (Trudgen, Morgan, & Griffin, A flora survey, floristic analysis and vegetation survey of the Coomberdale Chert TEC, 2006).</td><td>High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and Rare/Priority search transects.</td><td>Possible, suitable habitat known to occur within the survey area.</td><td>Highly unlikely. The closest records for this species to the proposed North Kiaka Mine are from ca. 20 km to the north (near Watheroo). One collection from near Watheroo was collected on quartzite, but</td><td>TPLF, WAHerb</td></tr>
</tbody>
</table>

Family	Taxon	Status		Description	Survey efficacy	Likelihood of occurrence		Source
		EPBC Act	WC Act /DBCA			Pre-Survey	Post-Survey	
				Distribution: Arrino, Watheroo, Eneabba. Flowering period: August (State of Western Australia, 2022). Three records approx. 17 km north of the survey area on quartz hill/ chert (DBCA, 2023).			others were collected from Wandoo woodland. *Acacia flabellifolia* has not been collected in the 2012 survey area. *Acacia ericksoniae*, has been recorded, but is clearly different to *Acacia flabellifolia*.	

Family	Taxon	Status		Description	Survey efficacy	Likelihood of occurrence		Source
		EPBC Act	WC Act /DBCA			Pre-Survey	Post-Survey	
Fabaceae	*Acacia splendens*	EN	CR	Tree or shrub, to 8 m high. Flowers: yellow, May. White sand over clay, pale brown loam, cracked brown soil, gravel, laterite, ironstone. Slopes of breakaways, especially southern slopes, hills (Trudgen, Morgan, & Griffin, A flora survey, floristic analysis and vegetation survey of the Coomberdale Chert TEC, 2006). Distribution: Dandaragan. Flowering period: August to September (State of Western Australia, 2022). One record approx. 20 km south west of the survey area on a dry water course (DBCA, 2023).	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and Rare/Priority search transects.	Unlikely, limited suitable habitat within the survey area. Area surveyed during flowering period.	Highly unlikely to occur. Outside known range.	WAHerb
Fabaceae	*Bossiaea moylei*	-	P2	Distribution: Moora. Flowering period: September (State of Western Australia, 2022).	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and DRF/Priority transects.	Known to occur within the 2012 survey area.	Known to occur in 2012 survey area; population well defined. *Bossiaea moylei* has a sporadic	NatureMap, WAHerb

Family	Taxon	Status		Description	Survey efficacy	Likelihood of occurrence		Source
		EPBC Act	WC Act /DBCA			Pre-Survey	Post-Survey	
				Nine records within Cairn Hill and Moora Mine (DBCA, 2023).			distribution in the TEC south of Kiaka Road. It has not been recorded north of Kiaka Road in any quadrat, releve, or any rare flora search transect.	
Fabaceae	*Chorizema humile*	EN	CR	Sprawling, prostrate or decumbent shrub. Flowers yellow and red/brown, July to September. Sandy clay or loam. Plains (Trudgen, Morgan, & Griffin, A flora survey, floristic analysis and vegetation survey of the Coomberdale Chert TEC, 2006).	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and Rare/Priority search transects.	Unlikely, limited suitable habitat within the survey area. Area surveyed during flowering period.	Highly unlikely to occur. Outside known range.	PMST
Fabaceae	*Daviesia dielsii*	EN	EN	Divaricate shrub, 0.5-0.9 m high. Flower: orange and red, July. Sandy, often gravelly soils (Trudgen, Morgan, & Griffin, A flora survey, floristic analysis and vegetation survey of the Coomberdale Chert TEC, 2006).	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and DRF/Priority transects. Population well defined.	Recorded. Scattered records in the TEC, mostly south of Kiaka Road but also in the southern part of the area north of that road.	Known to occur in 2012 survey area; population well defined. After fire or disturbance may appear from soil stored seed at additional locations to those already known.	PMST, NatureMap, TPLF, WAHerb

Family	Taxon	Status		Description	Survey efficacy	Likelihood of occurrence		Source
		EPBC Act	WC Act /DBCA			Pre-Survey	Post-Survey	
				Distribution: Moora, Watheroo, Marchagee, Dalwallinu. Flowering period: July to August (State of Western Australia, 2022). Nineteen records within Cairn Hill and Moora Mine (DBCA, 2023).				
Fabaceae	*Gastrolobium appressum*	VU	EN	Erect shrub, to 0.3 m high. Flowers: Yellow and orange and red and purple, August to December. White/yellow sand with quartz gravel. Sandplains, low rises (Trudgen, Morgan, & Griffin, A flora survey, floristic analysis and vegetation survey of the Coomberdale Chert TEC, 2006).	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and DRF/Priority transects.	Small possibility of occurrence, but closest records 25 km to east and 40 km to north of Cairn Hill. Habitat largely not suitable.	Highly unlikely to occur. Outside known range, soil, habitat not suitable.	PMST
Fabaceae	*Gastrolobium hamulosum*	EN	CR	Low shrub, 0.2-0.45 m high. Flowers: yellow and orange and red and purple, August to October. Sandy, often gravelly soils or clay. Flats, slopes,	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and DRF/Priority transects.	Possible, suitable habitat occurs within the survey area.	Highly unlikely to occur, due to survey intensity and size of the species.	PMST, NatureMap, WAHerb

Family	Taxon	Status		Description	Survey efficacy	Likelihood of occurrence		Source
		EPBC Act	WC Act /DBCA			Pre-Survey	Post-Survey	
				ridges (Trudgen, Morgan, & Griffin, A flora survey, floristic analysis and vegetation survey of the Coomberdale Chert TEC, 2006). Two records approx. 2 km north west of the survey area (DBCA, 2023).				
Fabaceae	*Isotropis cuneifolia subsp. glabra*	-	P3	Prostrate to ascending, spreading perennial, herb or shrub, 0.05-0.15 m high. Flowers: yellow/orange and red, September. Sand, clay loam. Winter-wet flats (Trudgen, Morgan, & Griffin, A flora survey, floristic analysis and vegetation survey of the Coomberdale Chert TEC, 2006).	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and Rare/Priority search transects.	Unlikely, limited suitable habitat within the survey area. Area surveyed during flowering period.	Highly unlikely to occur. Survey area outside range of taxon.	WAHerb
Frankeniaceae	*Frankenia conferta*	EN	VU	Frankenia conferta is a small shrub and is widely distributed, growing in clayey soils on the edge of salt lakes, between Koorda, Dalwallinu, Perenjori and	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and Rare/Priority search transects.	Unlikely, no suitable habitat within the survey area. Area surveyed during flowering period.	Highly unlikely to occur. No saline habitats in survey area.	PMST

Family	Taxon	Status		Description	Survey efficacy	Likelihood of occurrence		Source
		EPBC Act	WC Act /DBCA			Pre-Survey	Post-Survey	
				Coorow. However, sites are localised and sparsely scattered within lake chains and major drainage lines in the Yarra Yarra, Ninghan and Avon catchments. Flowering October (DEC, 2009).				
Goodeniaceae	*Goodenia arthrotricha*	EN	EN	Erect perennial, herb, to 0.4 m high. Flower: blue, October to November. Gravel. Granite rocks, slopes (Trudgen, Morgan, & Griffin, A flora survey, floristic analysis and vegetation survey of the Coomberdale Chert TEC, 2006).	High coverage of 2012 survey area with 99 quadrats, numerous releves and transects.	Recorded in the TEC south of Kiaka Road.	Known to occur in survey area. After fire or disturbance may appear from soil stored seed at additional locations to those already known.	PMST, NatureMap, TPLF, WAHerb
Haemodoraceae	*Anigozanthos humilis* subsp. Badgingarra (S.D. Hopper 7114)	-	P2	Erect, hirsute rhizomatous, herb, to 0.9 m high. Grey-white sand, rich brown sandy loam, sandy clay, alluvial soils. Low plains, river-banks, winter-wet swamps (Trudgen, Morgan, & Griffin, A flora survey, floristic	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and Rare/Priority search transects.	Unlikely, no suitable habitat within the survey area. Area surveyed during flowering period.	Highly unlikely to occur.	WAHerb

Family	Taxon	Status		Description	Survey efficacy	Likelihood of occurrence		Source
		EPBC Act	WC Act /DBCA			Pre-Survey	Post-Survey	
				analysis and vegetation survey of the Coomberdale Chert TEC, 2006). Distribution: North east Cataby, flowering September to October (State of Western Australia, 2022).				
Hemerocallidaceae	*Tricoryne* sp. Wongan Hills (B.H. Smith 794)	-	P2	Multi-stemmed, open, caespitose rhizomatous, perennial, herb, to 0.2 m high. Yellow to grey sand, gravelly clay quartz, laterite, limestone. (Trudgen, Morgan, & Griffin, A flora survey, floristic analysis and vegetation survey of the Coomberdale Chert TEC, 2006). Seven known occurrences in Coomberdale TEC survey area (Trudgen, Griffin, & Morgan, 2012)	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and DRF/Priority transects.	Recorded in the TEC with most records south of Kiaka Road and one record north of Kiaka Road.	Known to occur in survey area. Population well defined, although some plants not in flower during surveys may be present in areas where not recorded.	NatureMap, WAHerb
Lamiaceae	*Dasymalla axillaris*	CR	CR	Previously known as Pityrodia axillaris (Trudgen, Morgan, & Griffin, A flora survey, floristic	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and Rare/Priority search transects.	Unlikely, limited suitable habitat within the survey area. Area surveyed during flowering period.	Highly unlikely to occur. Range is well to east of Moora.	PMST

Family	Taxon	Status		Description	Survey efficacy	Likelihood of occurrence		Source
		EPBC Act	WC Act /DBCA			Pre-Survey	Post-Survey	
				analysis and vegetation survey of the Coomberdale Chert TEC, 2006). Small shrub to 30 cm high, flowering period July to December, found in disturbed areas of deep yellow sand in *Allocasuarina* and *Acacia* shrubland approximately 200 km south-east of Geraldton (DEC, 2008).				

Family	Taxon	Status		Description	Survey efficacy	Likelihood of occurrence		Source
		EPBC Act	WC Act /DBCA			Pre-Survey	Post-Survey	
Lamiaceae	*Dicrastylis velutina*	-	P3	Shrub, 0.1-0.6 m high. Flowers: white, October to December. Sandy soils, gravelly loam (Trudgen, Morgan, & Griffin, A flora survey, floristic analysis and vegetation survey of the Coomberdale Chert TEC, 2006). Distribution: Watheroo National Park, Yorkrakine and Bindi (State of Western Australia, 2022). One previous record approx. 15 km north east in a sandy rise between salt lakes in Namban Nature Reserve (DBCA, 2023).	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and Rare/Priority search transects.	Unlikely, limited suitable habitat within the survey area. Area surveyed during flowering period.	Highly unlikely to occur. Range is well to north and east of Moora.	WAHerb
Lamiaceae	*Hemiandra gardneri*	EN	CR	Prostrate, pungent shrub, 0.1-0.2 m high, to 1 m wide. Flowers: red/pink-red, August to October. Grey or yellow sand, clayey sand. Sandplains (Trudgen, Morgan, & Griffin, A flora survey, floristic	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and DRF/Priority transects.	Unlikely as mostly grows on yellow sand and this soil cleared in survey area.	Highly unlikely to occur. due to survey intensity. Apart from one old record in the Moora area known occurrences are more than 25 km away. Soil types	PMST, WAHerb

Family	Taxon	Status		Description	Survey efficacy	Likelihood of occurrence		Source
		EPBC Act	WC Act /DBCA			Pre-Survey	Post-Survey	
				analysis and vegetation survey of the Coomberdale Chert TEC, 2006).			in TEC remnants not suitable.	
Lamiaceae	*Hemigenia conferta*	-	P4	Erect to spreading shrub, 0.3-1.4 m high. Flower: white-cream-purple, September to October. Shallow soils (Trudgen, Morgan, & Griffin, A flora survey, floristic analysis and vegetation survey of the Coomberdale Chert TEC, 2006). Two occurrences in Coomberdale TEC survey area(Trudgen 2012).	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and DRF/Priority transects.	Know to occur in the TEC survey area at two localities and nearby on a road verge.	The occurrence in the TEC survey area is localised. Additional localities possible but unlikely. Unlikely to occur in TEC north of Kiaka Road due to habitat differences.	Trudgen 2012
Lamiaceae	*Hemigenia curvifolia*	-	P2	Shrub, 0.2-0.7 m high. Flower: blue, September to October. Sandy soils (Trudgen, Morgan, & Griffin, A flora survey, floristic analysis and vegetation survey of the Coomberdale Chert TEC, 2006). Five records approx. 15-20 km southwest	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and Rare/Priority search transects.	Unlikely, limited suitable habitat within the survey area. Area surveyed during flowering period.	Highly unlikely to occur.	WAHerb

Family	Taxon	Status		Description	Survey efficacy	Likelihood of occurrence		Source
		EPBC Act	WC Act /DBCA			Pre-Survey	Post-Survey	
				of the survey area (DBCA, 2023).				
Malvaceae	*Guichenotia tuberculata*	-	P3	Erect, open shrub, (0.25-)0.6-0.9 m high. Flower: purple-pink, August to October. Sand clay over laterite, sand. (Trudgen, Morgan, & Griffin, A flora survey, floristic analysis and vegetation survey of the Coomberdale Chert TEC, 2006). One population recorded in regional mapped extent of Coomberdale TEC (Trudgen, Griffin, & Morgan, 2012)	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and DRF/Priority transects.	Know to occur in the TEC survey area at one locality.	The occurrence in the TEC survey area is localised. Additional localities possible but unlikely. Unlikely to occur in TEC north of Kiaka Road	NatureMap, WAHerb
Myrtaceae	*Babingtonia cherticola*	-	P3	Baeckea sp. Moora (R. Bone 1993/1) is more recently known as *Babingtonia cherticola* Rye & Trudgen (Trudgen, Morgan, & Griffin, 2006). Shrubs low-growing to erect, 0.3–1.5(–3) m high, flowering spring and summer, especially from October to February	Occurrence in TEC well defined by quadrats, releves and transects,	Occurs in the TEC. Known at 77 locations in TEC survey area (Trudgen 2012).	All occurrences in the 2012 survey area are in Cairn Hill or Cairn Hill North. Unlikely to occur north of Kiaka Road.	NatureMap, WA Herb

Family	Taxon	Status		Description	Survey efficacy	Likelihood of occurrence		Source
		EPBC Act	WC Act /DBCA			Pre-Survey	Post-Survey	
				(Rye, A revision of the south-western Australian genus Babingtonia (Myrtaceae: Chamelaucieae), 2015). 77 populations in regional mapped extent of Coomberdale TEC (Trudgen, Griffin, & Morgan, 2012).				
Myrtaceae	*Babingtonia urbana*	-	P3	Shrubs low-growing to erect, 0.3–1.5(–3) m high, flowering spring and summer, especially from October to February (Rye, 2015).	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and DRF/Priority transects.	Unlikely. Babingtonia urbana is only known from the Swan Coastal Plain, where it occurs in or adjacent to seasonal damplands or wetlands.	Highly unlikely to occur. The lack of wetland habitat excludes any reasonable chance of this taxon occurring in the TEC survey area.	TPLF
Myrtaceae	*Balaustion grande*	-	P3	Low-growing shrub, usually 0.4–0.5 m high, flowers recorded from July to October and mature fruits from September to November, commonly occurs on sandplains or in sand overlying laterite (Rye, 2022).	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and Rare/Priority search transects.	Unlikely, limited suitable habitat within the survey area. Area surveyed during flowering period.	Highly unlikely to occur.	NatureMap, WAHerb

Family	Taxon	Status		Description	Survey efficacy	Likelihood of occurrence		Source
		EPBC Act	WC Act /DBCA			Pre-Survey	Post-Survey	
Myrtaceae	*Beaufortia bicolor*	-	P3	Dense shrub, 0.3-1 m high. Flowers: red and yellow and orange, November to December. White sand over laterite. Sandplains (Trudgen, Morgan, & Griffin, 2006).	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and Rare/Priority search transects.	Unlikely, limited suitable habitat within the survey area. Area surveyed during flowering period.	Highly unlikely to occur.	NatureMap, WAHerb
Myrtaceae	*Calothamnus accedens*	-	P4	Erect and slender shrub, to 1.8 m high. Flowers: pink-red. Sandy soils over laterite. Road verge (Trudgen, Morgan, & Griffin, 2006). Flowering period: February (State of Western Australia, 2022).	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and Rare/Priority search transects.	Unlikely, limited suitable habitat within the survey area. Area surveyed during flowering period.	Highly unlikely to occur.	WAHerb
Myrtaceae	*Chamelaucium lullfitzii*	EN	VU	Listed as Endangered as Chamelaucium sp. Gingin (N.G.Marchant 6). Shrub 100 to 200 cm high, flowers from September to December, restricted to a very small area associated with the Gingin scarp, south of Gingin. Plants grow on white, grey, or yellow sands in	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and Rare/Priority search transects.	Unlikely, no suitable habitat within the survey area. Area surveyed during flowering period.	Highly unlikely to occur. Survey area well outside known range.	PMST

Family	Taxon	Status		Description	Survey efficacy	Likelihood of occurrence		Source
		EPBC Act	WC Act /DBCA			Pre-Survey	Post-Survey	
				low open Banksia woodland (Marchant, 2019).				
Myrtaceae	*Eleocharis keigheryi*	VU	VU	Rhizomatous, clumped perennial, grass-like or herb (sedge), to 0.4 m high. Flowers: green, August to November. Clay, sandy loam. Emergent in freshwater: creeks, claypans (Trudgen, Morgan, & Griffin, 2006).	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and Rare/Priority search transects.	Unlikely, NO suitable habitat within the survey area. Area surveyed during flowering period.	Highly unlikely to occur.	PMST
Myrtaceae	Eremaea sp. Cairn Hill (B. Morgan 532)	-	P2	Distribution: Avon Wheatbelt, Geraldton Sandplains, Swan Coastal Plain. Shires of Coorow, Dandaragan and Moora. Flowering period: October to November (State of Western Australia, 2022). One population recorded in regional mapped extent of Coomberdale TEC (Trudgen, Griffin, & Morgan, 2012).	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and DRF/Priority transects.	This taxon is known to occur at one location in the TEC survey area. Area surveyed during flowering period.	Occurs at one location in 2012 survey area. A distinctive medium sized shrub, unlikely to occur at other locations there. Suitable habitat does not occur north of Kiaka Road.	NatureMap, TPLF, WAHerb

Family	Taxon	Status		Description	Survey efficacy	Likelihood of occurrence		Source
		EPBC Act	WC Act /DBCA			Pre-Survey	Post-Survey	
Myrtaceae	*Eucalyptus absita*	EN	CR	(Mallee) or tree, 2.3-10 m high, bark rough, fibrous. Flowers: white, April to July. White lateritic sand. Paddocks (Trudgen, Morgan, & Griffin, A flora survey, floristic analysis and vegetation survey of the Coomberdale Chert TEC, 2006).	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and Rare/Priority search transects.	Unlikely, no suitable habitat within the survey area. Area surveyed during flowering period.	Highly unlikely to occur.	TPLF, WAHerb
Myrtaceae	*Eucalyptus x carnabyi*	-	P4	(Mallee), 1.5-6 m high. Flowers: pink-cream, October to November. Grey sand, sandy loam. Lateritic ridges (Trudgen, Morgan, & Griffin, A flora survey, floristic analysis and vegetation survey of the Coomberdale Chert TEC, 2006).	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and Rare/Priority search transects.	Unlikely, limited suitable habitat within the survey area. Area surveyed during flowering period.	Highly unlikely to occur.	WAHerb
Myrtaceae	*Eucalyptus crispata*	VU	EN	(Mallee), 3-7 m high. Flowers: yellow-cream, March to June. Sand, loam with lateritic gravel. Lateritic breakaways (Trudgen, Morgan, & Griffin, A flora survey, floristic analysis and	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and Rare/Priority search transects.	Unlikely, limited suitable habitat within the survey area. Area surveyed during flowering period.	Highly unlikely to occur. Well outside range of species.	PMST

Family	Taxon	Status		Description	Survey efficacy	Likelihood of occurrence		Source
		EPBC Act	WC Act /DBCA			Pre-Survey	Post-Survey	
				vegetation survey of the Coomberdale Chert TEC, 2006).				
Myrtaceae	*Eucalyptus leprophloia*	EN	EN	(Mallee), 2-5(-8) m high. Flowers: cream-white, August to October. White or grey sand over laterite. Valley slopes (Trudgen, Morgan, & Griffin, A flora survey, floristic analysis and vegetation survey of the Coomberdale Chert TEC, 2006).	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and Rare/Priority search transects.	Unlikely, no suitable habitat within the survey area. Area surveyed during flowering period.	Highly unlikely to occur. Well outside range of species.	PMST
Myrtaceae	*Eucalyptus macrocarpa x pyriformis*	-	P3	Erect, open mallee tree, 1.2-6 m high. Flowers: red, April or August to October. Sand, lateritic sandy soils. Hills, rocky ironstone ridges, sandplains (Trudgen, Morgan, & Griffin, A flora survey, floristic analysis and vegetation survey of the Coomberdale Chert TEC, 2006).	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and Rare/Priority search transects.	Unlikely, limited suitable habitat within the survey area. Area surveyed during flowering period.	Highly unlikely to occur.	TPLF, WAHerb
Myrtaceae	*Eremophila scaberula*	EN	CR	Low compact or sprawling to upright shrub, 0.15-0.7(-1.5) m high. Flowers:	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and Rare/Priority search transects.	Unlikely, NO suitable habitat within the survey area. Area surveyed during flowering period.	Highly unlikely to occur	PMST, TPLF, WAHerb

Family	Taxon	Status		Description	Survey efficacy	Likelihood of occurrence		Source
		EPBC Act	WC Act /DBCA			Pre-Survey	Post-Survey	
				purple-blue, August to October. Clay, sandy clay or loam. Winter-wet plains, inundated areas (Trudgen, Morgan, & Griffin, A flora survey, floristic analysis and vegetation survey of the Coomberdale Chert TEC, 2006).				
Myrtaceae	*Eucalyptus pruiniramis*	EN	EN	(Mallee) or tree, 2.5-7 m high. Flowers: cream, December. Skeletal soils over sandstone or laterite. Rocky hillslopes (Trudgen, Morgan, & Griffin, A flora survey, floristic analysis and vegetation survey of the Coomberdale Chert TEC, 2006).	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and Rare/Priority search transects.	Known to occur in the survey area. Area surveyed during flowering period.	Known to occur in 2012 survey area. Only occurs there in Cairn Hill NR.	PMST, TPLF, NatureMap
Myrtaceae	*Eucalyptus rhodantha var. rhodantha*	VU	VU	(Spreading mallee), 1.5-4 m high. Flowers: red/cream-white, July or September to December or January. Grey/yellow/red sand over laterite. Undulating country, hillslopes (Trudgen,	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and Rare/Priority search transects.	Unlikely, limited suitable habitat within the survey area. Area surveyed during flowering period.	Highly unlikely to occur. Outside range. Distinctive form means unlikely to not be observed.	PMST, WAHerb

Family	Taxon	Status		Description	Survey efficacy	Likelihood of occurrence		Source
		EPBC Act	WC Act /DBCA			Pre-Survey	Post-Survey	
				Morgan, & Griffin, A flora survey, floristic analysis and vegetation survey of the Coomberdale Chert TEC, 2006).				
Myrtaceae	*Melaleuca sclerophylla*	-	P3	Erect-spreading to prostrate shrub, 0.15-0.9 m high. Fl. purple-pink, June to September. Gravelly sand, clayey sand. Granite outcrops, rises (Trudgen, Morgan, & Griffin, A flora survey, floristic analysis and vegetation survey of the Coomberdale Chert TEC, 2006). Three populations recorded in regional mapped extent of Coomberdale TEC (Trudgen, Griffin, & Morgan, An extension of a flora survey, floristic analysis and vegetation survey of areas of the Coomberdale Chert TEC to include a further area, 2012).	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and DRF/Priority transects.	Three populations recorded in the southern part of the 2012 TEC survey area.	Known to occur in southern part of 2012 survey area. No suitable habitat north of Kiaka Road.	NatureMap, TPLF, WAHerb

Family	Taxon	Status		Description	Survey efficacy	Likelihood of occurrence		Source
		EPBC Act	WC Act /DBCA			Pre-Survey	Post-Survey	
Myrtaceae	*Regelia megacephala*	-	P4	Shrub, 2-5 m high. Flowers: purple-red, October to December. Red sand. Quartzite hills (Trudgen, Morgan, & Griffin, A flora survey, floristic analysis and vegetation survey of the Coomberdale Chert TEC, 2006). 71 populations recorded in regional mapped extent of Coomberdale TEC (Trudgen, Griffin, & Morgan, An extension of a flora survey, floristic analysis and vegetation survey of areas of the Coomberdale Chert TEC to include a further area, 2012).	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and DRF/Priority transects.	Recorded at 71 occurrences in the 2012 survey area. The occurrences are vegetation stands dominated by the species.	Forms numerous stands in the 2012 survey area. Given the size of this taxon, it is likely all stands in the TEC survey area have been recorded.	NatureMap, TPLF, WAHerb
Myrtaceae	*Verticordia insignis* subsp. *eomagis*	-	P3	Erect shrub, 0.2-1(-1.5) m high. Flowers white-pink/white, August to November. Sandy soils over laterite. Sandplains, rocky rises (Trudgen, Morgan, & Griffin, A flora survey, floristic	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and Rare/Priority search transects.	Unlikely, limited suitable habitat within the survey area. Area surveyed during flowering period.	Highly unlikely to occur.	WAHerb

Family	Taxon	Status		Description	Survey efficacy	Likelihood of occurrence		Source
		EPBC Act	**WC Act /DBCA**			**Pre-Survey**	**Post-Survey**	
				analysis and vegetation survey of the Coomberdale Chert TEC, 2006).				
Myrtaceae	*Verticordia muelleriana* subsp. *muelleriana*	-	P3	Spindly shrub, 0.45-2(-3.5) m high. Flowers: pink-purple-red/brown, September to December or January. White/grey or yellow sand. Sandplains (Trudgen, Morgan, & Griffin, A flora survey, floristic analysis and vegetation survey of the Coomberdale Chert TEC, 2006).	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and Rare/Priority search transects.	Unlikely, limited suitable habitat within the survey area. Area surveyed during flowering period.	Highly unlikely to occur.	TPLF, WAHerb
Orchidaceae	*Caladenia drakeoides*	EN	CR	Tuberous, perennial, herb, 0.12-0.3 m high. Flowers: green, September to October. Grey clayey sand, red sandy loam, in damp situations. Margins of salt lakes (Trudgen, Morgan, & Griffin, 2006). Flowering period: August to October (State of Western Australia, 2022).	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and Rare/Priority search transects.	Unlikely, no suitable habitat within the survey area. Area surveyed during flowering period.	Highly unlikely to occur.	PMST, TPLF

Family	Taxon	Status		Description	Survey efficacy	Likelihood of occurrence		Source
		EPBC Act	WC Act /DBCA			Pre-Survey	Post-Survey	
Orchidaceae	*Caladenia dundasiae*	-	P1	Herb, 0.15-0.35 m high, Poorly known species, appears to be confined to Watheroo area. Flowers: red/cream-yellow, July to August. Clayey loam. Well-drained soils under scattered wandoo (Trudgen, Morgan, & Griffin, A flora survey, floristic analysis and vegetation survey of the Coomberdale Chert TEC, 2006).	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and Rare/Priority search transects.	Unlikely, limited suitable habitat within the survey area. Area surveyed during flowering period.	Highly unlikely to occur.	TPLF, WAHerb
Orchidaceae	*Diuris recurva*	-	P4	Tuberous, perennial, herb, 0.2-0.3 m high. Flowers: yellow and brown, July to August. Loam. Winter-wet areas. (Trudgen, Morgan, & Griffin, A flora survey, floristic analysis and vegetation survey of the Coomberdale Chert TEC, 2006). 31 populations in regional mapped extent of Coomberdale TEC (Trudgen, Griffin, &	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and DRF/Priority transects.	Known from 35 occurrences in the 2012 survey area. The occurrences vary from single plants to small populations.	Known to occur. The small size of this taxon and flowering necessary for identification it is likely that a small increase in occurrences would be found if the whole TEC survey area was more intensively searched.	NatureMap, TPLF, WAHerb

Family	Taxon	Status		Description	Survey efficacy	Likelihood of occurrence		Source
		EPBC Act	WC Act /DBCA			Pre-Survey	Post-Survey	
				Morgan, An extension of a flora survey, floristic analysis and vegetation survey of areas of the Coomberdale Chert TEC to include a further area, 2012).				
Pertusariaceae	*Pertusaria trachyspora*	-	P2	Distribution: Camp Creek, Mitchell Plateau, Moora, Collie, Mount Chudalup, Walpole (State of Western Australia, 2022). One record approx. 8 km south of the survey area, on plain with littered dry semi saline brown clay. (DBCA, 2023).	Lichens were not collected during the survey.	Possible, limited suitable habitat within the survey area.	May occur.	NatureMap, TPLF, WAHerb

Family	Taxon	Status		Description	Survey efficacy	Likelihood of occurrence		Source
		EPBC Act	WC Act /DBCA			Pre-Survey	Post-Survey	
Poaceae	*Austrostipa nunaginensis*	-	P3	*Austrostipa nunaginensis* (A. sp. Cairn Hill) is known from seven sites in the northern wheatbelt (Greenough to Bruce Rock). Perennial tussock grass, 200–500 mm tall, flowering late spring, fruiting early summer (Williams, 2022). One population located in regional mapped extent of Coomberdale TEC (Trudgen, Griffin, & Morgan, An extension of a flora survey, floristic analysis and vegetation survey of areas of the Coomberdale Chert TEC to include a further area, 2012).	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and DRF/Priority transects.	One occurrence known in the TEC survey area native vegetation, also two from rehabilitation areas.	Given the small size of this taxon and the frequency of other Austrostipa of similar size in the TEC, it is possible that a small number of additional occurrences may occur. Weed levels in the proposed mine area reduce the likelihood of occurrence there.	NatureMap, WAHerb
Proteaceae	*Banksia fuscobractea*	CR	CR	Erect, prickly, non-lignotuberous shrub, ca 1 m high. Flower yellow, flowering period July to October. Lateritic gravel, grey sand over laterite	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and Rare/Priority search transects.	Unlikely, no suitable habitat within the survey area. Area surveyed during flowering period.	Highly unlikely to occur. Outside range. Distinctive form means unlikely to not be observed.	PMST

Family	Taxon	Status		Description	Survey efficacy	Likelihood of occurrence		Source
		EPBC Act	WC Act /DBCA			Pre-Survey	Post-Survey	
				(Trudgen, Morgan, & Griffin, A flora survey, floristic analysis and vegetation survey of the Coomberdale Chert TEC, 2006).				
Proteaceae	*Banksia dallanneyi* subsp*. pollosta*	-	P3	Prostrate, lignotuberous shrub. Flowers: yellow-brown, August to September. Grey/yellow sand. Flats, lateritic rises (Trudgen, Morgan, & Griffin, A flora survey, floristic analysis and vegetation survey of the Coomberdale Chert TEC, 2006).	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and Rare/Priority search transects.	Unlikely, limited suitable habitat within the survey area. Area surveyed during flowering period.	Highly unlikely to occur.	TPLF, WAHerb
Proteaceae	*Conospermum densiflorum* subsp*. unicephalatum*	EN	EN	Erect, much-branched shrub, 0.3-0.6 m high, inflorescence a spike. Flowers: cream/white and blue, September to November. Clay soils. Low-lying areas (Trudgen, Morgan, & Griffin, A flora survey, floristic analysis and vegetation survey of	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and Rare/Priority search transects.	Known to occursurveyed during flowering period.	Highly unlikely to occur.	PMST, NatureMap, WAHerb

Family	Taxon	Status		Description	Survey efficacy	Likelihood of occurrence		Source
		EPBC Act	WC Act /DBCA			Pre-Survey	Post-Survey	
				the Coomberdale Chert TEC, 2006).				
Proteaceae	*Grevillea amplexans* subsp. *semivestita*	-	P2	Erect, open, pungent shrub, 1-3 m high. Flowers: white-cream, August to October. Yellow clayey sand, laterite. Two populations recorded in regional mapped extent of Coomberdale TEC (Trudgen, Griffin, & Morgan, An extension of a flora survey, floristic analysis and vegetation survey of areas of the Coomberdale Chert TEC to include a further area, 2012).	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and Rare/Priority search transects.	Known to occur in 2012 survey area, but limited suitable habitat there. Surveyed during flowering period.	Occurs in one TEC remnant in eastern part of 2012 survey area. No suitable habitat north of Kiaka Road.	
Proteaceae	*Grevillea christineae*	EN	EN	Erect, wiry shrub, 0.5-0.6 m high. Flowers: white-cream, August to September. Clay loam, sandy clay, often moist (Trudgen, Morgan, & Griffin, A flora survey, floristic analysis and vegetation survey of the Coomberdale Chert TEC, 2006).	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and Rare/Priority search transects.	Unlikely, limited suitable habitat within the survey area. Area surveyed during flowering period.	Highly unlikely to occur.	PMST, TPLF

Family	Taxon	Status		Description	Survey efficacy	Likelihood of occurrence		Source
		EPBC Act	WC Act /DBCA			Pre-Survey	Post-Survey	
Proteaceae	*Grevillea pythara*	EN	CR	Suckering shrub, 0.06-0.3 m high. Flowers: orange and red and blue, May to October (possibly all year). Sand or sandy loam with gravel (Trudgen, Morgan, & Griffin, A flora survey, floristic analysis and vegetation survey of the Coomberdale Chert TEC, 2006).	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and Rare/Priority search transects.	Unlikely, limited suitable habitat within the survey area. Area surveyed during flowering period.	Highly unlikely to occur. Well outside known range.	PMST
Proteaceae	*Grevillea haplantha* subsp. *recedens*	-	P3	Erect or spreading shrub, 0.6-1 m high. Flowers red, June to August. Sand, sandy loam (Trudgen, Morgan, & Griffin, A flora survey, floristic analysis and vegetation survey of the Coomberdale Chert TEC, 2006).	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and Rare/Priority search transects.	Unlikely, limited suitable habitat within the survey area. Area surveyed during flowering period.	Highly unlikely to occur. Outside known range.	WAHerb

Family	Taxon	Status		Description	Survey efficacy	Likelihood of occurrence		Source
		EPBC Act	WC Act /DBCA			Pre-Survey	Post-Survey	
Proteaceae	*Grevillea saccata*	-	P4	Diffuse scrambling or trailing shrub, 0.25-0.5 m high, 1-2 m wide. Flowers: red, April or June to November. Yellow or brown sand, often with lateritic gravel (Trudgen, Morgan, & Griffin, A flora survey, floristic analysis and vegetation survey of the Coomberdale Chert TEC, 2006).	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and Rare/Priority search transects.	Unlikely, limited suitable habitat within the survey area. Area surveyed during flowering period.	Highly unlikely to occur.	WAHerb
Proteaceae	*Petrophile biternata*	-	P3	Stout, rigid, non-lignotuberous shrub, 0.8-1.5 m high. Flowers: yellow/cream-yellow, August to October. Yellow/grey sand and gravel, laterite, quartzite soils. Lateritic ridges, plains (Trudgen, Morgan, & Griffin, A flora survey, floristic analysis and vegetation survey of the Coomberdale Chert TEC, 2006)	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and DRF/Priority transects.	Possible, species habitat may occur within the survey area, but soil type probably not suitable.	Highly unlikely to occur.	WAHerb
Proteaceae	*Persoonia chapmaniana*	-	P3	Erect, spreading shrub, 1-2 m high. Flowers: yellow,	High coverage of all habitats in 2012 survey area with 99	Unlikely, no suitable habitat within the survey area. Area	Highly unlikely to occur.	NatureMap, WAHerb

Family	Taxon	Status		Description	Survey efficacy	Likelihood of occurrence		Source
		EPBC Act	WC Act /DBCA			Pre-Survey	Post-Survey	
				September to November. White sandy clay, yellow sand. Vicinity of salt lakes (Trudgen, Morgan, & Griffin, A flora survey, floristic analysis and vegetation survey of the Coomberdale Chert TEC, 2006).	quadrats, 398 releves and Rare/Priority search transects.	surveyed during flowering period.		
Proteaceae	*Synaphea quartzitica*	EN	EN	Small tufted shrub. Flowers: yellow, July to August. Rocky quartzite hill (Trudgen, Morgan, & Griffin, A flora survey, floristic analysis and vegetation survey of the Coomberdale Chert TEC, 2006).	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and DRF/Priority transects.	This species is known to occur at one location in the southern part of the survey area.	Known to occur at one location. Very distinctive and further occurrences in the survey area are unlikely. No suitable habitat north of Kiaka Road.	PMST, NatureMap, TPLF, WAHerb

Family	Taxon	Status		Description	Survey efficacy	Likelihood of occurrence		Source
		EPBC Act	WC Act /DBCA			Pre-Survey	Post-Survey	
Rhamnaceae	*Cryptandra glabriflora*	-	P2	Low shrub, (0.05-)0.1-0.5 m high. Flowers: white/pink, May to August. Yellow or grey sand, gravelly soils. Plains (Trudgen, Morgan, & Griffin, A flora survey, floristic analysis and vegetation survey of the Coomberdale Chert TEC, 2006). [Vouchers redetermined as C. myriantha]	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and Rare/Priority search transects.	Unlikely, limited suitable habitat occurs within the survey area. Area surveyed during flowering period.	Highly unlikely to occur. Well outside range.	Trudgen 2012
Rutaceae	*Boronia ericifolia*	-	P2	Erect shrub, 0.3-1.2 m high. Flowers: white/cream-yellow, April or June or August to September. Sandy loam, clay, laterite. Low-lying spots (Trudgen, Morgan, & Griffin, A flora survey, floristic analysis and vegetation survey of the Coomberdale Chert TEC, 2006).	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and Rare/Priority search transects.	Unlikely, no suitable habitat occurs within the survey area. Area surveyed during flowering period.	Highly unlikely to occur.	WAHerb
Scrophulariaceae	*Eremophila glabra* subsp. *chlorella*	EN	EN	Prostrate and spreading or sprawling shrub, 0.2-1 m high. Flowers: green-	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and Rare/Priority search transects.	Unlikely, limited suitable habitat occurs within the survey area. Area surveyed during flowering period.	Highly unlikely to occur.	WAHerb

Family	Taxon	Status		Description	Survey efficacy	Likelihood of occurrence		Source
		EPBC Act	WC Act /DBCA			Pre-Survey	Post-Survey	
				yellow, July to November. Sandy clay. Winter-wet depressions (Trudgen, Morgan, & Griffin, A flora survey, floristic analysis and vegetation survey of the Coomberdale Chert TEC, 2006). One previous record approx. 18 km south west of the survey area (DBCA, 2023).				
Stylidiaceae	*Stylidium glabrifolium*	-	P2	Rosetted perennial, herb, 0.2-0.3 m high. Flower: yellow, October to November. Grey brown clay loam over laterite. Hillslopes or gullies. Wandoo woodland (Trudgen, Morgan, & Griffin, A flora survey, floristic analysis and vegetation survey of the Coomberdale Chert TEC, 2006). Recorded from three quadrats in the survey, however has not been recorded	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and DRF/Priority transects.	Recorded from three quadrats in the central part of the TEC survey area,	Known to occur in 2012 survey area. Not recorded north of Kiaka Road. Weed levels in the proposed mine area reduce the likelihood of occurrence there.	Trudgen 2012 and 2018

Family	Taxon	Status		Description	Survey efficacy	Likelihood of occurrence		Source
		EPBC Act	WC Act /DBCA			Pre-Survey	Post-Survey	
				north of Kiaka Road (Trudgen, 2018)				

Family	Taxon	Status		Description	Survey efficacy	Likelihood of occurrence		Source
		EPBC Act	WC Act /DBCA			Pre-Survey	Post-Survey	
Stylidiaceae	*Stylidium milleri*	-	P2	Stilted perennial herb (10–)20–40 cm high. Flowering period: September to October. It favours upland habitats, growing in grey sand with lateritic gravel in *Allocasuarina* and *Lambertia* shrubland with Xanthorrhoea and scattered mallees, Proteaceous and Myrtaceous shrubland with *Allocasuarina* and scattered *Banksia attenuata*, or *B. carlinoides* heath. (Wege, 2022). Three populations recorded in regional mapped extent of Coomberdale TEC (Trudgen, Griffin, & Morgan, An extension of a flora survey, floristic analysis and vegetation survey of areas of the Coomberdale Chert TEC to include a further area, 2012).	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and DRF/Priority transects.	Unlikely as soil types not suitable and outside range.	Highly unlikely to occur as soil types and vegetation types not suitable.	WAHerb

Family	Taxon	Status		Description	Survey efficacy	Likelihood of occurrence		Source
		EPBC Act	WC Act /DBCA			Pre-Survey	Post-Survey	
Stylidiaceae	*Stylidium periscelianthum*	-	P3	Bulb-forming perennial, herb, 0.07-0.15 m high. Flower: pink, September to October. Loamy clay, moist soils pockets. Wet flats, low granitic hills (Trudgen, Morgan, & Griffin, A flora survey, floristic analysis and vegetation survey of the Coomberdale Chert TEC, 2006).	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and Rare/Priority search transects.	Unlikely, limited suitable habitat occurs within the survey area. Area surveyed during flowering period.	Highly unlikely to occur.	NatureMap
Stylidiaceae	*Stylidium* sp. Moora (J.A. Wege 713)	-	P2	Twenty-two records from the Gillingarra, Moora, Cairn Hill areas (ALA, 2023). Flowering period: October (State of Western Australia, 2022). Ten records within Cairn Hill to the south (DBCA, 2023).	High coverage of all habitats in 2012 survey area with 99 quadrats, 398 releves and DRF/Priority transects.	Relatively common in the 2012 survey area	Occurs north of Kiaka Road, including in the proposed mine footprint.	WAHerb

Appendix E

Vegetation Description and Dendrogram

Vegetation Alliance 1: *Eucalyptus salmonophloia* woodlands to open forests

Salmon gum open forest occurred in a few locations in the survey area, in small valleys between low ridges and in a few places in the remnant vegetation at the base of the chert ridges on the edge of broad valley floors now largely cleared for farming.

Vegetation Association Es: *Eucalyptus salmonophloia* (*Eucalyptus wandoo* subsp. *wandoo*) over *Dodonaea inaequifolia* high open shrubland.

This vegetation association included one plant community.

Vegetation Association EsEl: *Eucalyptus salmonophloia* woodland over *Eucalyptus loxophleba* subsp. *loxophleba* low woodland over scattered *Acacia erinacea* shrubs and scattered herbs and grasses including *Ptilotus divaricatus* var. *divaricatus*, *Rhodanthe polycephala* and **Bromus diandrus*.

This vegetation association included two plant communities. One plant community differed by having a number of Chenopod species present.

Vegetation Alliance 2: *Eucalyptus wandoo* subsp. *wandoo* woodlands and open forests

This vegetation alliance was not common among the chert ridges in the survey area. It occurred along some sections of narrow linear 'valleys' between some of the ridges (dykes) and sometimes in the remnant vegetation at the base of the chert ridges on the edge of broad valley floors now largely cleared for farming.

Vegetation Association Ew: Eucalyptus wandoo subsp. wandoo low woodland or open forest over open herb/grasslands that included Opercularia vaginata, Lomandra effusa, Crassula colorata var. colorata, Trachymene pilosa and Waitzia nitida herbs and Austrodanthonia setacea and Austrostipa exilis grasses.

Four plant communities were described in this vegetation association, one with wandoo woodland over scattered herbs (Ew1), one with wandoo woodland over Allocasuarina campestris high shrubland (Ew2 (probably an intermediate unit)), one with wandoo woodland over Acacia acuminata subsp. acuminata low woodland over herbland/sedgeland/grassland (Ew3) and one with wandoo woodland over Olearia dampieri subsp. eremicola and Hibbertia subvaginata open (low) shrubland (Ew4).

Vegetation Association EwDi: *Eucalyptus wandoo* subsp. *wandoo* low open forest over *Dodonaea inaequifolia* scattered tall shrubs to high shrubland.

This vegetation association was recorded in one salmon gum and wandoo valley in the south-east corner of Cairn Hill Reserve and included one plant community, EwDi1.

Vegetation Association EwTl: *Eucalyptus wandoo* subsp. *wandoo* open woodland over *Trymalium ledifolium* var. *rosmarinifolium* scattered shrubs to low open shrubland.

This vegetation association included two plant communities, which were recorded on rocky ridge slopes, one on Gardiner's Hill and one in Cairn Hill. In plant community EwTl.2 wandoo grew over *Allocasuarina huegeliana* scattered trees and *Allocasuarina campestris* scattered tall shrubs on a low ridge slope. Plant community EwTl.1, wandoo grew over an *Allocasuarina huegeliana* and *Acacia acuminata* subsp. *acuminata* low open woodland and *Xanthorrhoea drummondii* open shrubland and *Trymalium ledifolium* var. *rosmarinifolium* low open shrubland on the rocky upper slope at the end of a low ridge.

Vegetation Association EwAa: *Eucalyptus wandoo* subsp. *wandoo* open woodland over *Acacia acuminata* subsp. *acuminata* low open woodland over *Allocasuarina campestris* open scrub.

This vegetation association included only one plant community; EwAa.1. It was recorded on a gentle west-facing slope on A. & R. Tonkin's property. Although the stand is adjacent to cleared areas, it was in quite good condition.

Vegetation Alliance 3: *Eucalyptus loxophleba* subsp. *loxophleba* low woodlands to low open forests

Eucalyptus loxophleba subsp. *loxophleba* was mainly recorded in the survey area from lower slopes of ridges and the adjacent valley floor areas. It was also occasionally found growing on the crest of the low ridges and along some sections of narrow linear features between some of the ridges (dykes).

Vegetation Association El: *Eucalyptus loxophleba* subsp. *loxophleba* low woodland over scattered shrubs and very open herbland.

This vegetation association included five plant communities that differed in both the tree species occurring with the York Gum and the scattered shrub species.

Vegetation Association Elo: *Eucalyptus loxophleba* subsp. *loxophleba* low open to closed forest over scattered shrubs and very open herbland.

This vegetation association includes six plant communities that differed in the scattered shrub species present.

Vegetation Association ElEo: *Eucalyptus loxophleba* subsp. *loxophleba, Eucalyptus obtusiflora* low open woodland over scattered tall shrubs over *Dodonaea inaequifolia* low woodland over scattered shrubs over scattered sedges and very open herbland.

This unit included one plant community recorded in a deep gully along a shallow drainage line on the boundary of Cairn Hill and Cairn Hill North.

Vegetation Association ElXd: *Eucalyptus loxophleba* subsp. *loxophleba* low woodland to low open forest over *Xanthorrhoea drummondii* scattered shrubs to high open shrubland.

This vegetation association only included one plant community.

Vegetation Alliance 4: *Eucalyptus eudesmioides* low mallee woodlands to low mallee open forests

Vegetation Association Ee: *Eucalyptus eudesmioides* low mallee woodland to low mallee open forest over annual grassland.

This vegetation association included one plant community, recorded at one site where the vegetation was in Poor to Very Poor condition.

Vegetation Association EeDs: *Eucalyptus eudesmioides* low mallee open forest over *Dryandra sessilis* var. *sessilis* high open shrubland and *Hibbertia subvaginata* low open shrubland.

Vegetation Association EeKp: *Eucalyptus eudesmioides* low mallee woodland over *Kunzea praestans* scattered tall shrubs to high shrubland.

This vegetation association included three plant communities, which differed in the shrub species.

Vegetation Association EeId: *Eucalyptus eudesmioides* low mallee woodland over Xanthorrhoea drummondii and Isopogon divergens scattered shrubs.

Vegetation Association EeRm: *Eucalyptus eudesmioides* low mallee open forest over *Calothamnus* aff. *quadrifidus* (Moora-Watheroo), *Regelia megacephala* high open shrubland.

Vegetation Alliance 5: *Eucalyptus camaldulensis* open forest

Vegetation Association Ec: Eucalyptus camaldulensis open forest.

This vegetation association was recorded on the valley flats on the south-east side of the survey area.

Vegetation Alliance 6: *Eucalyptus obtusiflora* low woodlands to low open forests

A small area of this unit occurred on a section of the floor of a linear depression (dyke) that occurred near the Cairn Hill North ridge crest and on a similar feature in the southern part of Cairn Hill.

Vegetation Association Eo: *Eucalyptus obtusiflora,* (*Eucalyptus loxophleba* subsp. *loxophleba*) low mallee open forest over *Acacia erinacea* scattered shrubs over a very open herbland.

Vegetation Association EoTd: *Eucalyptus obtusiflora* low mallee woodland to low open forest over *Trymalium daphnifolium*, *Acacia erinacea* shrubland.

Vegetation Alliance 7: *Eucalyptus horistes* low woodlands to low open forests

A small area of this eucalypt was found in Cairn Hill North, at the base of a low ridge near the southern boundary of Cairn Hill and at the base of the same ridge several hundred meters further south of Cairn Hill.

Vegetation Association EhAh: *Eucalyptus horistes* mallee woodland over *Allocasuarina huegeliana* low open woodland over scattered shrubs.

Vegetation Association EhEe: Eucalyptus horistes, (Eucalyptus eudesmioides) mallee woodland to low open forest.

This vegetation association included two plant communities. One was a low open forest over little understorey (Very Poor condition due to grazing) and the other was a woodland over a mixed high open shrubland and open shrubland.

Vegetation Alliance 8: *Eucalyptus pruiniramis* low woodland

A group of *Eucalyptus pruiniramis* mallees, described here as a small woodland, was found on the top of a rounded low hill east of Cairn Hill. A small clump of this mallee also occurred a few hundred meters to the south-east of the woodland and one small clump was found on the mid-slopes of a low ridge in Cairn Hill about 800 meters north of west of the small woodland.

Vegetation Association Ep: Eucalyptus pruiniramis low mallee woodland.

Vegetation Alliance 9: *Allocasuarina huegeliana* low woodlands to low open forests

Allocasuarina huegeliana grew as low woodland and low open forest on the sections of the ridge crests and slopes in the survey area.

Vegetation Association Ah: *Allocasuarina huegeliana* low woodland to low open forest over scattered shrubs.

Four plant communities were included in this vegetation association, differentiated by the composition of the tree layer and the shrub species.

Vegetation Association AhAc: *Allocasuarina huegeliana* low woodland to low open forest over *Allocasuarina campestris* scattered shrubs to high open shrubland.

Five plant communities were included in this vegetation association, differentiated by the composition of the tree layer and the shrub species growing under or with the *Allocasuarina campestris*.

Vegetation Association AhDf: Allocasuarina huegeliana low open forest over Stylobasium australe scattered shrubs and Dryandra fraseri, Calytrix depressa low open shrubland over Lepidosperma leptostachyum very open sedgeland.

One plant community was recorded in this vegetation association. It was recorded from the flat valley floor on the western boundary of Cairn Hill.

Vegetation Association AhDp: *Allocasuarina huegeliana* low woodland to low open forest over *Dodonaea pinifolia* scattered shrubs with *Xanthosia fruticulosa* very open herbland.

Two small plant communities were recorded in this vegetation association. Both units occurred along a breakaway on the side of a ridge. They differed in the associated tree and shrub species.

Vegetation Association AhDs: *Allocasuarina huegeliana* low woodland to low open forest over *Dryandra sessilis var. sessilis* scattered tall shrubs to high open shrubland.

Four plant communities were included in this vegetation association. They differed in the associated and sub-dominant species in the tree and shrub layers. One of these plant communities was distinguished by a low (open) shrubland of *Hibbertia subvaginata,* while another occurred on rocky ridge slopes in Gardiner's Hill and included *Trymalium ledifolium* ver. *rosmarinifolium low open shrubland*.

Vegetation Association AhDsKp: *Allocasuarina huegeliana* low woodland to low open forest over *Dryandra sessilis var. sessilis* scattered tall shrubs to high shrubland over *Kunzea praestans* scattered tall shrubs to high open shrubland.

This vegetation was recorded from John Tonkin's, Ridgway's, Cairn Hill North, Cairn Hill and Gardiner's Hill. Four plant communities were included in this vegetation association. They differed in the composition of the tree and shrub strata. One plant community was differentiated by having *Hibbertia subvaginata* scattered low shrubs to low open shrubland, while another plant community was a single stand at Gardiner's Hill where the *Dryandra sessilis var. sessilis* formed an open scrub under an *Allocasuarina huegeliana* low open forest. A third plant community was distinguished by having a *Baeckea* sp. Moora (R. Bone 1993/1) low open shrubland to shrubland.

Vegetation Association AhHr: *Allocasuarina huegeliana* low open forest over *Hakea recurva* subsp. *recurva* scattered tall shrubs.

This vegetation association included one plant community that was recorded at Gardiner's Hill.

Vegetation Association AhHs: *Allocasuarina huegeliana* low open woodland to low woodland over *Hibbertia subvaginata* low open shrubland to low shrubland.

This vegetation association was only recorded on the Eastern Ridge. It included one plant community.

Vegetation Association AhKp: *Allocasuarina huegeliana* low woodland to low open forest over *Kunzea praestans* scattered tall shrubs to high open shrubland.

This vegetation association included three plant communities. One plant community was differentiated by having *Hibbertia subvaginata* scattered low shrubs to low open shrubland, while another plant community included a *Xanthorrhoea drummondii* high shrubland and a *Calytrix leschenaultia*, (*Hibbertia subvaginata*) low open shrubland. A third plant community included an *Allocasuarina campestris* high open shrubland.

Vegetation Association AhRm: *Allocasuarina huegeliana* low open forest over *Regelia megacephala*, *Allocasuarina campestris* high open shrubland.

This vegetation was recorded on the crest and slopes of two neighbouring ridges in the central western part of the Cairn Hill survey area. The vegetation association included two plant communities, with one occurring on the ridge slopes and including a *Kunzea praestans* high shrubland.

Vegetation Association AhRmAc: Allocasuarina huegeliana low open woodland over Regelia megacephala, Allocasuarina campestris open scrub over Ricinocarpos muricatus scattered shrubs to open shrubland

This vegetation was recorded on the low rocky chert ridges within the area north of Kiaka Road. One vegetation community was recorded with Ricinocarpos muricatus as a shrub layer.

Vegetation Association AhTl: *Allocasuarina huegeliana* low woodland to low open forest over *Trymalium ledifolium* ver. *rosmarinifolium, Hibbertia subvaginata* scattered shrubs to low open shrubland over scattered sedges and grasses, with *Xanthosia fruticulosa* very open herbland and *Cheilanthes adiantoides* scattered ferns.

This vegetation association consisted of two plant communities, which occurred on three breakaways at Cairn Hill and Eastern Ridge. The plant community at Cairn Hill was an *Allocasuarina huegeliana* low open forest over *Trymalium ledifolium* var. *rosmarinifolium* scattered shrubs.

Vegetation Association AhXd: *Allocasuarina huegeliana* low open woodland to low woodland over *Xanthorrhoea drummondii* scattered tall shrubs to high open shrubland over scattered low shrubs including *Trymalium ledifolium* ver. *rosmarinifolium* and *Hibbertia subvaginata* shrubs.

Five plant communities were included in this vegetation association. They varied in the shrub subdominants. One plant community was recorded from rocky slopes and included *Trymalium ledifolium* ver. *rosmarinifolium* scattered shrubs to low open shrubland. Another included a *Hibbertia subvaginata* low open shrubland. A third included an *Opercularia vaginata* open herbland.

Vegetation Alliance 10: *Casuarina obesa* open forest

Vegetation Association Co: Casuarina obesa open forest.

This vegetation association included one plant community that was described from one stand which occurred on the valley floor flats at the base of a low ridge.

Vegetation Alliance 11: *Acacia acuminata* low woodlands to low open forests

Acacia acuminata subsp. *acuminata* formed stands of low woodlands to low open forests in mainly small areas along the lower slopes of ridges. It commonly occurred with *Allocasuarina huegeliana* throughout the survey area.

Vegetation Association Aa: *Acacia acuminata* subsp. *acuminata* low open forest over scattered grasses sedges and very open herbland.

This vegetation association was made up of three plant communities. One plant community was distinguished by having *Allocasuarina huegeliana* present in the tree layer. Another plant community was distinguished by having a *Xanthorrhoea drummondii* high open shrubland.

Vegetation Association AaAc: *Acacia acuminata* subsp. *acuminata* low woodland over *Allocasuarina campestris* scattered tall shrubs to high open shrubland over very open herbland.

This vegetation association was made up of three plant communities. One plant community differed by having *Allocasuarina huegeliana* present in the tree layer. Another plant community was distinguished by having *Allocasuarina huegeliana* present in the tree layer and a *Xanthorrhoea drummondii* high open shrubland.

Vegetation Association AaDs: Acacia acuminata subsp. acuminata, Allocasuarina huegeliana low woodland over Dryandra sessilis var. sessilis (Xanthorrhoea drummondii) scattered tall shrubs over very open herbland.

Two plant communities were included in this vegetation association. One was distinguished by the presence of an Opercularia vaginata herbland.

Vegetation Association AaDsKp: *Acacia acuminata* subsp. *acuminata* low woodland over *Dryandra sessilis var. sessilis (Xanthorrhoea drummondii*) scattered tall shrubs over *Kunzea praestans* scattered tall shrubs to high open shrubland over very open herbland.

There were two plant communities in this vegetation association which differed in the shrub layer species. One plant community had *Hibbertia vaginata* scattered low shrubs while the other plant community had a *Melaleuca calyptroides* open shrubland.

Vegetation Association AaEl: *Acacia acuminata* subsp. *acuminata, Eucalyptus loxophleba* subsp. *loxophleba* low woodland to low open forest over very open grassland/herbland.

This vegetation association included three plant communities. One plant community was distinguished by the presence of *Allocasuarina campestris* scattered tall shrubs while another plant community had scattered *Xanthorrhea drummondii* and *Olearia dampieri* subsp. *eremicola* in the shrub layer.

Vegetation Association AaHr: *Acacia acuminata* subsp. *acuminata, (Eucalyptus loxophleba* subsp. *loxophleba*) scattered low trees over *Hakea recurva subsp. recurva* scattered tall shrubs to high open shrubland over very open herbland.

There were two plant communities in this vegetation association. One plant community differed by having an *Allocasuarina campestris* scattered tall shrubs component and a *Dodonaea pinifolia* low open shrubland over *Stenanthemum tridentatum* scattered low shrubs

Vegetation Association AaHs: Acacia acuminata subsp. acuminata, Allocasuarina huegeliana, (Eucalyptus loxophleba subsp. loxophleba) low woodland over Allocasuarina campestris scattered tall shrubs over Hibbertia subvaginata low open shrubland to low shrubland.

There was one plant community in this vegetation association. It was only recorded on the Eastern Ridge and is similar to the unit AhHs.

Vegetation Association AaKp: *Acacia acuminata* subsp. *acuminata, Allocasuarina huegeliana* low woodland to low open forest over *Kunzea praestans* scattered tall shrubs to high open shrubland over very open herbland.

There were two plant communities in this vegetation association. One plant community was differentiated by having *Allocasuarina campestris* and *Xanthorrhoea drummondii* in the high open shrubland layer.

Vegetation Association AaMcor: (*Eucalyptus wandoo* scattered trees) over *Acacia acuminata* subsp. *acuminata* scattered low trees over *Melaleuca coronicarpa* low open shrubland over very open herbland.

One plant community, recorded from a small stand at the southern corner of Gardiner's Hill, was included in this vegetation association.

Vegetation Association AaMr: *Acacia acuminata* subsp. *acuminata, Allocasuarina huegeliana* low woodland over *Melaleuca radula* scattered tall shrubs to high shrubland.

Two plant communities were included in this vegetation association, one distinguished by having an *Allocasuarina campestris* high shrubland.

Vegetation Association AaTl: Acacia acuminata subsp. acuminata scattered low trees over Trymalium ledifolium var. rosmarinifolium open shrubland.

One plant community was included in this vegetation association.

Vegetation Alliance 12: *Banksia prionotes* scattered low trees.

Vegetation Association Bp: *Banksia prionotes* scattered low trees over *Dryandra sessilis* var. *sessilis* scattered tall shrubs to high open shrubland.

Two plant communities were included in this vegetation association. One plant community was recorded near the head of a gully between low ridges, just east of Cairn Hill. The other plant community was quite different and recorded on the crest of a low rise a few hundred meters to the north-east.

Vegetation Alliance 13: *Allocasuarina campestris* high shrublands to open and closed scrub

Allocasuarina campestris formed high shrublands to open and closed scrubs extensively throughout the survey area. They were most common on lower slopes around and between the low chert ridges and on parts of the ridges where there was deeper soil over the underlying rock and probably where the underlying rock was more fractured and penetrable.

The *Allocasuarina campestris* scrub often grew with no tree layer in the survey area. Stands of *Allocasuarina campestris* scrub varied throughout the survey area with the presence and species composition of low woodlands and with associated plant species that varied in some part with sub-areas of the survey area and with habitat.

Vegetation Association Ac: *Allocasuarina campestris* open to closed scrub over scattered sedges/grasses/herbs.

There were eight plant communities in this vegetation association. They differed mainly in the presence and composition of a tree layer (scattered low trees to low open woodland) and the species of associated scattered low shrubs. One plant community differed by having an *Acacia acuminata* subsp. *acuminata* scattered low trees to low open woodland strata. Another had a *Eucalyptus loxophleba* subsp. *loxophleba*, (*Acacia acuminata* subsp. *acuminata*, *Allocasuarina huegeliana*) scattered low trees to low open woodland layer. Another differed by having an *Allocasuarina huegeliana*, (*Acacia acuminata* subsp. *acuminata*) scattered low trees to low open woodland layer. Different shrub and low shrub species that were present (scattered) in different plant communities were *Calytrix depressa*, *Dryandra fraseri*, *Hibbertia subvaginata* and *Melaleuca calyptroides*.

Vegetation Association AcAa: Acacia acuminata subsp. acuminata, Allocasuarina huegeliana low woodland over Allocasuarina campestris high open shrubland to high shrubland.

There was one plant community in this vegetation association.

Vegetation Association AcAh: *Allocasuarina huegeliana*, (*Acacia acuminata* subsp. *acuminata*) low open woodland to low open forest over *Allocasuarina campestris* high open shrubland to open to closed scrub.

There were two plant communities included in this vegetation association. They differed in the *Allocasuarina huegeliana* cover and *Allocasuarina campestris* cover.

Vegetation Association AcAhu: *Dryandra sessilis* var. sessilis scattered tall shrubs over *Allocasuarina campestris*, *Allocasuarina humilis* open scrub over *Hibbertia subvaginata* shrubland.

One plant community was included in this vegetation association. It occurred on a steep, lower to mid slope of a low chert ridge.

Vegetation Association AcAs: *Acacia scirpifolia*, *Acacia saligna* high open shrubland over *Allocasuarina campestris*, (*Calothamnus* aff. *quadrifidus* (Moora-Watheroo)) closed scrub over *Melaleuca calyptroides*, *Acacia congesta* subsp. *congesta* open shrubland.

There was one plant community included in this vegetation association. It was recorded in Cairn Hill from one stand on a broad valley floor, with no defined drainage line. The likelihood of recording other areas of this vegetation unit would have been much reduced by the clearing of much of that habitat in the survey area for gravel mining (in Cairn Hill Reserve) and for pasture and cropping.

Vegetation Association AcB: *Allocasuarina campestris* open scrub over *Baeckea* sp. Moora (R. Bone 1993/1) low open shrubland to open heath.

Four plant communities were included in this vegetation association. One plant community that was recorded on lower slopes, differed by having *Melaleuca radula*, *Baeckea* sp. Moora (R. Bone 1993/1) scattered shrubs to open shrubland under an *Allocasuarina campestris* open scrub. Another plant community was recorded at three sites on the broad top of a low ridge in Cairn Hill and Cairn Hill North and was differentiated by having a strata of scattered *Allocasuarina huegeliana* low trees over *Dryandra sessilis* var. *sessilis* scattered tall shrubs. Another differed by having a *Baeckea* sp. Moora (R. Bone 1993/1), *Melaleuca calyptroides* (open) shrubland to open heath under an *Allocasuarina campestris* closed scrub.

Vegetation Association AcCq: *Allocasuarina campestris*, *Calothamnus* aff. *quadrifidus* (Moora-Watheroo) open to closed scrub.

There were three plant communities assigned to this vegetation association. One was differentiated by having a *Melaleuca calyptroides* scattered shrubs to open shrubland layer. Another plant community differed by having a had scattered *Astroloma serratifolium* and *Hakea lissocarpha* low shrub layer.

Vegetation Association AcDs: *Allocasuarina huegeliana*, (*Acacia acuminata* subsp. *acuminata*) low open woodland scattered low trees to low open woodland over *Dryandra sessilis* var. *sessilis* scattered tall shrubs to high open shrubland over *Allocasuarina campestris* open to closed scrub.

Four plant communities were included in this vegetation association. One was distinguished by the presence of *Kunzea praestans* in the open scrub layer. Another plant community differed by having a high open shrubland of *Xanthorrhoea drummondii*. Another plant community differed by having a high open shrubland of *Melaleuca radula* and *Xanthorrhoea drummondii*.

Vegetation Association AcEe: *Eucalyptus eudesmioides* scattered low mallees to low mallee woodland over *Allocasuarina campestris* open scrub over *Baeckea* sp. Moora (R. Bone 1993/1) scattered low shrubs to low shrubland.

This vegetation association included two plant communities. One differed from the generic description above by having *Kunzea praestans*, *Regelia megacephala* high shrubland component and a *Melaleuca calyptroides* open shrubland to shrubland component.

Vegetation Association AcEl: *Eucalyptus loxophleba* subsp. *loxophleba* low open woodland to low open forest over *Allocasuarina campestris* open scrub.

There were two plant communities included in this vegetation association. They differed in their *Eucalyptus loxophleba* subsp. *loxophleba* low tree cover, one having a low open woodland to low woodland of *Eucalyptus loxophleba* subsp. *loxophleba*, while the other had a *Eucalyptus loxophleba* subsp. *loxophleba* low open forest.

Vegetation Association AcEw: *Eucalyptus wandoo* subsp. *wandoo* low open woodland over *Allocasuarina campestris* open to closed scrub.

There were four plant communities included in this vegetation association. They tended to be intermediate vegetation units on the lower slopes of rocky ridges, adjacent to *Eucalyptus wandoo* subsp. *wandoo* woodlands down slope and *Allocasuarina campestris* open to closed scrubs. One of the four plant communities differed by having a *Calothamnus* aff. *quadrifidus* (Moora-Watheroo) high shrubland component. Another plant community differed by having an *Acacia acuminata* subsp. *acuminata*, (*Allocasuarina huegeliana*) scattered low trees to low open woodland layer. Another plant community was described from a breakaway rocky slope of a low ridge with scattered *Kunzea praestans* and *Melaleuca calyptroides* present and typical breakaway slope species present (*Xanthosia fruticulosa*, *Stypandra glauca* and *Trymalium ledifolium* subsp. *rosmarinifolium*).

Vegetation Association AcHa: *Allocasuarina campestris* scattered tall shrubs over *Hypocalymma angustifolium* low open shrubland over *Pityrodia dilatata* low open shrubland.

Two plant communities were included in this vegetation association. Each plant community was recorded from one small stand each. The two stands were adjacent to each other and were both on top of a very small, very low rocky rise. One plant community differed by having *Dryandra fraseri* and *Hakea lissocarpha* in the low open shrubland over a low open shrubland of *Acacia aristulata* with only scattered *Pityrodia dilatata.*

The specimen identified as *Hypocalymma angustifolium* is a poor match for most of the material under this name in the Western Australian Herbarium, but matches some material there.

Vegetation Association AcHs: *Allocasuarina campestris* open to closed scrub over *Hibbertia subvaginata* scattered low shrubs to low open shrubland.

Two plant communities were included in this vegetation association. One plant community differed by having a *Eucalyptus loxophleba* subsp. *loxophleba*, *Allocasuarina huegeliana*, (*Acacia acuminata* subsp. *acuminata*) low open woodland layer.

Vegetation Association AcId: Allocasuarina campestris open to closed scrub over Isopogon divergens open shrubland.

This vegetation association was mainly recorded on ridge tops or upper slopes in Cairn Hill. It included three plant communities. One differed by including a *Melaleuca calyptroides*, *Baeckea* sp. Moora (R. Bone 1993/1), (*Calothamnus sanguineus*) open shrubland to shrubland and *Calytrix leschenaultii*, *Dryandra fraseri* scattered low shrubs. Another plant community differed by having an *Allocasuarina huegeliana* scattered low tree layer along with a *Kunzea praestans* high open shrubland component and *Melaleuca calyptroides* shrubland over *Calytrix leschenaultii* scattered low shrubs.

Vegetation Association AcMr: *Allocasuarina huegeliana*, *Acacia acuminata* subsp. *acuminata* low open woodland to low woodland over *Allocasuarina campestris*, (*Melaleuca radula*) open scrub.

Three plant communities were included in this vegetation association. One differed by having an *Acacia acuminata* subsp. *acuminata* scattered low trees to low open woodland tree layer. Another plant community differed by having no tree layer and an *Allocasuarina campestris*, (*Calothamnus* aff. *quadrifidus* (Moora-Watheroo), *Melaleuca radula*) closed scrub.

Vegetation Association AcMs: *Acacia acuminata* subsp. *acuminata* scattered low trees over *Allocasuarina campestris* open to closed scrub over *Melaleuca sclerophylla* open shrubland.

One plant community was included in this vegetation association. It was described from a small stand on the south-west boundary of Gardiner's Hill.

Vegetation Association AcRm: *Regelia megacephala* high open shrubland to shrubland over *Allocasuarina campestris* open to closed scrub.

Four plant communities were included in this vegetation association. They were probably intermediate vegetation to *Regelia megacephala* scrub and *Allocasuarina campestris* scrub units. One plant community, which occurred on a chert breakaway, differed by having *Santalum acuminatum* low open woodland and included a *Calothamnus* aff. *quadrifidus* (Moora-Watheroo) high open shrubland. Another plant community differed by having an *Allocasuarina huegeliana* scattered low trees layer, a *Calothamnus* aff. *quadrifidus* (Moora-Watheroo), *Kunzea praestans* high shrubland component and *Melaleuca calyptroides* scattered shrubs. One vegetation community was recorded with *Ricinocarpos muricatus* as a shrub layer.

Vegetation Alliance 14: *Allocasuarina microstachya* open scrub.

Allocasuarina microstachya was only recorded at Gardiner's Hill. It formed an open scrub in a small area of hill crest.

Vegetation Association Am: *Allocasuarina huegeliana* scattered low trees over *Allocasuarina microstachya*, *Kunzea praestans* open scrub over *Calytrix leschenaultii*, *Calytrix depressa* scattered low shrubs over scattered sedges/grasses and open herbland.

One plant community was included in this vegetation association.

Vegetation Alliance 15: *Regelia megacephala* high shrubland to open and closed scrub

Regelia megacephala high shrubland to open and closed scrub occurred on the exposed chert slopes and sometimes crests of the chert ridges in the survey area. In places *Regelia* scrub stands occurred in low open woodlands and occurred with different associated tree and shrub species which varied depending on the area within the survey area.

Vegetation Association Rm: Regelia megacephala open scrub.

One plant community was included in this vegetation association. The condition at the recording site was Very Poor and so this plant community may be a consequence of the vegetation deterioration.

Vegetation Association RmAh: *Allocasuarina huegeliana* low open woodland to low open forest over *Regelia megacephala* open scrub over scattered sedges and herbs.

This vegetation was recorded from sites in Cairn Hill, Cairn Hill North and Gardiner's Hill. Four plant communities were included in this vegetation association. In one plant community, *Allocasuarina huegeliana* formed a low open forest over a *Regelia megacephala* open scrub on the lower slopes of a chert ridge in the north-east corner of Cairn Hill. Another plant community was differentiated by having *Kunzea praestans* high open shrubland and *Hibbertia subvaginata* low open shrubland.

Vegetation Association RmB: *Regelia megacephala*, (*Kunzea praestans*) open scrub over *Baeckea* sp. Moora (R. Bone 1993/1) low open shrubland.

This vegetation association included one plant community.

Vegetation Association RmDs: Regelia megacephala, (Dryandra sessilis var. sessilis) open scrub.

One plant community was included in this vegetation association.

Vegetation Association RmEe: *Eucalyptus eudesmioides* scattered low trees to low woodland over *Regelia megacephala* open to closed scrub.

Two plant communities were included in this vegetation association. One was distinguished by having a *Kunzea praestans* high shrubland and *Melaleuca calyptroides* scattered shrubs to open shrubland.

Vegetation Association RmHs: *Regelia megacephala* open scrub over *Hibbertia subvaginata* low open shrubland to low shrubland.

This vegetation association included three plant communities. One plant community differed by the presence of a low tree layer (scattered *Allocasuarina huegeliana*). Another plant community was differentiated by having a low tree layer (scattered *Acacia acuminata* subsp. *acuminata*, *Allocasuarina huegeliana*), an *Allocasuarina campestris* high open shrubland and *Hibbertia subvaginata* scattered shrubs.

Vegetation Association RmKp: *Regelia megacephala* high shrubland to open scrub over *Kunzea praestans* high open shrubland to open scrub over *Hibbertia subvaginata* scattered shrubs to low open shrubland.

This vegetation association included three plant communities. One plant community was a *Regelia megacephala* high shrubland over *Kunzea praestans* open scrub over very open herbland. The second plant community differed by having a lower cover of *Kunzea praestans* (high open shrubland to high shrubland) over *Hibbertia subvaginata* scattered shrubs. The third plant community had a *Regelia megacephala*, *Kunzea praestans* open scrub over *Hibbertia subvaginata* with *Ricinocarpus muricatus* as an associated species.

Vegetation Association RmKpMc: *Regelia megacephala* open to closed scrub and *Kunzea praestans* high open shrubland to open scrub over *Melaleuca calyptroides* open shrubland to shrubland over *Hibbertia subvaginata* low open shrubland.

This vegetation association included three plant communities. One plant communities structure included a *Kunzea praestans* high shrubland to open scrub and a *Melaleuca calyptroides* open shrubland. Another plant community only had a lower *Kunzea praestans* cover (high open shrubland) and a higher cover of *Melaleuca calyptroides* (open shrubland to shrubland). The third plant community differed by having *Allocasuarina campestris* in the scrub layer.

Vegetation Alliance 16: *Kunzea Praestans* high shrubland to open and closed scrub

Kunzea praestans grew as high shrublands and open scrubs on parts of the slopes and crests of the chert ridges. It commonly grew over *Hibbertia subvaginata* (low) open shrublands to (low) open heaths.

Vegetation Association KpAh: *Allocasuarina huegeliana* (*Acacia acuminata* subsp. *acuminata)* low open woodland to low woodland over *Kunzea praestans* high shrubland to open scrub over *Hibbertia subvaginata* scattered shrubs to low open shrubland.

This vegetation association includes one plant community. One plant community is differentiated by having an open heath of *Hibbertia subvaginata*.

Vegetation Association KpAhB: *Allocasuarina huegeliana* (*Acacia acuminata* subsp. *acuminata)* scattered trees to low open woodland over *Kunzea praestans* high shrubland to open scrub over shrubland including *Melaleuca calyptroides* and *Baeckea* sp. Moora (R. Bone 1993/1) scattered shrubs to open shrubland.

This vegetation was recorded from numerous locations at Cairn hill and Cairn Hill North where *Melaleuca calyptroides* and *Baeckea* sp. Moora (R. Bone 1993/1) were widespread. Three plant communities were included in the vegetation association. One plant community differed by having a strata of *Dryandra sessilis* var. *sessilis* high open shrubland and no *Melaleuca calyptroides* open shrubland. Another plant community was distinguished by having *Allocasuarina humilis* in the open scrub on a rocky chert slope.

Vegetation Association KpAhDs: Allocasuarina huegeliana (Acacia acuminata subsp. acuminata) scattered trees to low open woodland over Dryandra sessilis var. sessilis scattered tall shrubs over Kunzea praestans, (Xanthorrhoea drummondii) high shrubland to open scrub over Hibbertia subvaginata low open shrubland.

Three plant communities were included in this vegetation association. While one plant community had a *Kunzea praestans*, (*Xanthorrhoea drummondii*) high shrubland over *Hibbertia subvaginata* low open shrubland, another plant community differed by having a *Kunzea praestans*, (*Xanthorrhoea drummondii*) high open shrubland over *Hibbertia subvaginata* low heath. The third plant community differed by not having *Hibbertia subvaginata* in the low shrub layer.

Vegetation Association KpAhMc: *Allocasuarina huegeliana* (*Acacia acuminata* subsp. *acuminata)* scattered trees to low open woodland over *Kunzea praestans* open scrub over *Melaleuca calyptroides* open shrubland to shrubland.

This vegetation association included one plant community.

Vegetation Association KpDs: *Dryandra sessilis* var. *sessilis* high open shrubland over *Kunzea praestans* (*Xanthorrhoea drummondii*) open scrub over *Hibbertia subvaginata* scattered low shrubs.

One plant community was included in this vegetation association.

Vegetation Association KpDsMc: *Dryandra sessilis* var. *sessilis* scattered tall shrubs to high open shrubland over *Kunzea praestans* high shrubland to open scrub over *Melaleuca calyptroides* scattered shrubs to shrubland over *Hibbertia subvaginata* scattered low shrubs to low open shrubland.

Three plant communities were recorded in this vegetation association. One plant community differed by having a tree strata (*Allocasuarina huegeliana* (*Acacia acuminata* subsp. *acuminata)* scattered low trees to low woodland). Another plant community differed by having a *Xanthorrhoea drummondii* high open shrubland strata.

Vegetation Association KpEe: *Eucalyptus eudesmioides* low woodland over *Kunzea praestans* open scrub over *Melaleuca calyptroides* and *Baeckea* sp. Moora (R. Bone 1993/1) open shrubland.

This unit was recorded at Cairn Hill.

Vegetation Association KpHs: *Kunzea praestans* high shrubland to open scrub over *Hibbertia subvaginata* (low) open shrubland to (low) open heaths over scattered to very open sedgeland/grassland/herbland.

Two plant communities were included in this vegetation association. One of these differed by having *Allocasuarina campestris* in the open scrub.

Vegetation Association KpXd: *Xanthorrhoea drummondii* high open shrubland over *Kunzea praestans* high open shrubland.

One plant community was included in this vegetation association.

Vegetation Alliance 17: *Melaleuca calyptroides* open to closed heath

Most of the units of this vegetation were recorded on John Tonkin's and the Ridgway's properties.

Vegetation Association Mc: *Kunzea praestans* high open shrubland over *Melaleuca calyptroides* open to closed heath over *Hibbertia subvaginata, Calytrix leschenaultii* scattered low shrubs to low open shrubland.

Four plant communities were included in this vegetation association. One plant community differed by having a scattered *Dryandra sessilis* var. *sessilis* upper strata. Another differed by having a scattered *Dryandra sessilis* var. *sessilis* upper strata and a *Baeckea* sp. Moora (R. Bone 1993/1) open shrubland. The fourth plant community differed by having a low tree layer (*Allocasuarina huegeliana*, (*Acacia acuminata* subsp. *acuminata*) scattered low trees).

Vegetation Alliance 18: *Hibbertia subvaginata* low shrublands to low open heath

Hibbertia subvaginata commonly grew as scattered shrubs or low shrubland in association with *Regelia megacephala* and *Kunzea praestans* high shrublands and open scrubs. However, at a few site *Hibbertia subvaginata* grew as a low shrubland or open heath with no other dominants or under scattered trees. Most recordings of this unit were on the Eastern Ridge.

Vegetation Association Hs: Hibbertia subvaginata open heath.

This vegetation association included one plant community.

Vegetation Association HsAh: *Allocasuarina huegeliana* scattered trees over *Hibbertia subvaginata* (low open shrubland) open heath.

Three plant communities were included in this vegetation association. Two of these were recorded on rocky, south-facing slopes on the Eastern Ridge. One of these plant communities differed by having a *Pityrodia dilatata* low shrubland. The other was distinguished by its *Allocasuarina campestris* high open shrubland. The third plant community had *Kunzea praestans* scattered shrubs to open shrubland over *Hibbertia subvaginata* low open shrubland.

Vegetation Association HsDs: *Nuytsia floribunda* scattered low trees over *Dryandra sessilis* var. *sessilis* high open shrubland over *Hibbertia subvaginata* low shrubland.

One plant community was included in this vegetation association.

Vegetation Alliance 19: *Xanthorrhoea drummondii* high open shrubland

Vegetation Association Xd: *Xanthorrhoea drummondii* high open shrubland over grassland/herbland/sedgeland

One plant community was recorded in this vegetation association.

Vegetation Alliance 20: Miscellaneous heaths

Vegetation Alliance 20/1: *Dryandra sessilis* high shrubland to open scrub

Vegetation Association Ds: Dryandra sessilis var. sessilis, Xanthorrhoea drummondii high open shrubland over Allocasuarina campestris scattered tall shrubs.

There was one plant community in this vegetation association.

Vegetation Association DsHs: *Allocasuarina huegeliana*, (*Acacia acuminata*) scattered low trees to low open woodland over *Dryandra sessilis* var. *sessilis* high open shrubland to open scrub over *Hibbertia subvaginata* low shrubland.

There was one plant community in this vegetation association.

Vegetation Association DsKp: Dryandra sessilis var. sessilis high shrubland to open scrub over Kunzea praestans, Leptospermum erubescens high shrubland over Acacia pulchella, Baeckea aff. preissiana, Daviesia dielsii, Dryandra nivea ssp. nivea (narrow leaf, mound) Banksia sphaerocarpa low open shrubland.

There was one plant community in this vegetation association. This plant community was recorded on the gentle slopes of a broad low rise with some exposed chert.

Vegetation Alliance 20/2: *Melaleuca concreta* open scrub.

Vegetation Association Mco: *Eucalyptus loxophleba* subsp. *loxophleba, Acacia acuminata* subsp. *acuminata* scattered low trees over *Melaleuca concreta* open scrub over scattered low shrubs over scattered sedges.

Two plant communities were recorded in this vegetation association. One plant community occurred in a small area of a linear depression (?dyke) that occurred near the Cairn Hill North ridge crest. The other plant community occurred in a small area in the south-west corner of Gardiner's Hill and differed in not having a tree layer and having a *Melaleuca sclerophylla*, Olearia dampieri subsp. eremicola open shrubland.

Vegetation Alliance 20/3: *Melaleuca radula* high shrubland to open scrub

Vegetation Association Mr: Allocasuarina huegeliana, (Acacia acuminata subsp. acuminata) scattered low trees to low woodland over Melaleuca radula, (*Calothamnus* aff. *quadrifidus* (Moora-Watheroo), Xanthorrhoea drummondii) high shrubland to open scrub.

One plant community was included in this vegetation association, with all sites recorded at Gardiner's Hill.

Vegetation Alliance 20/4: *Melaleuca sclerophylla* open heath

Vegetation Association Ms: Melaleuca sclerophylla, (Grevillea sp. (GHR270-2)) open heath over Dodonaea pinifolia, Gastrolobium obovatum low open shrubland.

One plant community was included in this vegetation association. It was recorded from one small area in the south-west corner of Gardiner's Hill.

Vegetation Alliance 20/5: *Baeckea* sp. Moora (R. Bone 1993/1) low open heath

Vegetation Association B: *Allocasuarina huegeliana* scattered low trees to low open woodland over *Allocasuarina campestris*, (*Xanthorrhoea drummondii*) high open shrubland over *Baeckea* sp. Moora (R. Bone 1993/1), (*Calytrix leschenaultii*) low shrubland to low open heath.

One plant community was recorded in this vegetation association. It was recorded on the top of a low ridge in the Cairn Hill North area.

Vegetation Alliance 20/6: *Calytrix leschenaultii* open heath

Vegetation Association Cl: Allocasuarina campestris, Kunzea praestans scattered tall shrubs over Calytrix leschenaultii, (Hibbertia subvaginata) open heath.

One plant community was included in this vegetation association. One stand on a lower slope of a low chert ridge varied significantly by having a low open woodland of Eucalyptus wandoo subsp. wandoo, possibly indicating underlying doleritic soils.

Vegetation Association ClAh: Allocasuarina huegeliana, (Acacia acuminata subsp. acuminata) low open woodland to low woodland over Kunzea praestans, Xanthorrhoea drummondii high open shrubland over Calytrix leschenaultii open heath.

There were two plant communities in this vegetation association. One differed by having a Dryandra sessilis var. sessilis scattered tall shrub layer and a Hibbertia subvaginata low open shrubland component.

Vegetation Alliance 20/7: *Calytrix depressa* low open heath

Vegetation Association Cd: *Allocasuarina campestris* scattered tall shrubs over *Melaleuca radula*, *Grevillea* sp. (JTR270-2) open shrubland over *Calytrix depressa* low shrubland.

One plant community was recorded in this vegetation association. It was recorded on the slopes of a low ridge in Gardiner's Hill.

Vegetation Association CdAh: *Allocasuarina huegeliana* low woodland over *Allocasuarina campestris*, *Kunzea praestans*, *Xanthorrhoea drummondii* high open shrubland over *Baeckea* sp. Moora (R. Bone 1993/1) scattered shrubs over *Calytrix depressa* low open heath.

One plant community was recorded in this vegetation association. Very small areas of this plant community were recorded on the top of the low ridge at Cairn Hill North.

Vegetation Alliance 20/8: *Calothamnus* aff. *quadrifidus* (Moora-Watheroo) high shrubland

Vegetation Association CqMc (1): *Calothamnus* aff. *quadrifidus* (Moora-Watheroo) high shrubland over *Xanthorrhoea drummondii* scattered shrubs over *Melaleuca calyptroides* shrubland.

One plant community was included in this vegetation association.

Vegetation Association CqAh (1): *Allocasuarina huegeliana* scattered low trees over *Calothamnus* aff. *quadrifidus* (Moora-Watheroo), (*Kunzea praestans*, *Allocasuarina campestris*) high open shrubland to high shrubland over *Hibbertia subvaginata* scattered low shrubs to low open shrubland.

One plant community was included in this vegetation association.

Vegetation Alliance 20/9: *Ricinocarpus muricatus* shrubland to open heath

Vegetation Association Rmu: Allocasuarina huegeliana, Acacia acuminata subsp. acuminata low woodland to low open forest over Ricinocarpus muricatus shrubland to open heath.

One plant community was included in this vegetation association. It was described from the slopes of two low ridges in Ridgway's property, just north of Kiaka Rd.

Vegetation Alliance 20/10: *Ricinocarpus velutinus* open heath

Vegetation Association Rv: Allocasuarina huegeliana, Acacia acuminata subsp. acuminata low open woodland to low woodland over Allocasuarina campestris scattered tall shrubs over Xanthorrhoea drummondii scattered shrubs over Ricinocarpus velutinus open heath.

One plant community was included in this vegetation association. One stand of this plant community was recorded in a remnant vegetation block about 500 meters east of the southern end of the Eastern Ridge.

Vegetation Alliance 21: Other miscellaneous

Vegetation Alliance 21/1: *Lepidosperma pubisquameum* sedgeland

Vegetation Association Lp: *Xanthorrhoea drummondii* open shrubland over *Lepidosperma pubisquameum* sedgeland with an annual herbland and open annual grassland.

One plant community was included in this vegetation association. It occurred in one small area on the top of a low rocky ridge near the south end of Eastern Ridge.

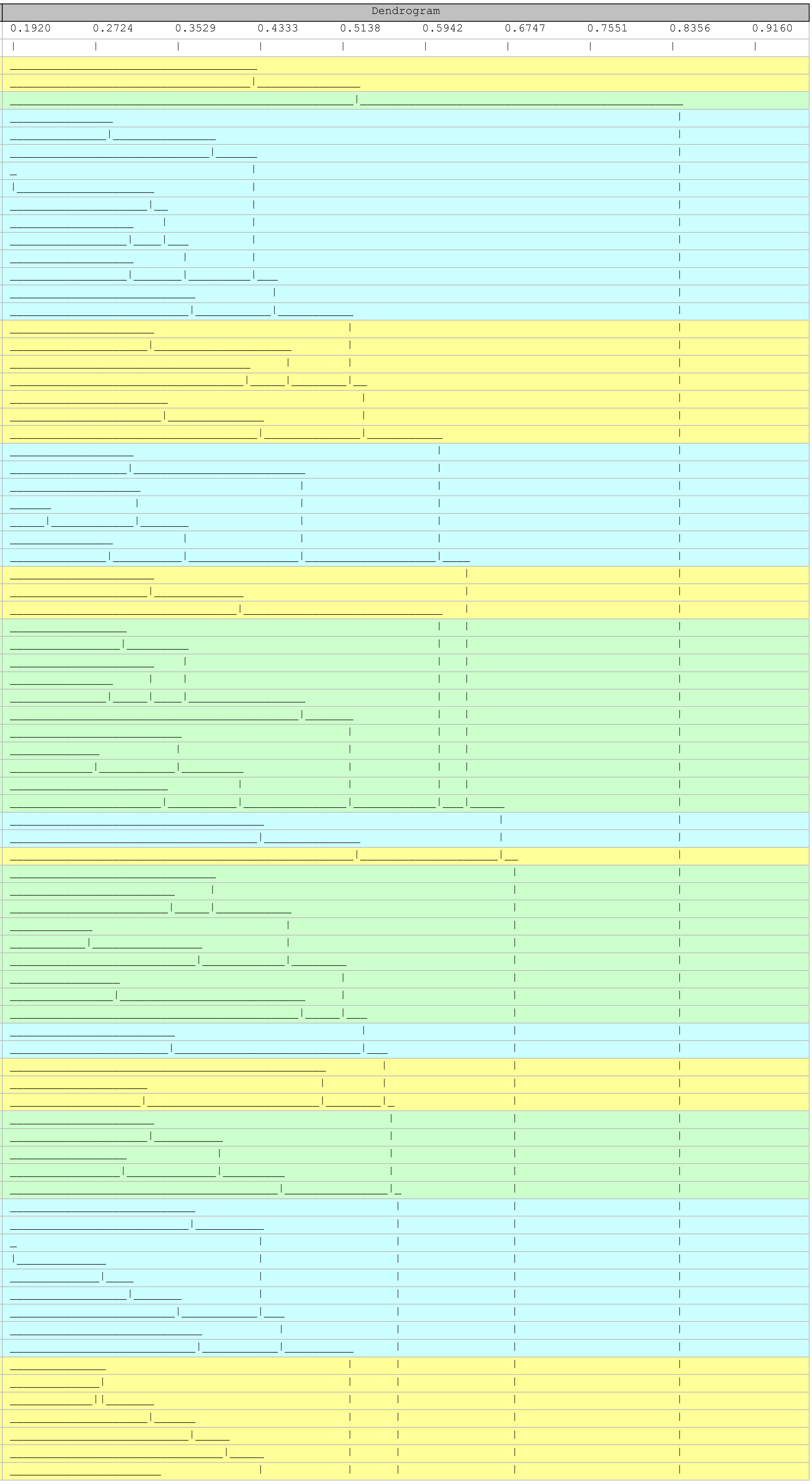
Vegetation Alliance 22: *Casuarina obesa* (*Eucalyptus loxophleba* subsp. *loxophleba*) low open forest

Vegetation Association CoAl.1: *Casuarina obesa* (*Eucalyptus loxophleba* subsp. *loxophleba*) low open forest over *Acacia ligustrina* and *Hakea preissii* high open shrubland over **Cynosurus echinatus* and **Vulpia myuros* closed annual grassland.

This alliance differed from the previous *Casuarina obesa* alliance as it contains an additional structural unit. One community was recorded in this vegetation association.

Dendrogram from the floristic analysis of the 88 quadrats from the 2006 report survey area

Notes: Based on all species (native and introduced). Gp10 and Gp20 are site classification numbers at the ten and twenty group classification levels respectively. The Gp 20 groups are coloured to allow them to be easily distinguished in the dendrogram.



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CAH001	1	1
CAH006	1	1
CAH018	1	2
CAH002	2	3
CAH005	2	3
CAH011	2	3
CHN002	2	3
CHN003	2	3
CHN006	2	3
CHN004	2	3
CHN008	2	3
CHN007	2	3
ERG014	2	3
WDM001	2	3
WOR002	2	3
CAH007	2	4
CAH015	2	4
CAH008	2	4
CAH013	2	4
CAH004	2	5
CAH017	2	5
CAH019	2	5
EOR002	3	6
EOR003	3	6
WOR001	3	6
WOR004	3	6
WOR005	3	6
WOR003	3	6
WOR006	3	6
GH001	4	7
GH003	4	7
GH002	4	7
JT001	5	8
JT008	5	8
JT003	5	8
JT007	5	8
JT011	5	8
JT010	5	8
JT002	5	8
JT005	5	8
JT009	5	8
JT004	5	8
JT006	5	8
CAH003	6	9
CAH009	6	9
CHN010	6	10
CAH010	7	11
GH005	7	11
GH009	7	11
GH004	7	11
GH008	7	11
GH010	7	11
ERG004	7	11
ERG016	7	11
GH007	7	11
CAH012	7	12
GH006	7	12
CHN001	7	13
WDM002	7	13
WDM003	7	13
ERG017	7	14
ERG019	7	14
ERG018	7	14
ERG020	7	14
ERG022	7	14
CHN005	7	15
EOR001	7	15
ERG002	7	15
ERG021	7	15
ERG009	7	15
ERG011	7	15
ERG003	7	15
ERG010	7	15
ERG012	7	15
ERG001	7	16
ERG005	7	16
ERG007	7	16
ERG013	7	16
ERG008	7	16
ERG006	7	16
ERG015	7	16

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<tr><td>CAH020</td><td>9</td><td>19</td><td>____ | |</td></tr>
<tr><td>JT012</td><td>10</td><td>20</td><td>____ | | |</td></tr>
<tr><td>SW1</td><td>10</td><td>20</td><td>____|_____________|_______________|_______________________________|</td></tr>
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Appendix F

Desktop Database searches

Australian Government

Department of Climate Change, Energy, the Environment and Water

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected. Please see the caveat for interpretation of information provided here.

Report created: 09-Feb-2023

Summary

Matters of National Environment Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance (Ramsar	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	2
Listed Threatened Species:	33
Listed Migratory Species:	6

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at https://www.dcceew.gov.au/parks-heritage/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Lands:	1
Commonwealth Heritage Places:	None
Listed Marine Species:	12
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	None
Habitat Critical to the Survival of Marine Turtles:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have

State and Territory Reserves:	2
Regional Forest Agreements:	None
Nationally Important Wetlands:	None
EPBC Act Referrals:	2
Key Ecological Features (Marine):	None
Biologically Important Areas:	None
Bioregional Assessments:	None
Geological and Bioregional Assessments:	None

Details

Matters of National Environmental Significance

Listed Threatened Ecological Communities [Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.
Status of Vulnerable, Disallowed and Ineligible are not MNES under the EPBC Act.

Community Name	Threatened Category	Presence Text	Buffer Status
Banksia Woodlands of the Swan Coastal Plain ecological community	Endangered	Community likely to occur within area	In buffer area only
Eucalypt Woodlands of the Western Australian Wheatbelt	Critically Endangered	Community likely to occur within area	In feature area

Listed Threatened Species [Resource Information]

Status of Conservation Dependent and Extinct are not MNES under the EPBC Act.
Number is the current name ID.

Scientific Name	Threatened Category	Presence Text	Buffer Status
BIRD			
Calidris ferruginea			
Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area	In feature area
Falco hypoleucos			
Grey Falcon [929]	Vulnerable	Species or species habitat may occur within area	In feature area
Leipoa ocellata			
Malleefowl [934]	Vulnerable	Species or species habitat likely to occur within area	In feature area
Rostratula australis			
Australian Painted Snipe [77037]	Endangered	Species or species habitat likely to occur within area	In feature area
Zanda latirostris listed as Calyptorhynchus latirostris			
Carnaby's Black Cockatoo, Short-billed Black-cockatoo [87737]	Endangered	Species or species habitat known to occur within area	In feature area
FISH			

Scientific Name	Threatened Category	Presence Text	Buffer Status
Nannatherina balstoni			
Balston's Pygmy Perch [66698]	Vulnerable	Species or species habitat likely to occur within area	In buffer area only
MAMMAL			
Dasyurus geoffroii			
Chuditch, Western Quoll [330]	Vulnerable	Species or species habitat may occur within area	In feature area
PLANT			
Acacia aristulata			
Watheroo Wattle [64822]	Endangered	Species or species habitat known to occur within area	In feature area
Acacia cochlocarpa subsp. cochlocarpa			
Spiral-fruited Wattle [23877]	Endangered	Species or species habitat may occur within area	In buffer area only
Andersonia gracilis			
Slender Andersonia [14470]	Endangered	Species or species habitat may occur within area	In feature area
Banksia fuscobractea			
Dark-bract Banksia [83059]	Critically Endangered	Species or species habitat may occur within area	In buffer area only
Caladenia drakeoides			
Hinged Dragon Orchid [68687]	Endangered	Species or species habitat may occur within area	In buffer area only
Chamelaucium lullfitzii listed as Chamelaucium sp. Gingin (N.G.Marchant 6)			
Gingin Wax [92777]	Endangered (listed as Chamelaucium sp. Gingin	Species or species habitat may occur within area	In buffer area only
Chorizema humile			
Prostrate Flame Pea [32573]	Endangered	Species or species habitat may occur within area	In feature area
Conospermum densiflorum subsp. unicephalatum			
One-headed Smokebush [64871]	Endangered	Species or species habitat known to occur within area	In feature area
Dasymalla axillaris			
Native Foxglove [38829]	Critically Endangered	Species or species habitat may occur within area	In feature area

Scientific Name	Threatened Category	Presence Text	Buffer Status
Daviesia dielsii Diels' Daviesia [19617]	Endangered	Species or species habitat known to occur within area	In feature area
Eleocharis keigheryi Keighery's Eleocharis [64893]	Vulnerable	Species or species habitat may occur within area	In buffer area only
Eremophila scaberula Rough Emu Bush [16729]	Endangered	Species or species habitat likely to occur within area	In feature area
Eucalyptus crispata Yandanooka Mallee [24268]	Vulnerable	Species or species habitat may occur within area	In buffer area only
Eucalyptus leprophloia Scaly Butt Mallee, Scaly-butt Mallee [56712]	Endangered	Species or species habitat may occur within area	In buffer area only
Eucalyptus pruiniramis Midlands Gum, Jingymia Gum [56403]	Endangered	Species or species habitat likely to occur within area	In buffer area only
Eucalyptus rhodantha Rose Mallee [9362]	Vulnerable	Species or species habitat likely to occur within area	In buffer area only
Frankenia conferta Silky Frankenia [6074]	Endangered	Species or species habitat may occur within area	In buffer area only
Gastrolobium appressum Scale-leaf Poison [7358]	Vulnerable	Species or species habitat may occur within area	In buffer area only
Gastrolobium hamulosum Hook-point Poison [9212]	Endangered	Species or species habitat likely to occur within area	In feature area
Goodenia arthrotricha [12448]	Endangered	Species or species habitat known to occur within area	In feature area

Scientific Name	Threatened Category	Presence Text	Buffer Status
Grevillea christineae Christine's Grevillea [64520]	Endangered	Species or species habitat likely to occur within area	In feature area
Grevillea pythara Pythara Grevillea [64525]	Endangered	Species or species habitat may occur within area	In buffer area only
Hemiandra gardneri Red Snakebush [7945]	Endangered	Species or species habitat known to occur within area	In feature area
Synaphea quartzitica Quartz-loving Synaphea [64978]	Endangered	Species or species habitat known to occur within area	In feature area
REPTILE			
Egernia stokesii badia Western Spiny-tailed Skink, Baudin Island Spiny-tailed Skink [64483]	Endangered	Species or species habitat may occur within area	In feature area
SPIDER			
Idiosoma nigrum Shield-backed Trapdoor Spider, Black Rugose Trapdoor Spider [66798]	Vulnerable	Species or species habitat likely to occur within area	In feature area

Listed Migratory Species [Resource Information]

Scientific Name	Threatened Category	Presence Text	Buffer Status
Migratory Marine Birds			
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area	In feature area
Migratory Terrestrial Species			
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area	In feature area
Migratory Wetlands Species			
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area	In feature area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area	In feature area

Scientific Name	Threatened Category	Presence Text	Buffer Status
Calidris ferruginea			
Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area	In feature area
Calidris melanotos			
Pectoral Sandpiper [858]		Species or species habitat may occur within area	In feature area

Other Matters Protected by the EPBC Act

Commonwealth Lands [Resource Information]

The Commonwealth area listed below may indicate the presence of Commonwealth land in this vicinity. Due to the unreliability of the data source, all proposals should be checked as to whether it impacts on a Commonwealth area, before making a definitive decision. Contact the State or Territory government land department for further information.

Commonwealth Land Name	State	Buffer Status
Unknown		
Commonwealth Land - [50914]	WA	In buffer area only

Listed Marine Species [Resource Information]

Scientific Name	Threatened Category	Presence Text	Buffer Status
Bird			
Actitis hypoleucos			
Common Sandpiper [59309]		Species or species habitat may occur within area	In feature area
Apus pacificus			
Fork-tailed Swift [678]		Species or species habitat likely to occur within area overfly marine area	In feature area
Bubulcus ibis as Ardea ibis			
Cattle Egret [66521]		Species or species habitat may occur within area overfly marine area	In feature area
Calidris acuminata			
Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area	In feature area
Calidris ferruginea			
Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area overfly marine area	In feature area

Scientific Name	Threatened Category	Presence Text	Buffer Status
Calidris melanotos			
Pectoral Sandpiper [858]		Species or species habitat may occur within area overfly marine area	In feature area
Chalcites osculans as Chrysococcyx osculans			
Black-eared Cuckoo [83425]		Species or species habitat likely to occur within area overfly marine area	In feature area
Haliaeetus leucogaster			
White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area	In feature area
Merops ornatus			
Rainbow Bee-eater [670]		Species or species habitat may occur within area overfly marine area	In feature area
Motacilla cinerea			
Grey Wagtail [642]		Species or species habitat may occur within area overfly marine area	In feature area
Rostratula australis as Rostratula benghalensis (sensu lato)			
Australian Painted Snipe [77037]	Endangered	Species or species habitat likely to occur within area overfly marine area	In feature area
Thinornis cucullatus as Thinornis rubricollis			
Hooded Plover, Hooded Dotterel [87735]		Species or species habitat may occur within area overfly marine area	In buffer area only

Extra Information

State and Territory Reserves

[Resource Information]

Protected Area Name	Reserve Type	State	Buffer Status
Manaling	Nature Reserve	WA	In buffer area only
Unnamed WA47694	Nature Reserve	WA	In buffer area only

EPBC Act Referrals

[Resource Information]

Title of referral	Reference	Referral Outcome	Assessment Status	Buffer Status

Title of referral	Reference	Referral Outcome	Assessment Status	Buffer Status
North Kiaka Project Quartzite Mine Expansion	2021/9089		Assessment	In feature area
Not controlled action				
Improving rabbit biocontrol: releasing another strain of RHDV, sthrn two thirds of Australia	2015/7522	Not Controlled Action	Completed	In feature area

Caveat

1 PURPOSE

This report is designed to assist in identifying the location of matters of national environmental significance (MNES) and other matters protected by the Environment Protection and Biodiversity Conservation Act 1999 (Cth) (EPBC Act) which may be relevant in determining obligations and requirements under the EPBC Act.

The report contains the mapped locations of:

- World and National Heritage properties;
- Wetlands of International and National Importance;
- Commonwealth and State/Territory reserves;
- distribution of listed threatened, migratory and marine species;
- listed threatened ecological communities; and
- other information that may be useful as an indicator of potential habitat value.

2 DISCLAIMER

This report is not intended to be exhaustive and should only be relied upon as a general guide as mapped data is not available for all species or ecological communities listed under the EPBC Act (see below). Persons seeking to use the information contained in this report to inform the referral of a proposed action under the EPBC Act should consider the limitations noted below and whether additional information is required to determine the existence and location of MNES and other protected matters.

Where data are available to inform the mapping of protected species, the presence type (e.g. known, likely or may occur) that can be determined from the data is indicated in general terms. It is the responsibility of any person using or relying on the information in this report to ensure that it is suitable for the circumstances of any proposed use. The Commonwealth cannot accept responsibility for the consequences of any use of the report or any part thereof. To the maximum extent allowed under governing law, the Commonwealth will not be liable for any loss or damage that may be occasioned directly or indirectly through the use of, or reliance

3 DATA SOURCES

Threatened ecological communities

For threatened ecological communities where the distribution is well known, maps are generated based on information contained in recovery plans, State vegetation maps and remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species

Threatened, migratory and marine species distributions have been discerned through a variety of methods. Where distributions are well known and if time permits, distributions are inferred from either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc.) together with point locations and described habitat; or modelled (MAXENT or BIOCLIM habitat modelling) using

Where little information is available for a species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc.).

In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More detailed distribution mapping methods are used to update these distributions

4 LIMITATIONS

The following species and ecological communities have not been mapped and do not appear in this report:

- threatened species listed as extinct or considered vagrants;
- some recently listed species and ecological communities;
- some listed migratory and listed marine species, which are not listed as threatened species; and
- migratory species that are very widespread, vagrant, or only occur in Australia in small numbers.

The following groups have been mapped, but may not cover the complete distribution of the species:

- listed migratory and/or listed marine seabirds, which are not listed as threatened, have only been mapped for recorded
- seals which have only been mapped for breeding sites near the Australian continent

The breeding sites may be important for the protection of the Commonwealth Marine environment.

Refer to the metadata for the feature group (using the Resource Information link) for the currency of the information.

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact us page.

Department of Climate Change, Energy, the Environment and Water
GPO Box 3090
Canberra ACT 2601 Australia
+61 2 6274 1111

Appendix G

Vouchered specimens

Specimens vouchered from collections on the Coomberdale Chert TEC

More the 200 specimens have been vouchered from the studies of the Coomberdale threatened Ecological Community vegetation and flora. The list is incomplete as Priority Flora records were not delivered in the ALA occurrence download (some have been entered manually).

Note that since 2018 some *Lepidosperma* collections have been redetermined at the Western Australian Herbarium simply to genus (rather than the names originally vouchered as). This reflects the problem that *Lepidosperma* is notoriously poorly understood taxonomically. See limitations section.

Notes: All the specimens are held at the Western Australian Herbarium. Data derived from the following The Australasian Virtual Herbarium download: Atlas of Living Australia occurrence download. *Accessed on 03 February 2024.*

Table 8.2 Species vouchered from collections made for surveys of Coomberdale Chert TEC by M.E. Trudgen & Associates

Botanist	Voucher #	Species Name	Family
Morgan, B.	BM 142	Acacia daphnifolia	Fabaceae
Henson, M.	MJH 72	Acacia erinacea	Fabaceae
Henson, M.	MJH 71	Acacia hemiteles	Fabaceae
Henson, M.	MJH 70	Acacia hemiteles	Fabaceae
Morgan, B.	BM 143	Acacia hemiteles	Fabaceae
Henson, M.	MJH 16	Acacia lasiocarpa var. sedifolia	Fabaceae
Trudgen, M.	MET 21228	Acacia lasiocarpa var. sedifolia	Fabaceae
Henson, M.	MJH 68	Acacia scirpifolia	Fabaceae
Morgan, B.	BM 49	Acacia stenoptera	Fabaceae
Morgan, B.	BM 48	Acacia stenoptera	Fabaceae
Henson, M.	MJH 31	Aira elegantissima	Poaceae
Henson, M.	MJH 30	Aira elegantissima	Poaceae
Morgan, B.	BM 45	Allocasuarina campestris	Casuarinaceae
Morgan, B.	BM 44	Allocasuarina campestris	Casuarinaceae
Morgan, B.	BM 42	Allocasuarina campestris	Casuarinaceae
Morgan, B.	BM 43	Allocasuarina campestris	Casuarinaceae
Trudgen, M.	21234	Allocasuarina campestris	Casuarinaceae
Morgan, B.	BM 30	Alyogyne sp. Hutt River (B.J.Lepschi & T.R.Lally 2310)	Malvaceae
Trudgen, M.	MET 21203	Amphipogon caricinus var. caricinus	Poaceae
Trudgen, M.	MET 21204	Amphipogon caricinus var. caricinus	Poaceae
Morgan, B.	BM 35	Aristida contorta	Poaceae
Henson, M.	MJH 35	Aristida holathera var. holathera	Poaceae
Morgan, B.	BM 35	Banksia fraseri	Proteaceae

Botanist	Voucher #	Species Name	Family
Morgan, B.	BM 148	Banksia sphaerocarpa var. sphaerocarpa	Proteaceae
Henson, M.	MJH 24	Blennospora drummondii	Asteraceae
Trudgen, M.E.	MET 21227	Bossiaea moylei	Fabaceae
Trudgen, M.E.	MET 21226	Bossiaea moylei	Fabaceae
Trudgen, M.E.	MET 21225	Bossiaea moylei	Fabaceae
Morgan, B.	BM 50	Bossiaea moylei	Fabaceae
Morgan, B.	BM 50	Bossiaea moylei	Fabaceae
Henson, M.	MJH 2-28	Bossiaea moylei	Fabaceae
Morgan, B.	BMor 63	Blennospora drummondii	Asteraceae
Trudgen, M.	21215	Borya sphaerocephala	Boryaceae
Trudgen, M.	MET 21205	Brachypodium distachyon	Poaceae
Morgan, B.	BM 87	Bromus rubens	Poaceae
Henson, M.	MJH 47	Calothamnus quadrifidus subsp. angustifolius	Myrtaceae
Morgan, B.	s.n.	Calothamnus quadrifidus subsp. angustifolius	Myrtaceae
Morgan, B.	BM 122	Calothamnus quadrifidus subsp. angustifolius	Myrtaceae
Trudgen, M.	MET 21178	Calothamnus quadrifidus subsp. angustifolius	Myrtaceae
Trudgen, M.	MET 21182	Calothamnus quadrifidus subsp. angustifolius	Myrtaceae
Trudgen, M.	MET 21185	Calytrix depressa	Myrtaceae
Henson, M.	MJH 45	Calytrix leschenaultii	Myrtaceae
Morgan, B.	BM 119	Calytrix leschenaultii	Myrtaceae
Morgan, B.	BM 120	Calytrix leschenaultii	Myrtaceae
Morgan, B.	BM 118	Calytrix leschenaultii	Myrtaceae
Trudgen, M.	MET 21184	Calytrix leschenaultii	Myrtaceae
Henson, M.	MJH 12	Cassytha pomiformis	Lauraceae
Henson, M.	MJH 28	Centrolepis pilosa	Centrolepidaceae
Trudgen, M.	21213	Chamaescilla corymbosa	Asparagaceae
Henson, M.	MJH 39	Cheilanthes distans	Pteridaceae
Trudgen, M.	21223	Comesperma integerrimum	Polygalaceae
Trudgen, M.	21224	Comesperma integerrimum	Polygalaceae
Morgan, B.	BM 41	Crassula colorata var. acuminata	Crassulaceae
Trudgen, M.	21236	Crassula colorata var. acuminata	Crassulaceae
Henson, M.	MJH 8	Cryptandra myriantha	Rhamnaceae

Botanist	Voucher #	Species Name	Family
Henson, M.	MJH 7	Cryptandra myriantha	Rhamnaceae
Henson, M.	MJH 21	Cyanothamnus ramosus subsp. anethifolius	Rutaceae
Henson, M.	MJH 65	Cyanothamnus ramosus subsp. anethifolius	Rutaceae
Morgan, B.	BM 55	Cyanothamnus ramosus subsp. anethifolius	Rutaceae
Morgan, B.	BM 130	Daucus glochidiatus	Apiaceae
Morgan, B.	BM 52	Daviesia hakeoides subsp. subnuda	Fabaceae
Morgan, B.	BM 141	Daviesia hakeoides subsp. subnuda	Fabaceae
Morgan, B.	BM 73	Desmocladus asper	Restionaceae
Morgan, B.	BM 74	Desmocladus asper	Restionaceae
Morgan, B.	BM 72	Desmocladus asper	Restionaceae
Trudgen, M.	MET 21210	Desmocladus asper	Restionaceae
Henson, M.	MJH 27	Dianella revoluta var. divaricata	Hemerocallidaceae
Henson, M.	MJH 27	Dianella revoluta var. divaricata	Hemerocallidaceae
Morgan, B.	BM 68	Dichopogon capillipes	Asparagaceae
Trudgen, M.	21216	Dichopogon capillipes	Asparagaceae
Morgan, B.	BM 56	Dioscorea hastifolia	Dioscoreaceae
Morgan, B.	BM 57	Dioscorea hastifolia	Dioscoreaceae
Morgan, B.	BM 58	Dioscorea hastifolia	Dioscoreaceae
Henson, M.	MJH 79	Dodonaea inaequifolia	Sapindaceae
Morgan, B.	BM 29	Dodonaea pinifolia	Sapindaceae
Morgan, B.	BM 149	Dodonaea pinifolia	Sapindaceae
Henson, M.	MJH 13	Drosera hirsuta	Droseraceae
Henson, M.	MJH 14	Drosera hirsuta	Droseraceae
Trudgen, M.	21231	Drosera hirsuta	Droseraceae
Trudgen, M.	21233	Drosera sp. Branched styles (S.C.Coffey 193)	Droseraceae
Trudgen, M.	21232	Drosera sp. Branched styles (S.C.Coffey 193)	Droseraceae
Henson, M.	MJH 34	Ehrharta longiflora	Poaceae
Trudgen, M.	MET 21206	Ehrharta longiflora	Poaceae
Henson, M.	MJH 59	Eucalyptus eudesmioides	Myrtaceae
Henson, M.	MJH 46	Eucalyptus eudesmioides	Myrtaceae
Morgan, B.	BM 134	Eucalyptus eudesmioides	Myrtaceae
Trudgen, M.	MET 21183	Eucalyptus eudesmioides	Myrtaceae
Henson, M.	MJH 48	Eucalyptus loxophleba subsp. loxophleba	Myrtaceae
Henson, M.	MJH 57	Eucalyptus obtusiflora subsp. obtusiflora	Myrtaceae
Morgan, B.	BM 123	Eucalyptus wandoo subsp. pulverea	Myrtaceae

Botanist	Voucher #	Species Name	Family
Henson, M.	MJH 19	Gastrolobium acutum	Fabaceae
Henson, M.	MJH 18	Gastrolobium acutum	Fabaceae
Morgan, B.	BMor 64	Gilberta tenuifolia	Asteraceae
Morgan, B.	BMor 65	Gilberta tenuifolia	Asteraceae
Trudgen, M.	21220	Gilberta tenuifolia	Asteraceae
Henson, M.	BM 131	Glischrocaryon flavescens	Haloragaceae
Henson, M.	MJH 54	Glischrocaryon flavescens	Haloragaceae
Trudgen, M.E.	MET 21193	Goodenia berardiana	Goodeniaceae
Henson, M.	BM 138	Goodenia hassallii	Goodeniaceae
Henson, M.	MJH 61	Goodenia hassallii	Goodeniaceae
Henson, M.	MJH 75	Grevillea biternata	Proteaceae
Henson, M.	MJH 22	Haemodorum simulans	Haemodoraceae
Morgan, B.	BMor 59	Haemodorum simulans	Haemodoraceae
Trudgen, M.	21222	Haemodorum simulans	Haemodoraceae
Morgan, B.	BM 36	Hakea incrassata	Proteaceae
Trudgen, M.	21238	Hakea incrassata	Proteaceae
Morgan, B.	BM 140	Hemiandra incana	Lamiaceae
Morgan, B.	BM 32	Hibbertia subvaginata	Dilleniaceae
Trudgen, M.	21219	Hyalosperma cotula	Asteraceae
Trudgen, M.	21218	Hyalosperma cotula	Asteraceae
Trudgen, M.	MET 21173	Isopogon divergens	Proteaceae
Henson, M.	MJH 67	Isotropis drummondii	Fabaceae
Henson, M.	MJH 49	Kunzea praestans	Myrtaceae
Henson, M.	MJH 50	Kunzea praestans	Myrtaceae
Morgan, B.	BM 124	Kunzea praestans	Myrtaceae
Trudgen, M.E.	21179	Kunzea praestans	Myrtaceae
Morgan, B.	BMor 66	Lawrencella rosea	Asteraceae
Trudgen, M.	21217	Lawrencella rosea	Asteraceae
Trudgen, M.	21212	Laxmannia omnifertilis	Asparagaceae
Morgan, B.	BM 71	Lepidobolus chaetocephalus	Restionaceae
Trudgen, M.	MET 21211	Lepidobolus chaetocephalus	Restionaceae
Morgan, B.	BM 76	Lepidosperma	Cyperaceae
Morgan, B.	BM 135	Lepidosperma	Cyperaceae
Morgan, B.	BM 77	Lepidosperma	Cyperaceae
Morgan, B.	BM 80	Lepidosperma	Cyperaceae

Botanist	Voucher #	Species Name	Family
Trudgen, M.	MET 21175	Lepidosperma	Cyperaceae
Trudgen, M.	MET 21209	Lepidosperma	Cyperaceae
Morgan, B.	BM 75	Lepidosperma pubisquameum	Cyperaceae
Henson, M.	MJH 29	Lepidosperma tenue	Cyperaceae
Morgan, B.	BM 78	Lepidosperma tenue	Cyperaceae
Morgan, B.	BM 79	Lepidosperma tenue	Cyperaceae
Morgan, B.	BM 133	Leptospermum	Myrtaceae
Morgan, B.	BM 70	Lomandra	Asparagaceae
Henson, M.	MJH 40	Lysimachia arvensis	Primulaceae
Henson, M.	MJH 56	Melaleuca concreta	Myrtaceae
Morgan, B.	BM 125	Melaleuca leuropoma	Myrtaceae
Trudgen, M.	MET 21181	Melaleuca leuropoma	Myrtaceae
Morgan, B.	BM 126	Melaleuca radula	Myrtaceae
Trudgen, M.	MET 21188	Millotia myosotidifolia	Asteraceae
Trudgen, M.	MET 21189	Millotia tenuifolia var. tenuifolia	Asteraceae
Morgan, B.	BM 34	Muehlenbeckia adpressa	Polygonaceae
Morgan, B.	BM 82	Neurachne alopecuroidea	Poaceae
Morgan, B.	BM 81	Neurachne alopecuroidea	Poaceae
Morgan, B.	BM 83	Neurachne alopecuroidea	Poaceae
Morgan, B.	BMor 67	Olearia sp. Eremicola (Diels & Pritzel s.n. PERTH 00449628)	Asteraceae
Morgan, B.	BM 105	Opercularia vaginata	Rubiaceae
Trudgen, M.	MET 21194	Opercularia vaginata	Rubiaceae
Trudgen, M.	21235	Orthrosanthus laxus var. gramineus	Iridaceae
Morgan, B.	BM 104	Parentucellia latifolia	Orobanchaceae
Henson, M.	s.n.	Pentameris airoides	Poaceae
Morgan, B.	BM 85	Pentameris airoides subsp. airoides	Poaceae
Morgan, B.	BM 86	Pentameris airoides subsp. airoides	Poaceae
Morgan, B.	MJH 33	Pentameris airoides subsp. airoides	Poaceae
Morgan, B.	BM 84	Pentameris airoides subsp. airoides	Poaceae
Henson, M.	MJH 11	Petrorhagia dubia	Caryophyllaceae
Morgan, B.	BM 37	Petrorhagia dubia	Caryophyllaceae
Morgan, B.	BM 38	Petrorhagia dubia	Caryophyllaceae

Botanist	Voucher #	Species Name	Family
Morgan, B.	BM 39	Petrorhagia dubia	Caryophyllaceae
Morgan, B.	BM 100	Phyllangium sulcatum	Loganiaceae
Morgan, B.	BM 101	Phyllangium sulcatum	Loganiaceae
Morgan, B.	BM 33	Pimelea imbricata var. piligera	Thymelaeaceae
Trudgen, M.	21237	Pimelea imbricata var. piligera	Thymelaeaceae
Henson, M.	MJH 41	Podolepis gracilis	Asteraceae
Henson, M.	MJH 42	Podolepis lessonii	Asteraceae
Morgan, B.	BM 112	Podolepis lessonii	Asteraceae
Trudgen, M.	MET 21187	Podolepis lessonii	Asteraceae
Morgan, B.	BM 103	Quoya dilatata	Lamiaceae
Morgan, B.	BM 102	Quoya dilatata	Lamiaceae
Trudgen, M.	MET 21195	Quoya dilatata	Lamiaceae
Trudgen, M.	MET 21196	Quoya dilatata	Lamiaceae
Trudgen, M.	MET 21186	Rhodanthe laevis	Asteraceae
Henson, M.	MJH 38	Rytidosperma acerosum	Poaceae
Morgan, B.	BM 98	Rytidosperma acerosum	Poaceae
Morgan, B.	s.n.	Rytidosperma acerosum	Poaceae
Morgan, B.	s.n.	Rytidosperma setaceum	Poaceae
Morgan, B.	BM 95	Rytidosperma setaceum	Poaceae
Morgan, B.	BM 97	Rytidosperma setaceum	Poaceae
Morgan, B.	BM 150	Santalum acuminatum	Santalaceae
Henson, M.	MJH 60	Scaevola glandulifera	Goodeniaceae
Trudgen, M.	MET 21192	Scaevola glandulifera	Goodeniaceae
Morgan, B.	BM 109	Scaevola phlebopetala	Goodeniaceae
Morgan, B.	BM 107	Scaevola phlebopetala	Goodeniaceae
Morgan, B.	BM 108	Scaevola phlebopetala	Goodeniaceae
Trudgen, M.	MET 21207	Schoenus latitans	Cyperaceae
Trudgen, M.E.	MET 21208	Schoenus latitans	Cyperaceae
Morgan, B.	BM 40	Silene gallica var. gallica	Caryophyllaceae
Henson, M.	MJH 63	Solanum oldfieldii	Solanaceae
Trudgen, M.	21239	Stackhousia pubescens	Celastraceae
Morgan, B.	BM 62	Stylidium androsaceum	Stylidiaceae

Botanist	Voucher #	Species Name	Family
Henson, M.	MJH 23	Stylidium caricifolium	Stylidiaceae
Morgan, B.	BM 61	Stylidium caricifolium	Stylidiaceae
Morgan, B.	BM 60	Stylidium caricifolium	Stylidiaceae
Trudgen, M.	21221	Stylidium miniatum	Stylidiaceae
Morgan, B	BM 110	Stylidium sp. Moora (J.A.Wege 713)	Stylidiaceae
Henson, M.	MJH 26	Stypandra glauca	Hemerocallidaceae
Henson, M.	MJH 64	Styphelia retrorsa	Ericaceae
Trudgen, M.	MET 21197	Styphelia serratifolia	Ericaceae
Trudgen, M.	MET 21174	Styphelia serratifolia	Ericaceae
Henson, M.	MJH 10	Thomasia grandiflora	Malvaceae
Morgan, B.	BM 31	Thomasia grandiflora	Malvaceae
Henson, M.	MJH 25	Thysanotus manglesianus	Asparagaceae
Trudgen, M.	21214	Thysanotus multiflorus	Asparagaceae
Morgan, B.	BM 127	Trachymene ornata	Araliaceae
Henson, M.	MJH 52	Trachymene pilosa	Araliaceae
Morgan, B.	BMor 54	Trifolium arvense var. arvense	Fabaceae
Morgan, B.	BMor 53	Trifolium arvense var. arvense	Fabaceae
Henson, M.	MJH 20	Trifolium repens var. repens	Fabaceae
Henson, M.	MJH 6	Tripterococcus brunonis	Celastraceae
Morgan, B.	BM 28	Tripterococcus brunonis	Celastraceae
Morgan, B.	BM 26	Tripterococcus brunonis	Celastraceae
Trudgen, M.	21240	Tripterococcus brunonis	Celastraceae
Henson, M.	MJH 9	Trymalium ledifolium var. rosmarinifolium	Rhamnaceae
Morgan, B.	BM 113	Ursinia anthemoides subsp. anthemoides	Asteraceae
Henson, M.	MJH 58	Ustilago tepperi	Ustilaginaceae
Trudgen, M.	MET 21180	Verticordia chrysanthella	Myrtaceae
Henson, M.	MJH 55	Verticordia densiflora var. densiflora	Myrtaceae
Morgan, B.	BM 106	Wahlenbergia preissii	Campanulaceae
Morgan, B.	BM 137	Waitzia nitida	Asteraceae
Morgan, B.	BM 114	Waitzia nitida	Asteraceae
Morgan, B.	BM 116	Waitzia nitida	Asteraceae
Morgan, B.	BM 115	Waitzia nitida	Asteraceae
Henson, M.	MJH 53	Xanthosia fruticulosa	Apiaceae
Morgan, B.	BM 129	Xanthosia fruticulosa	Apiaceae
Morgan, B.	BM 128	Xanthosia fruticulosa	Apiaceae

Appendix H

Other flora of conservation interest

Other flora of conservation interest (Trudgen et al 2012)

Agrostocrinum scabrum aff. ssp. scabrum

The collections referred to *Agrostocrinum scabrum* aff. ssp. *scabrum* from the Coomberdale Chert Threatened Ecological Community represent a small population that lies half way between the north end of the main occurrence and one outlying record from north of Three Springs (see Map 11). The disjunction is more than eighty kilometres from the Coomberdale Chert TEC records to the northernmost record in the main population. The size of the disjunction and the uncommon geology the Coomberdale Chert TEC is located on suggests the population is likely to represent at least a different variety. The material is also somewhat atypical, but better collections are needed to examine the status of the population. Even if the material does not represent a new variety, the population has significance as an outlier. The taxon was recorded (see Map 12) at three quadrats by Trudgen *et al.* (2012), but has not been recorded north of Kiaka Road.

Map 11: Distribution of *Agrostocrinum scabrum* aff. ssp. *scabrum* north of Perth

Note: Map from records on the site The Australasian Virtual Herbarium.

Map 12: Records of *Agrostocrinum scabrum* aff. ssp. *scabrum* in the Coomberdale Chert TEC

Note: From data recorded by Trudgen *et al.* (2012) for areas of the Coomberdale Chert TEC surveyed.

Austrostipa exilis (Former priority species, near range limit)

Austrostipa exilis was formerly a Priority 3 species, but has been removed from the priority flora list. It is now considered (The Australasian Virtual Herbarium 7/2017)) to be quite widespread in the southwest of Western Australia, although most records are south of Perth and the species is not very common. Apart from two coastal records, the three Coomberdale Chert Threatened Ecological Community records are near the norther limit of the species in Western Australia (there is a disjunct population in South Australia). One of the three records in the TEC is from north of Kiaka Road, but is not from the proposed North Kiaka Road Mine area.

Banksia sphaerocarpa var. *aff. caesia* (Atypical , range extension, range end)

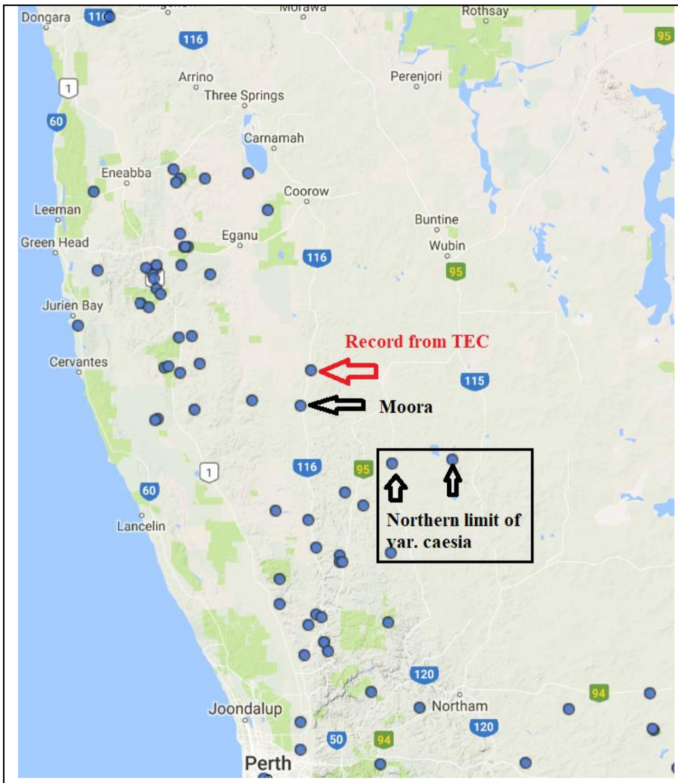
A form of *Banksia sphaerocarpa* has been recorded at three localities in the area of the Coomberdale Chert Threatened Ecological Community surveyed by Trudgen *et al.* (2012), with two of the localities in the proposed North Kiaka Mine area. The material needs further study to determine its taxonomic identity within the species, but is closest to var. *caesia.* Due to the uncertainty naming the material, it is referred to here as *Banksia sphaerocarpa* var. aff. *caesia*. After var. *caesia*, the material is closest to var. *sphaerocarpa*.

Banksia sphaerocarpa var. *sphaerocarpa* has a large distribution and is known to include several forms and there are some differences in the application of the name. The variety is still mapped as occurring to well north of Perth on Florabase (the Western Australian Herbarium species information portal), but is considered by A.S. George (2008) the authority on the genus, to occur “from the Darling Plateau east of Perth south to the Whicher Range and east to the Stirling Range and Cape Riche”. The apparent conflict in application may simply be that specimens have not been redetermined, meaning the map is outdated. In the same publication, George (2008) considered that most of the collections north of Perth belonged to a new variety, *Banksia sphaerocarpa* var. *pumilio*, which is usually a shrub less than one metre tall. A third variety, *Banksia sphaerocarpa* var. *caesia*, also occurs north of Perth, but the population there (three records) is disjunct from the main population and the nearest record to the occurrence in the Coomberdale Chert TEC is near Piawaning, fifty kilometres to the south-east.

The specimens from the Coomberdale Chert Threatened Ecological Community (see photographs and Map 13 below) key to a couplet with var. *sphaerocarpa* and var. *caesia*, so we can exclude var. *pumilio* (another two described varieties occur well south of Perth and can also be excluded).

Banksia sphaerocarpa var. *aff. caesia* has been recorded at three localities in the area of the Coomberdale Chert Threatened Ecological Community mapped by Trudgen *et al.* (2012). The three localities are shown on Map 14. George (1981) in his revision of the genus *Banksia* mentions an atypical specimen (Kenneally 5889) from 4 km east of Piawaning (see Map13A). George notes that this collection and others from the north and western part of the distribution of the variety have fruit more similar in size to var. *sphaerocarpa* than var. *caesia*. Map 13B shows all records on Australasia’s Virtual Herbarium of *Banksia sphaerocarpa* var. *caesia*, with Kenneally 5889 arrowed and the Coomberdale Chert population added. The map shows that the Kenneally collection, two other collections and the Chert localities are disjunct from other localities of var. *caesia* by some 70 kilometres, with all other collections south of Great Eastern Highway. The disjunction and the difference in fruit size indicate that the north-western populations referred to *Banksia sphaerocarpa* var. *caesia* and the Coomberdale Chert population should be treated as a distinct taxon. Inspection of the Piawaning population (a few plants on a disturbed roadside) suggests that this form is the same as the population n the Coomberdale Chert.

While the status of *Banksia sphaerocarpa* var. aff. *caesia* undoubtedly needs further investigation, Nistelberger *et al.* (2015) investigating genetic diversity in part of the distribution of var. *caesia* found “a stark and unexpected division of the landscape into two genetic subregions”. This was in an area of the varieties distribution with no disjunction, suggesting that the “variety” is somewhat more than it seems. Bearing in mind comments by George (2008) about other variation in *Banksia sphaerocarpa* it seems likely that the species as a whole needs a detailed revision. The Piawaning population grows on yellow sand, and the main chert population is on chert adjacent to an area of yellow sand.

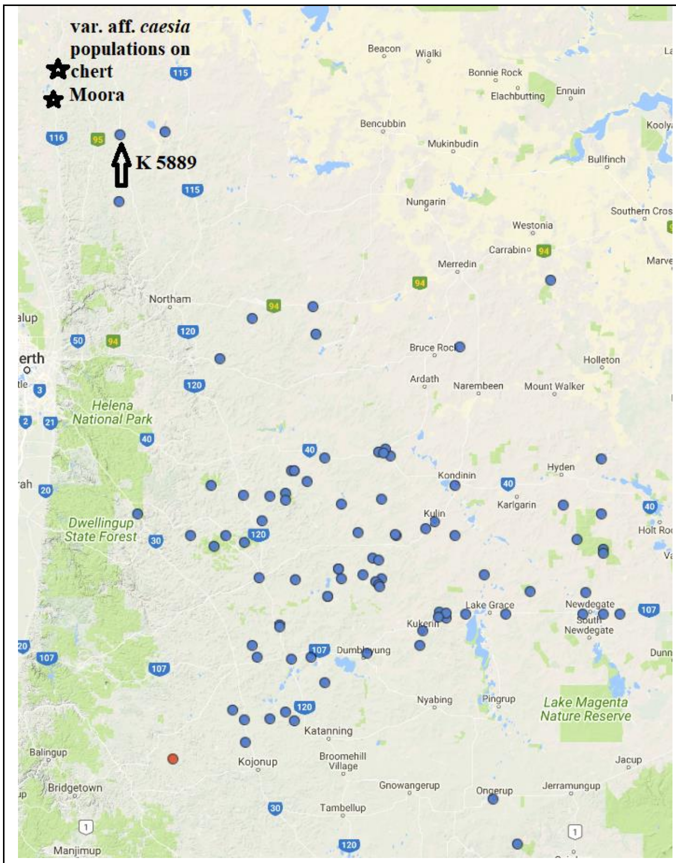


Map 13A: Records of all varieties of *Banksia sphaerocarpa* between Perth and Dongara.

Notes. The red arrow indicates the location of one of three occurrences of *Banksia sphaerocarpa* var. *aff. caesia* on the Coomberdale Chert (the others are nearby; see Map 14).

The black rectangle shows the three locations of the disjunct north-western occurrence of var. *caesia*, two of which are indicted by black arrows. The left hand arrow in the box indicates the locality of Kenneally 5889.

The map is from The Australasian Virtual Herbarium (accessed 8/2017).



Map 13B: All records of *Banksia sphaerocarpa* var. *caesia*

Notes. The black arrow indicates the location of Kenneally 5889. Also note the disjunction between the north-western locations and the locations between Northam and Bruce Rock. And, that the latter locations are disjunct from the main occurrence.

The map is from The Australasian Virtual Herbarium (accessed 3/2018).

Photographs 1 & 2: Two shrubs of *Banksia sphaerocarpa* var. *aff. caesia* showing variation in habitat. The right hand individual may have been affected by grazing of the lower branches.

Map 14: Records of *Banksia sphaerocarpa* var. *aff. caesia* from quadrat and releve data of Trudgen *et al.* (2012) and from 2016 & 2017 field data.

The northern localities in the TEC are in the area of the proposed North Kiaka Mine. There are four plants of the *Banksia* at the northernmost locality and two at the nearby locality. These were the only localities found in the area of the proposed mine pits when they were searched in 2016. The southern locality is in a small remnant of native vegetation (one of a cluster in a paddock). It was visited in 2017 and the *Banksia* plants there counted, their condition noted and their locations recorded with a GPS unit. There are about 65 plants in the population, varying in size and condition. Smaller plants and the lower parts of larger plants were heavily grazed (probably by rabbits). The plants at this location were definitely lignotuberous and some plants were up to 1.9 metres tall.

Calothamnus quadrifidus subsp. angustifolius (Chert form)

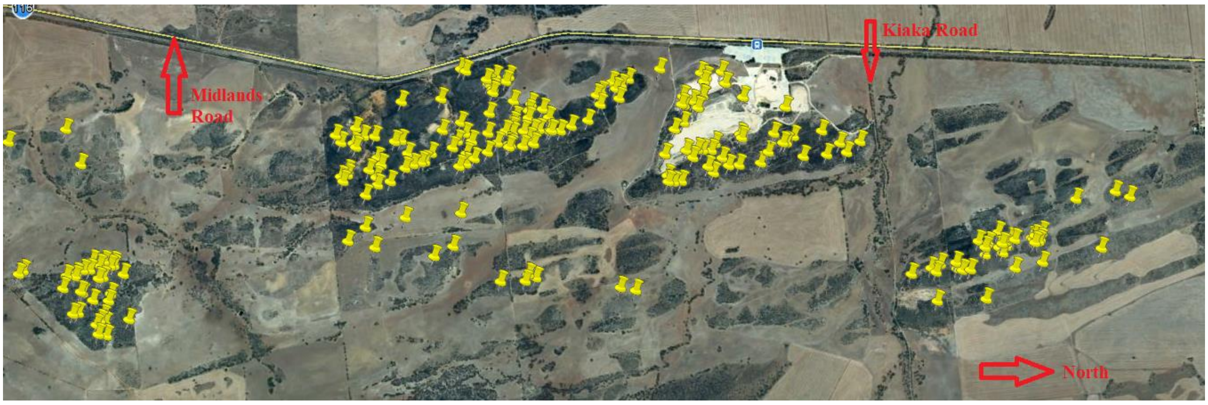
This taxon was separated out from other variants of *Calothamnus quadrifidus* at the Western Australian Herbarium during preparation of earlier reports for Simcoa Operations Ltd. It was recorded at fifty-five (55) sites during the surveys. Since this taxon was separated out in Herbarium material at that time. Since then, material of it has been included in *Calothamnus quadrifidus* ssp. *angustifolius* by George and Gibson (2010). It has not been possible to examine this assignment in detail for this report, and it has been decided to leave the reference to the entity as in the earlier reports. This has been done as the author of this report has considerable experience in the taxonomy of the Myrtaceae, examined the material in the Western Australian Herbarium and came to the conclusion specimens from the geographic area including the Coomberdale Chert were a distinct entity. This is not necessarily incompatible with the paper by George and Gibson, and this taxon and closely related ones need further taxonomic work to confirm their status.

Map 16: *Calothamnus quadrifidus* subsp. *angustifolius* (Chert form) from data of Trudgen *et al.* (2012) for the Coomberdale Chert TEC and data of E.A. Griffin.

Calothamnus quadrifidus subsp. *angustifolius* (Chert form) is restricted to the Coomberdale Floristic Region of Griffin (1992) and it should be treated as a geographically restricted taxon. There are about fifteen specimens in the collections at the Western Australian Herbarium, but this may over-estimate the abundance of the taxon as it is a large species (generally two to four metres tall) and thus more likely to be collected than smaller ones. It is moderately common (Map 16) in parts of the survey area of Trudgen *et al.* (2012), but is absent in others.

Calytrix sp. Coomberdale (M.E. Trudgen MET 21184)

Calytrix sp. Coomberdale (M. Trudgen MET 21184) has previously been confused with *Calytrix leschenaultii*, a name that has been applied to a significant sized complex of species that occurs over much of the South West Botanical District of Western Australia. It is a small, purple flowered shrub belonging to the plant family Myrtaceae. It is quite common in the Coomberdale Chert Threatened Ecological Community (Map 17) and has been observed outside the areas of that community mapped by Trudgen *et al.* (2012), on soils with similar (silica rich) underlying rocks (just south of Moora), but does not seem to be common outside the TEC. It is more common in the proposed North Kiaka Mine area than the quadrat and releve mapping data indicate, this is partly due to the fact that much of the proposed mine area has vegetation in poorer condition and therefore fewer quadrats and releve sites were recorded in it.



Map 17: Records of *Calytrix* sp. Coomberdale from data of Trudgen *et al.* (2012) for areas of the Coomberdale Chert TEC surveyed by them.

Notes: This species is common in the area north of Kiaka Rd. The white areas on the image are the existing Simcoa mine, waste dumps and storage areas. For convenience north is to the right on the image.

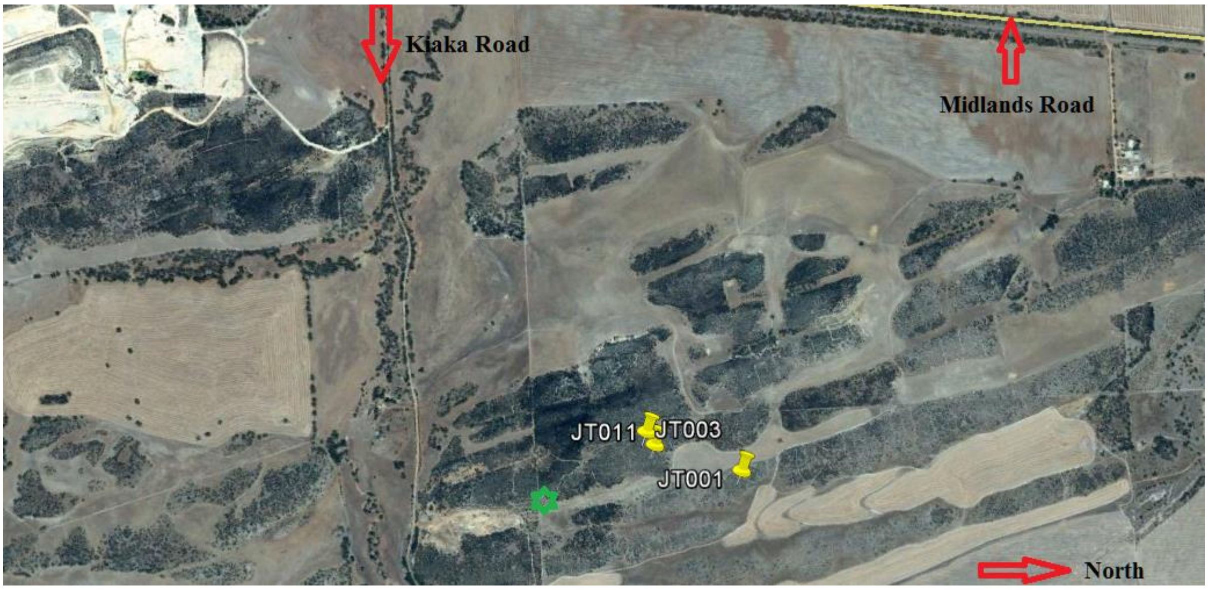
Photographs 3 & 4: Flowers and flowering plant of *Calytrix* sp. Coomberdale.

In the Coomberdale Chert TEC, *Calytrix* sp. Coomberdale occurs in more open vegetation (that is not under dense *Allocasuarina campestris* or dense *Regelia megacephala*). It was observed to have regenerated fairly recently in one disturbed area that had low weed cover. It is common in disturbed areas with high weed cover, but in such places all the plants are older and may predate the weed invasion. It may mostly establish after fire and may have taken advantage of disturbance of the TEC to increase its population size. The population in the proposed North Kiaka Mine area is significantly larger than the quadrat and releve records on Map 17 indicate.

Given the geographical restriction of *Calytrix* sp. Coomberdale it is likely to warrant priority flora status, although it appears to be more resilient than *Xanthorrhoea* sp. Coomberdale to the pressures on the vegetation remnants of the Coomberdale Chert TEC.

Cristonia stenophylla **(Disjunct population)**

Three records of *Cristonia stenophylla* were made by Trudgen *et al.* (2012) during their survey, all on the J. Tonkin property north of Kiaka Road (Map 18). The material was identified in that report as *Cristonia biloba*. These are the only records from the Coomberdale Chert Threatened Ecological Community and are located 60 kilometres south-south-east of the main occurrence of the species. There is one record ninety kilometres further south-south-east, north of Bolgart. The TEC population has significance as an outlying record.



Map 18: Records of *Cristonia stenophylla* in the Coomberdale Chert TEC

Notes: Yellow pins records from data of Trudgen *et al.* (2012) green star from 2017 field survey. Two of the 2012 sites revisited and the *Cristonia* not found.

Two of the three quadrats *Cristonia stenophylla* was recorded at by Trudgen *et al.* (2012) were revisited in 2016 and again in 2017 and the species was not found on either occasion. It was also not found during any of the flora searches undertaken for the current report in 2016and 2017. However, one plant was observed in 2017 adjacent to the southern firebreak on the John Tonkin property. It seems likely that the species has become locally very rare due to a combination of climate change, grazing and other factors such as herbicide drift. However, it is possible that the species is still present as seed (which is likely to be long-lived) and might reappear after fire. One of the three quadrats the species was found in is in the proposed North Kiaka Mine area, the other two are nearby. The locality found in 2017 is part of one possible route for a haul road.

Cyrtostylis huegelii (Outlying population)

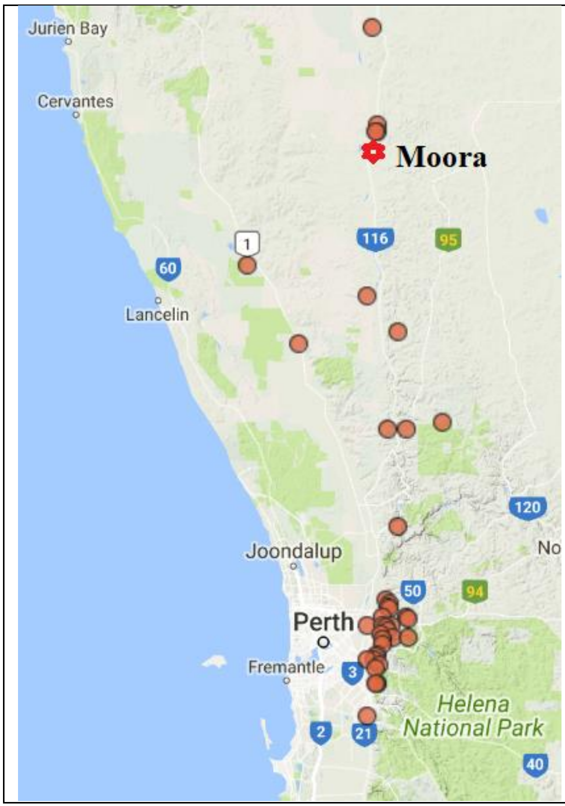
Cyrtostylis huegelii is the only *Cyrtostylis* recorded north of Perth, where the species, apart from the Coomberdale Chert Threatened Ecological Community records, is only recorded west of the Brand Highway. The TEC population is therefore a significant outlying record of the species. *Cyrtostylis huegelii* was recorded three times by Trudgen *et al.* (2012), once in Cairn Hill Reserve and twice adjacent to the current Simcoa mine (one of these records was in an area now mined). It was not recorded during flora searches of the proposed North Kiaka Mine area in 2016 and 2017.

Gastrolobium acutum (Disjunct population and near Northern limit)

There are only five records of *Gastrolobium acutum* north of Mogumber in herbarium collections, of which three are from the Coomberdale Chert Threatened Ecological Community (Map 19). The population of *Gastrolobium acutum* in the Coomberdale Chert TEC is disjunct from the main population by ca. 53 kilometres. As Map 19 shows the main population extends southwards from that point to the east of Perth, but is fairly restricted. Twenty-four kilometres to the north of the Coomberdale Chert TEC population there is one record (noted as growing on yellow sand with chert outcrop) in Watheroo National Park.

While the population there is disjunct from the main population, *Gastrolobium acutum* is not uncommon in the Coomberdale Chert TEC with nineteen records (Map 20) at the quadrats and releves recorded for Trudgen *et al.* (2012). However, other observations indicate that *Gastrolobium acutum* is somewhat more common in the North Kiaka Mine area than the quadrat and releve records indicate. As Map 20 shows only three of these records were located north of Kiaka Road. Given the disjunction and the different geologies the two populations grow on, it is possible that the Coomberdale Chert TEC population is different at the variety or subspecies level from the main population. This issue needs further study. The Watheroo record is likely to be the same taxon as the TEC population as it is associated with chert geology.

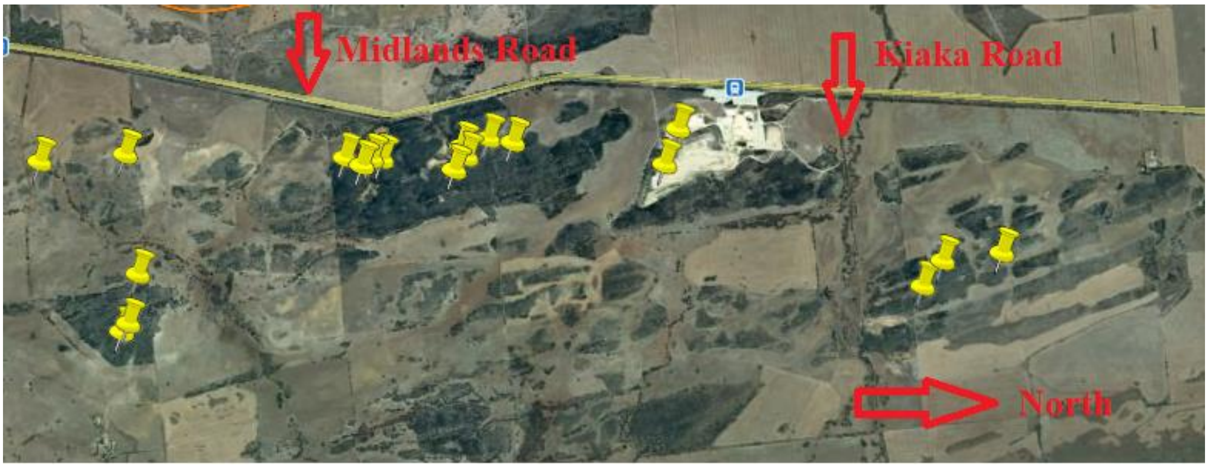
Gastrolobium acutum was once a Priority Species, however it was removed from the Priority Flora list after more information became available about its distribution and population status. If the Coomberdale Chert population is confirmed as different, it would deserve priority status because of its geographically limited extent and number of threatening factors. It is an erect, or occasionally straggly shrub to one metre tall. It was recorded in fourteen of their eighty-nine quadrats recorded in native vegetation and three vegetation recording releves by Trudgen *et al.* (2012). It was also observed as scattered individuals, or small groups of individuals, north of Kiaka Road.



Map 19: Distribution of *Gastrolobium acutum*

Notes. Map from The Australasian Virtual Herbarium, accessed 6/2017.

The Coomberdale Chert TEC records are the small cluster just north of Moora. Note the disjunction south from Moora



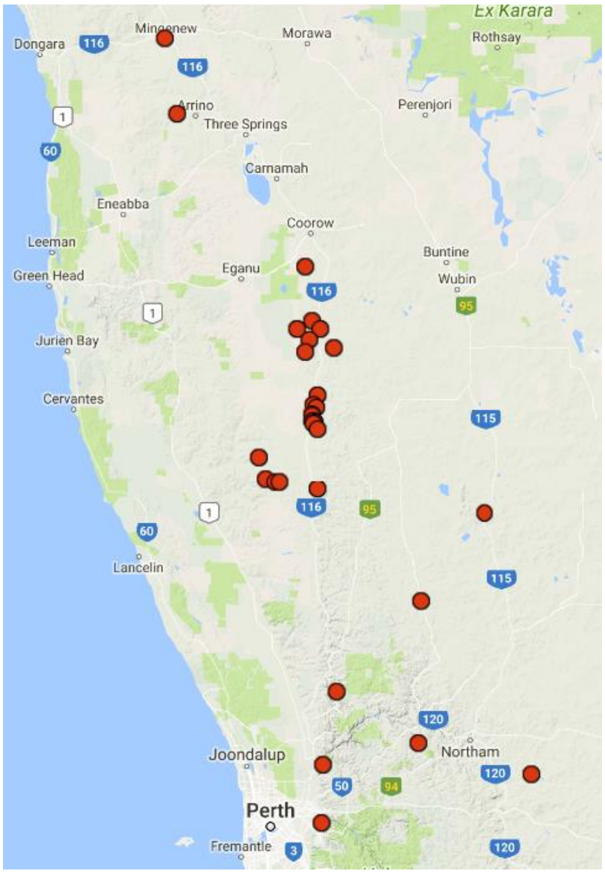
Map 20: Records of *Gastrolobium acutum* from quadrat and vegetation mapping releve data of Trudgen *et al.* (2012) for areas of the Coomberdale Chert TEC surveyed.

Notes: The white areas on the image are the existing Simcoa mine, waste dumps and storage areas.

[Records on The Australasian Virtual Herbarium for *Gastrolobium acutum* in the Kalbarri area are based on specimens held in eastern states herbaria which are likely to be wrongly named and these records are therefore not taken into account here.]

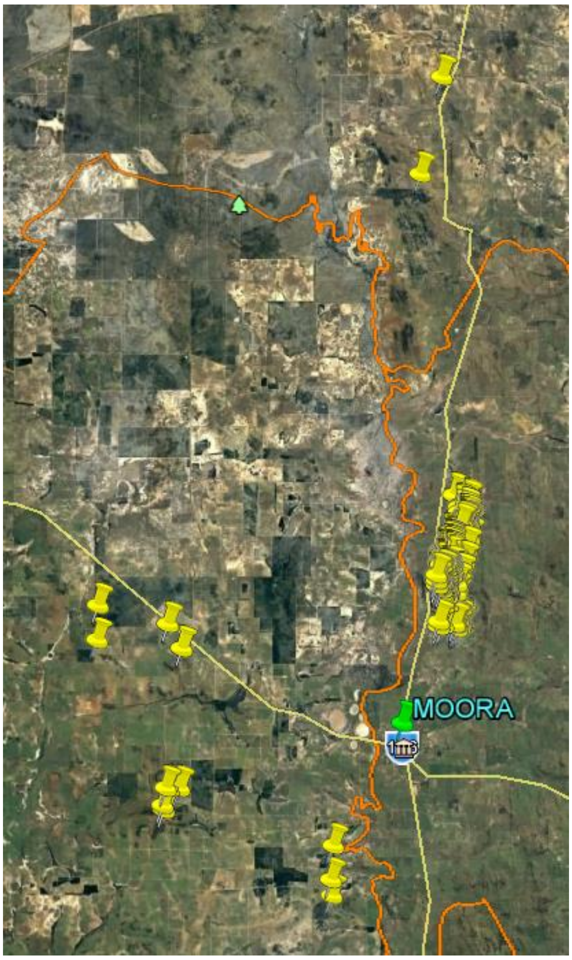
Kunzea praestans (Has disjunctions, needs taxonomic review)

The material from the Coomberdale Chert Threatened Ecological Community that has been identified as *Kunzea praestans* is a 1.5 to 2.5 metre tall shrub with pink flowers that in the TEC occurs mostly near the edges of chert outcrops on compacted gravelly soil (chert gravel colluvium) over chert. It was previously a Priority 3 species that was considered to have a fairly restricted distribution centred on the Coomberdale Chert, but was removed from the priority flora list on the basis of new collections from a broader range.



Map 21A: Distribution of *Kunzea praestans* based on herbarium records

Notes: Includes some mis-identified collections (see text). (Map from The Australasian Virtual Herbarium17/8/2017)



Map 21B: Records of *Kunzea praestans* in the Moora area from vegetation survey data.

The large cluster of sites is the Coomberdale Chert TEC survey area

Records (Map 21A) on The Australasian Virtual Herbarium (AVH) show a wider distribution than the Moora area, but with significant disjunctions. Some of the specimens on AVH are certainly not the same taxon as on the Coomberdale Chert. For example the record from near Arrino is from the margin of a wetland, the record from north of Wongan Hills is of a shrub to 30 cm with mauve flowers, one of the records near Dandaragan was recorded as having yellow flowers, the specimen from Mundaring was collected from adjacent to a river, the specimen from near Coorow was described as having mauve flowers, and two other collections were of shrubs under one metre tall.

The distribution of *Kunzea praestans* (or more correctly, the material placed under this name) from The Australasian Virtual Herbarium data (Map 21A) in the Moora area and the map from Moora area vegetation survey data of E.A. Griffin & M.E. Trudgen (Map 21B) have similar disjunctions and fairly restricted distributions. It therefore seems likely that the *Kunzea* on the chert is actually fairly restricted, but that further taxonomic work is needed to properly establish its limits as a species, whether or not it has subspecies, and from this its conservation status.

Lepidosperma aff. leptostachyum (Moora: ERG18-7)

Lepidosperma aff. leptostachyum (Moora: ERG18-7) is an informal name given to sixteen (16) specimens collected in the surveys of the Coomberdale Chert TEC. Fifteen of these were collected south of Kiaka Road and one north of Kiaka Road. The taxon has not been recorded from the proposed North Kiaka Mine impact areas. Four specimens of this taxon have been vouchered; they have been placed under Lepidosperma sp. at the Western Australian Herbarium.

Leptospermum aff. erubescens (Moora Chert; B. Morgan 133). (Rare, very restricted)

Two collections were known of this taxon prior to the field work for the current report. Both are from the Trudgen et al. (2012 etc.) survey area. One was collected during the rare flora survey of the Gardiner Hill bush area (on the property of P & J. Gardiner, at the same location as the Banksia sphaerocarpa form). The site was in a disturbed area on the edge of the vegetation remnant. The other (D.J.E. Whibley 4905) is from the gravel pit in Cairn Hill reserve. The two collections appear to represent a very uncommon undescribed taxon restricted to the Chert Hills at Moora (R. Davis pers. comm. 2006).

Until this taxon can be adequately surveyed, it should be treated as very rare. The earlier survey collection (Morgan 133) has been vouchered and is currently (30 January 2024) placed under Leptospermum sp. The taxon has not been recorded north of Kiaka Road (in fact, not north of Cairn Hill Reserve). The Morgan collection location on the Gardiner property was revisited in 2017 to survey the Banksia population; during the visit it was found that there was a moderate sized population of the Leptospermum present as well. The population was not counted, but certainly has more than 50 individuals.

Pauridia aff. occidentalis var. occidentalis (Probably an undescribed species)

The genus Pauridia (the Australian species were formerly placed in Hypoxis) consists of small herbaceous species that have few easy to use characters to define species. At least in Western Australia, the genus is in need of revision. In an earlier report (Trudgen et al. 2012) one specimen (CH12-11A from Cairn Hill Reserve) was referred to the name Hypoxis aff. glabella. Re-examination of this specimen has shown that it is a very poor specimen (one small old plant) of the taxon that was referred to Pauridia occidentalis var. occidentalis in the earlier report. Further examination of the collections has indicated that the material referred to Pauridia occidentalis var. occidentalis in Trudgen et al. (2012) does not fit well any described taxon and is likely to be undescribed. Given the state of the taxonomy of Pauridia, this must be a preliminary assessment. The important issue here is that in the area of the Coomberdale Chert Threatened Ecological Community that was surveyed by Trudgen et al. (2012) the taxon mainly occurs out of the proposed North Kiaka Mine area (Map 22).

The important characters are that the specimens have a pair of opposite bracteoles rather than a single bracteole and a different fruit shape to the two closest species, Pauridia occidentalis and Pauridia vaginata.

Photograph 5: Flowering plants of *Pauridia* aff. *occidentalis* var. *occidentalis*

Map 22: Records of *Pauridia* aff. *occidentalis* var. *occidentalis* from the quadrat and vegetation mapping releve records of Trudgen *et al.* (2012)

Note. These records underestimate the number of occurrences north of Kiaka Road due to the distribution of quadrats and timing of releve recording.

Petrophile brevifolia **(forma) (Needs taxonomic study)**

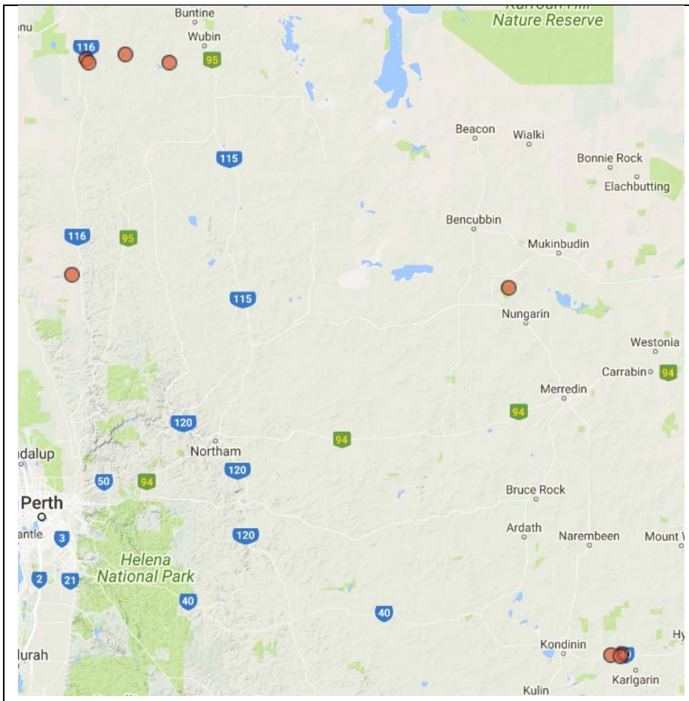
A collection (G316-4) referred to *Petrophile brevifolia* (forma) by Trudgen *et al.* (2012) is atypical for that species (B. Rye pers. comm. 2006), but flowering material and expert identification are necessary before the status of the collection can be fully assessed. This taxon has not been recorded north of Kiaka Road.

Pterostylis exserta **(Known from few localities)**

There are three records for *Pterostylis exserta* in the vegetation site data of Trudgen *et al.* (2012), although two of them were original determined as *Pterostylis* aff. *rufa*. One of these records was from quadrat JT010 which is in the proposed North Kiaka Mine area. The species was refound there in 2017 and this was the only locality in the proposed North Kiaka Mine where it was recorded (Map 23B). *Pterostylis exserta* is a small Greenhood orchid that is known from nine localities apart from those in the Coomberdale Chert Threatened Ecological Community (Map 23A). It would seem to deserve priority flora status given it is known from few localities and most of its range has been cleared.

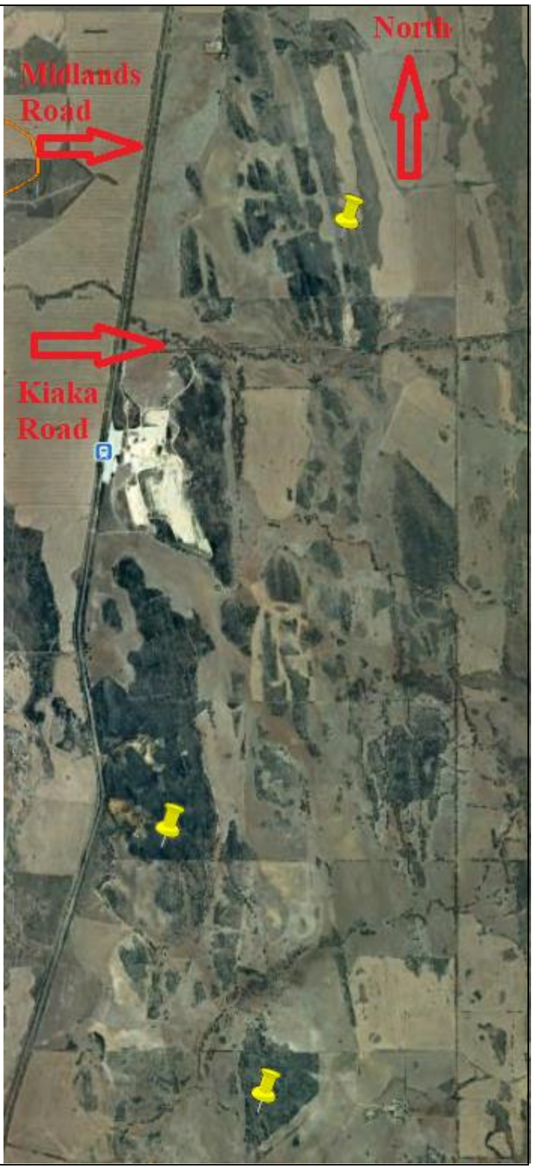
***Quoya* (formerly *Pityrodia) dilatata* (Disjunctions, possibly has subspecies)**

This species has a limited range from Three Springs to Wannamal, with most collections in a fairly narrow band. The distribution has three centres of distribution. The central one is in the Moora to Namban area and has a disjunction of forty-five kilometres to the southern population in the Mogumber area. The northern population is located south of Three Springs to the Coorow area. There are some scattered records between the northern and central populations and some other outlying records (of which some are much older with unlikely locations). The species needs investigation to see if there are sub-specific taxa. If there are, then this would mean that they could be of conservation concern.

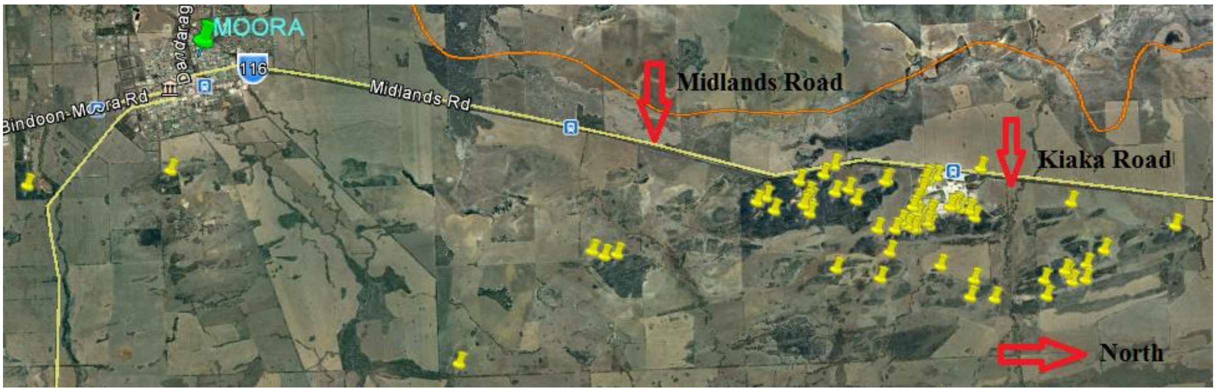


Map 23A: Distribution of *Pterostylis exserta*.

Note. The small number of records and how they are spread through a largely cleared part of the wheat belt.



Map 23B: Location of the records for *Pterostylis exserta* in the proposed North Kiaka Mine area



Map 24: Records of *Quoya dilatata* from the quadrat and vegetation mapping releve records of Trudgen *et al.* (2012) and two records (near Moora) from data of E.A. Griffin.

Quoya dilatata is fairly common (Map 24) in the Coomberdale Chert TEC area surveyed by Trudgen *et al.* (2012) and a number of other locations were recorded in the proposed North Kiaka Mine area in 2016 and 2017.

Stenanthemum tridentatum **(Near northern limit of species, disjunction.)**

Stenanthemum tridentatum is a very small shrub that was formerly a Priority 3 species, but has been removed from the Priority Flora List. In the Trudgen *et al.* (2012) survey area it was only recorded from the Gardiner's Hill survey sub-area (at one quadrat and five releves). This species has a moderate sized distribution with the survey area close to the north-west limit of the species range, which is at Gunyidi. The records from the Coomberdale Chert Threatened Ecological Community, one to the east (near Miling) and one to the north near Gunyidi are disjunct from the main population by about 60 kilometres. The species has not been recorded north of Kiaka Road in the Coomberdale Chert Threatened Ecological Community area.

Trichocline **sp. (Uncertain determination, if *Trichocline* new taxon)**

A sterile specimen from site GH7-57 on the Gardiner property (Trudgen *et al*. 2012) is possibly a *Trichocline* (an alternative of *Ptilotus* has been excluded (Trudgen *et al*. 2012)). However, it does not match *Trichocline spathulata* the only *Trichocline* species currently accepted for Western Australia. The site needs to be re-visited to collect flowering material, to enable proper identification. The species has not been recorded north of Kiaka Road.

Wurmbea drummondii

Wurmbea drummondii is a very small herb (ca. 5 cm tall with one or two leaves and usually one or two small flowers) that occurs in seasonally damp areas with thin soil over rock. It was only recorded at two places on John Tonkin's property during the Trudgen *et al.* (2012) survey, both outside the impact area of the proposed North Kiaka Mine. While it is present north of Kiaka Road, it is very uncommon there. *Wurmbea drummondii* was a Priority 4 species, but has been removed from the Priority Flora list. It was also observed once (one plant) during rare flora searches carried out in 2016 for the proposed North Kiaka Mine, again outside the proposed mine area. This species has a moderate distribution that has a small disjunction (from New Norcia and Wyening) between possible northern and southern occurrences (possibly varieties?).

Xanthorrhoea **sp. Coomberdale (M.E. Trudgen MET 25047)**

Xanthorrhoea sp. Coomberdale has previously been confused with *Xanthorrhoea drummondii*, a name that has been applied to a complex of species that occurs from the Kalbarri area southwards to north of Albany. It is a grass tree to just over two metres tall with greyish-green leaves that is usually single headed, but can have several heads (see Photographs 6 & 7).

Photograph 6: *Xanthorrhoea* sp. Coomberdale on slopes adjacent to remnant vegetation.

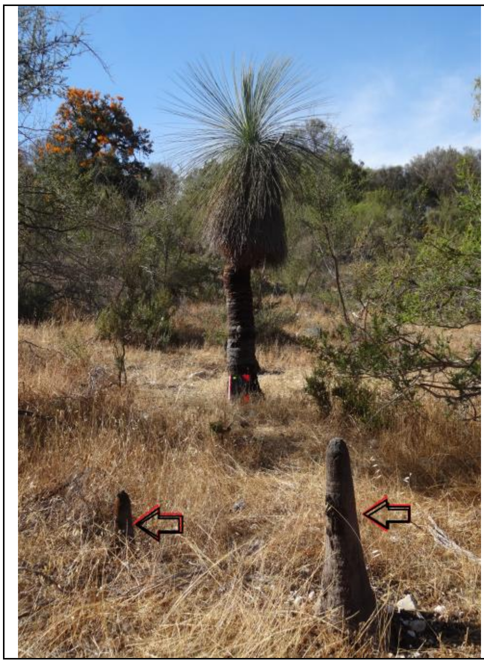
Notes: Individuals vary from single headed (most plants) to multiple headed.

Photograph 7: *Xanthorrhoea* sp. Coomberdale in remnant vegetation.

Notes: Comparison to the photograph to the left shows significant variation in stipe and inflorescence length.

On current knowledge *Xanthorrhoea* sp. Coomberdale is restricted to an area from just south of Moora to the area north of Kiaka Road (see Map 25a), but south of Coomberdale. Almost all of the records are from the Coomberdale (Noondine) Chert, with the majority of them from the study area of Trudgen *et al.* (2012). The other records are on chert east and south-south-east of Moora, except for one from 3 kilometres south-south-east of Moora near the Moora wheat bins. The latter record is on a different substrate (although there could be chert at depth) that is still silica rich.

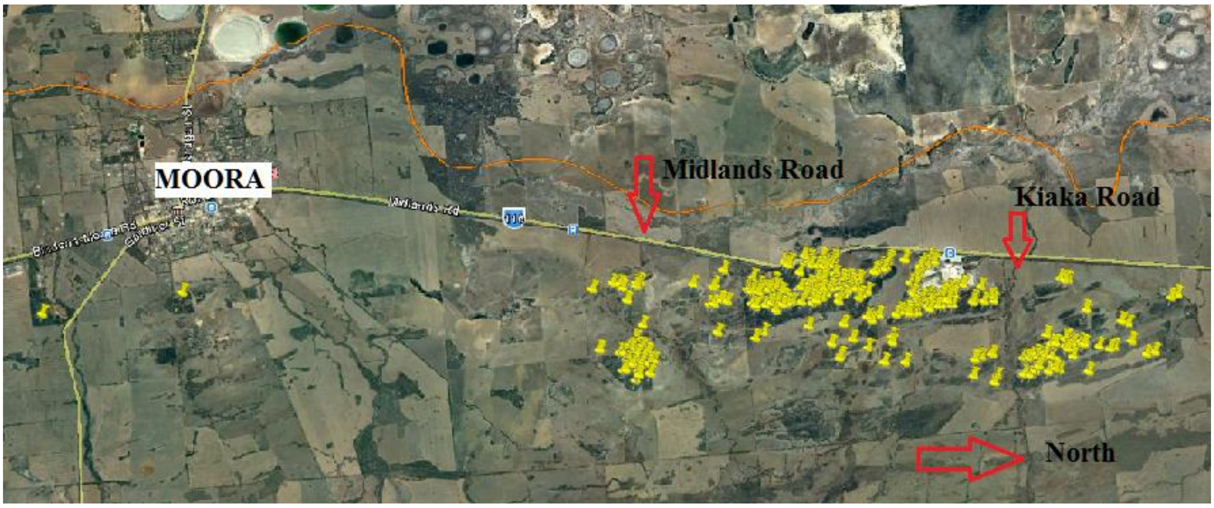
Map 25B puts the population of *Xanthorrhoea* sp. Coomberdale in a regional context. The two parts of the map show (left hand side) herbarium records that indicate the population is disjunct. The right hand side confirms this disjunction using vegetation site data records. Although, the disjunction is shown to be less than herbarium records show.



Photograph 8: *Xanthorrhoea* sp. Coomberdale with stumps of dead individuals.

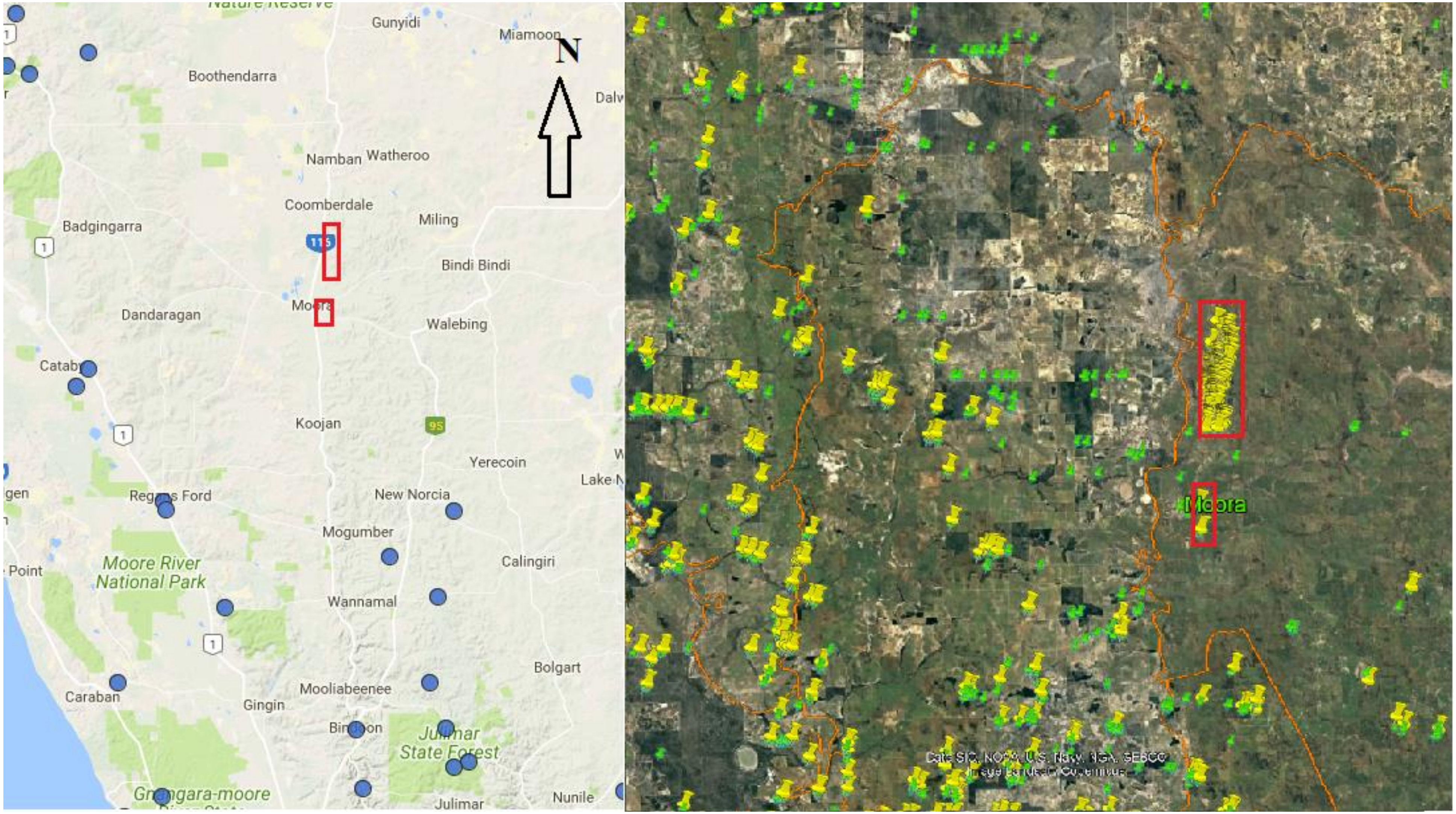
Notes: Within fifteen metres of the live plant of *Xanthorrhoea* sp. Coomberdale in the photograph there was one other live plant and the remains of ten (10) dead plants (two stumps arrowed). Such situations were not uncommon and a significant part of the population of *Xanthorrhoea* sp. Coomberdale has died in a relatively short time (< 10-20 years). Young plants were rarely seen during the flora searches for the proposed North Kiaka Mine or other work in the Coomberdale Chert TEC in 2016 and 2017.

Given the geographical restriction of *Xanthorrhoea* sp. Moora and the threatening factors affecting it (particularly climate change, but also factors preventing recruitment of new individual such as grazing and weed invasions), this species is likely to warrant priority flora status.



Map 25A: Records of *Xanthorrhoea* sp. Coomberdale from quadrat and vegetation mapping releve sites of Trudgen *et al.* (2012) for areas of the Coomberdale Chert TEC surveyed and from data collected by E.A. Griffin (the two southern records).

Notes: *Xanthorrhoea* sp. Coomberdale is more common in the areas mapped by Trudgen *et al.* (2012) than the quadrat and releve records indicate. The white areas on the image to the left of the Kiaka Road arrow are the existing Simcoa mine, waste dumps and storage areas. Image from Google Earth



Map 25B: Distribution of the genus *Xanthorrhoea* in the region around Moora showing the population of *Xanthorrhoea* sp. Coomberdale is disjunct

Notes: The left hand image shows all *Xanthorrhoea* records on The Australasian Virtual Herbarium (accessed 20/3/2018) in the region around Moora as blue dots, with *X.* sp. Coomberdale in the red rectangles. The right hand image shows records of *Xanthorrhoea* in vegetation data (mainly E.A. Griffins & M.E. Trudgen's data) as yellow pins. The RH image shows more accurately that the *Xanthorrhoea* sp. Coomberdale population (red rectangles) is disjunct from other *Xanthorrhoea* populations. The green pins indicate vegetation sites without *Xanthorrhoea*.

Xanthorrhoea sp. Coomberdale is common in the Coomberdale Chert TEC and is the only *Xanthorrhoea* recorded in the TEC. In the TEC it occurs in a range of habitat and vegetation types. The population has suffered a significant proportion of deaths of adult plants of the species in recent years. This may partly be due to declining rainfall and particularly the series of dry years between 2013 and 2016. There is almost no regeneration of this species occurring, with weed invasion likely to be a contributing factor, at least where weeds have higher cover.

To confirm that *Xanthorrhoea* sp. Moora is restricted to the Coomberdale Chert Threatened Ecological Community, searches were made along the Midlands Road and side roads from it from south of Moora to well north of Moora. Near Gillingarra (south of Moora) there is a similar entity that has different leaf cross section, slightly different fruit and grows on a different soil type.

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