

FAIRHILL COAL PROJECT

Soil and Land Suitability Assessment

Prepared for:
Fairhill Coking Coal Pty Ltd

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PREPARED BY

SLR Consulting Australia Pty Ltd
ABN 29 001 584 612
Level 2, 15 Astor Terrace
Spring Hill QLD 4000 Australia
(PO Box 26 Spring Hill QLD 4004 Australia)
T: +61 7 3858 4800
E: brisbane@slrconsulting.com www.slrconsulting.com

BASIS OF REPORT

This report has been prepared by SLR Consulting Australia Pty Ltd (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with Fairhill Coking Coal Pty Ltd (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of the Client. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR.

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DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
623.17171-R01-v0.4	17 May 2019	C Traill	R Masters	D Taylor

EXECUTIVE SUMMARY

SLR Consulting was commissioned to prepare this report to support a development application for the Fairhill Coking Coal Project (the Project). The report addresses a request for information notice issued by the Queensland Department of Environment and Science to 'Provide further detail on the suitability rule-set used to determine the suitability class for Beef Cattle Grazing and Rain Fed Broadacre Cropping' and several other questions that require the mine footprint to be altered from a 5-year pit shell to a 7-year pit shell. With this change and the amendment required to address the suitability rule-set, this new report was required.

As a soil and land suitability assessment report, it identifies, describes and maps the soil units and assesses their current suitability for agricultural production across the Project site through a detailed and rigorous desktop, field and laboratory assessment process. The results of the soil assessment identified the majority of the Project site is dominated by Vertosol (cracking clay) soils on both the Fair Hill Formation and Quaternary alluvium geological units. Within both of these geological units there were also occurrences of Dermosol (non-cracking) soils.

Through identification of the physical and chemical attributes of the overall landscape features and soil units, assessment of the agricultural land suitability and good quality agricultural land classes for the different soil units was undertaken. This assessment classified the soils as shown in **Table 1**.

Table 1 Land suitability and good quality agricultural land classes for the identified soil units within the Project site

Soil unit	Land Suitability Class		Good Quality Agricultural Land Class	
	Rainfed Broadacre Cropping	Beef Cattle Grazing	Cropping	Grazing
Delete row if not required				
Black, Brown and Grey Vertosols on Fair Hill Formation	4	2-3	B	C1-C2
Brown and Red Dermosols on Fair Hill Formation	4	4	B	C3
Black, Brown and Grey Vertosols on Quaternary alluvium	3	4	A1-A2	C3
Black, Brown and Grey Dermosols on Quaternary alluvium	4	3	B	C1-C2

Based on the above classifications, the mining operation will be required to manage the soils in accordance with the specified management practices to ensure rehabilitation, post-mining operations, returns the landscape to its current suitability for future agricultural use.

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- Appendix D Chain of Custody and Laboratory Certificates

Signed Statement by Suitably Qualified Person to Approve this Assessment Report

This assessment report references previous soil and land assessment reports prepared by others for the Fairhill Coal Project and surrounding landscape. These assessments were based on desktop assessments, field observations and soil profile descriptions and sampling, and laboratory analysis by laboratories with NATA accreditation for most analyses performed. The assessment report has been approved by Rodney Masters, Technical Director – Soil Science, SLR Consulting.

Rodney Masters, CPSS 3
Technical Director – Soil Science
SLR Consulting

Signed Statement by Suitably Qualified Person to Review this Assessment Report

This assessment report references previous soil and land assessment reports prepared by others for the Fairhill Coal Project and surrounding landscape. These assessments were based on desktop assessments, field observations and soil profile descriptions and sampling, and laboratory analysis by laboratories with NATA accreditation for most analyses performed. The assessment report has been prepared by Cameron Traill, Principal – Soil Science, SLR Consulting.

Qualifications and Experience

I am a soil scientist and water manager with a Bachelor of Applied Science Degree (Soil and Water Management) from The University of Queensland, Gatton Campus, that I graduated with in 1992. I have 28 years' experience in a diverse range of natural resource management projects, including a concentration of high intensity soil science projects over the last eight years.

I have considerable recent experience in undertaking soil surveys for the preparation of soil and land investigation reports, soil assessment and management plans, construction soil management plans, and erosion and sediment control plans for projects in a range of industry sectors, including the natural resource/ integrated catchment management, agricultural/horticultural, energy, transport infrastructure and extractive sectors. I am a member of Soil Science Australia (SSA), the Agricultural Institute of Australia (AIA), and the International Erosion Control Association (IECA) and am a trained and practising (but not yet certified) professional in erosion and sediment control.

After graduating from The University of Queensland, I had various roles in private, local and state government organisations associated with natural resource/integrated catchment management from 1992 to 2002 that developed and relied on my qualifications and, progressively expanding, experience in soil and water management. From 2002 to 2012, I was mostly employed in the private consulting sector providing general environmental science and management planning consulting services across climate and weather patterns; geology, topography and soils, including acid sulfate soils, erosion and sediment control, landscape design and contaminated land; terrestrial and aquatic (freshwater) flora and fauna, including regional ecosystems, macro-vertebrates, macro-invertebrates, macrophytes and blue-green algae; and water quality and quantity.

Towards the end of this period (2012), I graduated with a Graduate Certificate in Business Administration from the University of the Sunshine Coast. Since then, I have project managed and/or co-ordinated and/or technically led more than 30 detailed soil and land survey projects, the majority of which were for coal seam gas projects. These included broad-scale (gas field-wide or main pipeline long) and fine-scale (individual property) soil assessments to prepare more than 100 soil or land investigation reports, soil assessment and management plans, construction soil management plans, erosion and sediment control plans and contaminated land investigation reports.

Selected project experience includes:

- Preparing a soil and land suitability assessment report for the Cracow gold mine second tailings storage facility project for Evolution Mining Limited. The assessment included desktop assessment of historical soil and land resource assessment reports, previous NRC report for the project and GIS data, review of geotechnical field survey data including full representative profile description, laboratory analytical data assessment, and report drafting;

- Preparing a soil and strategic cropping land assessment report for the Wilton Coking Coal project for Wilton Coking Coal Pty Ltd. The assessment included desktop assessment of historical soil and land resource assessment reports, previous NRC report for the project and GIS data, field survey including full representative profile description, sample collection for laboratory analysis and check sites, laboratory data assessment, and report drafting;
- Technically reviewing the Desktop Soil Assessment & Rehabilitation Strategy for the New Acland Stage 2 Extension for New Hope Corporation Limited's New Acland Mine. The review included incorporating historical soil and land assessment information from the Central Darling Downs Land Management Manual, both the Resource Information Book and Field Manual, cross-referencing previous soil and land assessments conducted for the New Acland Mine by other consultants to correlate soil profiles with mapped soil units, and expanding on the rehabilitation plan prepared in accordance with the Guideline: Rehabilitation requirements for mining resource activities (DES, 2014)
- Preparing a soil assessment and management plan (SAMP) for the Meteor Downs South (MDS) Loading Facility for Sojitz Coal Mining Ltd & Endocoal Limited. The soil assessment was based on a literature review of historical soil and land resource assessment reports by CSIRO and QDPI as well as desktop assessment of recent GIS data and geotechnical investigation bore logs for the project. Two soil units were mapped across the project site and informed the management plan, which provided specific soil management measures and practices for the short, medium and long-term protection of mapped agricultural lands, including strategic cropping land;
- Project managing and technically co-ordinating and leading an investigation into 'sink hole' formation on two properties in the Chinchilla area for Origin Energy on the APLNG Upstream Project. The project was to identify the physical, chemical and/or biological factors causing the 'sink holes'. The study confirmed the 'sink holes' were in fact tunnel erosion resulting from degrading soil physical, chemical and biological properties. Works included a detailed literature review and landholder consultation, field planning, desktop and field assessment, assessment of laboratory analytical data, and report drafting;
- Project managing and technically co-ordinating and leading the two packages of work to undertake soil surveys on 18 properties across three gas fields for Origin Energy on the APLNG Upstream Project. The project was to prepare 24 construction soil management plans and erosion and sediment control plans. Works included field planning, desktop and field soil and landscape assessment, assessment of laboratory analytical data, and report drafting; and
- Project co-ordination and field work for a proportion of the 21 soil assessment and management plans prepared for Origin Energy on the APLNG Upstream Project. These plans were spread across the Condabri, Combabula and Talinga-Orana gas fields, interconnecting gas and water trunk mains, main pipeline from Miles to Gladstone and associated infrastructure, such as laydowns and camps. Works included field planning, desktop and field soil and landscape assessment, assessment of laboratory analytical data, and report drafting.

Cameron Traill



Principal – Soil Science
SLR Consulting

1 Introduction

SLR Consulting (SLR) was commissioned to prepare this report to support a development application for the Fairhill Coking Coal Project (the Project). An application was submitted to the Department of Environment and Science (DES) that included a soil and land suitability assessment report prepared by [Northern Resource Consultants \(NRC\) \(2018\)](#); however, the DES has not approved the development pending additional information being provided through a request for information (RFI) notice. The RFI notice requested the report *'Provide further detail on the suitability rule-set used to determine the suitability class for Beef Cattle Grazing and Rain Fed Broadacre Cropping'*.

Additionally, the RFI notice has several other questions that require the mine footprint to be altered from a 5-year pit shell to a 7-year pit shell. With this change and the amendment required to address the suitability rule-set, a new report is required.

This report provides the new assessment against the new 7-year pit shell and addresses the RFI notice.

1.1 Project Description

The Project is a proposed coal mine in central Queensland by Fairhill Coking Coal Pty Ltd (FCC), which is owned by Futura Resources Pty Ltd (Futura). FCC will be a coal test product, with an annual production rate of 1.7 Mt, focussing only on the Burngrove seam. The project is designed to test the viability of this coking coal product on the current market, trialling surface mining methodology in conjunction with 30 t excavators to strip-mine the coal in the layers in which it occurs.

There will be no on-site processing for the Project. Instead, FCC is seeking agreement from nearby owner operators of coal washing infrastructure to ship raw coal product to nearby operations and utilise existing CHPP and tailings infrastructure under agreement.

The Project will be staged over a period of 20 years.

1.2 Purpose

The purpose of this report is to present an assessment of the soils across the Project area and land suitability for agricultural production.

1.3 Scope

The scope of works to undertake the soil and land suitability assessment to prepare this report includes:

- Desktop assessment of:
 - Historical soil and landscape assessment reports prepared by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) ([Story et al. 1967](#)) and Queensland Department of Primary Industries (DPI) ([Bourne & Tuck, 1993a](#); [Bourne & Tuck, 1993b](#));
 - Previous soil and land suitability assessment report prepared by [NRC \(2018\)](#), including incorporation of relevant data from that report applicable to the new 7-year pit shell; and

- Geographic information system (GIS) data, including aerial photography, digital terrain modelling, existing surface geology, topography, soils, and agricultural land assessments;
- Field assessment of the soil and land surface through a field survey to identify, describe through representative profiles and other check sites, and sample the soils on the Project site;
- Laboratory analysis of selected representative profile samples to describe the physical and chemical properties of the soils on the Project site; and
- Prepare this soil and land suitability assessment report analysing all the above data to describe the identified soil units and evaluate the suitability for particular agricultural farming systems.

1.4 Goal

The goal of this report is to identify, describe and map the soil units and their current suitability for agricultural production across the Project site through a detailed and rigorous desktop, field and laboratory assessment process.

2 Regulatory Framework

2.1 Environmental Protection Act 1994

In Queensland, environmental impacts to land associated with environmentally relevant activities (ERAs) are regulated under the *Environmental Protection Act 1994* (EP Act) and subordinate legislation, including the *Environmental Protection Regulation 2008* (EP Reg). The EP Act sets out the criteria for ERAs, which are activities that are likely to cause environmental impacts. An activity that is an ERA is required to apply for an environmental authority (EA) and the activity must be conducted in accordance with the conditions of the EA to protect land from environmental harm and, where applicable, to ensure the land is rehabilitated.

Environmental harm includes any adverse effect, or potentially adverse effect, on an environmental value. The EP Act also recognises that there are ERAs as well as other types of activities that have the potential to cause land contamination. These are referred to as 'notifiable activities' and the EP Act includes provision for maintenance of the Environmental Management Register (EMR) and Contaminated Land Register (CLR). These registers keep a record of land on which notifiable activities have been conducted, or that may have otherwise been affected by hazardous contaminants.

The EP Act specifies what information must be included with applications for environmental authorities. The Queensland Department of Environment and Science (DES) has prepared a guideline, "*Guideline: Application requirements for activities with impacts to land*" ([DES, 2017](#)), that outlines the information required by the EP Act, which also explains how DES will use this information to decide on the ERA. This guideline is outlined below.

2.2 Guideline: Application Requirements for Activities with Impacts to Land

This guideline outlines the information required by the EP Act, but in more detail, that applications for EAs must include with the EA application. For EA applications that have potential impacts to land, the application must demonstrate how the following environmental objective and performance outcomes for the ERA will be achieved. Under Schedule 5, Part 3, Table 1 of the EP Regulation, the environmental objective and performance outcomes for land are detailed in **Table 2**.

Table 2 Environmental objective and performance outcomes for land

Environmental objective	Performance outcomes
The activity is operated in a way that protects the environmental values of land, including soils, subsoils, landforms, and associated flora and fauna.	There is no actual or potential disturbance or adverse effect to the environmental values of land as part of carrying out the activity, or All of the following: (a) Activities that disturb land, soils, subsoils, landforms and associated flora and fauna will be managed in a way that prevents or minimises adverse effects on the environmental values of land, and (b) Areas disturbed will be rehabilitated or restored to achieve sites that are: i) safe to humans and wildlife; ii) non-polluting; iii) stable; and iv) able to sustain an appropriate land use after rehabilitation or restoration. (c) The activity will be managed to prevent or minimise adverse effects on the environmental values of land due to unplanned releases or discharges, including spills and leaks of contaminants. (d) The application of water or waste to the land is sustainable and is managed to prevent or minimise adverse effects on the composition or structure of soils and subsoils.

To achieve the objective and performance outcomes, the environmental values of the location or proposed site must be described based on its previous and current land uses. This includes undertaking a site inspection to gather and collate relevant information to identify, describe and quantify the quality of environmental values that may be impacted by the proposed activity.

Identification and description of environmental values includes physical description of the land, including interpreting the climate, geology, topography and soils to understand their current condition and suitability for growing native vegetation, crops and other flora.

Identification and description of environmental values is to be undertaken with reference to identified information sources and reference material. This includes those listed below:

- State Planning Policy ([DILGP, 2017b](#))
- Guidelines for Agricultural Land Evaluation in Queensland, 2nd Ed. ([DSITI & DNRME, 2015](#));
- Guidelines for Surveying Soil and Land Resources ([McKenzie, et al., 2008](#));
- Australian Soil and Land Survey Field Handbook ([NCST, 2009](#));
- Munsell Soil Color Charts ([Munsell Color, 2009](#))
- Soil Chemical Methods – Australasia ([Rayment & Lyons, 2011](#));
- Measuring soil cation exchange capacity and exchangeable cations ([SSA, 2013](#))
- Interpreting Soil Test Results – What Do All The Numbers Mean? ([Hazelton and Murphy, 2004](#)); and
- Australian Soil Classification (ASC) system ([Isbell & NCST, 2016](#)).

Assessment of the identified and described soils for agricultural purposes is then made against the following guidelines:

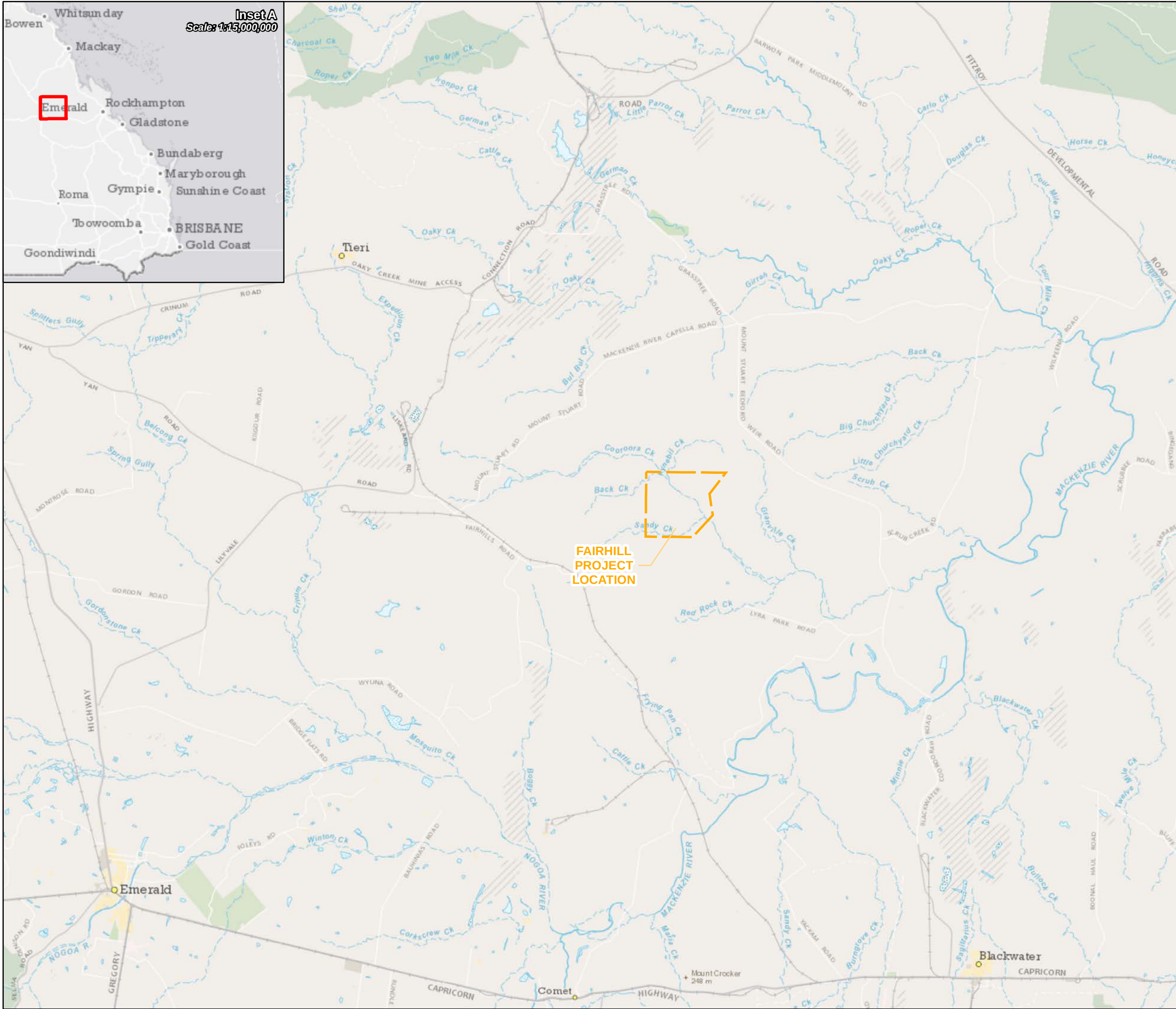
- Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland – Land Suitability Assessment Techniques ([DME, 1995](#));
- Planning Guidelines: The Identification of Good Quality Agricultural Land ([DPI & DHLGP, 1993](#)); and
- RPI Act Statutory Guideline 08/14: How to demonstrate that land in the strategic cropping area does not meet the criteria for strategic cropping land ([DILGP, 2017a](#)).

3 Project Site Description

The Project site is located in central Queensland approximately 60 km northeast of Emerald, 45 km northwest of Blackwater, and approximately 150 km west of Rockhampton, in Queensland's Bowen Basin (refer to **Figure 1**).

The Project site is situated on land within exploration permit for coal (EPC) 2177, which is approximately 6,296 ha. Within EPC 2177 is mining lease (ML) 700043, which is also known as 'Fairhill' (refer to **Figure 2**). Fairhill is approximately 3,054 ha. The Project site is located on land identified as Lot 2 on TT241.

The Project disturbance footprint is anticipated to include an open cut 7-year pit shell (including out of pit dump) and other infrastructure comprising an out of pit overburden dump, offices and maintenance pad, haul road, mine affected water storages, and run of mine, totalling a disturbance foot print of approximately 350 ha.



FAIRHILL COKING COAL PTY LTD

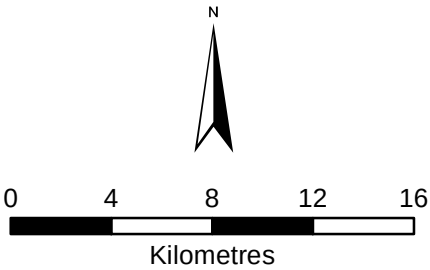
FAIRHILL

FIGURE 1
REGIONAL LOCATION

Legend

- Town
- Major Road
- Minor Road
- Railway
- Major Watercourse
- Minor Watercourse
- Protected Areas
- Mining Lease (Application)

Data Sources:
Topographic basemap and Mining Lease dataset: © State of Queensland (Department of Natural Resources, Mines, and Energy) 2019.
Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator
Datum: GDA 1994
Date: 24/06/2019



Scale: 1:300,000 at A3



FAIRHILL COKING COAL PTY LTD

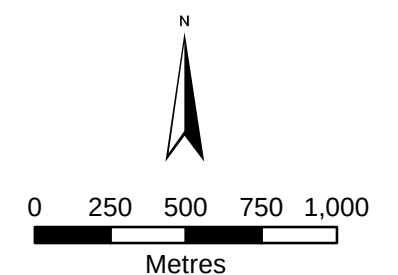
FAIRHILL

FIGURE 2
SITE INFRASTRUCTURE

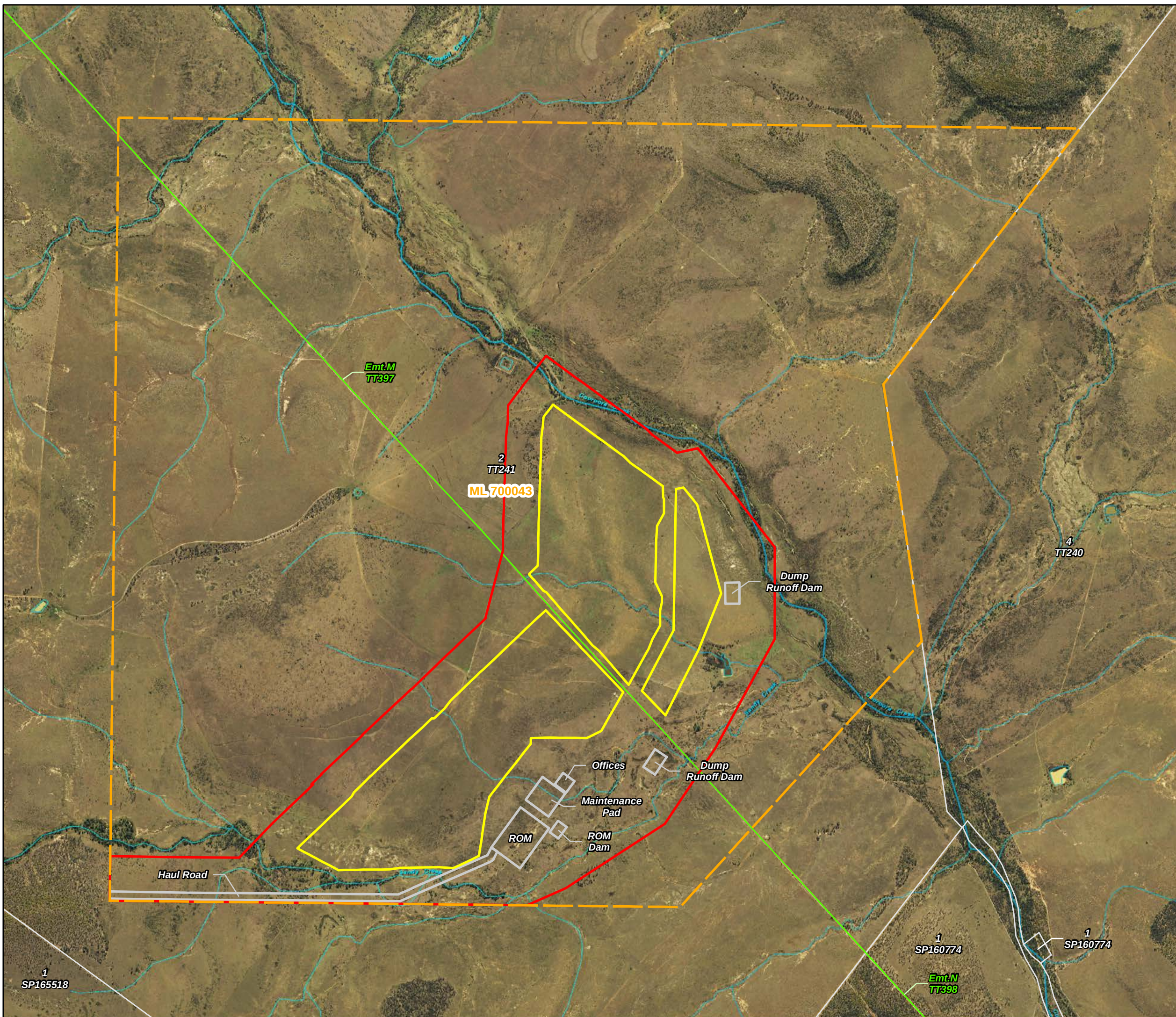
Legend

- Watercourse
- Mining Lease (Application)
- Investigation Area
- 7 Year Pit Shell
- Proposed Site Infrastructure
- Easement
- Base Cadastre

Data Sources:
Mining Lease, Watercourse, and Digital Cadastral Database (extracted April 2019) datasets: © State of Queensland (Department of Natural Resources, Mines, and Energy) 2019; 7 Year Pit Shell, Investigation Area, and Proposed Site Infrastructure datasets: (SLR Consulting) 2019.
Imagery Sources: 70cm Bowen Basin SISP PeriUrban 2012 Orthophoto Image Service: © State of Queensland (Department of Natural Resources, Mines, and Energy) 2019.
Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator
Datum: GDA 1994
Date: 22/06/2019



Scale: 1:25,000 at A3



3.1 Climate

The Project is located within the subtropics with warm, wet summers and cool, dry winters. The nearest Bureau of Meteorology (BOM) weather station is located at Emerald Airport (Station ID: 035264), approximately 60 km south-west of the Project.

According to the [BOM \(2017\)](#), the regional climate is characterised with:

- Mean maximum and minimum temperatures for summer months are approximately 34.1 °C and 20.1 °C, respectively;
- Mean maximum and minimum temperatures for winter months are approximately 23.9 °C and 9.8 °C, respectively; and
- Mean summer and winter rainfall is approximately 259 mm and 72.4 mm, respectively.

3.2 Geology

Surface geology, according to the Queensland Globe ([QG, 2019](#)), within and immediately surrounding the Project site (refer to **Figure 3**) includes:

- Fair Hill Formation (Pwt); and
- Quaternary alluvium (Qa).

3.2.1 Fairhill Formation (Pwt)

The Fairhill Formation is mapped by Geoscience Australia as occupying the majority of the Project site, including the plateau ridge and slopes, minor drainage depressions and the major drainage depression along the southern boundary of the Project site. Digital elevation modelling and field observations confirm the major drainage depression along the southern boundary is not Pwt.

This formation is a late Permian age sedimentary unit, including volcanic and metamorphic, comprising lithic and feldspathic labile sandstone, quartzose sublabile sandstone, siltstone, mudstone, calcareous and tuffaceous sandstone, volcanic conglomerate, carbonaceous mudstone and coal.

3.2.2 Quaternary Alluvium (Qa)

Quaternary alluvium is mapped by Geoscience Australia in the major drainage feature along the north-eastern boundary of the Project site, which drains from the north-west to the south-east. Digital elevation modelling and field observations confirm the major drainage depression along the southern boundary is Qa along most of the southern boundary.

This formation is of Pleistocene and Holocene age (recent) and comprises clay, silt, sand, gravel; flood plain alluvium.

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FIGURE 3
SITE GEOLOGY

Legend

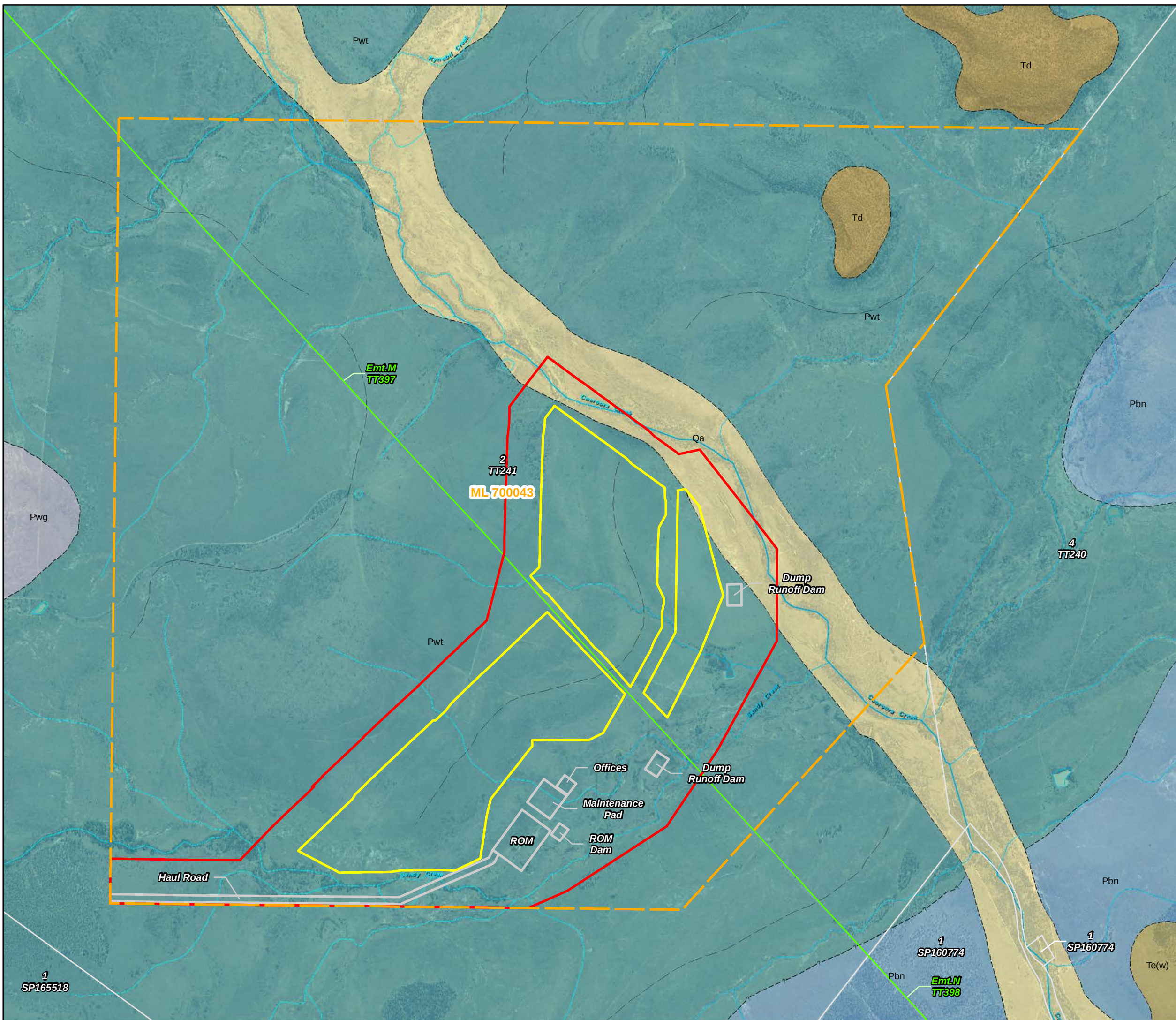
	Watercourse		Easement
	Mining Lease (Application)		Base Cadastre
	7 Year Pit Shell		Investigation Area
	Proposed Site Infrastructure	Geological Structures	
Detailed Surface Geology			Geological boundary (conformable) approximate
	Burngrove Formation (Pwg)		Geological boundary (conformable) inferred
	Emerald Formation(w) (Te(w))		Geological boundary (unconformable) approximate
	Fair Hill Formation (Pwt)		Trend line
	MacMillan Formation (Pbn)		
	Qa-QLD (Qa)		
	Td-QLD (Td)		

Data Sources:
Detailed Surface Geology, Detailed Geological Structures, Watercourse, and Mining Lease datasets: © State of Queensland (Department of Natural Resources, Mines, and Energy) 2019; 7 Year Pit Shell, Investigation Area, and Proposed Site Infrastructure datasets: (SLR Consulting) 2019.
Imagery Sources: 70cm Bowen Basin SISF PeriUrban 2012 Orthophoto Image Service: © State of Queensland (Department of Natural Resources, Mines, and Energy) 2019.
Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator
Datum: GDA 1994
Date: 22/06/2019



0 250 500 750 1,000
Metres

Scale: 1:25,000 at A3



3.3 Topography

The Project site is located primarily on a south-east facing slope emanating from a long plateau ridge running north-east through the regional landscape (refer to **Figure 4**).

The Fair Hill Formation occupies the plateau ridge, slopes, and minor drainage depressions on the Project site. The land is gently undulating hills and slopes, incised with ephemeral drainage depressions. Elevation ranges from 149 to 181 m Australian height datum (AHD). Slopes on this geological unit range from <1% on the plateau ridge to between 1 to 4% on the upper and mid-slopes down to <1% on the lower slopes.

The Quaternary alluvium occupies the major drainage depressions flowing along the north-eastern and southern boundaries of the Project site. This land is an alluvial plain with elevations ranging from 146 to 161 m AHD. Slopes on this geological unit are <1%.

The relief is described as undulating low hills.

3.4 Vegetation

Through a search of the Queensland Government's regional ecosystems database ([DES, 2019a](#)), the Project site is mapped, based on pre-clearing broad vegetation groups, as being dominated by the communities shown in **Figure 5** and listed and described ([DES, 2019b](#)) in **Table 3**. This data provides background to the likely types and distribution of soil units across the Project site and is referenced through the identification, description and mapping of the soil units.

Table 3 Pre-clearing vegetation communities mapped across the Project site

RE code	Proportion (%)	Short description	Detailed description	Geological units
11.9.1	60	<i>Acacia harpophylla</i> - <i>Eucalyptus cambageana</i> woodland to open forest on fine-grained sedimentary rocks	Open forest to woodland of <i>Eucalyptus cambageana</i> or <i>E. thozetiana</i> and <i>Acacia harpophylla</i> . <i>Eucalyptus cambageana</i> is commonly codominant with <i>Acacia harpophylla</i> in the open forest, or the open forest may be dominated by <i>A. harpophylla</i> and have scattered emergent <i>Eucalyptus cambageana</i> or <i>E. thozetiana</i> trees. The <i>A. harpophylla</i> trees range from about 12 m to 14 m in height and the eucalypts 15-18 m high. In central western areas the <i>Acacia harpophylla</i> may form tall shrubland c. 4 m high with emergent <i>Eucalyptus cambageana</i> trees 10-12 m high. The community has a moderately dense to dense lower tree/tall shrub layer dominated by species such as <i>Eremophila mitchellii</i> , <i>Carissa ovata</i> and <i>Geijera parviflora</i> , with <i>Terminalia oblongata</i> often present in the north. The ground layer is frequently sparse. Associated with slopes and crests of undulating plains and below low ridges and escarpments formed from Cainozoic to Proterozoic consolidated, fine-grained sediments. Texture contrast soils predominate, often with surface stone or gravel in sub-surface horizons, but other soils such as clays, sandy clay loams and cracking clays may also be present.	Fair Hill Formation (Pwt)

RE code	Proportion (%)	Short description	Detailed description	Geological units
11.9.2	40	<i>Eucalyptus melanophloia</i> +/- <i>E. orgadophila</i> woodland on fine-grained sedimentary rocks	<i>Eucalyptus melanophloia</i> and/or <i>E. orgadophila</i> grassy woodland to open woodland. Other tree species occasionally present as subdominants include <i>Corymbia erythrophloia</i> , <i>Eucalyptus populnea</i> or <i>Corymbia dallachiana</i> . Occurs on rises on undulating plains with cracking clay or texture contrast soils.	Fair Hill Formation (Pwt)
11.3.3	60	<i>Eucalyptus coolabah</i> woodland on alluvial plains	<i>Eucalyptus coolabah</i> woodland to open woodland with a grassy understorey. A mid layer is often absent but scattered tree or shrub species, such as <i>E. populnea</i> , <i>Melaleuca bracteata</i> , <i>Acacia stenophylla</i> , <i>Alectryon oleifolius</i> , <i>Terminalia oblongata</i> (in the north) and <i>Acacia pendula</i> , <i>A. cambagei</i> , and occasionally <i>Duma florulenta</i> may be present. The ground layer is dominated by a range of grass and forb species depending on season, soil and management conditions. Can include small areas of grassland with scattered trees. Occurs on Cainozoic alluvial plains or levees with clay or sometimes texture contrast soils.	Quaternary alluvium (Qa)
11.3.25	20	<i>Eucalyptus tereticornis</i> or <i>E. camaldulensis</i> woodland fringing drainage lines	<i>Eucalyptus camaldulensis</i> or <i>E. tereticornis</i> woodland to open forest. Other tree species such as <i>Casuarina cunninghamiana</i> , <i>E. coolabah</i> , <i>Melaleuca bracteata</i> , <i>Melaleuca viminalis</i> , <i>Livistona</i> spp. (in north), <i>Melaleuca</i> spp. and <i>Angophora floribunda</i> are commonly present and may be locally dominant. An open to sparse, tall shrub layer is frequently present dominated by species including <i>Acacia salicina</i> , <i>A. stenophylla</i> or <i>Lysiphyllum carronii</i> . Low shrubs are present, but rarely form a conspicuous layer. The ground layer is open to sparse and dominated by perennial grasses, sedges or forbs such as <i>Imperata cylindrica</i> , <i>Bothriochloa bladhii</i> , <i>B. ewartiana</i> , <i>Chrysopogon fallax</i> , <i>Cyperus dactyloides</i> , <i>C. difformis</i> , <i>C. exaltatus</i> , <i>C. gracilis</i> , <i>C. iria</i> , <i>C. rigidellus</i> , <i>C. victoriensis</i> , <i>Dichanthium sericeum</i> , <i>Leptochloa digitata</i> , <i>Lomandra longifolia</i> or <i>Panicum</i> spp. Occurs on fringing levees and banks of major rivers and drainage lines of alluvial plains throughout the region. Soils are very deep, alluvial, grey and brown cracking clays with or without some texture contrast. These are usually moderately deep to deep, soft or firm, acid, neutral or alkaline brown sands, loams or black cracking or non-cracking clays, and may be sodic at depth.	Quaternary alluvium (Qa)

RE code	Proportion (%)	Short description	Detailed description	Geological units
11.9.1	20	<i>Acacia harpophylla</i> - <i>Eucalyptus cambageana</i> woodland to open forest on fine-grained sedimentary rocks	Open forest to woodland of <i>Eucalyptus cambageana</i> or <i>E. thozetiana</i> and <i>Acacia harpophylla</i> . <i>Eucalyptus cambageana</i> is commonly codominant with <i>Acacia harpophylla</i> in the open forest, or the open forest may be dominated by <i>A. harpophylla</i> and have scattered emergent <i>Eucalyptus cambageana</i> or <i>E. thozetiana</i> trees. The <i>A. harpophylla</i> trees range from about 12 m to 14 m in height and the eucalypts 15-18 m high. In central western areas the <i>Acacia harpophylla</i> may form tall shrubland c. 4 m high with emergent <i>Eucalyptus cambageana</i> trees 10-12 m high. The community has a moderately dense to dense lower tree/tall shrub layer dominated by species such as <i>Eremophila mitchellii</i> , <i>Carissa ovata</i> and <i>Geijera parviflora</i> , with <i>Terminalia oblongata</i> often present in the north. The ground layer is frequently sparse. Associated with slopes and crests of undulating plains and below low ridges and escarpments formed from Cainozoic to Proterozoic consolidated, fine-grained sediments. Texture contrast soils predominate, often with surface stone or gravel in sub-surface horizons, but other soils such as clays, sandy clay loams and cracking clays may also be present.	Quaternary alluvium (Qa)

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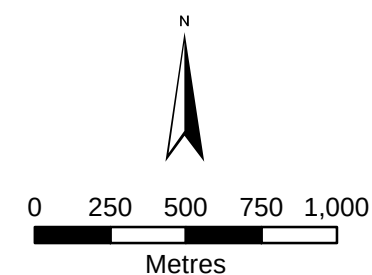
FAIRHILL

FIGURE 4
SITE TOPOGRAPHY

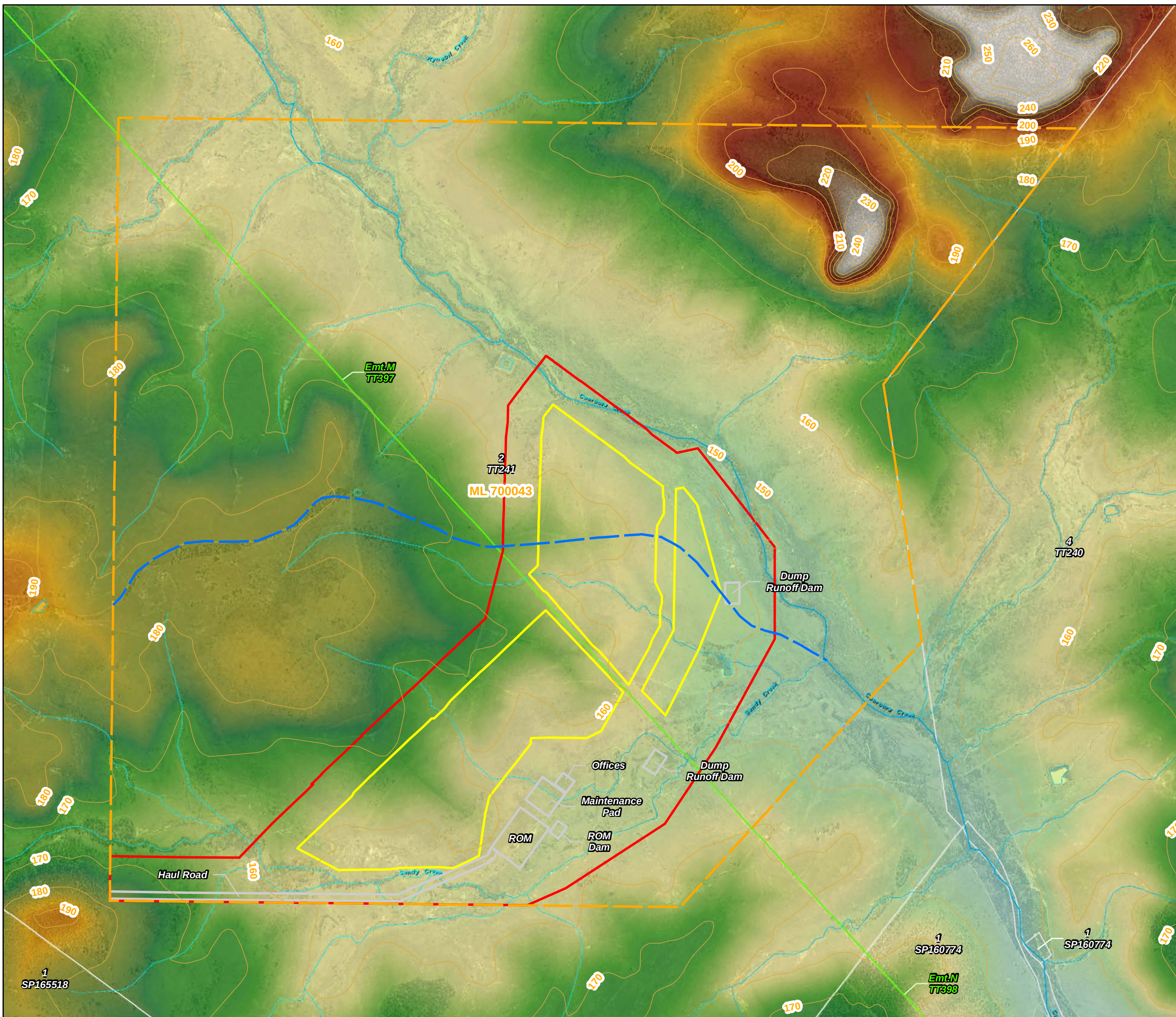
Legend

- Contour (mAHD)
 - Watercourse
 - Inferred Local Drainage Division Boundary
 - Mining Lease (Application)
 - Investigation Area
 - 7 Year Pit Shell
 - Proposed Site Infrastructure
- Elevation (mAHD)**
- High : 268
 - Low : 141.5

Data Sources:
Mining Lease, 10m Contours (mAHD), and
Watercourse dataset: © State of Queensland
(Department of Natural Resources, Mines, and Energy)
2019; 7 Year Pit Shell, Investigation Area, 10m DEM,
Inferred Local Drainage Division Boundary, and
Proposed Site Infrastructure datasets: (SLR
Consulting) 2019.
Imagery Sources: 70cm Bowen Basin SISPP PeriUrban
2012 Orthophoto Image Service: © State of
Queensland (Department of Natural Resources, Mines,
and Energy) 2019.
Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator
Datum: GDA 1994
Date: 24/06/2019



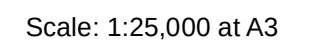
Scale: 1:25,000 at A3



FAIRHILL

Legend

- Data Sources:
Mining Lease, Vegetation Management Watercourse
(100/250K v3), Pre-Clearing Regional Ecosystems
(v11), and Digital Cadastral Database (extracted April
2019) datasets: © State of Queensland (Department of
Natural Resources, Mines, and Energy) 2019; 7 Year
Pit Shell, Investigation Area, and Proposed Site
Infrastructure datasets: (SLR Consulting) 2019.
Imagery Sources: 70cm Bowen Basin SISP PeriUrban
2012 Orthophoto Image Service: © State of
Queensland (Department of Natural Resources, Mines,
and Energy) 2019.
- Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator
Datum: GDA 1994
Date: 22/06/2019
- 



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3.5 Soils

3.5.1 Land Systems

[Story et al. \(1967\)](#) conducted a survey of the soil and land resources of the Isaac-Comet region on behalf of the Queensland Government to identify, describe and map the land systems. The MLA is located across the Girrah, Humboldt and Daunia land systems. Although the Project site appears to only be located on the Girrah land system, the mapping scale (1:500,000) for the land systems is such that one or both of Humboldt and/or Daunia land systems could also occur. Each of these land systems is described below.

3.5.1.1 Girrah Land System

The Girrah land system is characterised by lowlands with downs and brigalow and cracking clay soils on unweathered Permian shale and lithic sandstone in the north and centre ([Story et al., 1967](#)). Land forms within this land system include lowlands and low rises; lowlands and plains on shales and detrital clay; and alluvial flats.

Terrain, soils and vegetation associations with this land system include the following by land form:

- Lowlands and low rises – local relief 3 to 33 m, slopes 2 to 5%, mainly clay on shales but some stony patches on sandstone; mainly cracking clay soils (Bruce), minor shallow texture contrast soils (Southernwood) with open savannah woodland of *Eucalyptus orgadophila*, *E. populnea*, *E. dichromophloia*, *E. papuana*, narrow-leaved ironbark or *E. melanophloia* over dense ground cover of *Dichanthium* spp., *Bothriochloa* spp., *Themeda* spp., *Heteropogon* spp., *Iseilema* spp., *Cymbopogon* spp., *Aristida latifolia*, and *Enneapogon* spp. (area 30% and widespread);
- Lowlands and plains on shales and detrital clay – slopes 0 to 5%:
 - Mostly cracking clay soils (Teviot), commonly with linear gilgai, minor dark brown and grey-brown soils (Cheshire) with downs vegetation, dense grass flora as per lowlands and rises above (area 45% and widespread);
 - Some texture contrast soils mainly with thin sandy surface horizons and strongly alkaline sub-soils (Taurus, minor Wyesby) with open savannah woodland mainly of *E. populnea*, some *E. melanophloia* and *E. orgadophila*, ground cover as per lowlands and rises above (area 5% and limited); and
 - Texture contrast soils (Taurus) and cracking clay soils (Rolleston); brigalow with varied associates (*Carissa* spp., *Eremophila* spp., *Terminalia* spp., *Denhamia obscura*, *Acalypha eremorum*, *Brachychiton* spp., *Canthium vacciniifolium*, *Croton phabalioides*, *Erythroxylum australe*), fair to scanty cover of *Paspalidium* spp., *Aristida* spp., *Chloris* spp., *Enneapogon* spp., *Cheilanthes hirsuta*, and mosses (area 20% and widespread); and
- Alluvial flats – up to 800 m wide, mainly clay, probably flooded in parts, both single and braided channels; no soil specified but assumed to be mainly texture contrast soils; savannah woodland of *E. tessellaris* and *E. tereticornis* or *E. populnea*, ground cover of *Heteropogon* spp. (area <5% but widespread).

3.5.1.2 Humboldt Land System

The Humboldt land system is characterised by blackbutt and brigalow on weathered clay plains occurring in most parts of the area; texture contrast and cracking clay soils ([Story et al., 1967](#)). Land forms within this land system include crests of rises and low hills; slight rises; plains and lowlands; plains and shallow depressions with deep gilgai; and plains and depressions with sporadic gilgai.

Terrain, soils and vegetation associations with this land system include the following by land form:

- Crests of rises and low hills – sandy, local relief 3 to 15 m; mainly loamy red and yellow earths (Dunrobin and Struan, minor sandy red earths (Annandale); no consistency, bendee or lancewood over *Aristida* spp., or savannah woodland of bloodwood and ironbark over *Heteropogon* spp., or mixed shrub woodland grading into softwood scrub (area <5% and sporadic);
- Slight rises – local relief 2 to 10 m, sandy or loamy surface, some gullying and sheet erosion, includes some sandy colluvial aprons below crests of rises and low hills above; texture contrast soils (Luxor, Taurus and Broadmeadow); mixed shrub woodland of *E. populnea*, *E. cambageana*, and brigalow with *Eremophila* spp. and *Terminalia* spp. over scanty ground cover of *Bothriochloa* spp., *Asistida* spp., and *Heteropogon* spp. (area 10% and sporadic);
- Plains and lowlands – slopes less than 2%, up to 16 km across, deeply weathered Tertiary clay and older rocks, quartz and billy gravel common in places:
 - Texture contrast soils with thin sandy or loamy surface soils and strongly alkaline subsoils (Taurus and Retro); brigalow and *E. cambageana*, often open, with *Carissa* spp., *Eremophila* spp., and *Terminalia* spp., scanty ground cover of *Paspalidium* spp., *Aristida* spp., *Chloris* spp., and *Enneapogon* spp. (area 45% and widespread); and
 - Cracking clay soils (Rolleston); brigalow and mixed shrub woodland with occasional *E. cambageana* and (in Morepath area) abundant *Terminalia* spp., other shrubs and ground cover of *Carissa* spp., *Eremophila* spp., *Terminalia* spp., *Paspalidium* spp., *Aristida* spp., *Chloris* spp., and *Enneapogon* spp. (area 25% and widespread);
- Plains and shallow depressions with deep gilgai – slopes less than 1%, up to 6 km across, weathered clay with deep gilgai, narrow alluvial flats with braided channels; gilgaied cracking clay soils (Pegunny); brigalow and mixed shrub woodland with occasional *E. cambageana*, other shrubs and ground cover of *Carissa* spp., *Eremophila* spp., *Terminalia* spp., *Paspalidium* spp., *Aristida* spp., *Chloris* spp., and *Enneapogon* spp., *Leptochloa debilis*, *Muehlenbeckia*, and Cyperaceae common in depressions (area 10% and widespread); and
- Plains and shallow depressions with sporadic gilgai - slopes less than 1%, up to 6 km across, weathered clay with sporadic gilgai, narrow alluvial flats with braided channels; mosaic of cracking clay soils (Rolleston and Pegunny) and texture contrast soils (Taurus and Retro); small separate communities of brigalow and mixed shrub land with *E. cambageana*, mixed shrubs and ground cover of *Carissa* spp., *Eremophila* spp., *Terminalia* spp., *Paspalidium* spp., *Aristida* spp., *Chloris* spp., and *Enneapogon* spp. (area 10% and sporadic).

3.5.1.3 Daunia Land System

The Daunia land system is characterised by lowlands with brigalow and cracking clay soils on unweathered fsh Permian shales and lithic sandstone in the north and centre ([Story et al., 1967](#)). Land forms within this land system include rises and low hills; lowlands and very low strike ridges, and plains and depressions.

Terrain, soils and vegetation associations with this land system include the following by land form:

- Rises and low hills – local relief 3 to 33 m, slopes up to 15%, outcrop common some sandy aprons with slopes 2-5%; no soil specified but probably red and yellow earths; savannah woodland of narrow-leaved ironbark and *E. populnea*, patches of *Acacia cunninghamii*, *Alphitonia* spp., and *Petalostigma* spp., fair ground cover of *Heteropogon* spp., *Bothriochloa* spp., and *Aristida* spp. (area 15% and widespread);
- Lowlands and very low strike ridges – local relief 3 to 10 m, slopes up to 3%, probably some outcrop, gravelly in places:
 - Texture contrast soils with thin sandy surface and neutral subsoils (Springwood); mixed shrub woodland, commonly *E. populnea* with a great variety of woody associates (*Bauhinia*, *Brachychiton*, brigalow, *Canthium vacciniifolium*, *Capparis* spp., *Carissa* spp., *Croton phebaloides*, *Eremophila* spp.), ground cover rather sparse (*Bothriochloa* spp., *Aristida* spp., *Chrysopogon* spp., *Enneapogon* spp.) (area 5% and sporadic); and
 - Texture contrast soils with thin sandy surface and strongly alkaline subsoils (Taurus, minor Springwood); mainly brigalow and scattered *E. cambageana* with *Carissa* spp., *Eremophila* spp., *Terminalia* spp. over scanty ground cover of *Paspalidium* spp., *Aristida* spp., *Chloris* spp., and *Enneapogon* spp. (area 5% and sporadic);
- Lowlands and very low strike ridges – local relief lower than lowlands and very low strike ridges above, slopes up to 3%, probably some outcrop, gravelly in places
 - Cracking clay soils (Teviot and Rolleston); mixed shrub woodland, very varied, commonly brigalow, *Carissa* spp., *Eremophila* spp., *Terminalia* spp., (abundant between Fairhill and Emerald), *E. populnea*, *Erythroxylum austral*, *Bursaria spinescens*, *Brachychiton* spp., *Geijera* spp., *Owenia* spp., *Canthium vacciniifolium*, *E. cambageana*, ground cover of *Heteropogon* spp., *Bothriochloa* spp., and *Aristida* spp. (area 15% and sporadic); and
 - Cracking clay soils (Teviot, minor texture contrast soils Taurus); brigalow, usually with *Carissa* spp., *Eremophila* spp., and *Terminalia* spp., ground cover scanty of *Paspalidium* spp., *Aristida* spp., *Chloris* spp., and *Enneapogon* spp. (area 50% and widespread); and
- Plains and depressions – up to 800 m across, weathered clay with billy and sandstone gravels; gilgaied, cracking clay soils (Pegunny); brigalow, usually with *Carissa* spp., *Eremophila* spp., and *Terminalia* spp., ground cover scanty of *Paspalidium* spp., *Aristida* spp., *Chloris* spp., and *Enneapogon* spp. with *Panicum buncei*, *Leptochloa debilis*, *Muehlenbeckia* spp., and Cyperaceae common in depressions (area 5% and sporadic).

3.5.2 Land Resource Areas

The Queensland Department of Primary Industries (DPI) undertook a soil and landscape assessment to prepare a resource information report ([Bourne & Tuck, 1993b](#)) and field manual ([Bourne & Tuck, 1993a](#)). The report and manual were prepared for understanding and managing soils in the Central Highlands of Queensland as part of the State-wide land management manual project.

The MLA is located within the former Peak Downs local government area across land resource areas (LRAs) identified as undulating scrub plains (LRA 2) and undulating downs (LRA 4), refer to **Figure 6**. The majority of the Project site appears to be on LRA 4. Both LRA's are described below.

3.5.2.1 Undulating Scrub Plains LRA

According to [Bourne and Tuck \(1993b\)](#), the undulating scrub plains land resource area (LRA 2) “comprises soils formed from the deposition of weathered fine-grained sediments. The high degree of soil variation occurs due to the variety of parent material and weathering regimes. As a result, six major, and two minor agricultural management units (AMUs) make up the group.”

The major and minor AMUs of LRA 2 include those identified and described by [Bourne and Tuck \(1993b\)](#) based on their primary soil characteristics and landform, which are presented in **Table 4** along with their current equivalent Australian Soil Classification (ASC).

3.5.2.2 Undulating Downs LRA

According to [Bourne and Tuck \(1993b\)](#), the undulating downs land resource area (LRA 4) “includes the heavy clay soils formed in situ on basalt and fine-grained sedimentary rocks. Depth to parent rock and lithology are the major diagnostic AMU attributes.” There are two major and three minor AMUs.

The major AMUs of LRA 4 include those identified and described by [Bourne and Tuck \(1993b\)](#) based on their primary soil characteristics and landform, which are presented in **Table 5** along with their current equivalent Australian Soil Classification (ASC).

Table 4 Major and minor AMUs of LRA 2

AMU	Soil classification - GSG - Northcote	Colour	Texture profile; depth	Other profile features	Landform	Equivalent ASC
Major						
Rolleston	- Grey and brown clay - Ug 5.24, 5.27, 5.33	Grey to dark surface over grey to yellow-brown subsoil; red or yellow mottles at depth	Uniform medium to heavy clay; 0.9 m	Slight (< 0.4 m vertical interval) linear or normal gilgai may occur; self- mulching surface; soil reaction trend varies from acid to alkaline	Gently undulating to undulating plains	Black, Brown and Grey Vertosols
Picardy	- Red and brown clay - Ug 5.38, 5.34, 5.24	Grey, brown, dark to red surface over similar range of subsoil colours	Light to medium heavy clay over medium to heavy clay subsoils; 0.9 m to bedrock	Strong, fine self-mulching surface over strongly structured alkaline subsoils	Gently undulating rises to level plains	Black, Brown, Grey and Red Vertosols
Springton	- Red and brown clay and non-cracking clay - Ug 5.22, 5.37, Uf 6.31	Red to reddish brown surface over reddish brown to dark reddish brown subsoils often slightly mottled	Uniform light to medium heavy clay; > 0.6 m to bedrock	Neutral self-mulching to hard setting surface with alkaline reaction trend; often coarse structured subsoils	Undulating to gently undulating plains and rises	Red and Brown Vertosols and Ferrosols
Turkey Creek	- Alkaline greyish brown duplex and solodic soil - Dd 3.13, Dy 2.33, Db 3.13	Dark surface over brown, dark or grey subsoils; occasional mottling at depth	Sandy clay loam surface over medium to heavy clay; > 1.2 m	Thin (< 0.1 m) sandy hard setting surface over moderately blocky alkaline subsoils	Undulating to gently undulating plains	Brown and Grey Sodosols and Chromosols

AMU	Soil classification - GSG - Northcote	Colour	Texture profile; depth	Other profile features	Landform	Equivalent ASC
Glennagallan	- Solodic and solodized solonetz - Dy 3.43, 2.33, 2.43	Dark brown to yellowish brown over mottled yellowish grey to brown subsoil medium heavy clay subsoil	Sandy loam to sandy clay loam surface < 0.2 m; abruptly changes to medium heavy clay subsoil; >1.2 m	Hard setting surface, often bleached, over coarse columnar structured and alkaline subsoils	Gently undulating to undulating plains	Grey and Brown Sodosols
Glen Idol	- Red-brown duplex and associated non-cracking clay - Dr 4.13, Uf 6.3	Red to reddish brown surface over red to reddish brown subsoils	Clay loam to sandy clay loam over medium to medium heavy clay; generally >0.9 m	Generally hard setting surface and no bleach; moderate prismatic structured subsoil; alkaline subsoils; carbonate often present	Undulating to gently undulating plains	Red to Brown Sodosols and Dermosols
Minor						
Adelong	- Black earth, grey clay - Ug 5.16, 5.24	Dark to grey surface over dark to grey subsoil becoming lighter and slightly mottled at depth	Uniform medium to heavy clay; >1.5 m	Self-mulching and deeply cracking with alkaline reaction trend	Level alluvial plains	Black and Grey Vertosols
Lonesome	- Grey and brown clay - Ug 5.25, 5.28, 5.15	Grey to dark grey surface in depressions, grey-brown to brown on mounds; grey to yellow-grey subsoil with prominent yellow and brown mottles	Uniform medium to heavy clay; >1.2 m	Melonhole (> 0.4 m vertical interval) gilgai; coarse self-mulching surface in depressions, mounds often crusting and non-cracking; surface ironstone common; acid to alkaline reaction trend	Gently undulating and level plains	Grey and Brown Vertosols

Table 5 Major and minor AMUs of LRA 4

AMU	Soil classification - GSG - Northcote	Colour	Texture profile; depth	Other profile features	Landform	Equivalent ASC
Major						
Orion	- Black earth, grey clay - Ug 5.12, 5.22	Grey-brown to dark throughout	Uniform medium to heavy clay; 0.45 m to 1.2 m to bedrock	Coarse to moderate self-mulching surface; neutral to alkaline; surface stone can occur; alkaline and strongly structured subsoils	Gently undulating to undulating plains and rises	Black and Grey Vertosols
Jimbaroo	- Black earth and non-cracking clay - Ug 5.12, Uf 63.2	Dark to reddish brown over dark to reddish brown subsoil	Light to medium clay over medium to medium heavy clay; <0.45 m to bedrock	Neutral to alkaline self-mulching to hard setting surface; often stony throughout	Crests and upper slopes of rises	Black to Brown Vertosols and Ferrosols
Minor						
Kia Ora	- Black earth - Ug 5.11, 5.15	Dark olive-grey to brownish black over dark brown to olive-grey subsoil	Uniform heavy clay; >0.60 m	Fine to medium self-mulching surface over strongly structured alkaline subsoil	Undulating to gently undulating	Black Vertosols
Glen Idol	- Red-brown duplex and associated non-cracking clay - Dr 4.13, Uf 6.3	Red to reddish brown surface over red to reddish brown subsoils	Clay loam to sandy clay loam over medium to medium heavy clay; generally >0.9 m	Generally hard setting surface and no bleach; moderate prismatic structured subsoil; alkaline subsoils; carbonate often present	Undulating to gently undulating plains	Red to Brown Chromosols and Dermosols
Moramana	- Grey, brown and red clay - Ug 5.34, 5.24, 5.38	Brown to red over brown, dark or red subsoil	Medium clay over medium heavy clay; >1.5 m	Strongly self-mulching surface over alkaline strongly structured subsoil; often forms a gilgai complex	Level alluvial plains	Grey, Brown and Red Vertosols

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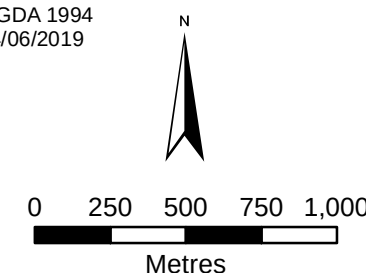
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FIGURE 6
LAND RESOURCE
AREAS

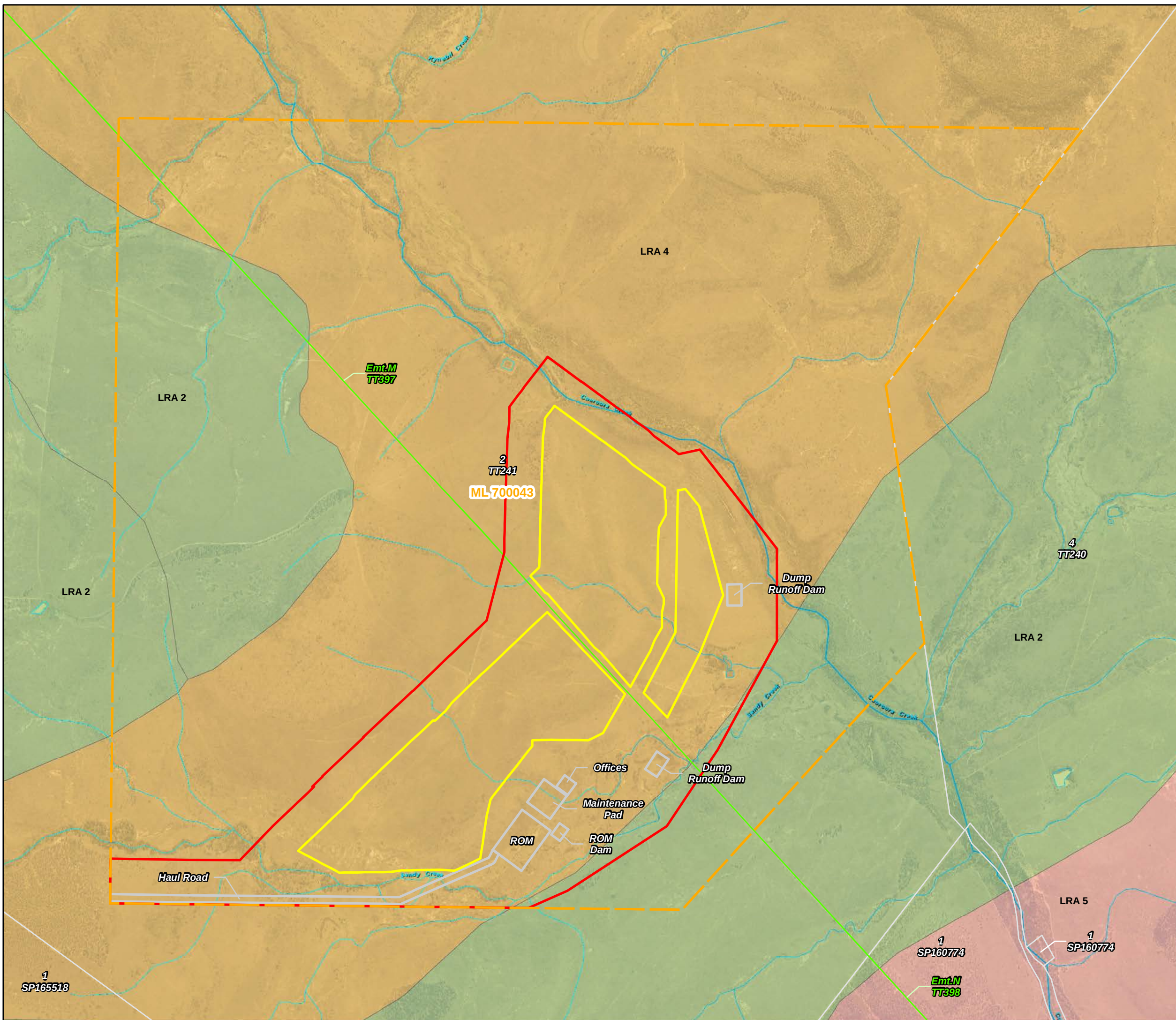
Legend

- Watercourse
- Mining Lease (Application)
- Investigation Area
- 7 Year Pit Shell
- Proposed Site Infrastructure
- Easement
- Base Cadastre
- Land Resource Areas**
 - Undulating Scrub Plains (LRA 2)
 - Undulating Downs (LRA 4)
 - Plateaus (LRA 5)

Data Sources:
Mining Lease, Watercourse, Land Resource Areas (derived from Land Systems of the Isaac-Comet Area (ZDK3)), and Digital Cadastral Database (extracted April 2019) datasets: © State of Queensland (Department of Natural Resources, Mines, and Energy) 2019; 7 Year Pit Shell, Investigation Area, and Proposed Site Infrastructure datasets: (SLR Consulting) 2019.
Imagery Sources: 70cm Bowen Basin SISF PeriUrban 2012 Orthophoto Image Service: © State of Queensland (Department of Natural Resources, Mines, and Energy) 2019.
Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator
Datum: GDA 1994
Date: 24/06/2019



Scale: 1:25,000 at A3



3.6 Current Land Use

The current land use on the Project site and immediate surrounds is primarily grazing on fairly extensively cleared lands and, in wider area, coal mining. Some areas under grazing have also been contoured and may have been sown to improved pasture.

Historical satellite imagery shows fairly extensive clearing across the project site and surrounds with some areas contoured, ripped or cultivated and sown to improved pasture while other areas appear to be in a more natural state with only clearing being carried out.

Despite contouring and possible ripping or cultivation, the imagery appears to show quite extensive areas of linear, and possibly some lattice, gilgai and minor areas of melonhole gilgai, as shown in **Figure 7**, **Figure 8**, **Figure 9** and **Figure 10**, suggesting the majority of the Project site comprises Vertosol soil units.

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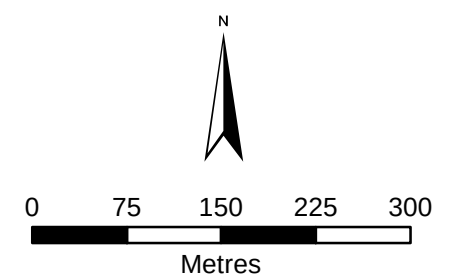
FAIRHILL

FIGURE 7 GILGAI NORTHERN EXTENT

Legend

- Watercourse
- Mining Lease (Application)
- Investigation Area
- 7 Year Pit Shell
- Proposed Site Infrastructure
- Easement
- Base Cadastre

Data Sources:
Mining Lease, Watercourse, and Digital Cadastral
Database (extracted April 2019) datasets: © State of
Queensland (Department of Natural Resources, Mines,
and Energy) 2019; 7 Year Pit Shell, Investigation Area,
and Proposed Site Infrastructure datasets: (SLR
Consulting) 2019.
Imagery Source: 50cm resolution WV02 Vivid -
Australia 2016 Orthophoto Imagery Service: © ESRI,
DigitalGlobe, GeoEye, Earthstar Geographics,
CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and
the GIS User Community.
Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator
Datum: GDA 1994
Date: 24/06/2019



Scale: 1:6,000 at A3

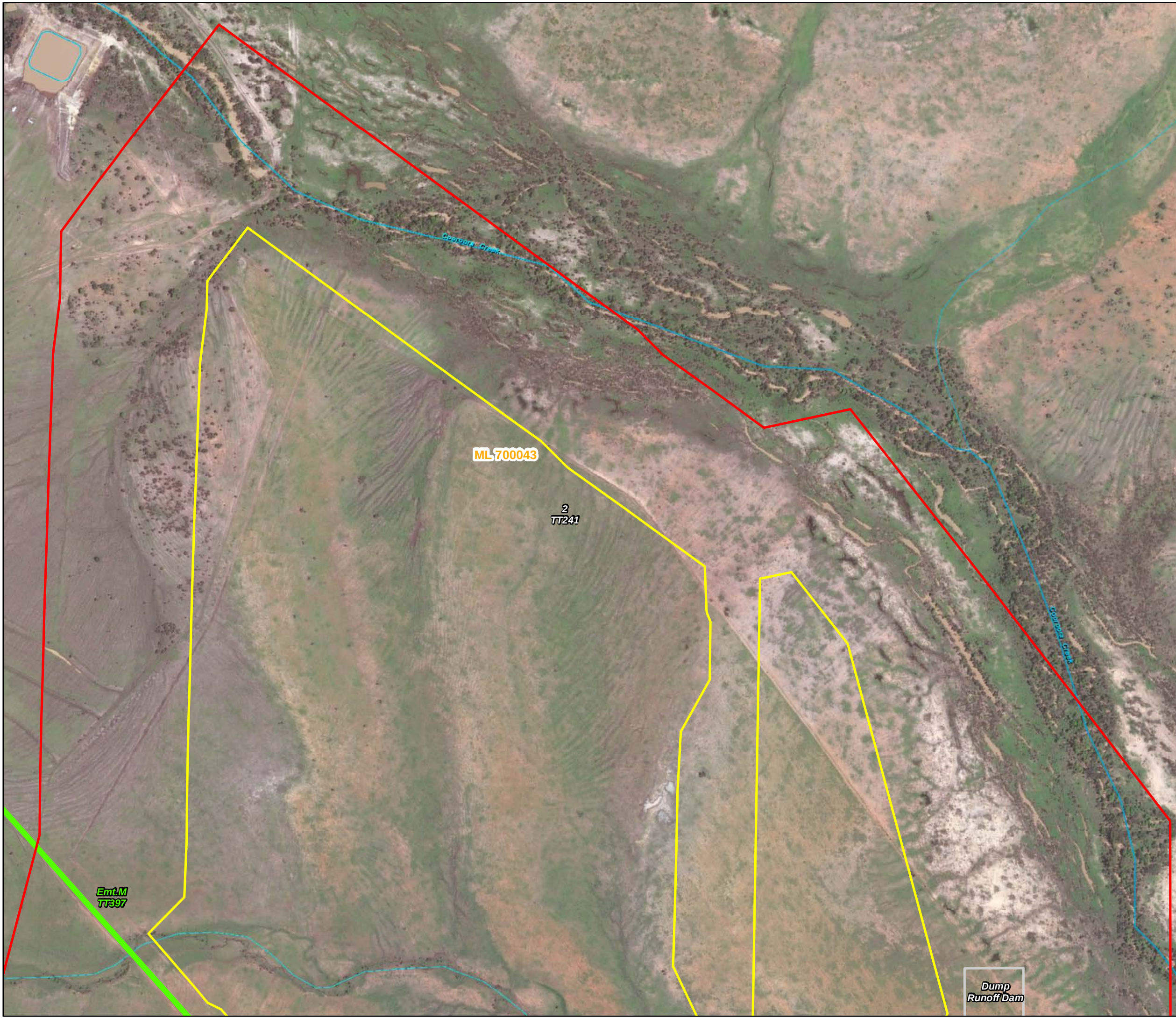


FIGURE 8
GILGAI
NORTH-CENTRAL EXTENT

- Watercourse
- Mining Lease (Application)
- Investigation Area
- 7 Year Pit Shell
- Proposed Site Infrastructure
- Easement
- Base Cadastre



FAIRHILL COKING COAL PTY LTD

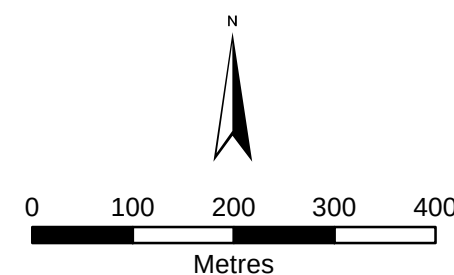
FAIRHILL

FIGURE 9 GILGAI SOUTH-CENTRAL EXTENT

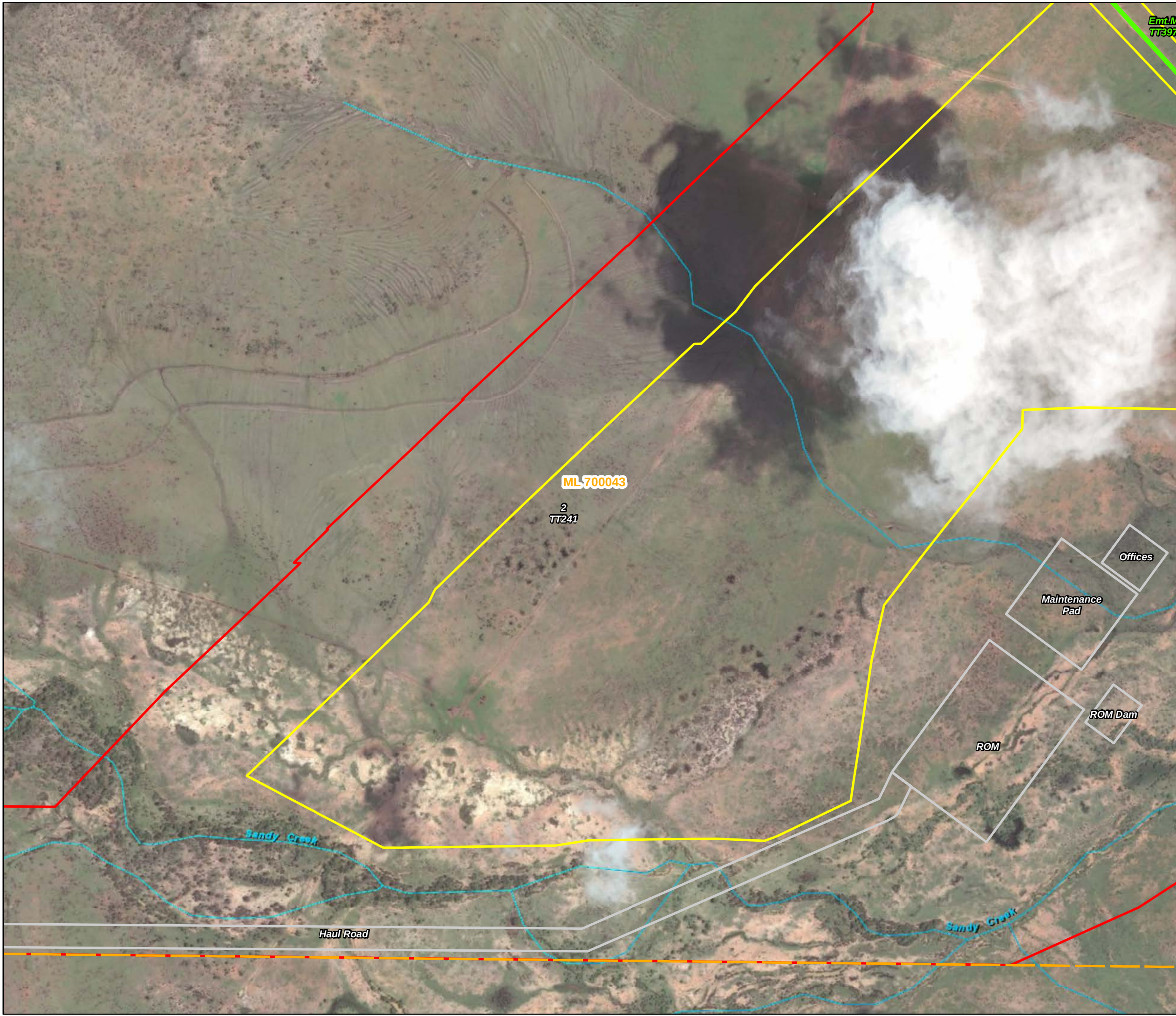
Legend

- Watercourse
- Mining Lease (Application)
- Investigation Area
- 7 Year Pit Shell
- Proposed Site Infrastructure
- Easement
- Base Cadastre

Data Sources:
Mining Lease, Watercourse, and Digital Cadastral
Database (extracted April 2019) datasets: © State of
Queensland (Department of Natural Resources, Mines,
and Energy) 2019; 7 Year Pit Shell, Investigation Area,
and Proposed Site Infrastructure datasets: (SLR
Consulting) 2019.
Imagery Source: 50cm resolution WV02 Vivid -
Australia 2016 Orthophoto Imagery Service: © ESRI,
DigitalGlobe, GeoEye, Earthstar Geographics,
CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and
the GIS User Community.
Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator
Datum: GDA 1994
Date: 24/06/2019



Scale: 1:7,500 at A3



FAIRHILL COKING COAL PTY LTD

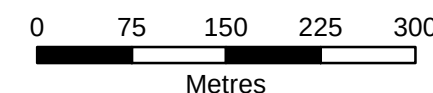
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FIGURE 10 GILGAI SOUTHERN EXTENT

Legend

- Watercourse
- Mining Lease (Application)
- Investigation Area
- 7 Year Pit Shell
- Proposed Site Infrastructure
- Easement
- Base Cadastre

Data Sources:
Mining Lease, Watercourse, and Digital Cadastral
Database (extracted April 2019) datasets: © State of
Queensland (Department of Natural Resources, Mines,
and Energy) 2019; 7 Year Pit Shell, Investigation Area,
and Proposed Site Infrastructure datasets: (SLR
Consulting) 2019.
Imagery Source: 50cm resolution WV02 Vivid -
Australia 2016 Orthophoto Imagery Service: © ESRI,
DigitalGlobe, GeoEye, Earthstar Geographics,
CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and
the GIS User Community.
Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator
Datum: GDA 1994
Date: 24/06/2019



Scale: 1:6,000 at A3



4 Soil Assessment

4.1 Methodology

Identification and description of soil units and their distribution across the Project site was undertaken based on:

- A desktop review of historical and more recent soil and land resource assessment reports and digital geographic information;
- Field soil and land surveying across the Project site; and
- Laboratory analysis of soil samples collected from described representative profiles.

The details associated with each of these aspects of the methodology are presented in the following sections.

4.1.1 Desktop Assessment

Preliminary identification and description of soils and their distribution across the Project site was undertaken based on a desktop review of historical and more recent soil and land resource assessment reports and online information sources, including the:

- Information Resource for Understanding and Managing soils in the Central Highlands ([Bourne & Tuck, 1993b](#));
- Field Manual for Understanding and Managing soils in the Central Highlands ([Bourne & Tuck, 1993a](#));
- Lands of the Isaac-Comte Area, Queensland ([Story et al. 1967](#));
- Queensland Globe spatial data portal ([QG, 2019](#)); and
- Fairhill Coal Project: Soils and Land Suitability Assessment ([NRC, 2018](#)).

Additionally, recent digital geographic information was also reviewed using GIS software. GIS data reviewed included:

- Aerial photography;
- Digital terrain modelling from which contours were generated;
- Existing surface geology;
- Existing soil mapping;
- Cadastre;
- Watercourses;
- Regional ecosystems;
- Exploration permits for coal mapping;
- Mining lease area mapping; and
- Proposed 7-year pit shell and associated infrastructure layout.

4.1.2 Field Assessment

Based on the desktop assessment, broad soil classes were identified and a field sampling plan formulated that included:

- A field reconnaissance of the Project site to familiarise with ground conditions and confirm the preliminary soil unit model;
- A check sites sampling plan to confirm the likely soil units and their characteristics to inform the detailed profile description and sampling program; and
- A detailed profile description and sampling plan to describe the soil units in detail and collect samples for analysis to confirm both physical and chemical characteristics.

The field sampling plan was developed in accordance with the following standards and guidelines:

- Guideline: Application requirements for activities with impacts to land ([DES, 2017](#))
- State Planning Policy ([DILGP, 2017b](#))
- Guidelines for Agricultural Land Evaluation in Queensland, 2nd Ed. ([DSITI & DNRME, 2015](#)); and
- Guidelines for Surveying Soil and Land Resources ([McKenzie, et al., 2008](#)).

Based on these guidelines and with consideration for the previously DES-accepted [NRC \(2018\)](#) report for the FCC project, which used a mapping scale of 1:25,000, a mapping scale of 1:25,000 was adopted for this new report. At 1:25,000 scale, according to [McKenzie, et al. \(2008\)](#), the number of observations required for the Project site, which was 790 ha, including 250 m buffer, is shown in **Table 6**. The sampling plan is also shown in **Table 6**, including consideration for previous observations made by [NRC \(2018\)](#) that were considered directly relevant and applicable to the Project site.

Table 6 Number of field survey observations required at 1:25,000 scale and field sampling plan

Scale	Intensity	Area /site	Obs /ha	Size	Total		Detailed profile descriptions		Profiles analysed		Mapping observations	
		(ha/obs)		(ha)	%	#	%	#	%	#	%	#
Required at 1:25,000 scale according to McKenzie, et al. (2008)												
Moderate intensity (1:25,000)	Upper	3.25	0.16	790	100%	126	35	44	5	6	60	76
	Lower	12.5	0.08			63		22		3		38
	Minimum	25	0.04			32		11		2		19
Observation sites by NRC applicable and relevant to the Project site						7		4		2		1
Required at 1:25,000 scale for field sampling plan												
Moderate intensity (1:25,000)	Upper	3.25	0.16	790	100%	114	35	40	5	4	60	75
	Lower	12.5	0.08			51		18		1		37
	Minimum	25	0.04			20		7		0		18
Observation sites by SLR for this new report						43		16		8		19
Total observation sites used for the report						50		20		10		20

The number of observations completed for the new report is more than the minimum intensity required and slightly less than the lower intensity required demonstrating compliance with the relevant standards and guidelines. The spatial distribution of all observation sites is shown on **Figure 11**.

Field assessment to identify and verify soil units across the Project site were described in detail through various types of observation sites. Observation sites included surface check sites, shallow subsurface check sites and full soil profile descriptions to 1.2 m or refusal, whichever came first. Observation data was recorded in accordance with the following standards and guidelines using the standard “green sheet” (copies of original field sheets are provided in **Appendix C**):

- Australian Soil and Land Survey Field Handbook ([NCST, 2009](#));
- Munsell Soil Color Charts ([Munsell Color, 2009](#)); and
- Australian Soil Classification (ASC) system ([Isbell & NCST, 2016](#)).

Subsurface observations were made using either an excavator with a 1.2 m wide mud bucket (refer to **Photo 1**) or an 82 mm diameter hand auger (refer to **Photo 2**).



Photo 1 Excavator used for representative soil profile observations



Photo 2 Hand auger used for representative soil profile and shallow subsurface observations

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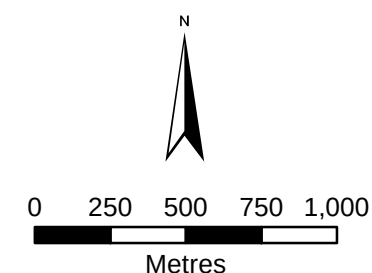
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FIGURE 11
SOIL OBSERVATIONS

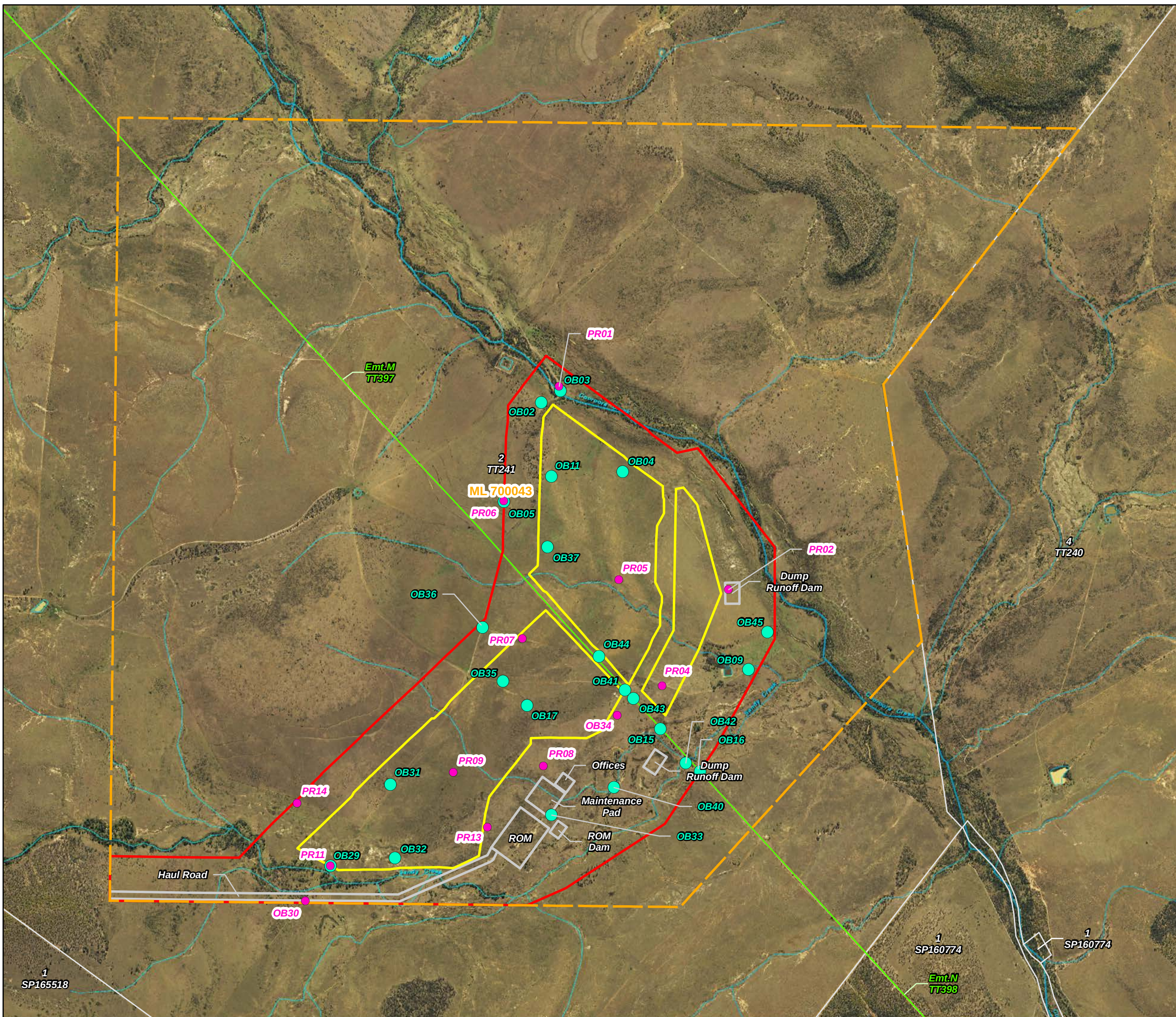
Legend

- Representative Soil Profile Site
- Soil Observation Site
- Watercourse
- Mining Lease (Application)
- Investigation Area
- 7 Year Pit Shell
- Proposed Site Infrastructure
- Easement
- Base Cadastre

Data Sources:
Mining Lease, Watercourse, and Digital Cadastral Database (extracted April 2019) datasets: © State of Queensland (Department of Natural Resources, Mines, and Energy) 2019; 7 Year Pit Shell, Investigation Area, Soil Observation Site, Representative Soil Profile Site, and Proposed Site Infrastructure datasets: (SLR Consulting) 2019.
Imagery Sources: 70cm Bowen Basin SISP PeriUrban 2012 Orthophoto Image Service: © State of Queensland (Department of Natural Resources, Mines, and Energy) 2019.
Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator
Datum: GDA 1994
Date: 28/06/2019



Scale: 1:25,000 at A3



4.1.3 Soil Sampling Methods

Field sampling procedures conformed to SLR's quality assurance/quality control (QA/QC) protocols to minimise the potential for cross contamination and preserve sample integrity. A summary of the soil sampling activities is outlined in **Table 7**.

Table 7 Soil sampling activities

Activity	Details
Soil profile locations	Navigation to soil core locations was undertaken using a Garmin Oregon 550 global positioning system (GPS) with an accuracy of +/- 3 m. The exact sample locations were recorded from this unit.
Soil profile excavations	Mechanical backhoe was used with a 0.6 m bucket to excavate a pit. The pit was excavated to between 1.2 and 1.5 m BGL or refusal, whichever occurred first.
Abandonment	Soil pits were backfilled to the existing natural ground level using soil retrieved during excavation.
Decontamination	The bucket was cleaned at each new pit through excavation of the new pit.
Soil logging	Soil characteristics were recorded and profiles classified in accordance with the Australian Soil and Land Survey Field Handbook (NCST, 2009). In addition to soil descriptions, associated landscape features, including terrain, land use, areas of degradation, slopes and vegetation were recorded and photographed. Original field soil profile logs, "green sheets", are provided in Appendix C .
Soil sampling	Soil samples, at least 750 g in volume, were obtained directly from the pit face at nominal depths of 0-10, 10-20, 20-30, 50-60, 80-90, 110-120 and 140-150 cm BGL. Discrete soil samples were collected and placed into resealable plastic bags and stored in cool boxes for dispatch to the laboratory.
Labelling	Sample bags were labelled with the project reference, sampler, site location and depth. For instance, a sample collected at PR01 at a depth of 0.0-0.1 m BGL was labelled as follows: Fairhill Coking Coal CT PR01 / 0.0-0.1 m 24/05/2019 / 2:00pm
Dispatch	Samples were stored in cool boxes out of the sun and couriered by road for analysis at Australian Laboratory Services (ALS) under chain of custody documentation.

4.1.4 Laboratory Analysis

For agronomic soil physical and chemical characteristics, laboratory analyses were primarily selected from the following resources:

- Soil Chemical Methods – Australasia ([Rayment & Lyons, 2011](#));
- Measuring soil cation exchange capacity and exchangeable cations ([SSA, 2013](#))

A total of 52 soil samples were analysed from eight of the 13 sampled profiles. These data were used to characterise the distribution of soil across the Project site and identify the soil mapping units.

Descriptions of the 13 soil profiles, based on field logs and laboratory results (where analysed), are provided in **Appendix A**, while chain of custody forms and laboratory certificates for the 52 samples analysed are provided in **Appendix D**. Original field soil profile description and check site green sheet logs are provided in **Appendix C**.

The eight recent soil profile analyses undertaken for this assessment were performed by ALS Environmental, a laboratory in Brisbane with National Association of Testing Authorities (NATA) accreditation for most of the laboratory analyses required for this soil assessment. The eight recent soil profile analyses undertaken for this assessment included:

- pH_{1:5 H₂O};
- Electrical conductivity (EC_{1:5 H₂O});
- Acid neutralising capacity;
- Moisture content (air dry);
- Emerson aggregate test, including colour, texture and Emerson class number;
- Particle size analysis (<2 µm (clay), 2-20 µm (silt), 0.02-0.2 mm (fine sand), 0.2-2.0 mm (coarse sand) and >2 mm (gravel));
- Soil particle density;
- Exchangeable cations (Al³⁺, Ca²⁺, Mg²⁺, Na⁺, K⁺) and cation exchange capacity plus exchangeable sodium percentage (ESP) and calcium/magnesium ratio (Ca:Mg);
- Total sulfur (S);
- Chloride (Cl⁻);
- Trace elements (boron (B), copper, (Cu), iron (Fe), manganese (Mn), and zinc (Zn));
- Nitrogen (N) as nitrite, nitrate, total Kheldal nitrogen (TKN) and total N;
- Phosphorus (P) as bicarbonate extractable P and total P; and
- Organic matter content (Walkley-Black) and total organic carbon by calculation.

4.2 Soil Units

Based on the desktop (refer to **Section 3**), field (refer to **Appendix A**) and laboratory assessment results (**Appendix D**), the soil units identified across the Project site are summarised in **Table 8** and shown in **Figure 12**.

Table 8 Soil units identified across the project site by surface geological unit

Surface geology	Soil mapping unit (SMU)		Soil unit description	Representative profiles	Check sites	Likely land system land facet soil unit (Story et al., 1967)	LRA AMU (Bourne & Tuck, 1993b)
	#	ASC					
Mapped as Fair Hill Formation (Pwt) and based on data occurs along southern major drainage line	1	Black, Brown and Grey Vertosols (>90%), possible minor occurrences of Black, Brown and Grey Dermosols (<10%)	Deep (>1.2 m) to moderately deep (>0.6-1.2 m), black, dark brown to brown and grey mostly cracking (possible minor occurrences of non-cracking, especially on gilgai mounds) clays on elevated crests and gently to very gently inclined upper, mid and lower slopes; surfaces mostly gravelly, loose, self-mulching to firm, crusting, sandy light clay to light medium clay grading through mottled, medium clay to light clay down the profile to weathered, metamorphic sandstone and mudstone; formed in situ	SLR: PR04 , PR05 , PR06 , PR07 , PR09 , PR14 NRC: 18, 20,	SLR: OB04 , OB05 , OB11 , OB17, OB31, OB35, OB36, OB37, OB44	Girrah, lowlands and plains, Teviot	Possibly a complex mix of LRA 4 (Orion) and LRA 2 (Rolleston and Lonesome)
	2	Brown and Red Dermosols	Moderately deep (>0.6-1.2 m) to shallow (<0.6 m) red, non-cracking clays on very gently inclined mid and lower slopes; surfaces gravelly, firm, crusting, clay loam, sandy, to sandy light clays grading through mottled, sandy light medium to medium clays down the profile to weathered, metamorphic sandstone; formed in situ	SLR: PR02 , PR08 , OB34 NRC: 25, 26	SLR: OB41, OB43 NRC: 24	Girrah, lowlands and plains, Cheshire	Mix of LRA 4 and LRA 2 (Glen Idol)

Surface geology	Soil mapping unit (SMU)		Soil unit description	Representative profiles	Check sites	Likely land system land facet soil unit (Story et al., 1967)	LRA AMU (Bourne & Tuck, 1993b)
	#	ASC					
Quaternary alluvium (Qa)	3	Black, Brown and Grey Vertosols (>80%), likely minor occurrences of Black, Brown and Grey Dermosols (<20%)	Deep (>1.2 m) to moderately deep (>0.6-1.2 m) to shallow (<0.6 m), black, dark brown to brown and grey mostly cracking (likely minor occurrences of non-cracking) clays on very gently undulating to flat alluvial plains; surfaces loose, self-mulching to firm, crusting, sandy light clay to light medium clay grading through mottled, medium clay to light clay down the profile	SLR: PR01	SLR: OB02 , OB09 , OB15, OB16, OB42 , OB45	Girrah, alluvial flats, no soils specified	LRA 2 (Adelong and Moramana)
	4	Black, Brown and Grey Dermosols (>80%), likely minor occurrences of Black, Brown and Grey Vertosols (<20%)	Deep (>1.2 m) to moderately deep (>0.6-1.2 m) to shallow (<0.6 m), black, dark brown to brown and grey mostly non-cracking (likely minor occurrences of cracking) clays on very gently undulating to flat alluvial plains; surfaces firm, crusting to hard-setting, clay loam, sandy, to sandy light clays grading through mottled, sandy light medium to medium clays down the profile	SLR: PR11 , PR13 , OB30	SLR: OB29, OB32, OB33, OB40	Girrah, alluvial flats, no soils specified	Mix of LRA 4 and LRA 2 (Glen Idol)

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FIGURE 12 SOIL UNITS

Legend

- Watercourse
- Mining Lease (Application)
- Investigation Area
- 7 Year Pit Shell
- Proposed Site Infrastructure
- Easement
- Base Cadastre

Soil Units

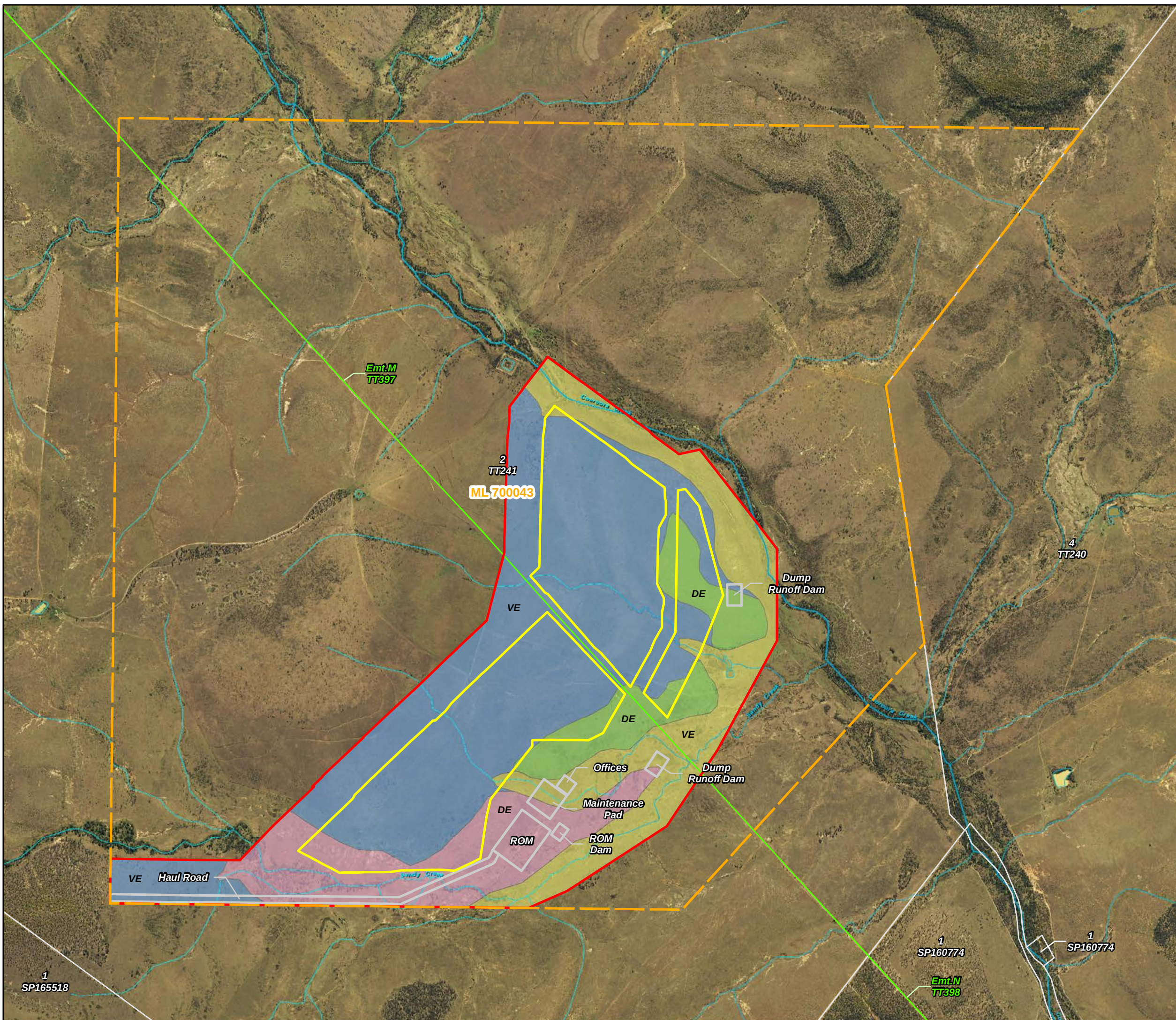
- Alluvial Dermosol
- Alluvial Vertosol
- Fair Hill Dermosol
- Fair Hill Vertosol

Data Sources:
Mining Lease, Watercourse, and Digital Cadastral Database (extracted April 2019) datasets: © State of Queensland (Department of Natural Resources, Mines, and Energy) 2019; 7 Year Pit Shell, Investigation Area, Soil Units, and Proposed Site Infrastructure datasets: (SLR Consulting) 2019.
Imagery Sources: 70cm Bowen Basin SISP PeriUrban 2012 Orthophoto Image Service: © State of Queensland (Department of Natural Resources, Mines, and Energy) 2019.
Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator
Datum: GDA 1994
Date: 22/06/2019



0 250 500 750 1,000
Metres

Scale: 1:25,000 at A3



4.3 Agricultural Lands

4.3.1 Land Suitability

The suitability of the Project site for agricultural production systems is based on an evaluation of the soils against the Land Suitability Assessment Techniques guideline ([DME, 1995](#)), referred to from hereon as the DME guidelines. The agricultural production systems include grazing and rainfed broadacre cropping. Land suitability classes are defined in the guideline and are presented in **Table 9**.

Table 9 Land suitability classes

Class	Definition
1	Suitable land with negligible limitations. Land is well suited to a proposed use.
2	Suitable land with minor limitations. Land is suited to a proposed use but which may require minor changes in management to sustain the use.
3	Suitable land with moderate limitations. Land is moderately suited to a proposed use but which requires significant inputs to ensure sustainable use.
4	Marginally suitable land. Land is marginally suited for a proposed use and would require major inputs to ensure sustainability. These inputs may not just be the benefits to be obtained in using the land for the particular purpose and is hence considered presently unsuited.
5	Unsuitable land with extreme limitations. Land is unsuited and cannot be sustainably used for a proposed use.

Evaluation of the Project site soils against the classes in **Table 9** for the different agricultural production systems is made based on interpretation of the physical, chemical and nutritional characteristics of each soil unit. The following sections present the criteria for evaluation in relation to each production system and the results of the assessment against those criteria.

4.3.1.1 Land Suitability Criteria for Rainfed Broadacre Cropping

The criteria used to assess land suitability for rainfed broadacre cropping at the Project site include:

- Water availability;
- Nutrient deficiency;
- Soil physical factors;
- Soil workability;
- Salinity;
- Rockiness;
- Micro relief;
- Wetness;
- Topography;
- Water erosion; and
- Flooding.

The limitations associated with each criterion are discussed in the following sections and summarised in **Section 4.3.1.1.9**.

4.3.1.1.1 Water Availability

Plant available water capacity (PAWC) for the soil types on the Project site have been estimated by reference to Table 2.3 of the DME guidelines. PAWC cut-off levels for each of the land suitability classes are as follows:

- Class 1: >150 mm;
- Class 2: 125-150 mm;
- Class 3: 100-125 mm;
- Class 4: 75-100 mm; and
- Class 5: <75 mm.

The land suitability classes identified for each soil type found are presented in **Table 10**.

Table 10 Land suitability classes for rainfed broadacre cropping based on PAWC

Soil Unit	Example Soil Profiles	Limiting Features	PAWC	Land Suitability Class
Black, Brown and Grey Vertosols on Fair Hill Formation	PR06 , PR14 , PR09	Cracking clays: ≥90 cm depth to weathered or hard rock and fine self-mulch (ped size 2-10 mm) and dense cracking at surface when dry (>1 crack per sq. m) and alkaline to neutral pH throughout and Cl <600 ppm within 90 cm of the surface and ESP <15 within 90 cm of the surface	125-150 mm	2
	PR07	Cracking clays, alkaline to neutral throughout and 60-90 cm depth to: 1. Weathered or hard rock; 2. CL ≥600 ppm; and 3. ESP ≥900 ppm	100-125 mm	3
	PR05	Cracking clays, alkaline pH throughout and 40-60 cm depth to weathered or hard rock	75-100 mm	4
Brown and Red Dermosols on Fair Hill Formation	PR02 , PR08 , OB34	Rigid soils (sodic)	75-100 mm	4
Black, Brown and Grey Vertosols on Quaternary alluvium	PR01	Cracking clays: ≥90 cm depth to weathered or hard rock and fine self-mulch (ped size 2-10 mm) and dense cracking at surface when dry (>1 crack per sq. m) and alkaline to neutral pH throughout and Cl <600 ppm within 90 cm of the surface and ESP <15 within 90 cm of the surface	125-150 mm	2
Black, Brown and Grey Dermosols on Quaternary alluvium	PR11 , PR13 , OB30	Rigid soils (sodic)	75-100 mm	4

4.3.1.1.2 Nutrient Deficiency

Nutrient deficiency for the soil types on the Project site have been assessed against Table 2.1 of the DME guidelines. The land suitability classes identified for each soil unit observed are presented in **Table 11**.

Table 11 Land suitability classes for rainfed broadacre cropping based on nutrient deficiency

Soil Unit	Example Soil Profiles	Limiting Features	Land Suitability Class
Black, Brown and Grey Vertosols on Fair Hill Formation	PR14	Bicarbonate P 5-10 ppm and exch. K >0.3 meq%	2
	PR07	pH >9 60-90 cm below surface	3
	PR06	Bicarbonate P <10 ppm and exch. K ≤0.3 meq%	4
Brown and Red Dermosols on Fair Hill Formation	PR02	pH >9 60-90 cm below surface	3
Black, Brown and Grey Vertosols on Quaternary alluvium	PR01	Bicarbonate P 5-10 ppm and exch. K >0.3 meq%	2
Black, Brown and Grey Dermosols on Quaternary alluvium	PR11 , OB30	Bicarbonate P 5-10 ppm and exch. K >0.3 meq%	2

4.3.1.1.3 Soil Physical Factors

Soil physical factors for the soil types on the Project site have been assessed against Table 2.1 of the DME guidelines. The land suitability classes identified for each soil unit observed are presented in

Table 12 Land suitability classes for rainfed broadacre cropping based on soil physical factors

Soil Unit	Example Soil Profiles	Limiting Features	Land Suitability Class
Black, Brown and Grey Vertosols on Fair Hill Formation	PR06 , PR14 , PR09	Cracking clays with fine self-mulch (peds 2-10 mm)	2
	PR07	Cracking clays with coarse peds at the surface (≥20 mm)	4
	PR05	Cracking clays with coarse peds at the surface (≥20 mm)	4
Brown and Red Dermosols on Fair Hill Formation	PR02 , PR08 , OB34	Rigid soils with loose, soft or firm surface when dry	1
Black, Brown and Grey Vertosols on Quaternary alluvium	PR01	Cracking clays with fine self-mulch (peds 2-10 mm)	2
Black, Brown and Grey Dermosols on Quaternary alluvium	PR11 , PR13 , OB30	Rigid soils with loose, soft or firm surface when dry	1

4.3.1.1.4 Soil Workability

Soil workability for the soil types on the Project site have been assessed against Table 2.1 of the DME guidelines. The land suitability classes identified for each soil unit observed are presented in **Table 13**.

Table 13 Land suitability classes for rainfed broadacre cropping based on soil workability

Soil Unit	Example Soil Profiles	Limiting Features	Land Suitability Class
Black, Brown and Grey Vertosols on Fair Hill Formation	PR06 , PR14 , PR09	Firm cracking clays (indicated by fine self-mulch)	2
	PR07	Stiff cracking clays (indicated by coarse self-mulch with peds >10 mm, crusting or hard-setting surface)	3
	PR05	Stiff cracking clays (indicated by coarse self-mulch with peds >10 mm, crusting or hard-setting surface)	3
Brown and Red Dermosols on Fair Hill Formation	PR02 , PR08 , OB34	Rigid soils with loose, soft or firm surface when dry	1
Black, Brown and Grey Vertosols on Quaternary alluvium	PR01	Firm cracking clays (indicated by fine self-mulch)	2
Black, Brown and Grey Dermosols on Quaternary alluvium	PR11 , PR13 , OB30	Rigid soils with loose, soft or firm surface when dry	1

4.3.1.1.5 Salinity

Salinity for the soil types on the Project site have been assessed against Table 2.1 of the DME guidelines. The land suitability classes identified for each soil unit observed are presented in **Table 14**.

Table 14 Land suitability classes for rainfed broadacre cropping based on salinity

Soil Unit	Example Soil Profiles	Limiting Features	Land Suitability Class
Black, Brown and Grey Vertosols on Fair Hill Formation	PR06	Rootzone EC <0.15 mS/cm and Cl <300 ppm	1
	PR07 , PR14	Rootzone EC 0.15-0.3 mS/cm and Cl 300-600 ppm	2
Brown and Red Dermosols on Fair Hill Formation	PR02	Rootzone EC <0.15 mS/cm and Cl <300 ppm	1
Black, Brown and Grey Vertosols on Quaternary alluvium	PR01	Rootzone EC <0.15 mS/cm and Cl <300 ppm	1
Black, Brown and Grey Dermosols on Quaternary alluvium	OB30	Rootzone EC <0.15 mS/cm	1
	PR11	Cl 300-600 ppm	2

4.3.1.1.6 Rockiness

Rockiness for the soil types on the Project site have been assessed against Table 2.1 of the DME guidelines. The land suitability classes identified for each soil unit observed are presented in **Table 15**.

Table 15 Land suitability classes for rainfed broadacre cropping based on rockiness

Soil Unit	Example Soil Profiles	Limiting Features	Land Suitability Class
Black, Brown and Grey Vertosols on Fair Hill Formation	PR06 , PR07 , PR14	<10% coarse surface gravel (>6 cm diam.) and rock outcrop	1
Brown and Red Dermosols on Fair Hill Formation	PR02 , PR08	<10% coarse surface gravel (>6 cm diam.) and rock outcrop	1
	OB34	50-90% surface cobble and rock outcrop	4
Black, Brown and Grey Vertosols on Quaternary alluvium	PR01	<10% coarse surface gravel (>6 cm diam.) and rock outcrop	1
Black, Brown and Grey Dermosols on Quaternary alluvium	OB30 , PR11	<10% coarse surface gravel (>6 cm diam.) and rock outcrop	1

4.3.1.1.7 Micro Relief

Micro relief for the soil types on the Project site have been assessed against Table 2.1 of the DME guidelines. The land suitability classes identified for each soil unit observed are presented in **Table 16**.

Table 16 Land suitability classes for rainfed broadacre cropping based on micro relief

Soil Unit	Example Soil Profiles	Limiting Features	Land Suitability Class
Black, Brown and Grey Vertosols on Fair Hill Formation	PR06 , PR07 , PR14	No melonholes	1
Brown and Red Dermosols on Fair Hill Formation	PR02 , PR08 , OB34	No melonholes	1
Black, Brown and Grey Vertosols on Quaternary alluvium	PR01	No melonholes	1
Black, Brown and Grey Dermosols on Quaternary alluvium	OB30 , PR11	No melonholes	1

4.3.1.1.8 Wetness

Wetness for the soil types on the Project site have been assessed against Table 2.1 of the DME guidelines. The land suitability classes identified for each soil unit observed are presented in **Table 17**.

Table 17 Land suitability classes for rainfed broadacre cropping based on wetness

Soil Unit	Example Soil Profiles	Limiting Features	Land Suitability Class
Black, Brown and Grey Vertosols on Fair Hill Formation	PR06 , PR07 , PR14	Undulating terrain or elevated plains	1
Brown and Red Dermosols on Fair Hill Formation	PR02	Undulating terrain or elevated plains	1
Black, Brown and Grey Vertosols on Quaternary alluvium	PR01	Low-lying level plains with melonholes covering <25% surface area	2
Black, Brown and Grey Dermosols on Quaternary alluvium	OB30 , PR11	Rigid soils with strongly sodic subsoil (ESP ≥15) within 60 cm of the surface	3

4.3.1.1.9 Topography

Topography for the soil types on the Project site have been assessed against Table 2.1 of the DME guidelines. The land suitability classes identified for each soil unit observed are presented in **Table 18**.

Table 18 Land suitability classes for rainfed broadacre cropping based on topography

Soil Unit	Limiting Features	Land Suitability Class
Black, Brown and Grey Vertosols on Fair Hill Formation	Occasional deep gullies impede cultivation slightly	2
Brown and Red Dermosols on Fair Hill Formation	No gully dissection	1
Black, Brown and Grey Vertosols on Quaternary alluvium	Occasional deep gullies impede cultivation slightly	2
Black, Brown and Grey Dermosols on Quaternary alluvium	Occasional deep gullies impede cultivation slightly	2

4.3.1.1.10 Water Erosion

Water erosion for the soil types on the Project site have been assessed against Table 2.1 of the DME guidelines. The land suitability classes identified for each soil unit observed are presented in **Table 19**.

Table 19 Land suitability classes for rainfed broadacre cropping based on water erosion

Soil Unit	Example Soil Profiles	Limiting Features	Land Suitability Class
Black, Brown and Grey Vertosols on Fair Hill Formation	PR06 , PR07 , PR14	Slopes 1-3% on cracking clays without melonholes	3
Brown and Red Dermosols on Fair Hill Formation	PR02 , PR08 , OB34	Slopes 1-2% on sodic rigid soils	3

Soil Unit	Example Soil Profiles	Limiting Features	Land Suitability Class
Black, Brown and Grey Vertosols on Quaternary alluvium	PR01	Slopes <0.5% on cracking clays without melonholes	1
Black, Brown and Grey Dermosols on Quaternary alluvium	OB30 , PR11	Slopes 0.5-1.0% on sodic rigid soils	2

4.3.1.1.11 Flooding

Flooding for the soil types on the Project site have been assessed against Table 2.1 of the DME guidelines. The land suitability classes identified for each soil unit observed are presented in **Table 20**.

Table 20 Land suitability classes for rainfed broadacre cropping based on flooding

Soil Unit	Limiting Features	Land Suitability Class
Black, Brown and Grey Vertosols on Fair Hill Formation	No flooding	1
Brown and Red Dermosols on Fair Hill Formation	No flooding	1
Black, Brown and Grey Vertosols on Quaternary alluvium	Infrequent flooding (inundation occurs <half the times that stream flow increases)	3
Black, Brown and Grey Dermosols on Quaternary alluvium	Infrequent flooding (inundation occurs <half the times that stream flow increases)	3

4.3.1.1.12 Summary of Assessment for Rainfed Broadacre Cropping

The land use limitations for rainfed broadacre cropping are summarised in **Table 21** and mapped in **Figure 13**.

Table 21 Land suitability limitations for rainfed broadacre cropping

Soil Unit	PAWC	Nutrients	Physical	Workability	Salinity	Rockiness	Micro Relief	Wetness	Topography	Water Erosion	Flooding	Overall Suitability Rating
Black, Brown and Grey Vertosols on Fair Hill Formation	2-3	2-4	2-4	2-3	1-2	1	1	1	2	3	1	4
Brown and Red Dermosols on Fair Hill Formation	4	3	1	1	1	1-4	1	1	1	3	1	4
Black, Brown and Grey Vertosols on Quaternary alluvium	2	2	2	2	1	1	1	2	2	1	3	3
Black, Brown and Grey Dermosols on Quaternary alluvium	4	2	1	1	1-2	1	1	3	2	2	3	4

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FIGURE 13
LAND SUITABILITY
FOR RAINFED
BROADACRE CROPPING

Legend

- Watercourse
- Mining Lease (Application)
- Investigation Area
- 7 Year Pit Shell
- Proposed Site Infrastructure
- Easement
- Base Cadastre

Land Suitability for Rainfed Broadacre Cropping

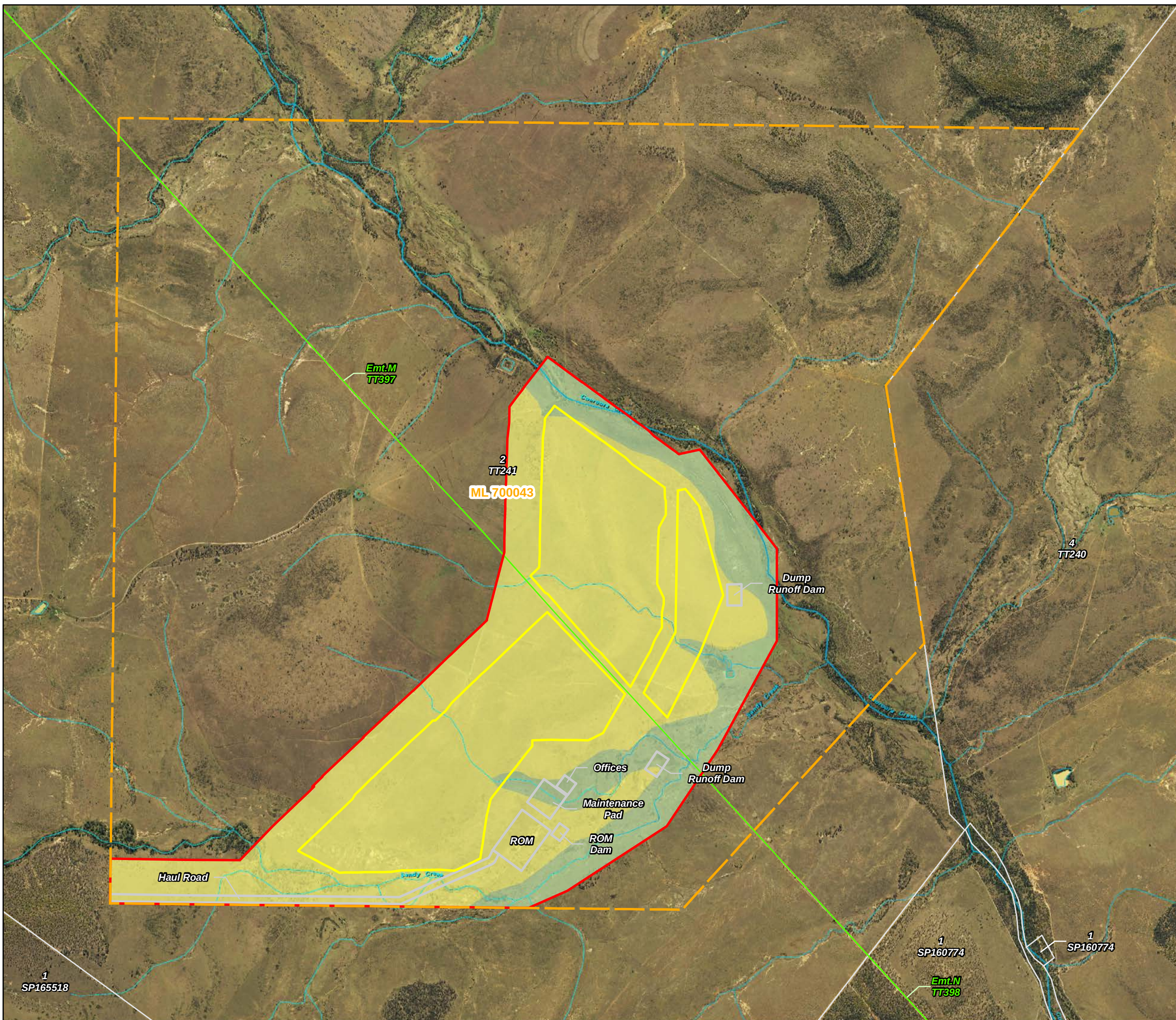
- Land Suitability Class 3
- Land Suitability Class 4

Data Sources:
Mining Lease, Watercourse, and Digital Cadastral
Database (extracted April 2019) datasets: © State of
Queensland (Department of Natural Resources, Mines,
and Energy) 2019; 7 Year Pit Shell, Investigation Area,
Land Suitability, and Proposed Site Infrastructure
datasets: (SLR Consulting) 2019.
Imagery Sources: 70cm Bowen Basin SISP PeriUrban
2012 Orthophoto Image Service: © State of
Queensland (Department of Natural Resources, Mines,
and Energy) 2019.
Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator
Datum: GDA 1994
Date: 22/06/2019



0 250 500 750 1,000
Metres

Scale: 1:25,000 at A3



4.3.1.2 Land Suitability Criteria for Beef Cattle Grazing

The criteria used to assess land suitability for beef cattle grazing at the Project site include:

- Water availability;
- Nutrient deficiency;
- Soil physical factors;
- Salinity;
- Rockiness;
- Micro relief;
- Soil pH;
- Soil ESP;
- Wetness;
- Topography;
- Water erosion;
- Flooding; and
- Vegetation regrowth.

The limitations associated with each criterion are discussed in the following sections and summarised in **Section 4.3.1.2.14**.

4.3.1.2.1 Water Availability

Plant available water capacity (PAWC) for the soil types on the Project site have been estimated by reference to Table 2.3 of the DME guidelines. PAWC cut-off levels for each of the land suitability classes are as follows:

- Class 1: >125 mm;
- Class 2: 100-125 mm;
- Class 3: 75-100 mm;
- Class 4: 50-75 mm; and
- Class 5: <50 mm.

The land suitability classes identified for each soil type found are presented in **Table 22**.

Table 22 Land suitability classes for beef cattle grazing based on PAWC

Soil Unit	Example Soil Profiles	Limiting Features	PAWC	Land Suitability Class
Black, Brown and Grey Vertosols on Fair Hill Formation	PR06 , PR14 , PR09	Cracking clays: ≥90 cm depth to weathered or hard rock and fine self-mulch (ped size 2-10 mm) and dense cracking at surface when dry (>1 crack per sq. m) and alkaline to neutral pH throughout and Cl <600 ppm within 90 cm of the surface and ESP <15 within 90 cm of the surface	>125 mm	1
	PR07	Cracking clays, alkaline to neutral throughout and 60-90 cm depth to: 1. Weathered or hard rock; 2. CL ≥600 ppm; and 3. ESP ≥900 ppm	100-125 mm	2
	PR05	Cracking clays, alkaline pH throughout and 40-60 cm depth to weathered or hard rock	75-100 mm	3
Brown and Red Dermosols on Fair Hill Formation	PR02 , PR08 , OB34	Rigid soils (sodic)	75-100 mm	3
Black, Brown and Grey Vertosols on Quaternary alluvium	PR01	Cracking clays: ≥90 cm depth to weathered or hard rock and fine self-mulch (ped size 2-10 mm) and dense cracking at surface when dry (>1 crack per sq. m) and alkaline to neutral pH throughout and Cl <600 ppm within 90 cm of the surface and ESP <15 within 90 cm of the surface	>125 mm	1
Black, Brown and Grey Dermosols on Quaternary alluvium	PR11 , PR13 , OB30	Rigid soils (sodic)	75-100 mm	3

4.3.1.2.2 Nutrient Deficiency

Nutrient deficiency for the soil types on the Project site have been assessed against Table 2.1 of the DME guidelines. The land suitability classes identified for each soil unit observed are presented in **Table 23**.

Table 23 Land suitability classes for beef cattle grazing based on nutrient deficiency

Soil Unit	Example Soil Profiles	Limiting Features	Land Suitability Class
Black, Brown and Grey Vertosols on Fair Hill Formation	PR14	Other soils with bicarbonate P 5-10 ppm	3
	PR06 , PR07	Bicarbonate P ≤4 ppm	4
Brown and Red Dermosols on Fair Hill Formation	PR02	Bicarbonate P ≤4 ppm	4
Black, Brown and Grey Vertosols on Quaternary alluvium	PR01	Other soils with bicarbonate P 5-10 ppm	3

Soil Unit	Example Soil Profiles	Limiting Features	Land Suitability Class
Black, Brown and Grey Dermosols on Quaternary alluvium	PR11 , OB30	Other soils with bicarbonate P 5-10 ppm	3

4.3.1.2.3 Soil Physical Factors

Soil physical factors for the soil types on the Project site have been assessed against Table 2.1 of the DME guidelines. The land suitability classes identified for each soil unit observed are presented in **Table 24**

Table 24 Land suitability classes for beef cattle grazing based on soil physical factors

Soil Unit	Example Soil Profiles	Limiting Features	Land Suitability Class
Black, Brown and Grey Vertosols on Fair Hill Formation	PR06 , PR14 , PR09	Cracking clays with fine self-mulch (peds 2-10 mm)	2
	PR07 , PR05	Cracking clays with coarse peds at the surface (≥ 10 mm) or crust on the surface	3
Brown and Red Dermosols on Fair Hill Formation	PR02 , PR08 , OB34	Rigid soils with loose, soft or firm surface when dry	1
Black, Brown and Grey Vertosols on Quaternary alluvium	PR01	Cracking clays with fine self-mulch (peds 2-10 mm)	2
Black, Brown and Grey Dermosols on Quaternary alluvium	PR11 , PR13 , OB30	Rigid soils with loose, soft or firm surface when dry	1

4.3.1.2.4 Salinity

Salinity for the soil types on the Project site have been assessed against Table 2.1 of the DME guidelines. The land suitability classes identified for each soil unit observed are presented in **Table 25**.

Table 25 Land suitability classes for beef cattle grazing based on salinity

Soil Unit	Example Soil Profiles	Limiting Features	Land Suitability Class
Black, Brown and Grey Vertosols on Fair Hill Formation	PR06	Rootzone EC < 0.15 mS/cm and Cl < 300 ppm	1
	PR07 , PR14	Rootzone EC $0.15-0.3$ mS/cm and Cl $300-600$ ppm	2
Brown and Red Dermosols on Fair Hill Formation	PR02	Rootzone EC < 0.15 mS/cm and Cl < 300 ppm	1
Black, Brown and Grey Vertosols on Quaternary alluvium	PR01	Rootzone EC < 0.15 mS/cm and Cl < 300 ppm	1
Black, Brown and Grey Dermosols on Quaternary alluvium	OB30	Rootzone EC < 0.15 mS/cm	1
	PR11	Cl $300-600$ ppm	2

4.3.1.2.5 Rockiness

Rockiness for the soil types on the Project site have been assessed against Table 2.1 of the DME guidelines. The land suitability classes identified for each soil unit observed are presented in **Table 26**.

Table 26 Land suitability classes for beef cattle grazing based on rockiness

Soil Unit	Example Soil Profiles	Limiting Features	Land Suitability Class
Black, Brown and Grey Vertosols on Fair Hill Formation	PR06 , PR07 , PR14	<20% coarse surface gravel (>6 cm diam.) and rock outcrop	1
Brown and Red Dermosols on Fair Hill Formation	PR02 , PR08	<20% coarse surface gravel (>6 cm diam.) and rock outcrop	1
	OB34	50-90% surface cobble and rock outcrop	3
Black, Brown and Grey Vertosols on Quaternary alluvium	PR01	<20% coarse surface gravel (>6 cm diam.) and rock outcrop	1
Black, Brown and Grey Dermosols on Quaternary alluvium	OB30 , PR11	<20% coarse surface gravel (>6 cm diam.) and rock outcrop	1

4.3.1.2.6 Micro Relief

Micro relief for the soil types on the Project site have been assessed against Table 2.1 of the DME guidelines. The land suitability classes identified for each soil unit observed are presented in **Table 27**.

Table 27 Land suitability classes for beef cattle grazing based on micro relief

Soil Unit	Example Soil Profiles	Limiting Features	Land Suitability Class
Black, Brown and Grey Vertosols on Fair Hill Formation	PR06 , PR07 , PR14	Melonholes cover <20% surface area	1
Brown and Red Dermosols on Fair Hill Formation	PR02 , PR08 , OB34	Melonholes cover <20% surface area	1
Black, Brown and Grey Vertosols on Quaternary alluvium	PR01	Melonholes cover <20% surface area	1
Black, Brown and Grey Dermosols on Quaternary alluvium	OB30 , PR11	Melonholes cover <20% surface area	1

4.3.1.2.7 Soil pH

Soil pH for the soil types on the Project site have been assessed against Table 2.1 of the DME guidelines. The land suitability classes identified for each soil unit observed are presented in **Table 28**.

Table 28 Land suitability classes for beef cattle grazing based on soil pH

Soil Unit	Example Soil Profiles	Limiting Features	Land Suitability Class
Black, Brown and Grey Vertosols on Fair Hill Formation	PR06 , PR07	pH 8.0-9.0	3
	PR14	pH 9.0-10.0	4
Brown and Red Dermosols on Fair Hill Formation	PR02	pH 6.6-8.0	2
Black, Brown and Grey Vertosols on Quaternary alluvium	PR01	pH 6.6-8.0	2
Black, Brown and Grey Dermosols on Quaternary alluvium	PR11	pH 8.0-9.0	3
	OB30	pH 6.6-8.0	2

4.3.1.2.8 Soil ESP

ESP for the soil types on the Project site have been assessed against Table 2.1 of the DME guidelines. The land suitability classes identified for each soil unit observed are presented in **Table 29**.

Table 29 Land suitability classes for beef cattle grazing based on ESP

Soil Unit	Example Soil Profiles	Limiting Features	Land Suitability Class
Black, Brown and Grey Vertosols on Fair Hill Formation	PR06	ESP <5	1
	PR07 , PR14	ESP 5-10	2
Brown and Red Dermosols on Fair Hill Formation	PR02	ESP <5	1
Black, Brown and Grey Vertosols on Quaternary alluvium	PR01	ESP <5	1
Black, Brown and Grey Dermosols on Quaternary alluvium	PR11	ESP 5-10	2
	OB30	ESP <5	1

4.3.1.2.9 Wetness

Wetness for the soil types on the Project site have been assessed against Table 2.1 of the DME guidelines. The land suitability classes identified for each soil unit observed are presented in **Table 30**.

Table 30 Land suitability classes for beef cattle grazing based on wetness

Soil Unit	Example Soil Profiles	Limiting Features	Land Suitability Class
Black, Brown and Grey Vertosols on Fair Hill Formation	PR06 , PR07 , PR14	Undulating terrain or elevated plains	1
Brown and Red Dermosols on Fair Hill Formation	PR02	Undulating terrain or elevated plains	1

Soil Unit	Example Soil Profiles	Limiting Features	Land Suitability Class
Black, Brown and Grey Vertosols on Quaternary alluvium	PR01	Low-lying level plains	2
Black, Brown and Grey Dermosols on Quaternary alluvium	OB30 , PR11	Low-lying level plains	2

4.3.1.2.10 Topography

Topography for the soil types on the Project site have been assessed against Table 2.1 of the DME guidelines. The land suitability classes identified for each soil unit observed are presented in **Table 31**.

Table 31 Land suitability classes for beef cattle grazing based on topography

Soil Unit	Limiting Features	Land Suitability Class
Black, Brown and Grey Vertosols on Fair Hill Formation	No limitation criteria	1
Brown and Red Dermosols on Fair Hill Formation	No limitation criteria	1
Black, Brown and Grey Vertosols on Quaternary alluvium	No limitation criteria	1
Black, Brown and Grey Dermosols on Quaternary alluvium	No limitation criteria	1

4.3.1.2.11 Water Erosion

Water erosion for the soil types on the Project site have been assessed against Table 2.1 of the DME guidelines. The land suitability classes identified for each soil unit observed are presented in **Table 32**.

Table 32 Land suitability classes for beef cattle grazing based on water erosion

Soil Unit	Example Soil Profiles	Limiting Features	Land Suitability Class
Black, Brown and Grey Vertosols on Fair Hill Formation	PR06 , PR07 , PR14	Slopes <3% on all other soils	1
Brown and Red Dermosols on Fair Hill Formation	PR02 , PR08 , OB34	Slopes 1-3% on sodic rigid soils	2
Black, Brown and Grey Vertosols on Quaternary alluvium	PR01	Slopes <3% on all other soils	1
Black, Brown and Grey Dermosols on Quaternary alluvium	OB30 , PR11	Slopes <1.0% on sodic rigid soils	1

4.3.1.2.12 Flooding

Flooding for the soil types on the Project site have been assessed against Table 2.1 of the DME guidelines. The land suitability classes identified for each soil unit observed are presented in **Table 33**.

Table 33 Land suitability classes for beef cattle grazing based on flooding

Soil Unit	Limiting Features	Land Suitability Class
Black, Brown and Grey Vertosols on Fair Hill Formation	No flooding	1
Brown and Red Dermosols on Fair Hill Formation	No flooding	1
Black, Brown and Grey Vertosols on Quaternary alluvium	Periodic flooding (from once in 50 years to whenever stream flow increases)	2
Black, Brown and Grey Dermosols on Quaternary alluvium	Periodic flooding (from once in 50 years to whenever stream flow increases)	2

4.3.1.2.13 Vegetation Regrowth

Vegetation for the soil types on the Project site have been assessed against Table 2.1 of the DME guidelines. The land suitability classes identified for each soil unit observed are presented in **Table 34**.

Table 34 Land suitability classes for beef cattle grazing based on soil workability

Soil Unit	Limiting Features	Land Suitability Class
Black, Brown and Grey Vertosols on Fair Hill Formation	Softwood, brigalow, gidgee or blackwood scrub without melonholes	1
Brown and Red Dermosols on Fair Hill Formation	Softwood, brigalow, gidgee or blackwood scrub without melonholes or mountain coolabah, bloodwood and iron bark woodlands	1
Black, Brown and Grey Vertosols on Quaternary alluvium	Softwood, brigalow, gidgee or blackwood scrub without melonholes or mountain coolabah, bloodwood and iron bark woodlands	1
Black, Brown and Grey Dermosols on Quaternary alluvium	Softwood, brigalow, gidgee or blackwood scrub without melonholes or mountain coolabah, bloodwood and iron bark woodlands	1

4.3.1.2.14 Summary of Assessment for Beef Cattle Grazing

The land use limitations for beef cattle grazing are summarised in **Table 35** and mapped in **Figure 14**.

Table 35 Land suitability limitations for beef cattle grazing

Soil Unit	PAWC	Nutrients	Physical	Salinity	Rockiness	Micro Relief	Soil pH	Soil ESP	Wetness	Topography	Water Erosion	Flooding	Vegetation	Overall Suitability Rating
Black, Brown and Grey Vertosols on Fair Hill Formation	1-3	3-4	2-3	1-2	1	1	3-4	1-2	1	1	1	1	1	2-3
Brown and Red Dermosols on Fair Hill Formation	3	4	1	1	1-3	1	2	1	1	1	2	1	1	4
Black, Brown and Grey Vertosols on Quaternary alluvium	1	4	2	1	1	1	2	1	2	1	1	2	1	4
Black, Brown and Grey Dermosols on Quaternary alluvium	3	3	1	1-2	1	1	2-3	1-2	2	1	1	2	1	3

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FIGURE 14
LAND SUITABILITY
FOR BEEF CATTLE
GRAZING

Legend

- Watercourse
- Mining Lease (Application)
- Investigation Area
- 7 Year Pit Shell
- Proposed Site Infrastructure
- Easement
- Base Cadastre

Land Suitability for Beef Cattle Grazing

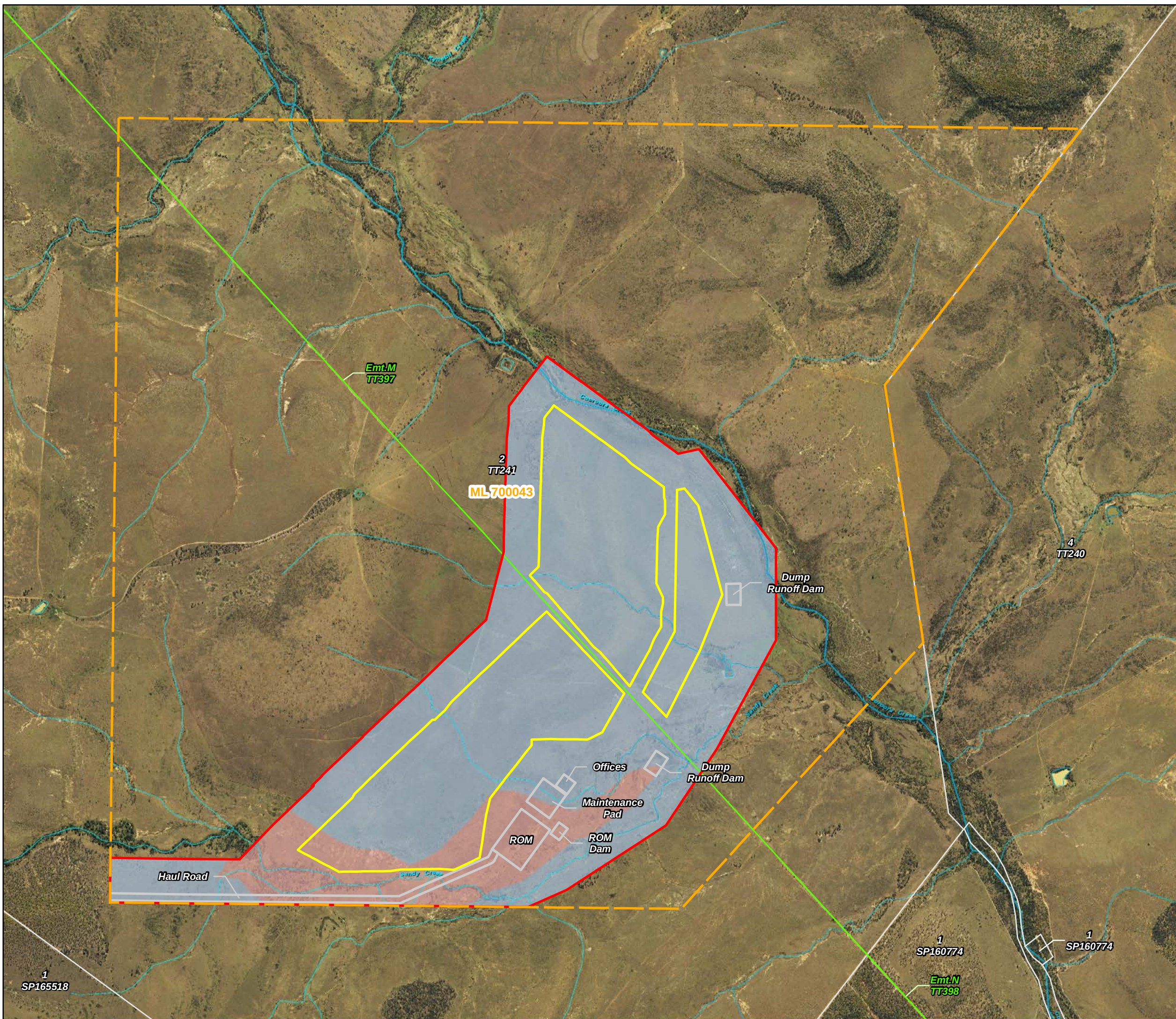
- Land Suitability Class 3
- Land Suitability Class 4

Data Sources:
Mining Lease, Watercourse, and Digital Cadastral
Database (extracted April 2019) datasets: © State of
Queensland (Department of Natural Resources, Mines,
and Energy) 2019; 7 Year Pit Shell, Investigation Area,
Land Suitability, and Proposed Site Infrastructure
datasets: (SLR Consulting) 2019.
Imagery Sources: 70cm Bowen Basin SISP PeriUrban
2012 Orthophoto Image Service: © State of
Queensland (Department of Natural Resources, Mines,
and Energy) 2019.
Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator
Datum: GDA 1994
Date: 22/06/2019



0 250 500 750 1,000
Metres

Scale: 1:25,000 at A3



4.3.2 Good Quality Agricultural Land

Assessment to determine the class of land for agricultural purposes is made against the Planning Guidelines: The Identification of Good Quality Agricultural Land ([DPI & DHLGP, 1993](#)) hereon referred to as the GQAL guideline. This assessment provides for designation of the land into one of four classes. The agricultural classes are outlined in **Table 36**.

Table 36 Good quality agricultural land classes

Class	Description
A	Crop land – land that is suitable for current and potential crops with limitations production that range from none to moderate levels
B	Limited crop land – land that is marginal for current and potential crops due to severe limitations; and suitable for improved pastures. Engineering and/or agronomic improvements may be required before the land is considered suitable for cropping
C	Pasture land – land that is suitable only for improved or native pastures due to limitations that preclude continuous cultivation for crop production; but some areas may tolerate a short period of ground disturbance for pasture establishment
D	Non-agricultural land – land not suitable for agricultural uses due to extreme limitations. This may be disturbed land significant habitat, conservation and/or catchment values or land that may be unstable because of very steep slopes, shallow soils, rock outcrop or poor drainage

A direct correlation between land suitability and GQAL classes can be made to classify the soil units on the Project site into the appropriate GQAL class. This correlation is presented in **Table 37** and the resultant GQAL Classes mapped on **Figure 15**.

Table 37 Correlation between land suitability and GQAL classes to classify the Project site soil units into GQAL classes

GQAL class	Land suitability		Description	Soil Mapping Unit	
	Cropping	Grazing		Cropping	Grazing
A			Crop land – land that is suitable for current and potential crops with limitations production that range from none to moderate levels		
A1	1-3	1-3	Land that is suitable for a wide range of current and potential broadacre and horticultural crops with limitations to production that range from none to moderate levels	3. Black, Brown and Grey Vertosols on Quaternary alluvium	
A2	1-3	1-3	Land that is suitable for a wide range of current and potential horticultural crops only, with limitations to production that range from none to moderate levels		
B	4	1-3	Limited crop land – land that is marginal for current and potential crops due to severe limitations; and suitable for improved pastures. Engineering and/or agronomic improvements may be required before the land is considered suitable for cropping	1. Black, Brown and Grey Vertosols on Fair Hill Formation 2. Brown and Red Dermosols on Fair Hill Formation 4. Black, Brown and Grey Dermosols on Quaternary alluvium	
C			Pasture land – land that is suitable only for improved or native pastures due to limitations that preclude continuous cultivation for crop production; but some areas may tolerate a short period of ground disturbance for pasture establishment		
C1	5	1-2	Suitable for grazing sown pastures (with ground disturbance for establishment) or native pastures on higher fertility soils		1. Black, Brown and Grey Vertosols on Fair Hill Formation
C2	5	3	Suitable for grazing native pastures with or without the introduction of pasture species and are lower fertility soils than C1		4. Black, Brown and Grey Dermosols on Quaternary alluvium

GQAL class	Land suitability		Description	Soil Mapping Unit	
	Cropping	Grazing		Cropping	Grazing
C3	5	4	Suitable for light grazing of native pastures in accessible areas, and includes steep land more suited to forestry or catchment protection		2. Brown and Red Dermosols on Fair Hill Formation 3. Black, Brown and Grey Vertosols on Quaternary alluvium
D	5	5	Non-agricultural land – land not suitable for agricultural uses due to extreme limitations. This may be disturbed land significant habitat, conservation and/or catchment values or land that may be unstable because of very steep slopes, shallow soils, rock outcrop or poor drainage		

4.3.3 Strategic Cropping Land

The Project site is not mapped as strategic cropping land (SCL) under the Queensland Government's SCL mapping, as shown in **Figure 16**. As such, an assessment against the SCL criteria is not required and has not been carried out.

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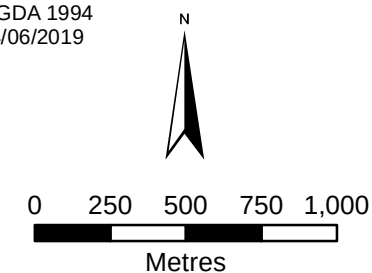
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FIGURE 15
GOOD QUALITY
AGRICULTURAL LAND

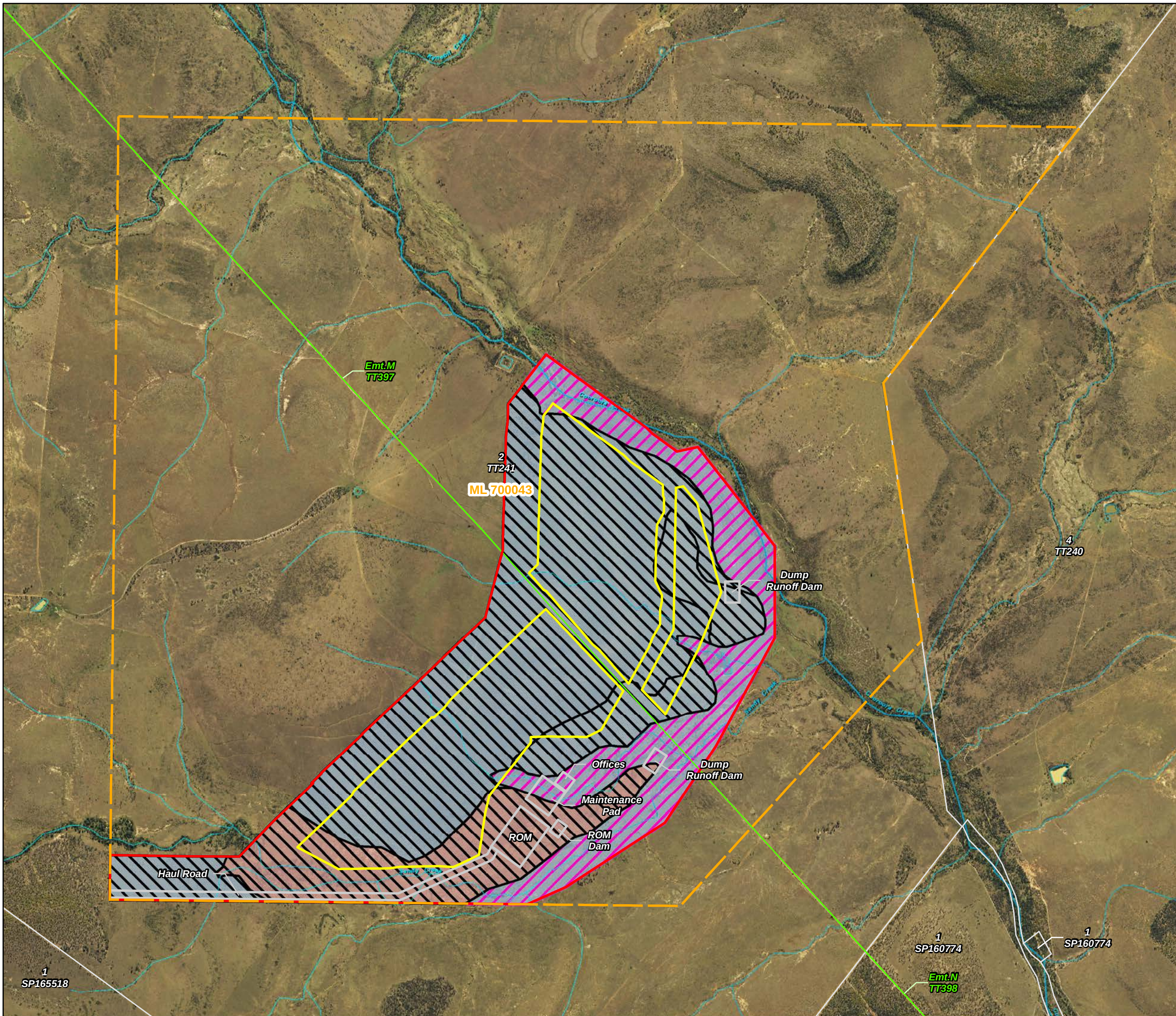
Legend

- Watercourse
- Mining Lease (Application)
- Investigation Area
- 7 Year Pit Shell
- Proposed Site Infrastructure
- Easement
- Base Cadastre
- Land Suitability for Rainfed Broadacre Cropping**
 - Land Suitability Class 3
 - Land Suitability Class 4
- Land Suitability for Beef Cattle Grazing**
 - Land Suitability Class 3
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Data Sources:
Mining Lease, Watercourse, and Digital Cadastral Database (extracted April 2019) datasets: © State of Queensland (Department of Natural Resources, Mines, and Energy) 2019; 7 Year Pit Shell, Investigation Area, Land Suitability, and Proposed Site Infrastructure datasets: (SLR Consulting) 2019.
Imagery Sources: 70cm Bowen Basin SISP PeriUrban 2012 Orthophoto Image Service: © State of Queensland (Department of Natural Resources, Mines, and Energy) 2019.
Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator
Datum: GDA 1994
Date: 24/06/2019



Scale: 1:25,000 at A3



FAIRHILL COKING COAL PTY LTD

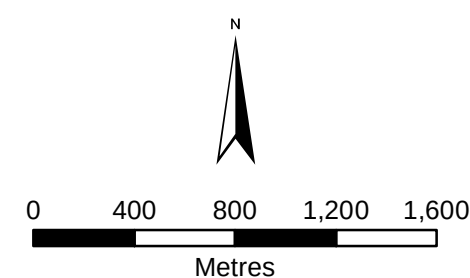
FAIRHILL

FIGURE 16 STRATEGIC CROPPING LAND

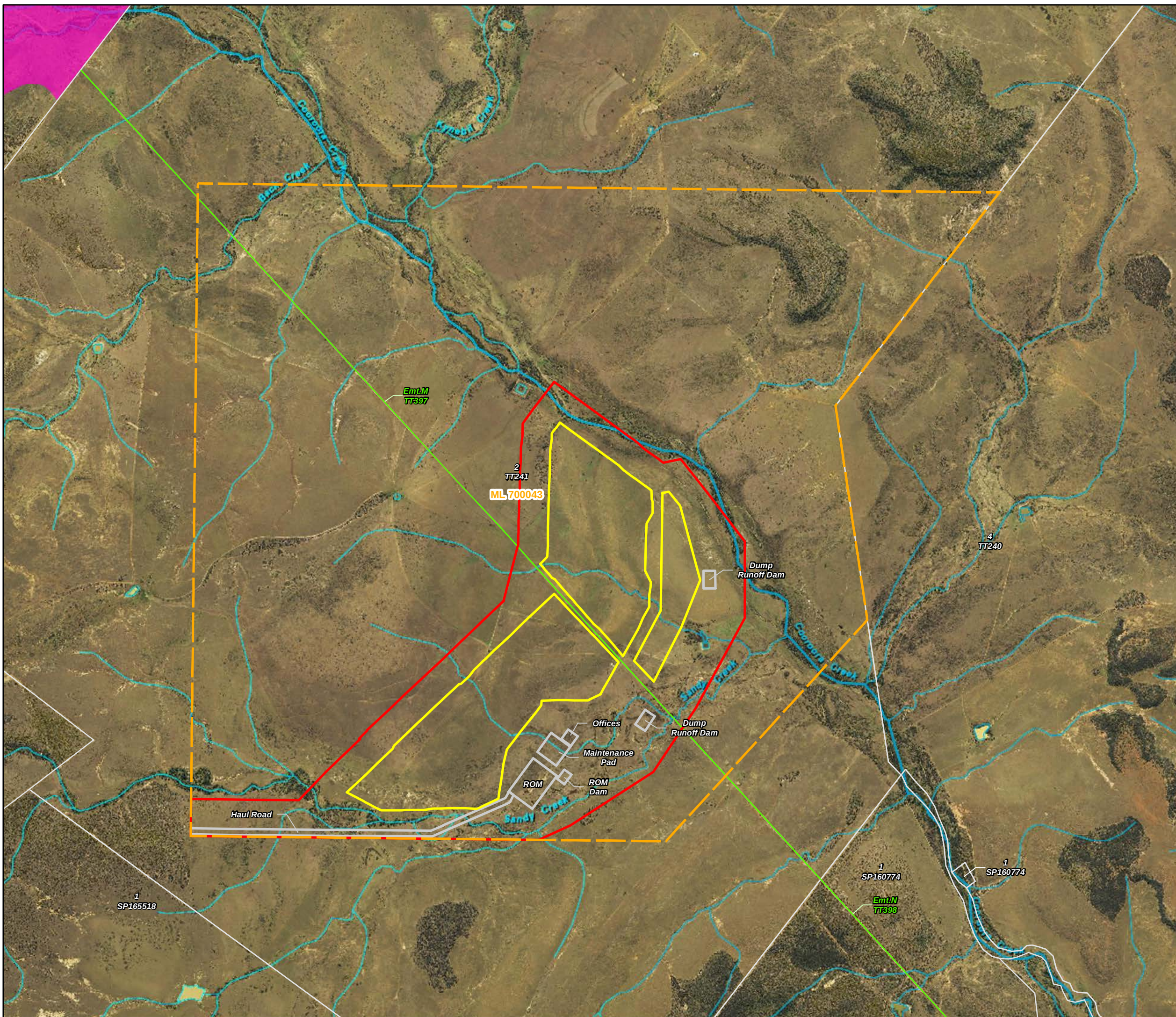
Legend

-  Watercourse
-  Mining Lease (Application)
-  Investigation Area
-  7 Year Pit Shell
-  Proposed Site Infrastructure
-  Strategic Cropping Land
-  Easement
-  Base Cadastre

Data Sources:
Mining Lease, Watercourse, Strategic Cropping Land,
and Digital Cadastral Database (extracted April 2019)
datasets: © State of Queensland (Department of
Natural Resources, Mines, and Energy) 2019; 7 Year
Pit Shell, Investigation Area, and Proposed Site
Infrastructure datasets: (SLR Consulting) 2019.
Imagery Sources: 70cm Bowen Basin SISP PeriUrban
2012 Orthophoto Image Service: © State of
Queensland (Department of Natural Resources, Mines,
and Energy) 2019.
Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator
Datum: GDA 1994
Date: 22/06/2019



Scale: 1:30,000 at A3



5 Soil Management Measures

The soil management measures proposed in **Table 38** have been formulated for the long-term protection and management of the soils on the Project Site thereby ensuring the soils are reinstated to their pre-disturbance productive capability post-disturbance.

Table 38 Soil Management Measures for the Protection and Management of Soils on the Project Site

Aspect	Acceptable Management Measures/Practices
Area of disturbance	- To minimise the extent of impact to the soils and their inherent agricultural capability, the disturbance footprint to construct, operate and deconstruct the rail loop and associated infrastructure will be minimised/confined to the greatest extent practicable. The only exception to this is the re-spreading of left-over topsoil at completion of construction. Management of this is outlined under topsoil stockpiling /windrowing. - This will be achieved by installing suitable fencing to contain construction, operations and decommissioning activities. - Signage will be installed to clearly identify no-go zones for construction, operation and decommissioning facilities, machinery and associated equipment. - Monitoring will be conducted weekly to ensure there are no breaches of these requirements. - Should there be any breaches, an incident will be recorded, investigations undertaken and actions taken to prevent re-occurrence and immediately rectify any damage caused.
Erosion and sediment control	- An erosion and sediment control plan will be prepared, updated and maintained current during construction, operations and decommissioning phases in accordance with the Best Practice Erosion and Sediment Control guidelines (IECA, 2008). - Clean water will be diverted around construction and decommissioning areas and managed to prevent increased scour resulting in sheet, rill or gully erosion. - Clean water will be reinstated to natural or as near as natural sheet flow and concentrated flow paths as practicably possible during operations through appropriate infrastructure layout design and following decommissioning to reinstate the natural landform. - Exposed soil surfaces will be covered and protected or reinstated and seeded/hydromulched as soon as reasonably practicable following earthworks and immediately prior to rainfall events likely to produce runoff. - Sediment control devices will be designed and installed to remove sediment from dirty water generated from within the disturbance footprint to the greatest extent practicable prior to discharge from the Project Site. - Sediment control devices will be installed around and immediately adjacent to stockpiles/windrows to capture sediment from each stockpile/windrow at the source to prevent mixing and contamination as far as reasonably practicable.
Depth of disturbance	The depth of disturbance will be restricted to the design depths specified on the approved construction plans.

Aspect	Acceptable Management Measures/Practices
	- On the surface of the natural soil or regolith material remaining after scraping or excavating to the required depth, geofabric or some other suitable lining material is to be placed to clearly demarcate the boundary between infrastructure materials and the natural ground. - On decommissioning, the infrastructure to be removed will be removed down to and including the geofabric or other lining material so that the original regolith can be reinstated to restore the soil profile to its original form. - Final 'as constructed' design drawings are to be retained for the life of the infrastructure so that decommissioning operations are informed of the final design details for removal planning.
Topsoil stripping	Topsoil in all SMUs will be stripped/excavated between 250-300 mm.
Topsoil stockpiling /windrowing	- Topsoil from each SMU will be stockpiled/windrowed separately from all the other SMUs, clearly signed, and the respective location mapped and confirmed using GPS for future reference and to avoid incorrect use. - Topsoil from all SMUs will also be stockpiled/windrowed separately from their respective subsoils. - All SMU topsoil stockpiles/windrows will be placed upslope from their respective subsoil and unweathered parent material stockpiles/windrows to prevent contamination and degradation from their subsoils and unweathered parent material. - Topsoil stockpiles/windrows will be no more than 2.0 m high to avoid degrading the topsoil and maintain fertility. - Topsoil fertility of short-term (<3 months) topsoil stockpiles/windrows will be maintained by a protective layer of mulch and the stockpile/windrow turned over and mulch thoroughly mixed through the soil on re-spreading the topsoil at rehabilitation. - Topsoil fertility of medium-term (>3 to <6 months) to long-term (>6 months) topsoil stockpiles/windrows will be maintained by repeated oversowing with sterile grasses (hydromulched), as required, until reuse and then the stockpile turned over and mixed prior to replacement. - Where possible, all remaining topsoil should be re-spread to the greatest extent practicable across the remaining undisturbed and reinstated areas applicable for each SMU post infrastructure establishment. - The details of topsoil volumes and GPS locations/extents will be recorded for decommissioning reference to recover the topsoil for reinstatement once the infrastructure is removed or with progressive pit rehabilitation. Spreading the topsoil in this manner for the duration of operations will better preserve the topsoil than long-term/indefinite stockpiling/windrowing and will require considerably less on-going maintenance to preserve the topsoil fertility.
Subsoil stripping	Subsoil in all SMUs will be stripped/excavated from 250-300 down to 1,500 mm or weathered parent material, where required.
Subsoil stockpiling /windrowing	Subsoil from all SMUs will be stockpiled/windrowed separately from all other SMUs, clearly signed, and their respective locations mapped and confirmed using GPS for future reference and to avoid incorrect use.

Aspect	Acceptable Management Measures/Practices
	- Subsoil from all SMUs will also be stockpiled/windrowed separately from their respective topsoil and unweathered parent material. - All SMU subsoil stockpiles/windrows will be placed downslope from their respective topsoil and upslope of their respective unweathered parent material stockpiles/windrows to prevent contamination and degradation of their subsoils.
Unweathered parent material	Unweathered parent material in all SMUs will be stripped/excavated from 1,500 mm or weathered parent material, where required.
Unweathered parent material stockpiling /windrowing	- Unweathered parent material from all SMUs will be stockpiled/windrowed separately from all other SMUs, clearly signed, and their respective locations mapped and confirmed using GPS for future reference and to avoid incorrect use. - Unweathered parent material from all SMUs will also be stockpiled/windrowed separately from their respective topsoils and subsoils. - All SMU unweathered parent material stockpiles/windrows will be placed downslope from their respective topsoil and subsoil stockpiles/windrows to prevent contamination and degradation of their respective topsoils and subsoils.
<i>In situ</i> soils	- Following construction and decommissioning, undisturbed and compacted <i>in situ</i> subsoils from machinery traffic, equipment and beneath removed infrastructure (including geofabric or some other lining material used), will have a suitable ameliorant applied (e.g., gypsum or lime (composition and concentration to be determined by laboratory analysis). The subsoil and ameliorant will be cultivated by ripping or scarifying to decompact and remove any potential hard pans and incorporate the ameliorant prior to backfilling on top with applicable SMU, as applicable to the area, topsoil to reinstate the original landform to the extent practicable. - Following construction and decommissioning, undisturbed and compacted <i>in situ</i> topsoils from machinery traffic, equipment and beneath removed infrastructure (including geofabric or some other lining material used), will have suitable ameliorants applied (e.g., gypsum or lime and/or organic matter/humus and/or fertiliser (composition and concentration to be determined by laboratory analysis for major and trace elements). The topsoil and ameliorants will be cultivated by ripping or scarifying to decompact and remove any potential hard pans and incorporate the ameliorants prior to hydromulching or oversowing with a suitable cover crop (e.g., pasture grasses). - At decommissioning, areas where topsoil was re-spread over undisturbed areas, to remove the need to manage stockpiles/windrows for the life of the coal mine, will need to be scraped off to the depth they were spread and stockpiled in accordance with topsoil stockpiling/windrowing practices outlined above. This material will be required for rehabilitating areas where no topsoil has been since construction and operation of the coal mine and associated infrastructure.
Subsoil reinstatement	Following construction, completion of extraction from each year pit shell and decommissioning works, disturbed subsoils from stockpiles/windrows will be spread evenly to reinstate the original landform where land disturbance can be reinstated. The subsoil will then have a suitable ameliorant applied (e.g., gypsum or lime (composition and concentration to be determined by laboratory analysis). It will then be cultivated by ripping or scarifying to decompact the subsoil from machinery traffic respreading activities and prepare it for topdressing with topsoil.

Aspect	Acceptable Management Measures/Practices
Topsoil reinstatement	Following construction, completion of extraction from each year pit shell and decommissioning, disturbed topsoils from stockpiles/windrows will be spread evenly to reinstate the original landform where land disturbance can be reinstated. The topsoil will then have suitable ameliorants applied (e.g., gypsum or lime and/or organic matter/humus and/or fertiliser (composition and concentration to be determined by laboratory analysis for major and trace elements). It will then be cultivated by ripping or scarifying to decompact the topsoil from machinery traffic respreading activities and prepare it for hydromulching or oversowing with a suitable cover crop (e.g., pasture grasses).

6 Abbreviations and Definitions of Terms

The abbreviations and terms used in this report are detailed in the following sections.

6.1 Abbreviations

Abbreviations used in this report are defined in **Table 39**.

Table 39 Abbreviations used in this report

Abbreviation	Definition
AHD	Australian height datum
AMU	Agricultural management unit
ASC	Australian Soil Classification
BoM	Bureau of Meteorology
CLR	Contaminated Land Register
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DES	Queensland Department of Environment and Science
DILGP	Department of Infrastructure, Local Government and Planning
DPI	Queensland Department of Primary Industries
EA	Environmental authority
EES	Environmental Earth Sciences
EMR	Environmental Management Register
EP Act	Queensland <i>Environmental Protection Act 1994</i>
EPC	Exploration permit for coal
EP Reg	Queensland <i>Environmental Protection Regulation 2008</i>
ERA	Environmentally relevant activity
FCC	Fairhill Coking Coal Pty Ltd
Futura	Futura Resources Pty Ltd
GIS	Geographic information systems
NRC	Northern Resource Consultants
RFI	Request for information notice
SLR	SLR Consulting Australia Pty Ltd or SLR Consulting

6.2 Definitions of Terms

Definitions of terms used within this report are provided in **Table 40**.

Table 40 Definitions of Terms

Term	Definition																														
A1 horizon	Mineral horizon at or near the surface with some accumulation of humified organic matter, usually darker in colour than underlying horizons and with maximum biological activity for any given soil profile (NCST, 2009)																														
A2 horizon	Mineral horizon having either, alone or in combination, less organic matter, sesquioxides or silicate clay than immediately adjacent horizons. It is usually differentiated from the A1 horizon by its paler colour (NCST, 2009)																														
Acid soil	Soil with a pH of less than 6.5 (Rayment and Lyons, 2011)																														
Alkaline soil	Soil with a pH greater than 7.4 (Rayment and Lyons, 2011)																														
API	Aerial photograph interpretation																														
Australian Soil Classification (ASC)	This is a multi-category scheme with classes defined on the basis of diagnostic horizons or materials and their arrangement in vertical sequence as seen in an exposed soil profile (Isbell and NCST, 2016)																														
B horizon	Horizons consisting of one or more mineral soil layers characterised by one or more of the following: a concentration of silicate clay, iron, aluminium, organic material or several of these; a structure and/or consistence unlike that of the A horizons above or of any horizons below; stronger colours, usually expressed as higher chroma and/or redder hue, than those of the A horizons above or of those horizons below (NCST, 2009)																														
Bicarb & acid extr. P	A measure of available soil phosphorus using a bicarbonate extract or acid extract																														
C horizon	Layers below the solum (AB profile) of consolidated or unconsolidated material, usually partially weathered, little affected by pedogenic processes, and either like or unlike the material from which the solum presumably formed																														
Ca:Mg	Ratios of exchangeable calcium (Ca) to exchangeable magnesium (Mg) are used to support assessments of subsoil dispersibility where Ca:Mg <0.1 are often associated with highly dispersive subsoils. Ca:Mg ratings <table><tr><th>Ratio</th><th>Rating</th></tr><tr><td>< 0.1</td><td>Very low</td></tr><tr><td>0.1 - 1</td><td>Low</td></tr><tr><td>1 - 2</td><td>Medium</td></tr><tr><td>> 2</td><td>High</td></tr></table>	Ratio	Rating	< 0.1	Very low	0.1 - 1	Low	1 - 2	Medium	> 2	High																				
Ratio	Rating																														
< 0.1	Very low																														
0.1 - 1	Low																														
1 - 2	Medium																														
> 2	High																														
Cation exchange capacity	CEC is a measure of a soils capacity to hold and exchange cations influenced by factors such as organic matter, clay percentage and clay type and pH. CEC ratings Exchangeable cations classification (Hazelton and Murphy, 2007) <table><tr><th>Cations</th><th>Very low</th><th>Low</th><th>Moderate</th><th>High</th><th>Very high</th></tr><tr><td>Ca (meq/100g)</td><td>0 – 2</td><td>2 – 5</td><td>5 -10</td><td>10 – 20</td><td>> 20</td></tr><tr><td>Mg (meq/100g)</td><td>0 – 0.3</td><td>0.3 – 1.0</td><td>1 - 3</td><td>3 - 8</td><td>> 8</td></tr><tr><td>K (meq/100g)</td><td>0 – 0.2</td><td>0.2 – 0.3</td><td>0.3 – 0.7</td><td>0.7 – 2.0</td><td>> 2</td></tr><tr><td>Na (meq/100g)</td><td>0 – 0.1</td><td>0.1 – 0.3</td><td>0.3 – 0.7</td><td>0.7 – 2.0</td><td>> 2</td></tr></table>	Cations	Very low	Low	Moderate	High	Very high	Ca (meq/100g)	0 – 2	2 – 5	5 -10	10 – 20	> 20	Mg (meq/100g)	0 – 0.3	0.3 – 1.0	1 - 3	3 - 8	> 8	K (meq/100g)	0 – 0.2	0.2 – 0.3	0.3 – 0.7	0.7 – 2.0	> 2	Na (meq/100g)	0 – 0.1	0.1 – 0.3	0.3 – 0.7	0.7 – 2.0	> 2
Cations	Very low	Low	Moderate	High	Very high																										
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Na (meq/100g)	0 – 0.1	0.1 – 0.3	0.3 – 0.7	0.7 – 2.0	> 2																										

Term	Definition																								
Cultivated	Turning and/or breaking soil into smaller aggregates and aerating it prior to planting crops or pastures using implements such as disc ploughs and tynes																								
Dermosols	ASC Soil Order classification – Soils with structured B2 horizons and lacking strong texture contrast between A and B horizons (Isbell & NCST, 2016)																								
Electrical conductivity	Measure of concentration of electrically charged water soluble salts (in a 1:5) soil water suspension. Used to quantify soil salinity																								
Emerson aggregate (class) test (EAT)	Clay dispersion is semi-quantitatively measured using the Emerson aggregate test. This test measures the instability of soil structure when immersed in water. Definition of Emerson class (AS1289.3.8.1—2006) <table><tr><th>Emerson class</th><th>Definition</th></tr><tr><td>Class 1</td><td>Air-dried crumbs of soil show a strong dispersing reaction, i.e. a colloidal cloud covers nearly the whole of the bottom of the beaker, usually in a very thin layer. The reaction should be evident within 10 min. In extreme cases all the water in the beaker becomes cloudy, leaving only a coarse residue in a cloud of clay</td></tr><tr><td>Class 2</td><td>Air-dried crumbs of soil show a moderate to slight reaction. A moderate reaction consists of an easily recognizable cloud of colloids in suspension, usually spreading in thin streaks on the bottom of the beaker. A slight reaction consists of the bare hint of cloud in water at the surface of the crumbs</td></tr><tr><td>Class 3</td><td>The soil remoulded at the plastic limit disperses in water</td></tr><tr><td>Class 4</td><td>The remoulded soil does not disperse in water. Calcium carbonate (calcite) or calcium sulfate (gypsum) is present</td></tr><tr><td>Class 5</td><td>The remoulded soil does not disperse in water and the 1:5 soil / water suspension remains dispersed after 5 min</td></tr><tr><td>Class 6</td><td>The remoulded soil does not disperse in water and the 1:5 soil / water suspension begins to flocculate within 5 min</td></tr><tr><td>Class 7</td><td>The air-dried crumbs of soil remain coherent (do not disperse) in water and swells</td></tr><tr><td>Class 8</td><td>The air-dried crumbs of soil remain coherent (do not disperse) in water and do not swell</td></tr></table>	Emerson class	Definition	Class 1	Air-dried crumbs of soil show a strong dispersing reaction, i.e. a colloidal cloud covers nearly the whole of the bottom of the beaker, usually in a very thin layer. The reaction should be evident within 10 min. In extreme cases all the water in the beaker becomes cloudy, leaving only a coarse residue in a cloud of clay	Class 2	Air-dried crumbs of soil show a moderate to slight reaction. A moderate reaction consists of an easily recognizable cloud of colloids in suspension, usually spreading in thin streaks on the bottom of the beaker. A slight reaction consists of the bare hint of cloud in water at the surface of the crumbs	Class 3	The soil remoulded at the plastic limit disperses in water	Class 4	The remoulded soil does not disperse in water. Calcium carbonate (calcite) or calcium sulfate (gypsum) is present	Class 5	The remoulded soil does not disperse in water and the 1:5 soil / water suspension remains dispersed after 5 min	Class 6	The remoulded soil does not disperse in water and the 1:5 soil / water suspension begins to flocculate within 5 min	Class 7	The air-dried crumbs of soil remain coherent (do not disperse) in water and swells	Class 8	The air-dried crumbs of soil remain coherent (do not disperse) in water and do not swell						
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Environmental value	The physical, aesthetic, social and cultural values of a location or proposed site (DES, 2017)																								
Fertility	Soil fertility (the capacity of the soil to support plant growth in a given climatic regime) is a function of the physical, chemical and biological characteristics of the soil. Indices used include Organic Carbon, Cation Exchange Capacity (CEC), exchangeable cations, Total Kjeldahl nitrogen (TKN) and available phosphorus (P). Some soil nutrient level ratings from Rayment and Lyons (2011) include: <table><tr><th>Analyte</th><th>Very low</th><th>Low</th><th>Moderate</th><th>High</th><th>Very high</th></tr><tr><td>TKN (%)</td><td>< 0.05</td><td>0.05 – 0.15</td><td>0.15 – 0.25</td><td>0.25 – 0.5</td><td>> 0.5</td></tr><tr><td>Bicarb & acid extr. P (mg/kg)</td><td>< 10</td><td>10 - 20</td><td>> 20 – 40</td><td>> 40 - 100</td><td>> 100</td></tr><tr><td>Organic Carbon (%)</td><td>< 0.5</td><td>0.5 - 1.5</td><td>> 1.5 - 2.5</td><td>> 2.5 - 5.0</td><td>> 5.0</td></tr></table>	Analyte	Very low	Low	Moderate	High	Very high	TKN (%)	< 0.05	0.05 – 0.15	0.15 – 0.25	0.25 – 0.5	> 0.5	Bicarb & acid extr. P (mg/kg)	< 10	10 - 20	> 20 – 40	> 40 - 100	> 100	Organic Carbon (%)	< 0.5	0.5 - 1.5	> 1.5 - 2.5	> 2.5 - 5.0	> 5.0
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Term	Definition										
Good quality agricultural land (GQAL)	There are four agricultural land classes as described by DPI/DHLGP (1993): <table> <tr> <th>Class</th><th>Description</th></tr> <tr> <td>A</td><td> Crop land Land that is suitable for current and potential crops with limitations to production, ranging from none to moderate levels. There are two sub-classes of crop land: A1 – Crop land suitable for rain-fed cropping A2 – Crop land suitable for horticulture All crop land is considered to be GQAL. </td></tr> <tr> <td>B</td><td> Limited crop land Land that is marginal for current and potential crops due to severe limitations, and suitable for pastures. Engineering and/or agronomic improvements may be required before the land is considered suitable for cropping. Land marginal for particular crops of local significance is considered to be GQAL. </td></tr> <tr> <td>C</td><td> Pasture land Land that is suitable only for improved or native pastures due to limitations which preclude continuous cultivation for crop production, but some areas may tolerate a short period of ground disturbance for pasture establishment. In areas where pastoral industries are the major primary industry, land suitable for improved or high-quality native pastures may be considered to be GQAL. There are three sub-classes of pasture land: C1 – Land suitable for sown pastures with moderate limitations C2 – Land suitable for sown pastures with severe limitations C3 – Land suitable for light grazing for native pastures in inaccessible areas </td></tr> <tr> <td>D</td><td> Non-agricultural land Land not suitable for agricultural uses due to extreme limitations. This may be undisturbed land with significant habitat, conservation and/or catchment values or land that may be unsuitable because of very steep slopes, shallow soils, rock outcrop or poor drainage. These limitations preclude any interference with land or biological resources for the production of agricultural goods. </td></tr> </table>	Class	Description	A	Crop land Land that is suitable for current and potential crops with limitations to production, ranging from none to moderate levels. There are two sub-classes of crop land: A1 – Crop land suitable for rain-fed cropping A2 – Crop land suitable for horticulture All crop land is considered to be GQAL.	B	Limited crop land Land that is marginal for current and potential crops due to severe limitations, and suitable for pastures. Engineering and/or agronomic improvements may be required before the land is considered suitable for cropping. Land marginal for particular crops of local significance is considered to be GQAL.	C	Pasture land Land that is suitable only for improved or native pastures due to limitations which preclude continuous cultivation for crop production, but some areas may tolerate a short period of ground disturbance for pasture establishment. In areas where pastoral industries are the major primary industry, land suitable for improved or high-quality native pastures may be considered to be GQAL. There are three sub-classes of pasture land: C1 – Land suitable for sown pastures with moderate limitations C2 – Land suitable for sown pastures with severe limitations C3 – Land suitable for light grazing for native pastures in inaccessible areas	D	Non-agricultural land Land not suitable for agricultural uses due to extreme limitations. This may be undisturbed land with significant habitat, conservation and/or catchment values or land that may be unsuitable because of very steep slopes, shallow soils, rock outcrop or poor drainage. These limitations preclude any interference with land or biological resources for the production of agricultural goods.
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Gravel	Soil particles in the size range >2.0-60 mm (NCST, 2009)										
Gully erosion	A wide and deep incision into topsoil and subsoil layers resulting from erosion by expansion of rill erosion and/or collapse of tunnel erosion										
Horizon	A layer within the soil profile with morphological characteristics and properties different from layers below and /or above it										
Land	Includes characteristics of the landscape, such as the topography or vegetation and ecosystems that it supports, as well as the chemical and physical properties of soils (DES, 2017)										
Mottles	The presence of more than one soil colour in the same soil horizon, not including segregations or cutan colours										
Ped	An individual natural soil aggregate consisting of a cluster of primary particles. Ped faces may have limited to much accommodation to the faces of surrounding peds										
Permian	Period of geological time that spans 47 million years from the end of the Carboniferous Period 298.9 million years ago (Mya) to the beginning of the Triassic period 251.902 Mya										

Term	Definition																																							
Project site	The Project disturbance footprint, including an open cut 7-year pit shell (including in pit dump) of approximately 289 ha and other infrastructure comprising an out of pit overburden dump (36.5 ha), offices and maintenance pad (approximately 5 ha), haul road (approximately 14 ha), mine affected water storages (approximately 4 ha), and run of mine (approximately 9 ha) within mining lease (ML) 700043, which is also known as ‘Fairhill’ located on Lot 2 on TT241																																							
Quaternary	Period of geological time including the Holocene and Pleistocene; up to approx. 2 million years BP																																							
Rill erosion	A narrow and shallow incision into topsoil layers resulting from erosion by overland flow or surface runoff																																							
Ripping	Deep cultivation with a tyned implement to a depth of > 300 mm																																							
Scarifying	Shallow cultivation usually with a tyned implement to a depth of < 300 mm																																							
Sheet erosion	The removal of a thin layer of soil by raindrop splash and runoff																																							
Silt	Fine soil particles in the size range 0.02 - 0.002 mm (NCST, 2009)																																							
Salinity	Salinity is the presence of soluble salts in soils, mainly Ca²⁺, Mg²⁺, Na⁺, Cl⁻, SO₄²⁻ and HCO₃⁻. Salinity ratings (Rayment and Lyons, 2011) <table><tr><th rowspan="2">Soil salinity rating</th><th colspan="4">EC1:5 (dSm-1)</th></tr><tr><th>10 - 20% clay</th><th>20 - 40% clay</th><th>40 - 60% clay</th><th>60 - 80% clay</th></tr><tr><td>Very low</td><td>< 0.07</td><td>< 0.09</td><td>< 0.12</td><td>< 0.15</td></tr><tr><td>Low</td><td>0.07 - 0.15</td><td>0.09 - 0.19</td><td>0.12 - 0.24</td><td>0.15 - 0.3</td></tr><tr><td>Medium</td><td>0.15 - 0.34</td><td>0.19 - 0.45</td><td>0.24 - 0.56</td><td>0.3 - 0.7</td></tr><tr><td>High</td><td>0.34 - 0.63</td><td>0.45 - 0.76</td><td>0.56 - 0.96</td><td>0.7 - 1.18</td></tr><tr><td>Very high</td><td>0.63 - 0.93</td><td>0.76 - 1.21</td><td>0.96 - 1.53</td><td>1.18 - 1.87</td></tr><tr><td>Extreme</td><td>> 0.93</td><td>> 1.21</td><td>> 1.53</td><td>> 1.87</td></tr></table>	Soil salinity rating	EC1:5 (dSm-1)				10 - 20% clay	20 - 40% clay	40 - 60% clay	60 - 80% clay	Very low	< 0.07	< 0.09	< 0.12	< 0.15	Low	0.07 - 0.15	0.09 - 0.19	0.12 - 0.24	0.15 - 0.3	Medium	0.15 - 0.34	0.19 - 0.45	0.24 - 0.56	0.3 - 0.7	High	0.34 - 0.63	0.45 - 0.76	0.56 - 0.96	0.7 - 1.18	Very high	0.63 - 0.93	0.76 - 1.21	0.96 - 1.53	1.18 - 1.87	Extreme	> 0.93	> 1.21	> 1.53	> 1.87
Soil salinity rating	EC1:5 (dSm-1)																																							
	10 - 20% clay	20 - 40% clay	40 - 60% clay	60 - 80% clay																																				
Very low	< 0.07	< 0.09	< 0.12	< 0.15																																				
Low	0.07 - 0.15	0.09 - 0.19	0.12 - 0.24	0.15 - 0.3																																				
Medium	0.15 - 0.34	0.19 - 0.45	0.24 - 0.56	0.3 - 0.7																																				
High	0.34 - 0.63	0.45 - 0.76	0.56 - 0.96	0.7 - 1.18																																				
Very high	0.63 - 0.93	0.76 - 1.21	0.96 - 1.53	1.18 - 1.87																																				
Extreme	> 0.93	> 1.21	> 1.53	> 1.87																																				
Sand	Fine soil particles in the size range 0.02-2.0 mm, where fine sand ranges from 0.02-0.2 mm and coarse sand ranges from 0.2-2.0 mm (NCST, 2009)																																							
Sodic soil/sodicity	Sodicity is a measure of exchangeable sodium (Na) in proportion to other exchangeable cations. Fine earth material with an ESP of 6 or greater is defined as sodic. Sodicity / ESP ratings (Northcote and Skene, 1972) <table><tr><th>Sodicity rating</th><th>ESPs proposed for Australian soils (%)</th></tr><tr><td>Non-sodic</td><td>0 – 6</td></tr><tr><td>Sodic</td><td>6 – 15</td></tr><tr><td>Strongly sodic</td><td>> 15</td></tr></table>	Sodicity rating	ESPs proposed for Australian soils (%)	Non-sodic	0 – 6	Sodic	6 – 15	Strongly sodic	> 15																															
Sodicity rating	ESPs proposed for Australian soils (%)																																							
Non-sodic	0 – 6																																							
Sodic	6 – 15																																							
Strongly sodic	> 15																																							
Soil horizon	A soil horizon is a layer of soil, approximately parallel to the surface, with morphological properties different from layers below and/or above it																																							
Soil pH	Soil pH can be used as an indicator of the chemical processes that occur in a soil – that is, can indicate certain nutrient deficiencies and toxic effects, which may have implications for soil management and rehabilitation measures. pH classification (Rayment and Lyons, 2011)																																							

Term	Definition																				
	<table> <tr> <th>pH</th><th>Rating</th></tr> <tr> <td>> 9.0</td><td>Very strongly alkaline</td></tr> <tr> <td>9.0 – 8.5</td><td>Strongly alkaline</td></tr> <tr> <td>8.4 – 7.9</td><td>Moderately alkaline</td></tr> <tr> <td>7.8 – 7.4</td><td>Mildly alkaline</td></tr> <tr> <td>7.3 – 6.6</td><td>Neutral</td></tr> <tr> <td>6.5 – 6.1</td><td>Slightly acid</td></tr> <tr> <td>6.0 – 5.6</td><td>Moderately acid</td></tr> <tr> <td>5.5 – 5.1</td><td>Strongly acid</td></tr> <tr> <td>5.0 – 4.5</td><td>Very strongly acid</td></tr> </table>	pH	Rating	> 9.0	Very strongly alkaline	9.0 – 8.5	Strongly alkaline	8.4 – 7.9	Moderately alkaline	7.8 – 7.4	Mildly alkaline	7.3 – 6.6	Neutral	6.5 – 6.1	Slightly acid	6.0 – 5.6	Moderately acid	5.5 – 5.1	Strongly acid	5.0 – 4.5	Very strongly acid
pH	Rating																				
> 9.0	Very strongly alkaline																				
9.0 – 8.5	Strongly alkaline																				
8.4 – 7.9	Moderately alkaline																				
7.8 – 7.4	Mildly alkaline																				
7.3 – 6.6	Neutral																				
6.5 – 6.1	Slightly acid																				
6.0 – 5.6	Moderately acid																				
5.5 – 5.1	Strongly acid																				
5.0 – 4.5	Very strongly acid																				
Soil structure	Soil structure refers to the distinctness, size and shape of natural soil aggregates																				
Subsoil	Subsoil is a commonly used term used to identify soil material below the topsoil (A horizons) and is usually comprised of B horizons																				
Soil texture (field)	The size distribution of particles finer than 2 mm as reflected in the behaviour of a small handful of soil when moistened and kneaded into a ball																				
Tertiary	Geological period approx. 65 – 2.0 Mya																				
Topsoil	Topsoil is a commonly used term to identify soil horizons designated as A horizon(s). It is described as the mineral horizon at or near the soil surface with some accumulation of humified organic matter. It is usually darker in colour than underlying horizons with maximum biologic activity for any given soil profile. For the purposes of this document, topsoil is defined as that proportion of the soil profile that is suitable for stockpiling and rehabilitation. Topsoil thickness classification (Maher, 1996) <table> <tr> <th>Horizon thickness (mm)</th><th>A horizon thickness rating</th></tr> <tr> <td>< 150</td><td>Thin</td></tr> <tr> <td>150 - 300</td><td>Medium</td></tr> <tr> <td>300 - 600</td><td>Thick</td></tr> <tr> <td>> 600</td><td>Very thick</td></tr> </table>	Horizon thickness (mm)	A horizon thickness rating	< 150	Thin	150 - 300	Medium	300 - 600	Thick	> 600	Very thick										
Horizon thickness (mm)	A horizon thickness rating																				
< 150	Thin																				
150 - 300	Medium																				
300 - 600	Thick																				
> 600	Very thick																				
Vertosols	ASC Soil Order – Clay soils with shrink-swell properties that exhibit strong cracking when dry and at depth have slickensides and/or lenticular structural aggregates (Isbell & NCST, 2002)																				

7 References

- Bourne, GF and Tuck, GA 1993a, Field Manual in RN Thwaites and JM Maher (eds.) *Understanding and Managing Soils in the Central Highlands*, Department of Primary Industries, Training Series QE93002, Brisbane, Qld.
- Bourne, GF and Tuck, GA 1993b, Resource Information in RN Thwaites and JM Maher (eds.) *Understanding and Managing Soils in the Central Highlands*, Department of Primary Industries, Training Series QE93002, Brisbane, Qld.
- Bureau of Meteorology (BOM) 2017, *Climate statistics for Australian Locations – Emerald Airport (Station ID 035264)*, http://www.bom.gov.au/climate/averages/tables/cw_035264.shtml.
- Department of Environment and Science (DES) 2017, *Guideline: Application requirements for activities with impacts to land*, ESR/2015/1839, Version 4.01, DES, Brisbane, Qld.
- Department of Environment and Science (DES) 2019a, *Request a map of Biodiversity Status (Version 11) or Broad Vegetation Group (Version 4.0)*, DES, Brisbane, Qld.
- Department of Environment and Science (DES) 2019b, *Search regional ecosystems descriptions, Version 11*, DES, Brisbane, Qld.
- Department of Infrastructure, Local Government and Planning (DILGP) 2017a, *RPI Act Statutory Guideline 08/14: How to demonstrate that land in the strategic cropping area does not meet the criteria for strategic cropping land*, DILGP, Brisbane, Qld.
- Department of Infrastructure, Local Government and Planning (DILGP) 2017b, *State Planning Policy*, DILGP, Brisbane, Qld.
- Department of Mines and Energy (DME) 1995, *Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland – Land Suitability Assessment Techniques*, DME, Brisbane, Qld.
- Department of Primary Industries (DPI) and Department of Housing, Local Government and Planning (DHLGP) 1993, *Planning Guidelines: The Identification of Good Quality Agricultural Land*, Queensland Government, Brisbane, Qld.
- Department of Science, information Technology and Innovation (DSITI) and Department of Natural Resources, Mines and Energy (DNRME) 2015, *Guidelines for Agricultural Land Evaluation in Queensland*, DES & DNRME, Brisbane, Qld.
- Hazelton, P and Murphy, B 2007, *Interpreting Soil Test Results – What Do All The Numbers Mean?*, CSIRO Publishing, Collingwood, VIC.
- International Erosion Control Association (IECA) 2008, *Best Practice Erosion and Sediment Control Guidelines*, IECA (Australasia), Picton, NSW.
- Isbell, RF and National Committee on Soil and Terrain (NCST) 2016, *The Australian Soil Classification*, 2nd Ed, CSIRO Publ., Collingwood, VIC.

McKenzie, NJ *et al.* 2008, *Guidelines for Surveying Soil and Land Resources*, 2nd Ed, CSIRO Publ., Collingwood, VIC.

Munsell Color 2009, *Munsell Soil Color Charts*, Munsell Color, Grand Rapids, Minnesota.

NCST 2009, *Australian Soil and Land Survey Field Handbook*, 3rd Ed, CSIRO Publishing, Collingwood, VIC.

Northern Resource Consultants (NRC) 2018, *Fairhill Coal Project: Soils and Land Suitability Assessment*, NRC, Townsville, Qld.

Queensland Government (QG) 2019, *Queensland Globe*, <https://qldglobe.information.qld.gov.au/>.

Rayment, GE and Lyons, DJ 2011, *Soil Chemical Methods – Australasia*, CSIRO Publishing, Collingwood, VIC.

Soil Science Australia (SSA) 2013, *Measuring soil cation exchange capacity and exchangeable cations*, Soil Science Australia, Queensland Branch, Brisbane, QLD.

Story, R, Galloway, RW, Gunn, RH, and Fitzpatrick, EA (Story, *et al.*) 1967, *Lands of the Isaac-Comte Area, Queensland*, Land Research Series No. 19, CSIRO, Melbourne, Vic.

APPENDIX A

Project site representative soil profiles

Black, Brown and Grey Vertosols on Fair Hill Formation (Pwt) occupying elevated crests and slopes

SITE DESCRIPTION		ASC Soil Order:	Black Vertosol			Site #:	PR04	
Coordinates:	Easting:	667703	Northing:	729592	Zone:	55	Datum:	GDA94
Location:	Fairhill		Describer:	C Traill	Elevation:		158 m AHD	

LANDFORM			
Slope:	Level (1%)	Runoff:	Slow
Morphological type:	Upper slope	Permeability:	Slowly permeable
Landform element:	Residual rise	Drainage:	Imperfectly drained
Landform pattern:	Rises	Surface condition:	Cracking, self-mulching
Relief Modal Class:	Gently undulating rises	Disturbance:	Cleared, ripped, improved pasture
Geology:	Fair Hill Formation (Pwt)	Rock outcrop:	Nil
Microrelief:	Nil, historical (2004) satellite imagery shows linear gilgai around sample site		
Coarse fragments:	Very few (<2%), angular tabular, metamorphic cobbles (20-60 mm)		
Erosion:	Minor, active sheet erosion		
Vegetation:	Buffel grass		



Site PR04 landscape



Site PR04 surface condition



Site PR04 profile, 1.2 m deep



Site PR04 profile, 0.0-0.4 m deep



Site PR04 profile, 0.8-1.2 m deep

SOIL DESCRIPTION		
Horizon	Depth (m)	Description
A1/B21p	0.0-0.1	Black (10YR 2/1) (moist); moderate, <2 mm, sub-angular blocky structure; sandy light clay; few, medium, sub-angular, metamorphic pebbles; pH 6.5; gradual change to -
B22	0.1-0.5	Dark grey (10YR 3/1) (moist); few, fine, faint, brown mottles; strong, 5-10 mm, sub-angular blocky structure; sandy light medium clay; common, coarse, sub-angular, metamorphic pebbles; few, fine, moderately calcareous soft segregations; pH 8.5; gradual change to -
B/C	0.5-1.2	Brown (7.5YR 4/3) (moist); few, medium, distinct, yellow mottles; strong, 5-10 mm, sub-angular blocky structure; sandy light clay; very few, medium, sub-angular, metamorphic pebbles; pH 5.0

SURFACE CHEMISTRY DATA											
Depth (m)	pH (H ₂ O)	Bicarbonate extr. P (Colwell) (mg/kg)	Total Kheldal nitrogen		Organic matter (%)	Total organic carbon (%)	Boron (mg/kg)	Trace Elements			
			(mg/kg)	(%)				Copper (mg/kg)	Iron (mg/kg)	Manganese (mg/kg)	Zinc (mg/kg)
0.0-0.1	7.8	<5	1,490	0.149	2.7	1.6	0.3	<1.00	13.9	22.0	<1.00
0.1-0.2	9.1	<5	890	0.089	1.4	0.8	0.4	<1.00	8.9	11.0	<1.00

SOIL PROFILE CHEMISTRY DATA																				
Depth (m)	Adjusted particle size to remove gravel (%)*				pH (H ₂ O)	EC (uS/cm)	EC rating (VL, L, M, H, VH, E)	Cl- (mg/kg)	Total Sulfur (%)	Exchangeable cations (meq/100 g)							ESP (%)	Sodicity (NS, S, SS)	Emer- son class	Ca:Mg ratio
	Clay	Silt	Sand	Gravel						H ⁺	Al ³⁺	Ca ²⁺	Mg ²⁺	K ⁺	Na ⁺	CEC				
0.0-0.1	59	14	27	4	7.8	115	VL	120	0.02	-	-	5.1	4.8	0.2	1.8	11.9	14.9	S	-	1.0
0.1-0.2	63	13	24	9	9.1	820	H	1,260	0.02	-	-	5.0	5.5	<0.2	2.8	13.3	20.8	SS	3	0.9
0.2-0.3	62	14	24	7	9.1	852	H	1,360	0.02	-	-	6.1	7.3	<0.2	4.0	17.6	22.7	SS	2	0.8
0.5-0.6	62	16	22	1	8.2	728	H	1,250	<0.01	-	-	3.8	6.0	<0.2	4.1	14.1	29.2	SS	2	0.6
0.8-0.9	61	15	24	<1	5.6	681	M	1,120	<0.01	0.2	<0.1	2.7	4.4	0.1	2.8	10.2	27.5	SS	1	0.6
1.0-1.1	59	13	28	<1	5.5	480	M	770	<0.01	0.2	0.1	1.7	2.9	<0.1	2.1	6.9	30.2	SS	1	0.6

Notes:

* Gravel (>2 mm), Sand (0.02–2 mm), Silt (2-20 µm), Clay (<2 µm); VL – Very Low, L – Low, M – Moderate, H – High, VH – Very High, E – Extreme; NS – Non-Sodic, S – Sodic, SS – Strongly Sodic; ID – Indeterminable

SITE DESCRIPTION		ASC Soil Order:	Brown Vertosol			Site #:	PR05	
Coordinates:	Easting:	667395	Northing:	7430343	Zone:	55	Datum:	GDA94
Location:	Fairhill		Describer:	C Traill	Elevation:	159 m AHD		

LANDFORM			
Slope:	Very gently inclined (1.7%)	Runoff:	Moderately rapid
Morphological type:	Simple slope	Permeability:	Slowly permeable
Landform element:	Residual rise	Drainage:	Imperfectly drained
Landform pattern:	Rises	Surface condition:	Cracking, crusting
Relief Modal Class:	Gently undulating rises	Disturbance:	Cleared, ripped, improved pasture
Geology:	Fair Hill Formation (Pwt)	Rock outcrop:	Nil
Microrelief:	Nil, historical (2004) satellite imagery shows no linear gilgai at site		
Coarse fragments:	Common (10-20%), sub-angular tabular, metamorphic, medium (6-20 mm) pebbles		
Erosion:	Minor, active, sheet erosion		
Vegetation:	Brigalow, buffel grass		



Site PR05 landscape



Site PR05 surface condition



Site PR05 profile, 0.6 m deep



Site PR05 profile, 0.0-0.3 m deep



Site PR05 profile, 0.3-0.6 m deep

SOIL DESCRIPTION		
Horizon	Depth (m)	Description
A1/B21p	0.0-0.1	Very dark brown (7.5YR 2.5/3) (moist); moderate, <2 mm, sub-angular blocky structure; fine sandy medium clay; very few, medium, sub-rounded tabular, metamorphic pebbles; very few, fine, highly calcareous soft segregations; pH 8.0; gradual change to -
B22	0.1-0.3	Dark brown (7.5YR 3/3) (moist); few, medium, distinct, brown mottles; moderate, 2-5 mm, sub-angular blocky structure; fine sandy medium clay; few, medium, sub-rounded tabular, metamorphic pebbles; few, medium, very highly calcareous soft segregations; pH 8.5; gradual change to -
B/C	0.3-0.6	Dark yellowish brown (10YR 4/4) (moist); few, medium, distinct, brown mottles; weak, <2 mm, angular blocky structure; fine sandy light medium clay; many, coarse, very highly calcareous soft segregations; pH 9.0; gradual change to -
C	0.6+	Weathered mudstone

SITE DESCRIPTION		ASC Soil Order:	Black Vertosol			Site #:	PR06
Coordinates:	Easting:	666582	Northing:	7430898	Zone:	55	Datum: GDA94
Location:	Fairhill		Describer:	C Traill	Elevation:	161 m AHD	

LANDFORM			
Slope:	Very gently inclined (2.4%)	Runoff:	Moderate
Morphological type:	Mid slope	Permeability:	Slowly permeable
Landform element:	Residual rise	Drainage:	Imperfectly drained
Landform pattern:	Rises	Surface condition:	Cracking, self-mulching
Relief Modal Class:	Gently undulating rises	Disturbance:	Cleared, contour banks
Geology:	Fair Hill Formation (Pwt)	Rock outcrop:	Nil
Microrelief:	Nil, historical (2004) satellite imagery shows contoured but ghost linear gilgai evident		
Coarse fragments:	Very few (<2%), angular tabular, metamorphic cobbles (20-60 mm)		
Erosion:	Nil		
Vegetation:	Buffel grass		



Site PR06 landscape



Site PR06 surface condition



Site PR06 profile, 0.8 m deep



Site PR06 profile, 0.0-0.4 m deep



Site PR06 profile, 0.3-0.7 m deep

SOIL DESCRIPTION		
Horizon	Depth (m)	Description
A1/B21p	0.0-0.3	Very dark grey (10YR 3/1) (moist); moderate, 2-5 mm, sub-angular blocky structure; light medium clay; very few, small, rounded, metamorphic pebbles; pH 7.0; gradual change to -
B22	0.3-0.9	Black (10YR 2/1) (moist); few, fine, faint, brown mottles; strong, 2-5 mm, sub-angular blocky structure; medium clay; few, fine, rounded, metamorphic pebbles; few, fine, moderately calcareous soft segregations; pH 8.5; gradual change to -
B/C	0.9-1.1	Very dark greyish brown (10YR 3/2) (moist); many, medium, prominent brown mottles; weak, 2-5 mm, sub-angular blocky structure; medium clay; many, large, angular tabular, metamorphic pebbles; pH 8.0; gradual change -
C	1.1+	Weathered mudstone

SURFACE CHEMISTRY DATA											
Depth (m)	pH (H ₂ O)	Bicarbonate extr. P (Colwell) (mg/kg)	Total Kheldal nitrogen		Organic matter (%)	Total organic carbon (%)	Boron (mg/kg)	Trace Elements			
			(mg/kg)	(%)				Copper (mg/kg)	Iron (mg/kg)	Manganese (mg/kg)	Zinc (mg/kg)
0.0-0.1	8.0	<5	1,050	0.105	1.9	1.1	0.4	2.24	11.0	19.8	<1.00
0.1-0.2	8.3	<5	1,000	0.100	1.7	1.0	0.4	2.27	11.3	15.0	<1.00

SOIL PROFILE CHEMISTRY DATA																			
Depth (m)	Adjusted particle size to remove gravel (%)*				pH (H ₂ O)	EC (uS/cm)	EC rating (VL, L, M, H, VH, E)	Cl- (mg/kg)	Total Sulfur (%)	Exchangeable cations (meq/100 g)						ESP (%)	Sodicity (NS, S, SS)	Emerson class	Ca:Mg ratio
	Clay	Silt	Sand	Gravel						Al ³⁺	Ca ²⁺	Mg ²⁺	K ⁺	Na ⁺	CEC				
0.0-0.1	71	19	10	1	8.0	33	VL	<10	<0.01	-	22.9	4.4	0.3	0.7	28.4	2.4	NS	-	5.2
0.1-0.2	64	16	20	1	8.3	39	VL	<10	0.02	-	23.4	4.4	0.3	1.0	29.1	3.6	NS	4	5.3
0.2-0.3	71	17	12	<1	8.4	45	VL	<10	0.02	-	19.3	3.8	0.2	1.2	24.5	4.8	NS	4	5.1
0.5-0.6	73	19	8	1	8.8	101	VL	60	<0.01	-	20.7	4.3	<0.2	2.2	27.4	8.1	S	3	4.8
0.8-0.9	70	13	17	1	8.5	204	L	240	<0.01	-	19.4	4.4	<0.2	2.8	26.8	10.4	S	3	4.4
1.0-1.1	60	22	18	8	8.5	229	L	230	<0.01	-	14.9	3.4	<0.2	2.3	20.3	11.2	S	3	4.4

Notes:

* Gravel (>2 mm), Sand (0.02–2 mm), Silt (2-20 µm), Clay (<2 µm); VL – Very Low, L – Low, M – Moderate, H – High, VH – Very High, E – Extreme; NS – Non-Sodic, S – Sodic, SS – Strongly Sodic; ID – Indeterminable

SITE DESCRIPTION		ASC Soil Order:	Brown Vertosol			Site #:	PR07	
Coordinates:	Easting:	666713	Northing:	7429925	Zone:	55	Datum:	GDA94
Location:	Fairhill		Describer:	C Traill	Elevation:	165 m AHD		

LANDFORM			
Slope:	Very gently inclined (1.3%)	Runoff:	Slow
Morphological type:	Upper slope	Permeability:	Slowly permeable
Landform element:	Residual rise	Drainage:	Imperfectly drained
Landform pattern:	Rises	Surface condition:	Cracking, crusting
Relief Modal Class:	Gently undulating rises	Disturbance:	Cleared, ripped, improved pasture
Geology:	Fair Hill Formation (Pwt)	Rock outcrop:	Nil
Microrelief:	Nil, historical (2004) satellite imagery shows cultivated/ ripped but ghost linear gilgai evident		
Coarse fragments:	Few (2-10%), sub-angular tabular, metamorphic, medium (6-20 mm) pebbles		
Erosion:	Minor, active, sheet erosion		
Vegetation:	Brigalow, buffel grass		



Site PR07 landscape



Site PR07 surface condition



Site PR07 profile, 0.8 m deep



Site PR07 profile, 0.0-0.4 m deep



Site PR07 profile, 0.3-0.7 m deep

SOIL DESCRIPTION		
Horizon	Depth (m)	Description
A1/B21p	0.0-0.3	Very dark brown (7.5YR 2.5/2) (moist); moderate, 2-5 mm, sub-angular blocky structure; fine sandy light clay; very few, medium, sub-rounded tabular, metamorphic pebbles; pH 8.5; gradual change to -
B22	0.3-0.6	Very dark brown (10YR 2/2) (moist); few, fine, faint, pale mottles; moderate, 2-5 mm, sub-angular blocky structure; light medium clay; few, coarse, angular tabular, metamorphic pebbles; few, fine, highly calcareous soft segregations; pH 9.5; gradual change to -
B/C	0.6-0.8	Brownish yellow (10YR 6/8) (moist); weak, <2 mm, sub-angular blocky structure; fine sandy medium clay; abundant, angular platy, metamorphic cobbles; many, fine, highly calcareous laminae; pH 8.0; gradual change -
C	0.8+	Weathered mudstone

SURFACE CHEMISTRY DATA											
Depth (m)	pH (H ₂ O)	Bicarbonate extr. P (Colwell) (mg/kg)	Total Kheldal nitrogen		Organic matter (%)	Total organic carbon (%)	Boron (mg/kg)	Trace Elements			
			(mg/kg)	(%)				Copper (mg/kg)	Iron (mg/kg)	Manganese (mg/kg)	Zinc (mg/kg)
0.0-0.1	8.5	<5	1,450	0.145	1.2	0.3	2.1	2.18	18.0	11.0	<1.00
0.1-0.2	8.6	<5	1,750	0.175	1.1	0.4	2.0	2.63	17.5	6.5	<1.00

SOIL PROFILE CHEMISTRY DATA																			
Depth (m)	Adjusted particle size to remove gravel (%)*				pH (H ₂ O)	EC (uS/cm)	EC rating (VL, L, M, H, VH, E)	Cl- (mg/kg)	Total Sulfur (%)	Exchangeable cations (meq/100 g)						ESP (%)	Sodicity (NS, S, SS)	Emerson class	Ca:Mg ratio
	Clay	Silt	Sand	Gravel						Al ³⁺	Ca ²⁺	Mg ²⁺	K ⁺	Na ⁺	CEC				
0.0-0.1	20	23	57	5	8.5	137	L	40	0.03	-	12.6	6.2	0.5	2.0	21.4	9.5	S	-	2.0
0.1-0.2	30	27	42	1	8.6	144	L	30	0.02	-	14.6	9.0	0.4	4.6	28.6	16.2	SS	2	1.6
0.2-0.3	34	35	30	1	9.3	440	M	360	0.02	-	14.1	10.7	0.4	6.8	31.9	21.2	SS	3	1.3
0.5-0.6	18	23	58	35	9.7	597	H	680	0.04	-	6.2	6.6	<0.2	5.4	18.4	29.4	SS	2	0.9
0.7-0.8	19	47	34	32	9.5	362	H	500	0.02	-	4.3	5.1	<0.2	4.0	13.5	29.6	SS	2	0.8

Notes:

* Gravel (>2 mm), Sand (0.02–2 mm), Silt (2–20 µm), Clay (<2 µm); VL – Very Low, L – Low, M – Moderate, H – High, VH – Very High, E – Extreme; NS – Non-Sodic, S – Sodic, SS – Strongly Sodic; ID – Indeterminable

SITE DESCRIPTION		ASC Soil Order: Brown Vertosol			Site #:	PR09	
Coordinates:	Easting:	666225	Northing:	7428981	Zone:	55	Datum: GDA94
Location:	Fairhill		Describer:	C Traill	Elevation:		160 m AHD

LANDFORM			
Slope:	Very gently inclined (1.8%)	Runoff:	Slow
Morphological type:	Lower slope	Permeability:	Slowly permeable
Landform element:	Residual rise	Drainage:	Imperfectly drained
Landform pattern:	Rises	Surface condition:	Crusting to self-mulching
Relief Modal Class:	Gently undulating rises	Disturbance:	Cleared, ripped, improved pasture
Geology:	Fair Hill Formation (Pwt)	Rock outcrop:	Nil
Microrelief:	Nil, historical (2004) satellite imagery shows ripped but ghost linear gilgai evident		
Coarse fragments:	Common (10-20%), sub-angular tabular, metamorphic, large (20-60 mm) pebbles		
Erosion:	Minor, active, sheet erosion		
Vegetation:	Brigalow, buffel grass		



Site PR09 landscape



Site PR09 surface condition



Site PR09 profile, 1.2 m deep



Site PR09 profile, 0.0-0.4 m deep



Site PR09 profile, 0.8-1.2 m deep

SOIL DESCRIPTION		
Horizon	Depth (m)	Description
A1/B21p	0.0-0.3	Very dark brown (10YR 2/2) (moist); weak, <2 mm, sub-angular blocky structure; light medium clay; very few, medium, sub-rounded tabular, metamorphic pebbles; very few, fine, moderately calcareous concretions; very few, fine, ferruginous concretions; pH 8.5; gradual change to -
B22	0.3-0.7	Black (10YR 2/1) (moist); many, coarse, distinct, orange mottles; moderate, 2-5 mm, sub-angular blocky structure; medium clay; very few, medium, sub-rounded tabular, metamorphic pebbles; common, fine, ferruginous concretions; pH 9.0; gradual change to -
B23	0.7-1.2	Yellowish brown (10YR 5/8) (moist); common, coarse, distinct, dark mottles; weak, 2-5 mm, sub-angular blocky structure; light medium clay; common, medium, very highly calcareous concretions; pH 8.5

SITE DESCRIPTION		ASC Soil Order:	Brown Vertosol			Site #:	PR14	
Coordinates:	Easting:	665120	Northing:	7428763	Zone:	55	Datum:	GDA94
Location:	Fairhill		Describer:	C Traill	Elevation:		166 m AHD	

LANDFORM			
Slope:	Very gently inclined (2%)	Runoff:	Slow
Morphological type:	Lower slope	Permeability:	Slowly permeable
Landform element:	Residual rise	Drainage:	Imperfectly drained
Landform pattern:	Rises	Surface condition:	Cracking, self-mulching
Relief Modal Class:	Gently undulating rises	Disturbance:	Cleared, ripped, improved pasture
Geology:	Fair Hill Formation (Pwt)	Rock outcrop:	Nil
Microrelief:	Nil, historical (2004) satellite imagery shows linear gilgai evident immediately upslope		
Coarse fragments:	Very few (<2%), subangular tabular, metamorphic, medium (6-20 mm) pebbles		
Erosion:	Minor, active, sheet erosion		
Vegetation:	Brigalow, caesalpinia, buffel grass		



Site PR14 landscape



Site PR14 surface condition



Site PR14 profile, 1.2 m deep



Site PR14 profile, 0.0-0.4 m deep



Site PR14 profile, 0.7-1.0 m deep

SOIL DESCRIPTION		
Horizon	Depth (m)	Description
A1/B21	0.0-0.3	Black (10YR 3/2) (moist); moderate, 2-5 mm, sub-angular blocky structure; light medium clay; pH 8.0; gradual change to -
B22	0.3-0.5	Dark yellowish brown (10YR 4/4) (moist); strong, 5-10 mm, sub-angular blocky structure; medium clay; very few, fine, faint, dark mottles; very few, medium, highly calcareous concretions; pH 8.5; diffuse change to -
B23	0.5-1.2	Strong brown (7.5YR 4/6) (moist); few, fine, faint, dark mottles; strong, 5-10 mm, sub-angular blocky structure; light medium clay; common, medium, very highly calcareous concretions; pH 9.0

SURFACE CHEMISTRY DATA											
Depth (m)	pH (H ₂ O)	Bicarbonate extr. P (Colwell) (mg/kg)	Total Kheldal nitrogen		Organic matter (%)	Total organic carbon (%)	Boron (mg/kg)	Trace Elements			
			(mg/kg)	(%)				Copper (mg/kg)	Iron (mg/kg)	Manganese (mg/kg)	Zinc (mg/kg)
0.0-0.1	8.6	18	1,880	3.6	2.1	0.188	0.3	1.86	11.0	12.0	<1.00
0.1-0.2	9.4	<5	680	1.7	1.0	0.068	0.6	1.83	12.8	12.6	<1.00

SOIL PROFILE CHEMISTRY DATA																			
Depth (m)	Adjusted particle size to remove gravel (%)*				pH (H ₂ O)	EC (uS/cm)	EC rating (VL, L, M, H, VH, E)	Cl- (mg/kg)	Total Sulfur (%)	Exchangeable cations (meq/100 g)						ESP (%)	Sodicity (NS, S, SS)	Emerson class	Ca:Mg ratio
	Clay	Silt	Sand	Gravel						Al ³⁺	Ca ²⁺	Mg ²⁺	K ⁺	Na ⁺	CEC				
0.0-0.1	60	18	20	2	8.6	168	L	20	0.02	-	21.7	7.0	1.2	2.1	31.9	6.5	S	-	3.1
0.1-0.2	52	17	31	<1	9.4	345	M	7	0.02	-	17.5	8.2	0.7	5.1	31.5	16.2	SS	3	2.1
0.2-0.3	57	17	26	1	9.3	563	H	540	0.03	-	15.7	8.6	0.7	6.2	31.3	19.9	SS	3	1.8
0.3-0.4	-	-	-	-	9.1	1,020	-	1,020	0.04	-	-	-	-	-	-	-	-	-	-
0.4-0.5	-	-	-	-	8.3	3,230	-	1,500	0.05	-	-	-	-	-	-	-	-	-	-
0.5-0.6	54	16	30	1	8.6	2,230	E	1,940	0.55	-	14.0	8.4	0.4	9.0	31.8	28.1	SS	3	1.7
0.6-0.7	-	-	-	-	8.1	3,660	-	1,910	0.20	-	-	-	-	-	-	-	-	-	-
0.7-0.8	-	-	-	-	8.6	2,110	-	2,340	0.06	-	-	-	-	-	-	-	-	-	-
0.8-0.9	57	17	26	1	8.9	1,680	E	2,560	0.06	-	12.3	9.0	0.4	9.7	31.4	30.8	SS	3	1.4

SOIL PROFILE CHEMISTRY DATA																			
0.9-1.0	-	-	-	-	8.9	1,670	-	2,730	0.04	-	-	-	-	-	-	-	-	-	-
1.0-1.1	-	-	-	-	9.0	1,760	-	2,690	0.04	-	-	-	-	-	-	-	-	-	-
1.1-1.2	58	17	25	1	9.0	1,740	E	2,820	0.04	-	7.8	6.2	0.4	7.0	21.3	32.8	SS	3	1.3

Notes:

* Gravel (>2 mm), Sand (0.02–2 mm), Silt (2-20 µm), Clay (<2 µm); VL – Very Low, L – Low, M – Moderate, H – High, VH – Very High, E – Extreme; NS – Non-Sodic, S – Sodic, SS – Strongly Sodic; ID – Indeterminable

SITE DESCRIPTION		ASC Soil Order:	Vertosol			Site #:	OB04	
Coordinates:	Easting:	667877	Northing:	7429047	Zone:	55	Datum:	GDA94
Location:	Fairhill		Describer:	C Traill	Elevation:		156 m AHD	

LANDFORM			
Slope:	Very gently inclined (1.3%)	Runoff:	Slow
Morphological type:	Simple slope	Permeability:	Slowly permeable
Landform element:	Residual rise	Drainage:	Imperfectly drained
Landform pattern:	Rises	Surface condition:	Cracking, surface crusting
Relief Modal Class:	Gently undulating rises	Disturbance:	Cleared, ripped, improved pasture
Geology:	Fair Hill Formation (Pwt)	Rock outcrop:	Nil
Microrelief:	Nil, historical (2004) satellite imagery shows linear gilgai		
Coarse fragments:	Many, medium, sub-angular tabular, metamorphic pebbles		
Erosion:	Minor, active, sheet erosion		
Vegetation:	Brigalow, buffel grass		



Site OB04 landscape



Site OB04 surface condition

SOIL DESCRIPTION		
Horizon	Depth (m)	Description
A1/B21p	0.0	Very dark brown (10YR 2/2) (moist); moderate, 10-20 mm, sub-angular blocky structure; fine sandy light medium clay

SITE DESCRIPTION		ASC Soil Order:	Vertosol			Site #:	OB05	
Coordinates:	Easting:	666583	Northing:	7430895	Zone:	55	Datum:	GDA94
Location:	Fairhill		Describer:	C Traill	Elevation:	161 m AHD		

LANDFORM			
Slope:	Very gently inclined (2.4%)	Runoff:	Moderate
Morphological type:	Mid slope	Permeability:	Slowly permeable
Landform element:	Residual rise	Drainage:	Imperfectly drained
Landform pattern:	Rises	Surface condition:	Cracking, self-mulching
Relief Modal Class:	Gently undulating rises	Disturbance:	Cleared, contour banks
Geology:	Fair Hill Formation (Pwt)	Rock outcrop:	Nil
Microrelief:	Nil, historical (2004) satellite imagery shows contoured but ghost linear gilgai evident		
Coarse fragments:	Very few (<2%), angular tabular, metamorphic cobbles (20-60 mm)		
Erosion:	Nil		
Vegetation:	Buffel grass		



Site OB05 landscape



Site OB05 surface condition

SOIL DESCRIPTION		
Horizon	Depth (m)	Description
A1/B21p	0.0	Very dark grey (10YR 3/1) (moist); moderate, 5-10 mm, sub-angular blocky structure; light medium clay; very few, small, sub-angular, metamorphic pebbles

SITE DESCRIPTION		ASC Soil Order:	Vertosol			Site #:	OB11	
Coordinates:	Easting:	666920	Northing:	7431077	Zone:	55	Datum:	GDA94
Location:	Fairhill		Describer:	C Traill	Elevation:		160 m AHD	

LANDFORM			
Slope:	Very gently inclined (1.2%)	Runoff:	Slow
Morphological type:	Upper slope	Permeability:	Slowly permeable
Landform element:	Residual rise	Drainage:	Imperfectly drained
Landform pattern:	Rises	Surface condition:	Cracking, surface crusting
Relief Modal Class:	Gently undulating rises	Disturbance:	Cleared, ripped, improved pasture
Geology:	Fair Hill Formation (Pwt)	Rock outcrop:	Nil
Microrelief:	Nil, historical (2004) aerial imagery shows linear gilgai		
Coarse fragments:	Common (10-20%), medium, sub-angular tabular, metamorphic pebbles (6-20 mm)		
Erosion:	Moderate, active sheet erosion		
Vegetation:	Brigalow, buffel grass		



Site OB11 landscape



Site OB11 surface condition

SOIL DESCRIPTION		
Horizon	Depth (m)	Description
A1/B21p	0.0	Very dark brown (7.5YR 2.5/2) (moist); moderate, 5-10 mm, sub-angular blocky structure; fine sandy light clay

SITE DESCRIPTION		ASC Soil Order:	Black Vertosol			Site #:	OB17	
Coordinates:	Easting:	666920	Northing:	7431077	Zone:	55	Datum:	GDA94
Location:	Fairhill		Describer:	C Traill	Elevation:	160 m AHD		

LANDFORM			
Slope:	Very gently inclined (1.0%)	Runoff:	Slow
Morphological type:	Open depression	Permeability:	Slowly permeable
Landform element:	Drainage depression	Drainage:	Imperfectly drained
Landform pattern:	Rises	Surface condition:	Cracking, surface crusting
Relief Modal Class:	Gently undulating rises	Disturbance:	Cleared, ripped, improved pasture
Geology:	Fair Hill Formation (Pwt)	Rock outcrop:	Nil
Microrelief:	Nil, historical (2004) aerial imagery shows linear gilgai around the sample site		
Coarse fragments:	Common (10-20%), large, sub-rounded tabular, metamorphic pebbles (20-60 mm)		
Erosion:	Moderate, active sheet erosion and <1.5 m deep, active gully erosion		
Vegetation:	Brigalow, buffel grass		



Site OB17 landscape



Site OB17 surface condition



Site OB17 profile, 0.0-0.35 cm deep



Site OB17 profile, 0.15-0.5 cm deep

SOIL DESCRIPTION		
Horizon	Depth (m)	Description
A1/B21p	0.0-0.1	Very dark brown (7.5YR 2.5/2) (moist); strong, 2-5 mm, sub-angular blocky structure; fine sandy medium clay; few, medium, ferromanganiferous concretions; few, small, sub-rounded tabular, metamorphic pebbles; pH 7.0; gradual change to -
B22	0.1-0.5	Very dark brown (10YR 2/2) (moist); strong, 5-10 mm, sub-angular blocky structure; fine sandy medium clay; few, small, ferromanganiferous concretions; few, moderate, sub-angular tabular, metamorphic pebbles; pH 8.5

SITE DESCRIPTION		ASC Soil Order:	Vertosol			Site #:	OB31	
Coordinates:	Easting:	665780	Northing:	7428893	Zone:	55	Datum:	GDA94
Location:	Fairhill		Describer:	C Traill	Elevation:		165 m AHD	

LANDFORM			
Slope:	Very gently inclined (1.7%)	Runoff:	Slow
Morphological type:	Upper slope	Permeability:	Very slowly permeable
Landform element:	Riseslope	Drainage:	Poorly drained
Landform pattern:	Rises	Surface condition:	Cracking, self-mulching
Relief Modal Class:	Gently undulating rises	Disturbance:	Cleared, ripped, improved pasture
Geology:	Fair Hill Formation (Pwt)	Rock outcrop:	Nil
Microrelief:	Melonhole gilgai surrounded by linear gilgai in the broader landscape		
Coarse fragments:	Few (2-10%), sub-angular tabular, metamorphic cobbles (60-200 mm)		
Erosion:	Nil		
Vegetation:	Brigalow, buffel grass		



Site OB31 landscape



Site OB31 surface condition

SOIL DESCRIPTION		
Horizon	Depth (m)	Description
A1/B21p	0.0-0.1	Very dark brown (10YR 2/1) (moist); strong, 5-10 mm, sub-angular blocky structure; light medium clay; few, medium, sub-rounded tabular, metamorphic pebbles

SITE DESCRIPTION		ASC Soil Order:	Black Vertosol			Site #:	OB35	
Coordinates:	Easting:	6665716	Northing:	7429622	Zone:	55	Datum:	GDA94
Location:	Fairhill		Describer:	C Traill	Elevation:	163 m AHD		

LANDFORM			
Slope:	Very gently inclined (2.0%)	Runoff:	Slow
Morphological type:	Simple slope	Permeability:	Slowly permeable
Landform element:	Riseslope	Drainage:	Imperfectly drained
Landform pattern:	Rises	Surface condition:	Cracking, surface crusting
Relief Modal Class:	Gently undulating rises	Disturbance:	Cleared, ripped, improved pasture
Geology:	Fair Hill Formation (Pwt)	Rock outcrop:	Nil
Microrelief:	Nil, historical (2004) aerial imagery shows linear gilgai around the sample site		
Coarse fragments:	Few (2-10%), medium, sub-angular platy, metamorphic pebbles (6-20 mm)		
Erosion:	Minor, active, sheet erosion		
Vegetation:	Brigalow, buffel grass		



Site OB35 landscape



Site OB35 surface condition



Site OB35 profile, 0.0-0.3 m deep



Site OB35 profile, 0.2-0.5 m deep

SOIL DESCRIPTION		
Horizon	Depth (m)	Description
A1/B21p	0.0-0.1	Dark yellowish brown (10YR 3/4) (moist); strong, 2-5 mm, sub-angular blocky structure; fine sandy light medium clay; pH 7.5
B22	0.1-0.5	Very dark brown (10YR 2/2) (moist); strong, 5-10 mm, sub-angular blocky structure; medium clay; very few, fine, very highly calcareous, soft segregations; pH 8.0

SITE DESCRIPTION		ASC Soil Order:	Vertosol			Site #:	OB36	
Coordinates:	Easting:	666433	Northing:	7430005	Zone:	55	Datum:	GDA94
Location:	Fairhill		Describer:	C Traill	Elevation:	168 m AHD		

LANDFORM			
Slope:	Very gently inclined (1.3%)	Runoff:	Slow
Morphological type:	Upper slope	Permeability:	Slowly permeable
Landform element:	Riseslope	Drainage:	Imperfectly drained
Landform pattern:	Rises	Surface condition:	Cracking, surface crusting
Relief Modal Class:	Gently undulating rises	Disturbance:	Cleared, ripped, improved pasture
Geology:	Fair Hill Formation (Pwt)	Rock outcrop:	Nil
Microrelief:	Nil, historical (2004) aerial imagery shows linear gilgai around the sample site		
Coarse fragments:	Many (20-50%), large, sub-rounded tabular, metamorphic pebbles (20-60 mm)		
Erosion:	Moderate, active, sheet erosion		
Vegetation:	Buffel grass		



Site OB36 landscape



Site OB36 surface condition

SOIL DESCRIPTION		
Horizon	Depth (m)	Description
A1/B21p	0.0	Very dark brown (7.5YR 2.5/2) (moist); moderate, 5-10 mm, sub-angular blocky structure; fine sandy light medium clay; few, small, sub-rounded, metamorphic pebbles

SITE DESCRIPTION		ASC Soil Order:	Vertosol			Site #:	OB37	
Coordinates:	Easting:	666892	Northing:	7430574	Zone:	55	Datum:	GDA94
Location:	Fairhill		Describer:	C Traill	Elevation:		163 m AHD	

LANDFORM			
Slope:	Very gently inclined (1.7%)	Runoff:	Slow
Morphological type:	Simple slope	Permeability:	Slowly permeable
Landform element:	Riseslope	Drainage:	Imperfectly drained
Landform pattern:	Rises	Surface condition:	Cracking, surface crusting to self-mulching
Relief Modal Class:	Gently undulating rises	Disturbance:	Cleared, ripped, improved pasture
Geology:	Fair Hill Formation (Pwt)	Rock outcrop:	Nil
Microrelief:	Nil, historical (2004) aerial imagery shows linear gilgai around the sample site		
Coarse fragments:	Few (2-10%), medium, sub-angular tabular, metamorphic pebbles (6-20 mm)		
Erosion:	Minor, active, sheet erosion		
Vegetation:	Buffel grass		



Site OB37 landscape



Site OB37 surface condition

SOIL DESCRIPTION		
Horizon	Depth (m)	Description
A1/B21p	0.0	Very dark brown (10YR 2/2) (moist); moderate, 5-10 mm, sub-angular blocky structure; light medium clay; few, small, sub-rounded tabular, metamorphic pebbles

SITE DESCRIPTION		ASC Soil Order:	Vertosol			Site #:	OB44	
Coordinates:	Easting:	667255	Northing:	7429799	Zone:	55	Datum:	GDA94
Location:	Fairhill		Describer:	C Traill	Elevation:	161 m AHD		

LANDFORM			
Slope:	Very gently inclined (1.3%)	Runoff:	Slow
Morphological type:	Simple slope	Permeability:	Slowly permeable
Landform element:	Riseslope	Drainage:	Imperfectly drained
Landform pattern:	Rises	Surface condition:	Cracking, surface crusting
Relief Modal Class:	Gently undulating rises	Disturbance:	Cleared, ripped, improved pasture
Geology:	Fair Hill Formation (Pwt)	Rock outcrop:	Nil
Microrelief:	Nil, historical (2004) aerial imagery shows linear gilgai away from but around the sample site		
Coarse fragments:	Common (10-20%), medium, sub-rounded tabular, metamorphic pebbles (6-20 mm)		
Erosion:	Moderate, active, sheet erosion		
Vegetation:	Brigalow, buffel grass		



Site OB44 landscape



Site OB44 surface condition

SOIL DESCRIPTION		
Horizon	Depth (m)	Description
A1/B21p	0.0	Very dark brown (7.5YR 2.5/2) (moist); moderate, 5-10 mm, sub-angular blocky structure; fine sandy light medium clay; few, medium, sub-angular platy, metamorphic pebbles

Brown and Red Dermosols on Fair Hill Formation (Pwt) occupying mid to lower ridges and slopes

SITE DESCRIPTION		ASC Soil Order:	Red Dermosol			Site #:	PR02	
Coordinates:	Easting:	668171	Northing:	7430273	Zone:	55	Datum:	GDA94
Location:	Fairhill		Describer:	C Traill	Elevation:		154 m AHD	

LANDFORM			
Slope:	Very gently inclined (1.2%)	Runoff:	Slow
Morphological type:	Ridge	Permeability:	Slowly permeable
Landform element:	Residual crest	Drainage:	Imperfectly drained
Landform pattern:	Rises	Surface condition:	Crusting, firm
Relief Modal Class:	Gently undulating rises	Disturbance:	Cleared, ripped, improved pasture
Geology:	Fair Hill Formation (Pwt)	Rock outcrop:	Nil
Microrelief:	Nil, historical (2004) satellite imagery shows linear gilgai immediately north of sample site		
Coarse fragments:	Common (10-20%), angular tabular, small metamorphic pebbles (2-6 mm)		
Erosion:	Minor, active, sheet erosion		
Vegetation:	Buffel grass		



Site PR02 landscape



Site PR02 surface condition



Site PR02 profile, 1.2 m deep



Site PR02 profile, 0.0-0.4 m deep



Site PR02 profile, 0.3-0.7 m deep

SOIL DESCRIPTION		
Horizon	Depth (m)	Description
A1p	0.0-0.2	Dark brown (7.5YR 3/3) (moist); weak, 2-5 mm, sub-angular blocky structure; clay loam, fine sandy; very few, fine sub-rounded tabular, metamorphic pebbles; pH 5.5; clear change to -
A2e	0.2-0.25	Brown (7.5YR 4/3) (moist), pinkish grey (7.5YR 7/2) (dry); weak, 2-5 mm, sub-angular blocky structure; clay loam, fine sandy; pH 5.5; clear change to -
B21	0.25-0.5	Dark reddish brown (2.5YR 3/3) (moist); very few, fine, faint, dark mottles; moderate, 2-5 mm, sub-angular blocky structure; light medium clay; very few, fine sub-rounded tabular, metamorphic pebbles; pH 7.0; gradual change to -
B22	0.5-0.9	Brown (7.5YR 4/4) (moist); few, fine, faint, pale mottles; moderate, 5-10 mm, sub-angular blocky structure; light clay; common, fine highly calcareous, soft segregations; pH 8.5; gradual change to -
B/C	0.9-1.2	Weathered sandstone

SURFACE CHEMISTRY DATA											
Depth (m)	pH (H ₂ O)	Bicarbonate extr. P (Colwell) (mg/kg)	Total Kheldal nitrogen		Organic matter (%)	Total organic carbon (%)	Boron (mg/kg)	Trace Elements			
			(mg/kg)	(%)				Copper (mg/kg)	Iron (mg/kg)	Manganese (mg/kg)	Zinc (mg/kg)
0.0-0.1	7.0	<5	280	0.028	2.0	1.1	<0.2	<1.00	22.2	36.8	<1.00
0.1-0.2	6.9	<5	310	0.031	1.2	0.7	<0.2	<1.00	22.8	16.3	<1.00

SOIL PROFILE CHEMISTRY DATA																			
Depth (m)	Adjusted particle size to remove gravel (%)*				pH (H ₂ O)	EC (uS/cm)	EC rating (VL, L, M, H, VH, E)	Cl- (mg/kg)	Total Sulfur (%)	Exchangeable cations (meq/100 g)						ESP (%)	Sodicity (NS, S, SS)	Emerson class	Ca:Mg ratio
	Clay	Silt	Sand	Gravel						Al ³⁺	Ca ²⁺	Mg ²⁺	K ⁺	Na ⁺	CEC				
0.0-0.1	27	22	52	3	7.0	21	VL	<10	0.02	-	6.5	2.0	0.3	<0.1	8.9	1.1	NS	-	3.2
0.1-0.2	22	16	61	2	6.9	11	VL	<10	0.02	-	5.5	1.7	0.2	0.1	7.4	1.5	NS	2	3.2
0.3-0.4	65	8	27	<1	8.0	100	VL	100	<0.01	-	19.4	6.4	0.3	2.3	28.3	8.1	S	3	3.0
0.5-0.6	55	12	33	7	9.0	267	M	170	0.02	-	16.5	5.9	<0.2	2.2	24.9	9.0	S	4	2.8
0.8-0.9	42	20	38	5	9.0	346	M	250	0.02	-	23.9	9.7	0.4	4.0	38.0	10.7	S	4	2.5
1.1-1.2	27	10	63	2	9.4	188	L	20	<0.1	-	15.9	4.4	0.2	2.4	22.9	10.4	S	3	3.6

Notes:

* Gravel (>2 mm), Sand (0.02–2 mm), Silt (2–20 μm), Clay (<2 μm); VL – Very Low, L – Low, M – Moderate, H – High, VH – Very High, E – Extreme; NS – Non-Sodic, S – Sodic, SS – Strongly Sodic; ID – Indeterminable

SITE DESCRIPTION		ASC Soil Order:	Red Dermosol			Site #:	PR08	
Coordinates:	Easting:	666863	Northing:	7429026	Zone:	55	Datum:	GDA94
Location:	Fairhill		Describer:	C Traill	Elevation:		158 m AHD	

LANDFORM			
Slope:	Very gently inclined (1%)	Runoff:	Slow
Morphological type:	Lower slope	Permeability:	Slowly permeable
Landform element:	Residual rise	Drainage:	Imperfectly drained
Landform pattern:	Rises	Surface condition:	Crusting, firm
Relief Modal Class:	Gently undulating rises	Disturbance:	Cleared, ripped, improved pasture
Geology:	Fair Hill Formation (Pwt)	Rock outcrop:	Nil
Microrelief:	Nil, historical (2004) satellite imagery shows linear gilgai immediately north-east of sample site		
Coarse fragments:	Few (2-10%), rounded tabular, small metamorphic pebbles (2-6 mm)		
Erosion:	Moderate, active, sheet erosion		
Vegetation:	Silver leaved ironbark, carissa, wilga, buffel grass		



Site PR08 landscape



Site PR08 surface condition



Site PR08 profile, 0.5 m deep



Site PR08 profile, 0.0-0.2 m deep



Site PR08 profile, 0.4-0.7 m deep

SOIL DESCRIPTION		
Horizon	Depth (m)	Description
A1p	0.0-0.1	Dark reddish brown (5YR 3/3) (moist); weak, <2 mm, sub-angular blocky structure; clay loam, fine sandy; pH 6.0; clear change to -
B21	0.1-0.2	Dark reddish brown (5YR 3/4) (moist); very few, fine, faint, pale mottles; weak, 2-5 mm, sub-angular blocky structure; fine sandy light clay; few, fine, sub-angular tabular, metamorphic pebbles; many, fine, ferromanganiferous concretions; pH 5.5; gradual change to -
B22	0.2-0.6	Dark red (2.5YR 3/6) (moist); few, medium, faint, pale mottles; moderate, 5-10 mm, sub-angular blocky structure; fine sandy light medium clay; many, sub-angular tabular, metamorphic cobbles; common, medium, ferromanganiferous concretions; pH 5.0; gradual change to -
B/C	0.6+	Weathered sandstone

SITE DESCRIPTION		ASC Soil Order:	Brown Dermosol			Site #:	OB34	
Coordinates:	Easting:	667385	Northing:	7429383	Zone:	55	Datum:	GDA94
Location:	Fairhill		Describer:	C Traill	Elevation:	159 m AHD		

LANDFORM			
Slope:	Very gently inclined (2%)	Runoff:	Moderately rapid
Morphological type:	Simple slope	Permeability:	Moderately permeable
Landform element:	Residual rise	Drainage:	Moderately well-drained
Landform pattern:	Rises	Surface condition:	Surface flake, firm
Relief Modal Class:	Gently undulating rises	Disturbance:	Cleared, ripped, improved pasture
Geology:	Fair Hill Formation (Pwt)	Rock outcrop:	Nil
Microrelief:	Nil, historical (2004) satellite imagery shows ghost linear gilgai north of sample site		
Coarse fragments:	Abundant (50-90%), sub-rounded tabular, medium metamorphic pebbles (6-20 mm)		
Erosion:	Moderate, active, sheet erosion		
Vegetation:	Silver-leaved ironbark, grey gum, buffel grass		



Site PR34 landscape



Site PR34 surface condition



Site PR34 profile, 0.5 m deep



Site PR34 surface condition

SOIL DESCRIPTION		
Horizon	Depth (m)	Description
A1/B21p	0.0-0.2	Yellowish red (5YR 4/6) (moist); moderate, 5-10 mm, sub-angular blocky structure; fine sandy light clay; very few, medium, sub-angular tabular, metamorphic pebbles; very few, fine, ferromanganiferous concretions; few, fine, very highly calcareous, soft segregations; pH 8.5; gradual change to -
B/C	0.2-0.35	Strong brown (7.5YR 4/6) (moist); weak, 2-5 mm, sub-angular blocky structure; fine sandy light medium clay; very few, medium, sub-angular tabular, metamorphic pebbles; very few, fine, ferromanganiferous concretions; common, medium, very highly calcareous, soft segregations; pH 8.0; clear change to -
C	0.35+	Weathered sandstone; dark yellowish brown (10YR 4/6); few, fine, distinct, orange mottles; weak, <2 mm, sub-angular blocky structure; sandy light clay; few, medium, sub-angular platy, sandstone pebbles

SITE DESCRIPTION		ASC Soil Order:	Dermosol			Site #:	OB41	
Coordinates:	Easting:	667441	Northing:	7429561	Zone:	55	Datum:	GDA94
Location:	Fairhill		Describer:	C Traill	Elevation:	160 m AHD		

LANDFORM			
Slope:	Level (0.3%)	Runoff:	Slow
Morphological type:	Crest	Permeability:	Slowly permeable
Landform element:	Residual crest	Drainage:	Imperfectly drained
Landform pattern:	Rises	Surface condition:	Firm, surface crusting
Relief Modal Class:	Gently undulating rises	Disturbance:	Cleared, ripped, improved pasture
Geology:	Fair Hill Formation (Pwt)	Rock outcrop:	Nil
Microrelief:	Nil		
Coarse fragments:	Many (20-50%), medium, rounded tabular, metamorphic pebbles (6-20 mm)		
Erosion:	Moderate, active, sheet erosion		
Vegetation:	Silver-leaved ironbark, buffel grass		
			
Site OB41 landscape		Site OB41 surface condition	

SOIL DESCRIPTION		
Horizon	Depth (m)	Description
A1/B21p	0.0	Yellowish red (5YR 4/6) (moist); weak, 2-5 mm, sub-angular blocky structure; fine sandy light clay; few, medium, sub-angular tabular, metamorphic pebbles; very few, fine, ferromanganiferous concretions

SITE DESCRIPTION		ASC Soil Order:	Dermosol			Site #:	OB43	
Coordinates:	Easting:	667499	Northing:	7429501	Zone:	55	Datum:	GDA94
Location:	Fairhill		Describer:	C Traill	Elevation:	160 m AHD		

LANDFORM			
Slope:	Level (0.9%)	Runoff:	Slow
Morphological type:	Crest	Permeability:	Slowly permeable
Landform element:	Residual crest	Drainage:	Imperfectly drained
Landform pattern:	Rises	Surface condition:	Firm, surface crusting
Relief Modal Class:	Gently undulating rises	Disturbance:	Cleared, ripped, improved pasture
Geology:	Fair Hill Formation (Pwt)	Rock outcrop:	Nil
Microrelief:	Nil		
Coarse fragments:	Many (20-50%), medium, sub-angular tabular, metamorphic pebbles (6-20 mm)		
Erosion:	Moderate, active, sheet erosion		
Vegetation:	Silver-leaved ironbark, buffel grass		



Site OB43 landscape



Site OB43 surface condition

SOIL DESCRIPTION		
Horizon	Depth (m)	Description
A1/B21p	0.0	Reddish brown (5YR 4/3) (moist); weak, 5-10 mm, sub-angular blocky structure; fine sandy light clay; few, medium, angular tabular, metamorphic pebbles

Black, Brown, Grey and Red Dermosols on Quaternary alluvium (Qa) occupying floodplains

SITE DESCRIPTION		ASC Soil Order:	Brown Dermosol			Site #:	PR11	
Coordinates:	Easting:	665354	Northing:	7428318	Zone:	55	Datum:	GDA94
Location:	Fairhill		Describer:	C Traill	Elevation:		159 m AHD	

LANDFORM			
Slope:	Level (0.6%)	Runoff:	Very slow
Morphological type:	Flat	Permeability:	Slowly permeable
Landform element:	Plain	Drainage:	Imperfectly drained
Landform pattern:	Plain	Surface condition:	Surface crust, hard-setting
Relief Modal Class:	Level plain	Disturbance:	Cleared, ripped, improved pasture
Geology:	Quaternary alluvium (Qa)	Rock outcrop:	Nil
Microrelief:	Nil, historical (2004) satellite imagery shows linear gilgai north of sample site off floodplain		
Coarse fragments:	Very few (<2%), medium, sub-angular tabular, metamorphic pebbles (6-20 mm)		
Erosion:	Moderate, active, sheet erosion and moderate, active, gully erosion (<1.5 m deep)		
Vegetation:	River red gum, Queensland blue gum, brigalow, carissa, buffel grass		



Site PR11 landscape



Site PR11 surface condition – sheet and gully erosion



Site PR11 surface condition



Site PR11 profile, 1.2 m deep



Site PR11 profile, 0.0-0.4 m deep

LANDFORM		
		
Site PR11 profile, 0.2-0.6 m deep	Site PR11 profile, 0.5-0.9 m deep	Site PR11 profile, 0.7-1.2 m deep

SOIL DESCRIPTION		
Horizon	Depth (m)	Description
A1	0.0-0.1	Black (7.5YR 2.5/1) (moist); weak, <2 mm, angular blocky structure; clay loam, sandy; pH 6.0; clear change to -
B21	0.1-0.3	Very dark grey (7.5YR 3/1) (moist); moderate, 5-10 mm, sub-angular blocky structure; light medium clay; pH 8.0; gradual change to -
B22	0.3-0.5	Dark brown (7.5YR 3/2) (moist); very few, fine, distinct, dark mottles; moderate, 2-5 mm, sub-angular blocky structure; fine sandy light medium clay; few, very fine, highly calcareous concretions; pH 8.5; gradual change to -
B23	0.5-1.2	Brown (7.5YR 5/4) (moist); few, fine, distinct, orange mottles; moderate, 2-5 mm, sub-angular blocky structure; fine sandy light medium clay; common, medium, very highly calcareous concretions; pH 9.0

SURFACE CHEMISTRY DATA											
Depth (m)	pH (H ₂ O)	Bicarbonate extr. P (Colwell) (mg/kg)	Total Kheldal nitrogen		Organic matter (%)	Total organic carbon (%)	Boron (mg/kg)	Trace Elements			
			(mg/kg)	(%)				Copper (mg/kg)	Iron (mg/kg)	Manganese (mg/kg)	Zinc (mg/kg)
0.0-0.1	7.1	26	1,040	0.104	3.8	2.2	<0.2	<1.00	54.0	12.4	<1.00
0.1-0.2	7.6	<5	840	0.084	2.0	1.2	0.4	1.02	17.0	9.4	<1.00

SOIL PROFILE CHEMISTRY DATA																			
Depth (m)	Adjusted particle size to remove gravel (%)*				pH (H ₂ O)	EC (uS/cm)	EC rating (VL, L, M, H, VH, E)	Cl- (mg/kg)	Total Sulfur (%)	Exchangeable cations (meq/100 g)						ESP (%)	Sodicity (NS, S, SS)	Emerson class	Ca:Mg ratio
	Clay	Silt	Sand	Gravel						Al ³⁺	Ca ²⁺	Mg ²⁺	K ⁺	Na ⁺	CEC				
0.0-0.1	20	14	66	<1	7.1	39	VL	20	0.02	-	7.1	3.1	0.4	1.0	11.6	8.9	S	-	2.3
0.1-0.2	40	14	46	<1	8.9	149	L	110	0.02	-	7.6	5.3	0.2	3.7	16.8	22.2	SS	2	1.4
0.2-0.3	36	13	51	<1	9.6	661	H	560	0.02	-	4.7	5.6	0.2	6.5	17.0	38.2	SS	2	0.8
0.5-0.6	35	12	50	<1	9.6	1,330	E	1,680	0.03	-	1.8	4.7	0.3	9.3	16.2	57.6	SS	2	0.4
0.8-0.9	36	15	49	4	9.7	1,340	E	1,700	0.03	-	2.1	5.0	0.4	9.7	17.2	56.3	SS	2	0.4
1.1-1.2	41	16	43	<1	9.2	1,180	VH	1,700	0.02	-	1.9	5.0	0.4	9.8	17.1	57.3	SS	1	0.4

Notes:

* Gravel (>2 mm), Sand (0.02–2 mm), Silt (2-20 µm), Clay (<2 µm); VL – Very Low, L – Low, M – Moderate, H – High, VH – Very High, E – Extreme; NS – Non-Sodic, S – Sodic, SS – Strongly Sodic; ID – Indeterminable

SITE DESCRIPTION		ASC Soil Order:	Brown Dermosol			Site #:	OB30	
Coordinates:	Easting:	665178	Northing:	7428070	Zone:	55	Datum:	GDA94
Location:	Fairhill		Describer:	C Traill	Elevation:	159 m AHD		

LANDFORM			
Slope:	Level (1%)	Runoff:	Very slow
Morphological type:	Flat	Permeability:	Slowly permeable
Landform element:	Backplain	Drainage:	Imperfectly drained
Landform pattern:	Covered plain	Surface condition:	Surface crust, hard-setting
Relief Modal Class:	Gently undulating plain	Disturbance:	Partially cleared, improved pasture
Geology:	Quaternary alluvium (Qa)	Rock outcrop:	Nil
Microrelief:	Nil, historical (2004) satellite imagery shows linear gilgai further south-west out of floodplain		
Coarse fragments:	Few (2-10%), medium, sub-rounded, metamorphic pebbles (6-20 mm)		
Erosion:	Moderate, active, sheet erosion, particularly along cattle and vehicle wheel tracks		
Vegetation:	River red gum, Moreton Bay ash, poplar box, silver-leaved ironbark, brigalow, caesalpinia, wilga, buffel grass		



Site OB30 landscape



Site OB30 surface condition



Site OB30 profile, 0.6 m deep



Site OB30 profile, 0.0-0.4 m deep



Site OB30 profile, 0.2-0.6 m deep

SOIL DESCRIPTION		
Horizon	Depth (m)	Description
A1	0.0-0.2	Very dark greyish brown (10YR 3/2) (moist); massive, <2 mm, granular structure; sandy clay loam; pH 5.5; gradual change to -
A2e	0.2-0.35	Dark yellowish brown (10YR 3/4) (moist), grey (10YR 6/1) (dry); massive, <2 mm, granular structure; sandy clay loam; pH 6.0; clear change to -
B21	0.35+	Dark yellowish brown (10YR 3/4) (moist); common, fine, distinct, dark mottles and common, fine, distinct, pale mottles; weak, 5-10 mm, sub-angular blocky structure; sandy light clay; very few, fine, ferromanganiferous concretions; pH 7.5

SURFACE CHEMISTRY DATA											
Depth (m)	pH (H ₂ O)	Bicarbonate extr. P (Colwell) (mg/kg)	Total Kheldal nitrogen		Organic matter (%)	Total organic carbon (%)	Boron (mg/kg)	Trace Elements			
			(mg/kg)	(%)				Copper (mg/kg)	Iron (mg/kg)	Manganese (mg/kg)	Zinc (mg/kg)
0.0-0.1	6.2	28	750	0.075	1.8	1.0	<0.2	<1.00	39.2	24.5	<1.00
0.1-0.2	6.2	<5	490	0.049	1.1	0.6	<0.2	<1.00	37.3	17.5	<1.00

SOIL PROFILE CHEMISTRY DATA																			
Depth (m)	Adjusted particle size to remove gravel (%)*				pH (H ₂ O)	EC (uS/cm)	EC rating (VL, L, M, H, VH, E)	Cl- (mg/kg)	Total Sulfur (%)	Exchangeable cations (meq/100 g)						ESP (%)	Sodicity (NS, S, SS)	Emerson class	Ca:Mg ratio
	Clay	Silt	Sand	Gravel						Al ³⁺	Ca ²⁺	Mg ²⁺	K ⁺	Na ⁺	CEC				
0.0-0.1	19	6	74	6	6.2	14	VL	10	0.02	-	2.8	1.2	0.4	<0.1	4.5	1.3	NS	-	2.3
0.1-0.2	16	7	77	2	6.2	10	VL	<10	0.02	-	2.6	1.3	0.3	0.1	4.4	2.3	NS	2	2.0
0.2-0.3	15	8	77	1	7.0	21	VL	20	<0.01	-	1.7	1.2	0.1	0.4	3.5	13.4	S	2	1.4
0.4-0.5	27	6	67	1	8.0	130	L	150	<0.01	-	2.6	2.3	0.3	2.2	7.4	30.1	SS	2	1.1
0.5-0.6	31	6	63	2	8.6	294	M	360	0.02	-	3.8	3.9	0.4	3.7	11.8	31.0	SS	2	1.0

Notes:

* Gravel (>2 mm), Sand (0.02–2 mm), Silt (2-20 µm), Clay (<2 µm); VL – Very Low, L – Low, M – Moderate, H – High, VH – Very High, E – Extreme; NS – Non-Sodic, S – Sodic, SS – Strongly Sodic; ID – Indeterminable

SITE DESCRIPTION		ASC Soil Order:	Black Dermosol			Site #:	PR13	
Coordinates:	Easting:	666467	Northing:	7428591	Zone:	55	Datum:	GDA94
Location:	Fairhill		Describer:	C Traill	Elevation:	160 m AHD		

LANDFORM			
Slope:	Level (0.8%)	Runoff:	Moderately rapid
Morphological type:	Ridge	Permeability:	Slowly permeable
Landform element:	Residual rise	Drainage:	Imperfectly drained
Landform pattern:	Rises	Surface condition:	Surface crust, hard-setting
Relief Modal Class:	Gently undulating rises	Disturbance:	Cleared, ripped, improved pasture
Geology:	Quaternary alluvium (Qa)	Rock outcrop:	Nil
Microrelief:	Nil, historical (2004) satellite imagery shows linear gilgai north and west of sample site upslope		
Coarse fragments:	Common (10-20%), sub-rounded tabular, metamorphic cobbles (60-200 mm)		
Erosion:	Minor, active, sheet erosion		
Vegetation:	Brigalow, carissa, buffel grass		

SOIL DESCRIPTION		
Horizon	Depth (m)	Description
A1/B21p	0.0-0.1	Very dark brown (10YR 2/2) (moist); weak, <2 mm, angular blocky structure; clay loam, fine sandy; few, large, rounded, metamorphic pebbles; pH 6.0; gradual change to -
B22	0.1-0.4	Black (10YR 2/1) (moist); common, fine, faint, brown mottles; moderate, 2-5 mm, sub-angular blocky structure; fine sandy light clay; very few, medium, rounded, metamorphic pebbles; pH 8.5; gradual change to -
B23	0.4-0.8	Brown (7.5YR 4/4) (moist); common, medium, distinct, orange mottles; weak, <2 mm, sub-angular blocky structure; fine sandy light clay; very few, rounded, metamorphic cobbles; common, fine, ferruginous concretions; common, fine, very highly calcareous nodules; pH 9.0; gradual change to -
B/C	0.8-1.2	Yellowish brown (10YR 5/8) (moist); few, fine, faint, brown mottles; weak, <2 mm, sub-angular blocky structure; very few, rounded; metamorphic cobbles; few, fine, very highly calcareous nodules; pH 8.5

SITE DESCRIPTION		ASC Soil Order:	Dermosol			Site #:	PR29	
Coordinates:	Easting:	665357	Northing:	7428318	Zone:	55	Datum:	GDA94
Location:	Fairhill		Describer:	C Traill	Elevation:	159 m AHD		

LANDFORM			
Slope:	Level (0.6%)	Runoff:	Very slow
Morphological type:	Flat	Permeability:	Slowly permeable
Landform element:	Plain	Drainage:	Imperfectly drained
Landform pattern:	Plain	Surface condition:	Surface crust, hard-setting
Relief Modal Class:	Level plain	Disturbance:	Cleared, ripped, improved pasture
Geology:	Quaternary alluvium (Qa)	Rock outcrop:	Nil
Microrelief:	Nil, historical (2004) satellite imagery shows linear gilgai north of sample site off floodplain		
Coarse fragments:	Very few (<2%), medium, sub-angular tabular, metamorphic pebbles (6-20 mm)		
Erosion:	Moderate, active, sheet erosion and moderate, active, gully erosion (<1.5 m deep)		
Vegetation:	River red gum, Queensland blue gum, brigalow, carissa, buffel grass		



Site PR29 landscape



Site PR29 surface condition

SOIL DESCRIPTION		
Horizon	Depth (m)	Description
A1	0.0	Black (7.5YR 2.5/1) (moist); weak, <2 mm, angular blocky structure; clay loam, sandy; very few, fine sub-rounded tabular, metamorphic pebbles

SITE DESCRIPTION		ASC Soil Order:	Dermosol			Site #:	PR32	
Coordinates:	Easting:	665812	Northing:	7428373	Zone:	55	Datum:	GDA94
Location:	Fairhill		Describer:	C Traill	Elevation:		159 m AHD	

LANDFORM			
Slope:	Level (0.6%)	Runoff:	Very slow
Morphological type:	Flat	Permeability:	Slowly permeable
Landform element:	Plain	Drainage:	Imperfectly drained
Landform pattern:	Plain	Surface condition:	Surface crust, hard-setting
Relief Modal Class:	Level plain	Disturbance:	Cleared, ripped, improved pasture
Geology:	Quaternary alluvium (Qa)	Rock outcrop:	Nil
Microrelief:	Nil, historical (2004) satellite imagery shows linear gilgai north of sample site off floodplain		
Coarse fragments:	Very few (<2%), small, sub-rounded, metamorphic pebbles (2-6 mm)		
Erosion:	Moderate, active, sheet erosion		
Vegetation:	Brigalow, buffel grass		



Site PR32 landscape



Site PR32 surface condition

SOIL DESCRIPTION		
Horizon	Depth (m)	Description
A1	0.0	Black (7.5YR 2.5/1) (moist); weak, <2 mm, angular blocky structure; clay loam, sandy; very few, fine sub-rounded tabular, metamorphic pebbles

SITE DESCRIPTION		ASC Soil Order:	Dermosol			Site #:	PR33	
Coordinates:	Easting:	666920	Northing:	7428679	Zone:	55	Datum:	GDA94
Location:	Fairhill		Describer:	C Traill	Elevation:		158 m AHD	

LANDFORM			
Slope:	Level (0.9%)	Runoff:	Slow
Morphological type:	Flat	Permeability:	Slowly permeable
Landform element:	Plain	Drainage:	Imperfectly drained
Landform pattern:	Plain	Surface condition:	Surface crust, hard-setting
Relief Modal Class:	Level plain	Disturbance:	Cleared, ripped, improved pasture
Geology:	Quaternary alluvium (Qa)	Rock outcrop:	Nil
Microrelief:	Nil, historical (2004) satellite imagery shows linear gilgai north-west of sample site off floodplain		
Coarse fragments:	Very few (<2%), small, sub-angular, metamorphic pebbles (2-6 mm)		
Erosion:	Moderate, active, sheet erosion		
Vegetation:	Brigalow, caesalpinia, river reg gum, buffel grass		
			
Site PR33 landscape		Site PR33 surface condition	

SOIL DESCRIPTION		
Horizon	Depth (m)	Description
A1	0.0	Very dark brown (7.5YR 2.5/2) (moist); weak, <2 mm, angular blocky structure; clay loam, sandy; very few, fine sub-angular tabular, metamorphic pebbles

SITE DESCRIPTION		ASC Soil Order:	Brown Dermosol			Site #:	PR40	
Coordinates:	Easting:	666920	Northing:	7428679	Zone:	55	Datum:	GDA94
Location:	Fairhill		Describer:	C Traill	Elevation:	158 m AHD		

LANDFORM			
Slope:	Level (0.0%)	Runoff:	Slow
Morphological type:	Closed depression	Permeability:	Slowly permeable
Landform element:	Oxbow	Drainage:	Imperfectly drained
Landform pattern:	Plain	Surface condition:	Surface crust, hard-setting
Relief Modal Class:	Gently undulating plain	Disturbance:	Cleared, improved pasture
Geology:	Quaternary alluvium (Qa)	Rock outcrop:	Nil
Microrelief:	Nil		
Coarse fragments:	Nil		
Erosion:	Moderate, active, sheet erosion		
Vegetation:	River red gum, Moreton Bay ash, brigalow, caesalpinia, sedges		



Site PR40 landscape



Site PR40 surface condition



Site PR40 profile, 0.7 m deep



Site PR40 profile, 0.0-0.3 m deep

LANDFORM	
	
Site PR40 profile, 0.2-0.6 m deep	Site PR40 profile, 0.5-0.7 m deep

SOIL DESCRIPTION		
Horizon	Depth (m)	Description
A1	0.0-0.2	Very dark brown (7.5YR 2.5/3) (moist); massive, <2 mm, granular structure; clay loam, sandy; pH 6.0; clear change to -
B21	0.2-0.5	Dark brown (7.5YR 3/4) (moist); many, medium distinct, grey mottles; weak, 5-10 mm, sub-angular blocky structure; sandy light medium clay; pH 5.0; gradual change to -
B22	0.5-0.7	Dark brown (7.5YR 3/4) (moist); many, medium distinct, grey mottles and common, medium, distinct, orange mottles; weak, 10-20 mm, sub-angular blocky structure; sandy light medium clay; pH 6.0

Black, Brown and Grey Vertosols on Quaternary alluvium (Qa) occupying drainage depressions and floodplains

SITE DESCRIPTION		ASC Soil Order:	Black Vertosol			Site #:	PR01	
Coordinates:	Easting:	666973	Northing:	7431710	Zone:	55	Datum:	GDA94
Location:	Fairhill		Describer:	C Traill	Elevation:		149 m AHD	

LANDFORM			
Slope:	Level (<1%)	Runoff:	Slow
Morphological type:	Flat	Permeability:	Slowly permeable
Landform element:	Levee	Drainage:	Imperfectly drained
Landform pattern:	Covered plain	Surface condition:	Cracking, surface crusting to self-mulching
Relief Modal Class:	Level plain	Disturbance:	Partially cleared, improved pasture
Geology:	Quaternary alluvium (Qa)	Rock outcrop:	Nil
Microrelief:	Nil, historical (2004) satellite imagery shows linear gilgai upslope to north-east of sample site		
Coarse fragments:	Nil		
Erosion:	Moderate, active, sheet erosion		
Vegetation:	Moreton Bay ash, Queensland blue gum, brigalow, poplar box, caesalpinia, melaleuca		



Site PR01 landscape



Site PR01 surface condition



Site PR01 profile, 1.2 m deep



Site PR01 profile, 0.0-0.5 m deep



Site PR01 profile, 0.7-1.2 m deep

SOIL DESCRIPTION		
Horizon	Depth (m)	Description
A1/B21	0.0-0.3	Very dark brown (10YR 2/2) (moist); strong, 10-20 mm, sub-angular blocky structure; fine sandy medium clay; pH 6.0; gradual change to -
B22	0.3-0.7	Black (10YR 2/1) (moist); very few, fine, faint, brown mottles; moderate, 2-5 mm, sub-angular blocky structure; fine sandy light medium clay; pH 7.5; gradual change to -
B23	0.7-1.2	Very dark brown (10YR 2/2) (moist); very few, fine, faint, brown mottles; moderate, 5-10 mm, sub-angular blocky structure; fine sandy light clay; very few, fine, non-calcareous segregations; pH 7.0

SURFACE CHEMISTRY DATA											
Depth (m)	pH (H ₂ O)	Bicarbonate extr. P (Colwell) (mg/kg)	Total Kheldal nitrogen		Organic matter (%)	Total organic carbon (%)	Boron (mg/kg)	Trace Elements			
			(mg/kg)	(%)				Copper (mg/kg)	Iron (mg/kg)	Manganese (mg/kg)	Zinc (mg/kg)
0.0-0.1	7.1	9	1,100	0.110	2.9	1.3	<0.2	1.74	4.5	30.9	<1.00
0.1-0.2	7.8	<5	450	0.045	1.7	0.8	<0.2	1.18	22.6	24.8	<1.00

SOIL PROFILE CHEMISTRY DATA																			
Depth (m)	Adjusted particle size to remove gravel (%)*				pH (H ₂ O)	EC (uS/cm)	EC rating (VL, L, M, H, VH, E)	Cl- (mg/kg)	Total Sulfur (%)	Exchangeable cations (meq/100 g)						ESP (%)	Sodicity (NS, S, SS)	Emerson class	Ca:Mg ratio
	Clay	Silt	Sand	Gravel						Al ³⁺	Ca ²⁺	Mg ²⁺	K ⁺	Na ⁺	CEC				
0.0-0.1	45	22	32	<1	7.1	22	VL	<10	<0.01	-	15.3	5.1	0.6	0.3	21.4	1.2	NS	-	3.0
0.1-0.2	33	18	49	<1	7.8	19	VL	<10	<0.01	-	12.7	2.9	0.4	0.2	16.3	1.6	NS	3	4.3
0.2-0.3	33	14	53	<1	7.9	20	VL	<10	<0.01	-	11.9	2.6	0.4	0.3	15.2	1.9	NS	3	4.5
0.5-0.6	32	9	59	<1	7.5	12	VL	<10	<0.01	-	10.2	2.3	0.4	0.5	13.4	3.8	NS	3	4.4
0.8-0.9	38	15	47	<1	7.8	114	L	110	<0.01	-	13.1	3.0	0.3	1.1	17.5	6.4	S	3	4.4
1.1-1.2	37	19	44	<1	8.0	301	M	410	<0.01	-	15.1	3.5	0.4	1.3	20.3	6.4	S	3	4.3

Notes:

* Gravel (>2 mm), Sand (0.02–2 mm), Silt (2-20 µm), Clay (<2 µm); VL – Very Low, L – Low, M – Moderate, H – High, VH – Very High, E – Extreme; NS – Non-Sodic, S – Sodic, SS – Strongly Sodic; ID – Indeterminable

SITE DESCRIPTION		ASC Soil Order:	Black Vertosol			Site #:	OB03	
Coordinates:	Easting:	666983	Northing:	7431676	Zone:	55	Datum:	GDA94
Location:	Fairhill		Describer:	C Traill	Elevation:		149 m AHD	

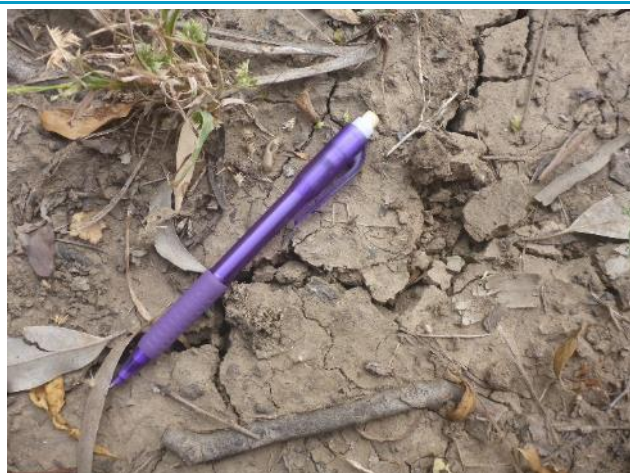
LANDFORM			
Slope:	Level (<1%)	Runoff:	Slow
Morphological type:	Flat	Permeability:	Slowly permeable
Landform element:	Levee	Drainage:	Imperfectly drained
Landform pattern:	Covered plain	Surface condition:	Cracking, surface crusting
Relief Modal Class:	Level plain	Disturbance:	Partially cleared, improved pasture
Geology:	Quaternary alluvium (Qa)	Rock outcrop:	Nil
Microrelief:	Nil, historical (2004) satellite imagery shows linear gilgai upslope to north-east of sample site		
Coarse fragments:	Nil		
Erosion:	Moderate, active, sheet erosion		
Vegetation:	Moreton Bay ash, Queensland blue gum, brigalow, poplar box, caesalpinia, wilga, melaleuca		



Site OB03 landscape



Site OB03 surface condition



Site OB03 surface condition



Site OB03 profile, 1.2 m deep

SOIL DESCRIPTION		
Horizon	Depth (m)	Description
A1/B21	0.0-0.3	Very dark brown (10YR 2/2) (moist); strong, 10-20 mm, sub-angular blocky structure; fine sandy medium clay; gradual change to -
B22	0.3-0.6	Black (10YR 2/1) (moist); few, fine, faint, brown mottles; moderate, 5-10 mm, sub-angular blocky structure; fine sandy light medium clay; gradual change to -
B23	0.6-1.2	Very dark brown (10YR 2/2) (moist); few, fine, faint, brown mottles; moderate, 5-10 mm, sub-angular blocky structure; fine sandy medium light clay; very few, fine non-calcareous, soft segregations

SITE DESCRIPTION		ASC Soil Order:	Brown Vertosol			Site #:	OB02	
Coordinates:	Easting:	666846	Northing:	7431594	Zone:	55	Datum:	GDA94
Location:	Fairhill		Describer:	C Traill	Elevation:		151 m AHD	

LANDFORM			
Slope:	Level (1%)	Runoff:	Slow
Morphological type:	Flat	Permeability:	Slowly permeable
Landform element:	Plain	Drainage:	Imperfectly drained
Landform pattern:	Plain	Surface condition:	Cracking, surface crusting
Relief Modal Class:	Level plain	Disturbance:	Cleared, improved pasture
Erosion:	Nil	Rock outcrop:	Nil
Coarse fragments:	Very few, medium, sub-angular to sub-rounded quartz and metamorphic pebbles		
Geology:	Thin layer (0.25 m) of Quaternary alluvium (Qa) over Fair Hill Formation (Pwt)		
Microrelief:	Nil, historical (2004) satellite imagery shows linear gilgai upslope to south of sample site		
Vegetation:	Brigalow, poplar box, melaleuca		



Site OB02 landscape



Site OB02 surface condition



Site OB02 surface condition



Site OB02 profile, 1.2 m deep

LANDFORM



Site OB02 profile, 0.0-0.3 m deep



Site OB02 profile, 0.2-0.4 m deep

SOIL DESCRIPTION

Horizon	Depth (m)	Description
A1/B21	0.0-0.2	Very dark brown (10YR 3/3) (moist); moderate, 2-5 mm, sub-angular blocky structure; sandy light clay; very few, large, rounded tabular, metamorphic pebbles; pH 7.5; gradual change to -
B22	0.2-0.25	Dark brown (7.5YR 3/3) (moist); few, medium, distinct, orange mottles; weak, 2-5 mm, sub-angular blocky structure; sandy light clay; very few, fine, rounded tabular, metamorphic pebbles; few, fine, non-calcareous nodules; pH 7.0; clear change to -
B23	0.25-0.4	Dark reddish brown (5YR 3/4) (moist); few, fine, faint, orange mottles; moderate, 5-10 mm, sub-angular blocky structure; sandy light medium clay; pH 8.0; gradual change to -
B/C	0.4+	Weathered sandstone

SITE DESCRIPTION		ASC Soil Order:	Brown Vertosol			Site #:	OB42	
Coordinates:	Easting:	667877	Northing:	7429047	Zone:	55	Datum:	GDA94
Location:	Fairhill		Describer:	C Traill	Elevation:		150 m AHD	

LANDFORM			
Slope:	Level (0.2%)	Runoff:	Very slow
Morphological type:	Open depression	Permeability:	Slowly permeable
Landform element:	Drainage depression	Drainage:	Imperfectly drained
Landform pattern:	Plain	Surface condition:	Cracking, surface crusting
Relief Modal Class:	Level plain	Disturbance:	Partially cleared, improved pasture
Microrelief:	Nil	Rock outcrop:	Nil
Coarse fragments:	Nil		
Geology:	Quaternary alluvium (Qa)		
Erosion:	Active stream bank erosion		
Vegetation:	Brigalow, caesalpinia, river red gum		



Site OB42 landscape



Site OB42 surface condition



Site OB42 profile, embankment cutting >1.2 m deep



Site OB42 profile, 0.0-0.8 m deep

SOIL DESCRIPTION		
Horizon	Depth (m)	Description
A1/B21	0.0-0.3	Very dark greyish brown (10YR 3/2) (moist); moderate, 10-20 mm, sub-angular blocky structure; fine sandy light medium clay; gradual change to -
B22	0.3-0.6	Dark yellowish brown (10YR 3/4) (moist); strong, 10-20 mm, sub-angular blocky structure; fine sandy medium clay; gradual change to -
B23	0.6-1.2	Brown (7.5YR 4/4) (moist); moderate, 10-20 mm, sub-angular blocky structure; fine sandy light medium clay

SITE DESCRIPTION		ASC Soil Order:	Vertosol			Site #:	OB09	
Coordinates:	Easting:	668312	Northing:	7429705	Zone:	55	Datum:	GDA94
Location:	Fairhill		Describer:	C Traill	Elevation:		151 m AHD	

LANDFORM			
Slope:	Very gently inclined (1.8%)	Runoff:	Slow
Morphological type:	Lower slope	Permeability:	Slowly permeable
Landform element:	Plain	Drainage:	Imperfectly drained
Landform pattern:	Plain	Surface condition:	Cracking, surface crusting
Relief Modal Class:	Level plain	Disturbance:	Cleared, ripped, improved pasture
Microrelief:	Nil	Rock outcrop:	Nil
Coarse fragments:	Many, medium, sub-angular tabular, metamorphic pebbles		
Geology:	Quaternary alluvium (Qa)		
Erosion:	Nil		
Vegetation:	Buffel grass		
			
Site OB09 landscape		Site OB09 surface condition	

SOIL DESCRIPTION		
Horizon	Depth (m)	Description
A1/B21p	0.0	Very dark brown (10YR 2/2) (moist); moderate, 5-10 mm, sub-angular blocky structure; fine sandy light medium clay; very few, small, sub-rounded tabular, metamorphic pebbles

SITE DESCRIPTION		ASC Soil Order:	Vertosol			Site #:	OB15	
Coordinates:	Easting:	667690	Northing:	7429286	Zone:	55	Datum:	GDA94
Location:	Fairhill		Describer:	C Traill	Elevation:		156 m AHD	

LANDFORM			
Slope:	Level (0.0%)	Runoff:	None
Morphological type:	Closed depression	Permeability:	Very slowly permeable
Landform element:	Prior stream	Drainage:	Very poorly drained
Landform pattern:	Plain	Surface condition:	Cracking, surface crusting
Relief Modal Class:	Level plain	Disturbance:	Cleared, improved pasture
Geology:	Quaternary alluvium (Qa)	Rock outcrop:	Nil
Coarse fragments:	Very few (<2%), small, sub-rounded platy, metamorphic pebbles (2-6 mm)		
Microrelief:	Nil, historical (2004) satellite imagery shows linear gilgai upslope to north of sample site		
Erosion:	Nil		
Vegetation:	Brigalow, wilga, buffel grass		



Site OB15 landscape



Site OB15 surface condition

SOIL DESCRIPTION		
Horizon	Depth (m)	Description
A1/B21	0.0	Dark brown (7.5YR 3/2) (moist); moderate, 5-10 mm, sub-angular blocky structure; fine sandy light medium clay; very few, small, sub-rounded platy, metamorphic pebbles

SITE DESCRIPTION		ASC Soil Order:	Vertosol			Site #:	OB16	
Coordinates:	Easting:	667690	Northing:	7429286	Zone:	55	Datum:	GDA94
Location:	Fairhill		Describer:	C Traill	Elevation:		152 m AHD	

LANDFORM			
Slope:	Level (0.0%)	Runoff:	Very slow
Morphological type:	Flat	Permeability:	Very slowly permeable
Landform element:	Prior stream	Drainage:	Poorly drained
Landform pattern:	Plain	Surface condition:	Cracking, surface crusting
Relief Modal Class:	Level plain	Disturbance:	Cleared, improved pasture
Geology:	Quaternary alluvium (Qa)	Rock outcrop:	Nil
Coarse fragments:	Common (10-20%), large, angular platy, metamorphic pebbles (20-60 mm)		
Microrelief:	Nil		
Erosion:	Nil		
Vegetation:	Brigalow, Cyperaceae		
			
Site OB16 landscape		Site OB16 surface condition	

SOIL DESCRIPTION		
Horizon	Depth (m)	Description
A1/B21	0.0	Very dark greyish brown (10YR 3/2) (moist); moderate, 10-20 mm, sub-angular blocky structure; fine sandy light medium clay; very few, small, sub-rounded tabular, metamorphic pebbles

SITE DESCRIPTION		ASC Soil Order:	Vertosol			Site #:	OB45	
Coordinates:	Easting:	668448	Northing:	7429972	Zone:	55	Datum:	GDA94
Location:	Fairhill		Describer:	C Traill	Elevation:		153 m AHD	

LANDFORM			
Slope:	Very gently inclined (1.3%)	Runoff:	Slow
Morphological type:	Lower slope	Permeability:	Slowly permeable
Landform element:	Residual rise	Drainage:	Imperfectly drained
Landform pattern:	Rises	Surface condition:	Cracking, surface crusting
Relief Modal Class:	Gently undulating rise	Disturbance:	Cleared, improved pasture
Geology:	Quaternary alluvium (Qa)	Rock outcrop:	Nil
Coarse fragments:	Common (10-20%), medium, sub-angular tabular, metamorphic pebbles (6-20 mm)		
Microrelief:	Nil		
Erosion:	Minor, active, sheet erosion		
Vegetation:	Brigalow, poplar box, caesalpinia		
			
Site OB45 landscape		Site OB45 surface condition	

SOIL DESCRIPTION		
Horizon	Depth (m)	Description
A1/B21	0.0	Dark brown (7.5YR 3/2) (moist); moderate, 5-10 mm, sub-angular blocky structure; fine sandy light medium clay; very few, small, sub-angular tabular, metamorphic pebbles

APPENDIX B

Summary of Laboratory Data by Representative Profile

Sample site	ASC	Depth (m)	Adjusted particle size to remove gravel (%)						Soil particle density (g/cm ³)	pH (H ₂ O)		EC (µS/cm)	Salinity rating	Moisture content dried at 105°C (%)	C ⁻ (mg/kg)	Total Sulfur (%)	Exchangeable cations (mg/100 g)										Sum of bases	ECp (%)	EAP (%)	EOP (%)	ESP (%)	Sodicity rating	
			Clay	Silt	Fine sand	Coarse sand	Sand SUM	Gravel		pH units	Rating						H	Al	Ca	Ex. Ca rating	Mg	Ex. Mg rating	K	Ex. K rating	Na	Ex. Na rating							CEC
PR01	Black Vertisol	0.0-0.1	45	22	28	4	32	<1	2.16	7.1	NEU	22	VL	9.8	<10	<0.01	-	-	15.3	H	5.1	M	0.6	M	0.3	L	21.4	98%	71.5	23.8	2.8	1.2	NS
		0.1-0.2	33	18	29	20	49	<1	2.44	7.8	SLAL	19	VL	8.9	<10	<0.01	-	-	12.7	H	2.9	M	0.4	M	0.2	L	16.3	99%	77.9	17.8	2.5	1.6	NS
		0.2-0.3	33	14	32	21	53	<1	2.35	7.9	MAL	20	VL	7.6	<10	<0.01	-	-	11.9	H	2.6	M	0.4	M	0.3	L	15.2	100%	78.3	17.1	2.6	1.9	NS
		0.5-0.6	32	9	30	29	59	<1	2.34	7.5	SLAL	12	VL	8.5	<10	<0.01	-	-	10.2	H	2.3	M	0.4	M	0.5	M	13.4	97%	76.1	17.2	3.0	3.8	NS
		0.8-0.9	38	15	29	18	47	<1	2.24	7.8	SLAL	114	L	10.3	110	<0.01	-	-	13.1	H	3.0	M	0.3	L	5.1	H	17.5	100%	74.9	17.1	1.7	6.4	S
		1.1-1.2	37	19	36	8	44	<1	2.66	8.0	MAL	301	M	9.2	410	<0.01	-	-	15.1	H	3.5	M	0.4	M	1.3	H	20.3	100%	74.4	17.2	2.0	6.4	S
PR02	Red Dermosol	0.0-0.1	27	22	32	20	52	3	2.36	7.0	NEU	21	VL	4.3	<10	0.02	-	-	6.5	M	2.0	M	0.3	L	<0.1	VL	8.9	99%	73.0	22.5	3.4	1.1	NS
		0.1-0.2	22	16	40	21	61	2	2.39	6.9	NEU	11	VL	5.7	<10	0.02	-	-	5.5	M	1.7	M	0.2	VL	0.1	L	7.4	100%	74.3	23.0	2.7	1.5	NS
		0.3-0.4	65	8	19	8	27	<1	2.28	8.0	MAL	100	VL	-	100	<0.01	-	-	19.4	H	6.4	H	0.3	L	2.3	VH	28.3	92%	68.6	22.6	1.1	8.1	S
		0.5-0.6	55	12	16	17	33	7	2.42	9.0	STAL	267	M	-	170	0.02	-	-	16.5	H	5.9	H	<0.2	VH	2.2	VH	24.9	99%	66.3	23.7	ID	9.0	S
		0.8-0.9	42	20	29	8	38	5	2.36	9.0	STAL	346	M	-	250	0.02	-	-	23.9	VH	9.7	VH	0.4	M	4.0	VH	38.0	89%	62.9	25.5	1.1	10.7	S
		1.1-1.2	27	10	52	11	63	2	2.40	9.4	VSAL	188	L	-	20	<0.1	-	-	15.9	H	4.4	M	0.2	VL	2.4	VH	22.9	98%	69.4	19.2	0.9	10.4	S
PR04	Grey Vertisol	0.0-0.1	59	14	9	18	27	4	2.34	7.8	SLAL	115	VL	5.8	120	0.02	-	-	5.1	M	4.8	H	0.2	VL	1.8	H	11.9	85%	42.9	40.3	1.7	14.9	S
		0.1-0.2	63	13	8	16	24	9	2.39	9.1	VSAL	820	H	9.7	1,260	0.02	-	-	5.0	L	5.5	M	<0.2	VL	2.8	VH	13.3	100%	37.6	41.4	ID	20.8	SS
		0.2-0.3	62	14	9	15	24	7	2.54	9.1	VSAL	852	H	-	1,360	0.02	-	-	6.1	M	7.3	H	<0.2	VL	4.0	VH	17.6	99%	34.7	41.5	ID	22.7	SS
		0.5-0.6	62	16	4	18	22	1	2.22	8.2	MAL	728	H	-	1,250	<0.01	-	-	3.8	L	6.0	H	<0.2	VL	4.1	VH	14.1	99%	27.0	42.6	ID	29.2	SS
		0.8-0.9	61	15	7	17	24	<1	2.17	5.6	MAC	681	M	24	1,120	<0.01	0.2	<0.1	2.7	L	4.4	H	0.1	VL	2.8	VH	10.2	71%	26.5	43.1	1.0	27.5	SS
		1.1-1.2	59	13	5	23	28	<1	2.35	5.5	STAC	480	M	-	770	<0.01	0.2	0.1	1.7	VL	2.9	M	<0.1	VL	2.1	VH	6.9	97%	24.6	42.0	#VALUE!	30.2	SS
PR06	Black Vertisol	0.0-0.1	71	19	5	5	10	1	2.26	8.0	MAL	33	VL	13.9	<10	<0.01	-	-	22.9	VH	4.4	H	0.3	L	0.7	M	28.4	97%	80.6	15.5	1.1	2.4	NS
		0.1-0.2	64	16	15	5	20	1	2.52	8.3	MAL	39	VL	20.4	<10	0.02	-	-	23.4	VH	4.4	M	0.3	L	1.0	H	29.1	97%	80.4	15.1	1.0	3.6	NS
		0.2-0.3	71	17	6	6	12	<1	2.44	8.4	MAL	45	VL	-	<10	0.02	-	-	19.3	H	3.8	H	0.2	VL	1.2	H	24.5	95%	78.8	15.5	0.8	4.8	NS
		0.5-0.6	73	19	3	5	8	1	2.42	8.8	STAL	101	VL	-	60	<0.01	-	-	20.7	VH	4.3	H	<0.2	VL	2.2	VH	27.4	99%	75.5	15.7	ID	8.1	S
		0.8-0.9	70	13	12	5	17	1	2.34	8.5	STAL	204	L	-	240	<0.01	-	-	19.4	M	4.4	M	<0.2	VL	2.8	VH	26.8	99%	72.4	16.4	ID	10.4	S
		1.0-1.1	60	22	8	11	18	8	2.22	8.5	STAL	229	L	-	230	<0.01	-	-	14.9	M	3.4	M	<0.2	VL	2.3	VH	20.3	101%	73.4	16.7	ID	11.2	S
PR07	Black Vertisol	0.0-0.1	20	23	44	13	57	5	2.29	8.5	STAL	137	L	9.4	40	0.03	-	-	12.6	M	6.2	M	0.5	M	2.0	H	21.4	98%	58.9	29.0	2.3	9.5	S
		0.1-0.2	30	27	32	10	42	1	2.33	8.6	STAL	144	L	12.2	30	0.02	-	-	14.6	M	9.0	VH	0.4	M	4.6	VH	28.6	84%	51.0	31.5	1.4	16.2	SS
		0.2-0.3	34	35	22	8	30	1	2.32	9.3	VSAL	440	M	14.8	360	0.02	-	-	14.1	H	10.7	VH	0.4	VL	6.8	VH	31.9	79%	44.2	33.5	1.3	21.2	SS
		0.5-0.6	18	23	45	14	58	35	2.38	9.7	VSAL	597	H	7.6	680	0.04	-	-	6.2	M	6.6	M	<0.2	VL	5.4	VH	18.4	99%	33.7	35.9	ID	29.4	SS
		0.7-0.8	19	47	29	4	34	32	2.47	9.5	VSAL	362	H	5.8	500	0.02	-	-	4.3	L	5.1	M	<0.2	VL	4.0	VH	13.5	99%	31.9	37.8	ID	29.6	SS
PR11	Black Dermosol	0.0-0.1	20	14	41	25	66	<1	2.25	7.1	NEU	39	VL	2.4	20	0.02	-	-	7.1	M	3.1	H	0.4	M	1.0	H	11.6	91%	61.2	26.7	3.4	8.9	S
		0.1-0.2	40	14	28	18	46	<1	2.24	8.9	STAL	149	L	7.5	110	0.02	-	-	7.6	M	5.3	M	0.2	VL	3.7	VH	16.8	78%	45.2	31.5	1.2	22.2	SS
		0.2-0.3	36	13	32	19	51	<1	2.40	9.6	VSAL	661	H	-	560	0.02	-	-	4.7	L	5.6	M	0.2	VL	6.5	VH	17.0	62%	27.6	32.9	1.2	38.2	SS
		0.5-0.6	35	12	29	21	50	<1	2.52	9.6	VSAL	1,330	E	-	1,680	0.03	-	-	1.8	VL	4.7	M	0.3	VL	9.3	VH	16.2	42%	11.1	29.0	1.9	57.6	SS
		0.8-0.9	36	15	31	18	49	4	2.44	9.7	VSAL	1,340	E	-	1,700	0.03	-	-	2.1	L	5.0	M	0.4	VL	9.7	VH	17.2	100%	12.2	29.1	2.3	56.3	SS
		1.1-1.2	41	16	25	18	43	<1	2.51	9.2	VSAL	1,180	VH	-	1,700	0.02	-	-	1.9	VL	5.0	M	0.4	VL	9.8	VH	17.1	100%	11.1	29.2	2.3	57.3	SS
PR14	Black Vertisol	0.0-0.1	60	18	12	8	20	2	2.31	8.6	STAL	168	L	10.4	20	0.02	-	-	21.7	VH	7.0	M	1.2	M	2.1	VH	31.9	94%	68.0	21.9	3.8	6.5	S
		0.1-0.2	52	17	22	9	31	<1	2.42	9.4	VSAL	345	M	13.7	7	0.02	-	-	17.5	H	8.2	VH	0.7	M	5.1	VH	31.5	84%	55.6	26.0	2.2	16.2	SS
		0.2-0.3	57	17	17	9	26	1	2.52	9.3	VSAL	563	H	13.7	540	0.03	-	-	15.7	M	8.6	VH	0.7	VL	6.2	VH	31.3	80%	50.2	27.5	2.2	19.9	SS
		0.3-0.4	-	-	-	-	-	-	-	9.1	VSAL	1,020	-	13.6	1,020	0.04	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		0.4-0.5	-	-	-	-	-	-	-	8.3	MAL	3,230	-	14	1,500	0.05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		0.5-0.6	54	16	21																												

Sample site	ASC	Depth (m)	Emerson aggregate test				Ca:Mg ratio	Mg:K ratio	Est. gypsum rate (t/ha)	Add neutralising capacity (1:3)			Phosphorus		Nitrogen						Organic matter (%)	Total organic carbon (%)	TOC rating	Boron (mg/kg)	Trace Elements					
			Munsell colour		Texture	Emerson Class				kg H ₂ SO ₄ eq/t	NaCO ₃	Flux rating	Bicarb. extr. P (Colwell)		Nitrbe (mg/kg)	Nitrade (mg/kg)	Nitrbe + Nitrade (mg/kg)	TKN (mg/kg)	TKN (%)	TKN rating					Total (mg/kg)	Copper (mg/kg)	Iron (mg/kg)	Manganese (mg/kg)	Zinc (mg/kg)	
			Code	Colour									(mg/kg)	Rating																Total (mg/kg)
PR01	Black Vertisol	0.0-0.1	-	-	-	-	3.0	7.9	0	-	-	-	9	VL	290	0.3	1.6	1.9	1,100	0.110	L	1,100	2.9	1.3	M2	<0.2	1.74	4.5	30.9	<1.00
		0.1-0.2	2.5Y 3/2	Very dark greyish brown	MC	3	4.3	7.1	0	5.2	0.5	0	+5	VL	176	<0.1	0.7	0.7	450	0.045	VL	450	1.7	0.8	L2	<0.2	1.18	22.6	24.8	<1.00
		0.2-0.3	2.5Y 3/2	Very dark greyish brown	MC	3	4.5	6.8	0	5.4	0.6	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		0.5-0.6	2.5Y 3/1	Very dark greyish brown	MC	3	4.4	5.9	0	8.6	0.9	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		0.8-0.9	2.5Y 3/1	Very dark greyish brown	MC	3	4.4	8.6	1	6.8	0.7	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1.1-1.2	2.5Y 3/1	Very dark greyish brown	MC	3	4.3	8.7	1	8.6	0.9	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PR02	Red Dermosol	0.0-0.1	-	-	-	-	3.2	6.0	0	-	-	-	+5	VL	125	0.1	0.4	0.5	280	0.028	VL	280	2.0	1.1	M1	<0.2	<1.00	22.2	36.8	<1.00
		0.1-0.2	7.5YR 3/3	Dark Brown	SCL	2	3.2	10.2	0	6.9	0.7	1	+5	VL	103	<0.1	0.4	0.4	310	0.031	VL	310	1.2	0.7	L1	<0.2	<1.00	22.8	16.3	<1.00
		0.3-0.4	5YR 3/4	Dark Reddish Brown	HC	3	3.0	22.8	2	12.1	1.2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		0.5-0.6	5YR 4/4	Reddish Brown	SC	4	2.8	ID	2	180.0	18.4	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		0.8-0.9	10YR 4/4	Dark Yellowish Brown	SC	4	2.5	23.7	5	105.0	10.7	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1.1-1.2	10YR 4/6	Dark Yellowish Brown	CS	3	3.6	21.7	3	39.5	4.0	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PR04	Grey Vertisol	0.0-0.1	-	-	-	-	1.0	19.9	2	-	-	-	+5	VL	222	0.4	0.9	1.3	1,490	0.149	L	1,490	2.7	1.6	H1	0.3	<1.00	13.9	22.0	<1.00
		0.1-0.2	10YR 4/1	Dark Grey	MC	3	0.9	ID	4	16.4	1.7	1	+5	VL	147	0.3	0.8	1.1	890	0.089	L	890	1.4	0.8	L2	0.4	<1.00	8.9	11.0	<1.00
		0.2-0.3	10YR 4/1	Dark Grey	MC	2	0.8	ID	6	16.7	1.7	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		0.5-0.6	10YR 5/1	Grey	MC	2	0.6	ID	7	4.1	0.4	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		0.8-0.9	10YR 4/1	Dark Grey	MC	1	0.6	44.0	5	2.3	0.2	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1.1-1.2	10YR 5/2	Greyish Brown	MC	1	0.6	ID	4	1.9	0.2	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PR06	Black Vertisol	0.0-0.1	-	-	-	-	5.2	13.3	0	-	-	-	+5	VL	246	0.3	0.9	1.2	1,050	0.105	L	1,050	1.9	1.1	M1	0.4	2.24	11.0	19.8	<1.00
		0.1-0.2	2.5Y 3/1	Very Dark Grey	HC	4	5.3	15.2	0	17.8	1.8	1	+5	VL	217	0.1	1.3	1.4	1,000	0.100	L	1,000	1.7	1.0	M1	0.4	2.27	11.3	15.0	<1.00
		0.2-0.3	2.5Y 3/1	Very Dark Grey	HC	4	5.1	17.0	0	15.3	1.6	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		0.5-0.6	2.5Y 3/1	Very Dark Grey	HC	3	4.8	ID	2	20.6	2.1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		0.8-0.9	2.5Y 4/1	Dark Grey	MC	3	4.4	ID	3	18.9	1.9	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1.0-1.1	2.5Y 3/2	Very Dark Greyish Brown	SC	3	4.4	ID	3	19.2	2.0	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PR07	Black Vertisol	0.0-0.1	-	-	-	-	2.0	13.3	1	-	-	-	+5	VL	277	0.6	1.9	2.5	1,450	0.145	L	1,450	2.1	1.2	M2	0.3	2.18	18.0	11.0	<1.00
		0.1-0.2	10YR 3/2	Very Dark Greyish Brown	MC	2	1.6	21.5	6	22.7	2.3	1	+5	VL	323	0.5	1.9	2.4	1,750	0.175	M	1,750	2.0	1.1	M1	0.4	2.63	17.5	6.5	<1.00
		0.2-0.3	2.5Y 3/2	Very Dark Greyish Brown	MC	3	1.3	30.1	10	46.7	4.8	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		0.5-0.6	10YR 5/3	Brown	CLS	2	0.9	ID	7	144.0	14.7	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		0.7-0.8	2.5Y 5/3	Light Olive Brown	CS	2	0.8	ID	5	7.7	0.8	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		0.0-0.1	-	-	-	-	-	2.3	8.3	1	-	-	-	26	M	332	0.4	0.3	0.7	1,040	0.104	L	1,040	3.8	2.2	VH2	<0.2	<1.00	54.0	12.4
PR11	Black Dermosol	0.1-0.2	10YR 3/1	Very Dark Grey	LC	2	1.4	21.4	5	12.2	1.2	1	+5	VL	248	<0.1	0.1	0.1	840	0.084	L	840	2.0	1.2	M2	0.4	1.02	17.0	9.4	<1.00
		0.2-0.3	2.5Y 3/2	Very Dark Greyish Brown	MC	2	0.8	24.3	11	18.2	1.8	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		0.5-0.6	7.5YR 5/3	Brown	SC	2	0.4	16.7	17	35.5	3.6	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		0.8-0.9	7.5YR 5/4	Brown	MC	2	0.4	12.8	19	31.8	3.2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1.1-1.2	10YR 5/3	Brown	LC	1	0.4	12.4	20	10.5	1.1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		0.0-0.1	-	-	-	-	-	3.1	6.0	1	-	-	-	18	L	411	0.9	2.2	3.1	1,880	0.188	M	1,880	3.6	2.1	VH1	0.3	1.86	11.0	12.0
PR14	Black Vertisol	0.1-0.2	10YR 4/2	Dark Greyish Brown	MC	3	2.1	12.1	7	61.4	6.3	2	+5	VL	277	<0.1	0.2	0.2	680	0.068	L	680	1.7	1.0	M1	0.6	1.83	12.8	12.6	<1.00
		0.2-0.3	10YR 4/3	Brown	HC	3	1.8	11.8	9	46.3	4.7	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		0.3-0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		0.4-0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		0.5-0.6	10YR 4/3	Brown	HC	3	1.7	20.4	15	37.7	3.8	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		0.6-0.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		0.7-0.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		0.8-0.9	10YR 4/3	Brown	MC	3	1.4	22.4	17	39.2	4.0	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		0.9-1.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1.0-1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.1-1.2	10YR 4/3	Brown	MC	3	1.3	17.4	13	32.7	3.3	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
OB30	Brown Dermosol	0.0-0.1	-	-	-	-	2.3	2.8	0	-	-	-	28	M	214	0.2	0.6	0.8	750	0.075	L	750	1.8	1.0	M1	<0.2	<1.00	39.2	24.5	<1.00
		0.1-0.2	10YR 3/2	Very Dark Greyish Brown	SL	2	2.0	4.4	0	1.8	0.2	0	+5	VL	401	0.1	0.2	0.3	490	0.049	VL	490	1.1	0.6	L1	<0.2	<1.00	37.3	17.5	<1.00
		0.2-0.3	10YR 3/4	Dark Yellowish Brown	LS	2	1.4	8.8	0	<0.5	<0.1	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		0.4-0.5	10YR 4/3	Brown	SC	2	1.1	8.6	3	6.4	0.6	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		0.5-0.6	10YR 3/4	Dark Yellowish Brown	SC	2	1.0	9.6	6	7.3	0.7	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

APPENDIX C

Copies of SLR Field Green Sheets and NRC Soil Logs

Prof. A. H. H. H.

NOTES:

P-Nie, u.d.

NOTES:

Apple Analysis

NOTES:

Adm. Analysis

NOTES:

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Profruct

NOTES:

W. H. H. H.

Geology		Slope		Landform Element			Landform Pattern			Land Use			Described By		Date (ddmmyy)		Project		Site		S Type		Obs		MCS				
PWT		VGL		RES			RIS			LU1			Mgt1			CT			230519		FAIRHALL		P214						
TSO		M Type		L Meas		Obs Reas		Runoff		Perm		M Smp		Aggre		Depth R Horiz		Type		Code		Tax Unit		Map Unit		Air Photos		Substrate	
P		223		223		223		223		223		223		223		223		223		223		223		223		223		223	
Dalum		Zone		Easting / Longitude		North / Longitude		Cont		Ord		Sub Ord		GG/ Ord		SG/ SO2		F1		F2		F3		F4		F5		PPF	
556651207A28763		VER		VER		VER		VER		VER		VER		VER		VER		VER		VER		VER		VER		VER		VER	
Dalum		Zone		Easting / Longitude		North / Longitude		Cont		Ord		Sub Ord		GG/ Ord		SG/ SO2		F1		F2		F3		F4		F5		PPF	
556651207A28763		VER		VER		VER		VER		VER		VER		VER		VER		VER		VER		VER		VER		VER		VER	
Dalum		Zone		Easting / Longitude		North / Longitude		Cont		Ord		Sub Ord		GG/ Ord		SG/ SO2		F1		F2		F3		F4		F5		PPF	
556651207A28763		VER		VER		VER		VER		VER		VER		VER		VER		VER		VER		VER		VER		VER		VER	
Dalum		Zone		Easting / Longitude		North / Longitude		Cont		Ord		Sub Ord		GG/ Ord		SG/ SO2		F1		F2		F3		F4		F5		PPF	
556651207A28763		VER		VER		VER		VER		VER		VER		VER		VER		VER		VER		VER		VER		VER		VER	
Dalum		Zone		Easting / Longitude		North / Longitude		Cont		Ord		Sub Ord		GG/ Ord		SG/ SO2		F1		F2		F3		F4		F5		PPF	
556651207A28763		VER		VER		VER		VER		VER		VER		VER		VER		VER		VER		VER		VER		VER		VER	
Dalum		Zone		Easting / Longitude		North / Longitude		Cont		Ord		Sub Ord		GG/ Ord		SG/ SO2		F1		F2		F3		F4		F5		PPF	
556651207A28763		VER		VER		VER		VER		VER		VER		VER		VER		VER		VER		VER		VER		VER		VER	
Dalum		Zone		Easting / Longitude		North / Longitude		Cont		Ord		Sub Ord		GG/ Ord		SG/ SO2		F1		F2		F3		F4		F5		PPF	
556651207A28763		VER		VER		VER		VER		VER		VER		VER		VER		VER		VER		VER		VER		VER		VER	
Dalum		Zone		Easting / Longitude		North / Longitude		Cont		Ord		Sub Ord		GG/ Ord		SG/ SO2		F1		F2		F3		F4		F5		PPF	
556651207A28763		VER		VER		VER		VER		VER		VER		VER		VER		VER		VER		VER		VER		VER		VER	
Dalum		Zone		Easting / Longitude		North / Longitude		Cont		Ord		Sub Ord		GG/ Ord		SG/ SO2		F1		F2		F3		F4		F5		PPF	
556651207A28763		VER		VER		VER		VER		VER		VER		VER		VER		VER		VER		VER		VER		VER		VER	
Dalum		Zone		Easting / Longitude		North / Longitude		Cont		Ord		Sub Ord		GG/ Ord		SG/ SO2		F1		F2		F3		F4		F5		PPF	
556651207A28763		VER		VER		VER		VER		VER		VER		VER		VER		VER		VER		VER		VER		VER		VER	
Dalum		Zone		Easting / Longitude		North / Longitude		Cont		Ord		Sub Ord		GG/ Ord		SG/ SO2		F1		F2		F3		F4		F5		PPF	
556651207A28763		VER		VER		VER		VER		VER		VER		VER		VER		VER		VER		VER		VER		VER		VER	
Dalum		Zone		Easting / Longitude		North / Longitude		Cont		Ord		Sub Ord		GG/ Ord		SG/ SO2		F1											

[illegible]

Test	Math	Result
pH - RP	8.0	8.2
EC		8.5
Disp		8.3
		9.0

NOTES:

check

Profile Diagram	PHOTOS 955-963
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[illegible]

Test	Meth
pH - RP	
EC	
Disp	

NOTES:

Check

Profile Diagram

[illegible]

SITE DESCRIPTION

check

Geology		Slope		Landform Element		Landform Pattern		Land Use		Described By		Date (ddmmyy)		Project		Site		S Type	
PwC		Elev		Type		Pattern		LU1		LCI		22/05/18		FAIRHILL		03/11			
M Type		Percent		Height		Class		Mg1		OT		Gr S		Str		Gen T		Mass Str	
L Meas		Incl		Type		Modal		Mg2		Distance		Str		Lith		Lith		MC1	
Obs Reas		MT		Code		RMS		Run No		Film No		Type		Abun		Abun		MDS	
TSO		Depth R Horiz		Type		Length		Code		Air Photos		Cracks		Str		Str		MC2	
		Aggradn		Type		Width		Type		Map Unit		Segrations		Type		Type			
		M Samp		Code		Height		Type		Tax Unit		Structure		Type		Type			
		Drainage		Code		Type		Type		Map Unit		Coarse Fragments		Type		Type			
		Perm		Code		Type		Type		Map Unit		Mottles		Type		Type			
		Runoff		Code		Type		Type		Map Unit		Colour		Type		Type			
		Runoff		Code		Type		Type		Map Unit		Book		Type		Type			
		Runoff		Code		Type		Type		Map Unit		Hue		Type		Type			
		Runoff		Code		Type		Type		Map Unit		V C		Type		Type			
		Runoff		Code		Type		Type		Map Unit		Moist		Type		Type			
		Runoff		Code		Type		Type		Map Unit		Abun		Type		Type			
		Runoff		Code		Type		Type		Map Unit		Size		Type		Type			
		Runoff		Code		Type		Type		Map Unit		Shape		Type		Type			
		Runoff		Code		Type		Type		Map Unit		Lith		Type		Type			
		Runoff		Code		Type		Type		Map Unit		Str		Type		Type			
		Runoff		Code		Type		Type		Map Unit		Alt		Type		Type			
		Runoff		Code		Type		Type		Map Unit		Dist		Type		Type			
		Runoff		Code		Type		Type		Map Unit		Grade		Type		Type			
		Runoff		Code		Type		Type		Map Unit		Compd		Type		Type			
		Runoff		Code		Type		Type		Map Unit		Nat		Type		Type			
		Runoff		Code		Type		Type		Map Unit		Form		Type		Type			
		Runoff		Code		Type		Type		Map Unit		Size		Type		Type			
		Runoff		Code		Type		Type		Map Unit		Edif		Type		Type			
		Runoff		Code		Type		Type		Map Unit		Cracks		Type		Type			
		Runoff		Code		Type		Type		Map Unit		SWS		Type		Type			
		Runoff		Code		Type		Type		Map Unit		Strgth		Type		Type			
		Runoff		Code		Type		Type		Map Unit		Cutans		Type		Type			
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		Runoff		Code		Type													

Wolf People

Profile Diagram

	Surface Coarse Gradients						Outcrop	
Ht	Abun	Size	Shape	Lith	Str	Alt	abun	Lith
	33	UTME						

	Prop	Species 3	Prop

GSG		Surface Condition	Microrelief					
	aff		Disturb	Type	Agent	Cmpl	Prop	VI
			GFC					

NOTES:

Check

NOTES:

888 site

0231

12014

Soil Field Survey Worksheet

Location: <u>Phakhe</u>		Site No. <u>18</u>	
Assessors: <u>Soil Core</u>		GPS no.: <u>2323188, 148.61765</u>	
Location Characteristics			
Site Landform	Flat	Crest	Hillock
	<u>Midslope</u>	Simple	Lower Slope
Slope Angle (%)	0-1	1-3	5-10
	10-20	20-32	>50
Rockoutcrop (%)	<u>Nil</u>		2-10
Current Land Use	<u>Grazing</u>		Vegetation
Microrelief			Runoff
Soil Profile Properties			
Soil Type Field Name (Australian Soil Classification)			
Surface Condition (crusted, mulched, soft, firm, gravelly, loose, trampled, cultivated)			
Erosion Type, Severity & Present Condition (rill, sheet, wind - minor, moderate, severe - stabilised, active)			
Horizon Layer	1	2	3
ASC Layer name	A	B2c	B22
Horizon Depth (eg 0 - 25 cm)	0-20	20-50	50-85
Sample Depth Collected			
Field Texture Grade	light clay	med. clay	med/heavy clay
Boundary			
Distinctiveness: (None, sharp, abrupt, clear, gradual, diffuse)	Gradual		
Shape: (even, wavy, irregular, tongued, broken)			
Peds			
Pedality Grade (Single Gr/ massive/weak/moderate/strong)	Weak	mod.	Strong
Ped Size (mm) & Fabric (Sandy, Earthy, Smooth, Rough)	5mm	10-20mm	20-40mm
Shape:	S.A.B.		
Consistence Force: (loose, weak, moderate, firm, strong)	mod.		
Fragments & Segregations			
Fragments (Type, %, mm)	Sh 3-5mm		
Segregations (Type, %, Size, Strength, Form)	Gypsum nodules	5% 2-5mm	
pH & Colour			
Field pH	4.1	7.5	7.5
Field Colour: (Munsell)	7.5	8.5	9.1
Mottles			
Abundance (%)			
Colour			
Contrast (Fnt, distinct, prominent)			
Roots & Moisture			
Size & Amount (few/common/many/abundant)	< 1mm	1-2 mm	< 1mm
Field Moisture	Dry	moist	
Drainage (V. Poor, Poor, Imperfect, Moderate, Well, Rapid)	Poor		
Comments:			

Vertisol.

mulched.

Sheet - moderate.

B2c

B22

50-85

85+

med/heavy clay

Gradual

Weak

mod.

Strong

5mm

10-20mm

20-40mm

S.A.B.

mod.

Sh 3-5mm

Gypsum nodules

5% 2-5mm

4.1

7.5

7.5

8.5

9.1

Dry

moist

Poor

SITE DESCRIPTION

[illegible]

NOTES:

Soil Field Survey Worksheet

Location:		Site No. 70	
Assessors:		GPS no.: -23.23418, 148.62811.	
Location Characteristics			
Site Landform	Flat	Crest	Hillock
	Midslope	Simple	Lower Slope
Slope Angle (%)	0-1	1-3	Op. Depres
	10-20	20-32	5-10
Rockoutcrop (%)	Nil	0-2	2-10
Current Land Use	Vegetation		
Microrelief	Runoff		
Soil Profile Properties			
Soil Type Field Name (Australian Soil Classification)			
Surface Condition (crusted, mulched, soft, firm, gravelly, loose, trampled, cultivated)			
Erosion Type, Severity & Present Condition (rill, sheet, wind - minor, moderate, severe - stabilised, active)			
Horizon Layer	1	2	3
ASC Layer name	A	B2c	B2c22
Horizon Depth (eg 0 - 25 cm)	0-20	20-40	40-80
Sample Depth Collected			50-70
Field Texture Grade	light clay	med. clay	Med. clay
Boundary			
Distinctiveness: (None, sharp, abrupt, clear, gradual, diffuse)			
Shape: (even, wavy, irregular, tongued, broken)			
Peds	Single	Columnar	Sub-angular blocky
Pedality Grade (Single Gr/ massive/weak/moderate/strong)	Weak	moderate	moderate
Ped Size (mm) & Fabric (Sandy, Earthy, Smooth, Rough)	5mm	15-20	25mm
Shape:	EAthy		
Consistence Force: (loose, weak, moderate, firm, strong)	moderate		
Fragments & Segregations			
Fragments (Type, %, mm)	5% iron stone 5-10mm	2% Gypsum 2mm	5% Gypsum 5mm
Segregations (Type, %, Size, Strength, Form)			
pH & Colour			
Field pH	8	8	8.5
Field Colour: (Munsell)	4/2 7.5YR	5/3 7.5YR	5/2 7.5YR
Mottles			54 7.5YR
Abundance (%)			
Colour			
Contrast (Fnt, distinct, prominent)			
Roots & Moisture			
Size & Amount (few/commom/many/abundant)	few	1-2 mm	1-2 mm
Field Moisture	Dry	mod	
Drainage (V. Poor, Poor, Imperfect, Moderate, Well, Rapid)	poor		
Comments:			

Butt, Bigelow

SITE DESCRIPTION

check

Geology		Slope		Landform Element		Landform Pattern		Land Use		Described By		Date (ddmmyy)		Project		Site		Obs		S Type	
P 40F		Percent		Type		Pattern		LU1		1CT		220519		EXHIBIT		0336					
TSO		Depth		Tax Unit		Map Unit		Air Photos		Distance		Depth		Gr S		Gen T		Mass Str		MC2	
M Type		M Smp		Type		Type		Film No		OT		Cont		Str		Lith		Text		MCS	
L Meas		Aggrdn		Code		Code		Run No		Agent		Shape		Lith		Alt				MC1	
Obs Reas		M Smp		Type		Type		Frame No		Type		Size		Lith		Str					
		Drainage		Code		Code				Type		Abun		Lith		Str					
		Perm		Code		Code				Type		Abun		Lith		Str					
		Runoff		Code		Code				Type		Abun		Lith		Str					
		Depth		Code		Code				Type		Abun		Lith		Str					
		M Smp		Code		Code				Type		Abun		Lith		Str					
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		Depth		Code		Code				Type											

SITE DESCRIPTION

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SITE DESCRIPTION

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Geology		Slope		Landform Element		Landform Pattern		Land Use		Described By		Date (ddmmyy)		Project		Site		S Type	
Pint		Percent Class		Type Height Width Length		Pattern Modal RMS		LU1 Mg1 Mg2		CT		250519		FAIRHILL		01344			
TSO		Depth R Horiz		Tax Unit		Map Unit		Air Photos		Distance		Depth		Gr S		Str		Gen T	
M Type		M Samp		Type Code		Type Code		Film No		OT		Coil		Sp F		Str		Lith	
L Meas		M Smp		Code		Code		Run No		Frame No		Coil		Gr S		Str		Lith	
Obs Reas		M Smp		Code		Code		Run No		Frame No		Coil		Gr S		Str		Lith	
Runoff		M Smp		Code		Code		Run No		Frame No		Coil		Gr S		Str		Lith	
Perme		M Smp		Code		Code		Run No		Frame No		Coil		Gr S		Str		Lith	
Drainage		M Smp		Code		Code		Run No		Frame No		Coil		Gr S		Str		Lith	
Aggrede		M Smp		Code		Code		Run No		Frame No		Coil		Gr S		Str		Lith	
Depth		M Smp		Code		Code		Run No		Frame No		Coil		Gr S		Str		Lith	
Class		M Smp		Code		Code		Run No		Frame No		Coil		Gr S		Str		Lith	
MT		M Smp		Code		Code		Run No		Frame No		Coil		Gr S		Str		Lith	
Int		M Smp		Code		Code		Run No		Frame No		Coil		Gr S		Str		Lith	

Profile Diagram		Surface Coarse Fragments		Microrelief		Surface Condition		GSG		PPF		Australian Soil Classification		Location		Community		Erosion	
MC2		Abun		Type		Disturb		Aff		F5		Sub Ord		Northing / Longitude		Ref No		Deg	
MC1		Shape		Prop		Gc		F4		F5		SG/ SO2		Easting / Latitude		Name		State	
MDS		Size		Agent		4C		F3		F4		G/ O2		72557429799		BRIGALOW		Type	
MC1		Lith		Type		4C		F2		F4		SG/ SO2		72557429799		BRIGALOW		Type	
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MC1		Lith		Type															

Profile, Andrew

Profile Diagram

PHOTOS
640-658

[illegible]

Test	MetH	A21	A22	A/C
pH - RP	5.5	7.0	8.5	8.0
EC				
Disp				

NOTES:

Plate 111

Profile Diagram	
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[illegible]

Test	Meth
pH - RP	A1 6.0
EC	1321 5.5
Disp	1322 5.0
	B/C 6.0

NOTES:

Rep site 0334

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200

/2014

Soil Field Survey Worksheet

Date:

Location:		Fairwell		Site No. 75	
Assessors:		Soil Core		GPS no.: 23.23625, 148.63601.	
Location Characteristics					
Site Landform	Flat	Crest	Hillock	Ridge	Upper Slope
	Midslope	Simple	Lower Slope	Op. Depres	Cl. Depres.
Slope Angle (%)	0-1	1-3	3-5	5-10	
	10-20	20-32	32-50	>50	
Rockoutcrop (%)		Nil			
Current Land Use	Grazing		Vegetation		
Microrelief			Runoff		
Soil Profile Properties					
Soil Type Field Name (Australian Soil Classification)					
Surface Condition (crusted, mulched, soft, firm, gravelly, loose, trampled, cultivated)					
Erosion Type, Severity & Present Condition (rill, sheet, wind - minor, moderate, severe - stabilised, active)					
Horizon Layer	1	2	3	4	
ASC Layer name	A	B	B/C		
Horizon Depth (eg 0 - 25 cm)	0-20	30-50	50-70		R.
Sample Depth Collected					
Field Texture Grade	light clay	medium			
Boundary					
Distinctiveness: (None, sharp, abrupt, clear, gradual, diffuse)					
Shape: (even, wavy, irregular, longued, broken)					
Peds	Prismatic	Columnar	Angular blocky	Sub-angular blocky	Polymictal
Pedality Grade (Single Gr/ massive/weak/moderate/strong)	Weak.	mod.			Weak.
Ped Size (mm) & Fabric (Sandy, Earthy, Smooth, Rough)	5mm - 10mm.	5-20mm.			5-10mm.
Shape:	SAB				
Consistence Force: (loose, weak, moderate, firm, strong)	mod.				
Fragments & Segregations					
Fragments (Type, %, mm)					2% Gypsum.
Segregations (Type, %, Size, Strength, Form)					
pH & Colour					
Field pH	7.5	8			8.5
Field Colour: (Munsell)	3/2 7.5R.	4/1 7.5R.			5/1 7.5R.
Moistures					
Abundance (%)					
Colour					
Contrast (Fnt, distinct, prominent)					
Roots & Moisture					
Size & Amount	<1mm	1-2mm	<1mm	1-2mm	<1mm
few/common/many/abundant	few.	few.			
Field Moisture	Dry				
Drainage (V. Poor, Poor, Imperfect, Moderate, Well, Rapid)	poor.				
Comments:					

SITE DESCRIPTION

PHOTO 842-853

Geology	Site
PWT	08134

Land Use	Project
LU1	FAIRHILL

Date (ddmmyy)	Described By
250519	CT

Landform Pattern	Landform Element
Pattern Class	Type
RUS	RES

Map Unit	Map Unit
Code	Code

Australian Soil Classification	PPF
Sub	
Ord	

Location	Nothing / Longitude
Easting / Latitude	
556673857429383	DE RE

Community	Community
Name	
SL IRON ORE, GREY GUM, BUFFEL GRASS	

Erosion	Ref No
SA2	1
	2
	3

TSO	M Type
A	

Substrate	Profile Diagram
SP	PHOTO 842-853

Surface Coarse Fragments	Outcrop
Abun	Abun
52	52

Microrelief	Surface Condition
VI	XF

Coarse Fragments	Structure
Shape	Type
12 ST ME	M3 S3

Mottles	Colour
Abun	Hue
1	5YR 4/6

Field Texture	Bound
Field Texture	Shape
FSLC	4

Depth	Upper
Lower	
20	

Horizon	Horizon
1	
2	
3	

Field Texture	Bound
Field Texture	Shape
FSLC	4

Depth	Upper
Lower	
20	

Coarse Fragments	Structure
Shape	Type
12 ST ME	M3 S3

Mottles	Colour
Abun	Hue
1	5YR 4/6

Field Texture	Bound
Field Texture	Shape
FSLC	4

Depth	Upper
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20	

Horizon	Horizon
1	
2	
3	

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Depth	Upper
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Horizon	Horizon
1	
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Field Texture	Shape
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Depth	Upper
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Field Texture	Shape
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Depth	Upper
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Horizon	Horizon
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2	
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Field Texture	Shape
FSLC	4

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Lower	
20	

Horizon	Horizon
1	
2	
3	

Field Texture	Bound
Field Texture	Shape
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Depth	Upper
Lower	
20	

Coarse Fragments	Structure
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Mottles	Colour
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1	
2	
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Field Texture	Bound
Field Texture	Shape
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Depth	Upper
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20	

Horizon	Horizon
1	
2	
3	

Field Texture	Bound
Field Texture	Shape
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Depth	Upper
Lower	
20	

Coarse Fragments	Structure
Shape	Type
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Field Texture	Bound
Field Texture	Shape
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Depth	Upper
Lower	
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Horizon	Horizon
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Field Texture	Bound
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Depth	Upper
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FSLC	4

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Coarse Fragments	Structure
Shape	Type
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Mottles	Colour
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Field Texture	Bound
Field Texture	Shape
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Horizon	Horizon
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Coarse Fragments	Structure
Shape	Type
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Abun	Hue
1	5YR 4/6

Field Texture	Bound
Field Texture	Shape
FSLC	4

Depth	Upper
Lower	
20	

Ch. 2

GR-	BR
Chay is down the line	GC surface
Rob: DE Chay another	HC surface

Obs site

08/11

Date: 12014

Soil Field Survey Worksheet

Location: FRANKLIN		Site No. 24	
Assessors: (Soil Core)		GPS no.: 23.23529 148.63601	
Location Characteristics			
Site Landform	Flat	Hillock	Ridge
	Midslope	Lower Slope	Op. Depres.
Slope Angle (%)	1-3	3-5	5-10
	20-32	32-50	>50
Rockoutcrop (%)	Nil	0-2	2-10
Current Land Use	Vegetation		
Microrelief	Runoff		
Soil Profile Properties			
Soil Type Field Name (Australian Soil Classification)			
Surface Condition (crusted, mulched, soft, firm, gravelly, loose, trampled, cultivated)			
Erosion Type, Severity & Present Condition (rill, sheet, wind - minor, moderate, severe - stabilised, active)			
Horizon Layer	1	2	3
ASC Layer name			4
Horizon Depth (eg 0 - 25 cm)	0 - 15	15 - 40	40 - 80+
Sample Depth Collected			
Field Texture Grade	light clay	medium clay	weathered.
Boundary			
Distinctiveness: (None, sharp, abrupt, clear, gradual, diffuse)	Clear	Gradual.	
Shape: (even, wavy, irregular, tongued, broken)			
Peds			
Pedality Grade (Single Gr/ massive/weak/moderate/strong)	weak	mod	
Ped Size (mm) & Fabric (Sandy, Earthy, Smooth, Rough)	5mm Earthy	5mm - 20mm	
Shape:	Polyhedral	S.A.B.	
Consistence Force: (loose, weak, moderate, firm, strong)	mod.		
Fragments & Segregations			
Fragments (Type, %, mm)	10% ironstone 10mm		ironstone Sst 20%
Segregations (Type, %, Size, Strength, Form)			
pH & Colour			
Field pH	7.5	8.5	8.5
Field Colour: (Munsell)	4/2 7.5R	5/3 7.5R	5/4 7.5R
Mottles			
Abundance (%)			
Colour			
Contrast (Fnt, distinct, prominent)			
Roots & Moisture			
Size & Amount	few		
Field Moisture	Dry		
Drainage (V. Poor, Poor, Imperfect, Moderate, Well, Rapid)	Poor		
Comments:			

Chalk

NOTES:

REP site 0047

2014

Soil Field Survey Worksheet

Location: FAIRFALL		Site No. 26	
Assessors: (Soil Core)		GPS no.: 23-23603, 148.63601	
Location Characteristics			
Site Landform	Flat	Hillock	Upper Slope
	Midslope	Lower Slope	Cl. Depres.
Slope Angle (%)	0-1	3-5	Slope Type
	10-20	32-50	
Rockoutcrop (%)	Nil	0-2	20-30
Current Land Use	Vegetation		Runoff
Soil Profile Properties			
Soil Type Field Name (Australian Soil Classification)			
Surface Condition (crusted, mulched, soft, firm, gravelly, loose, trampled, cultivated)			
Erosion Type, Severity & Present Condition (rill, sheet, wind - minor, moderate, severe - stabilised, active)			
Horizon Layer	1	2	3
ASC Layer name			4
Horizon Depth (eg 0 - 25 cm)	0 - 20	20 - 40	40 - 80
Sample Depth Collected			
Field Texture Grade	light clay		light sandy clay
Boundary			
Distinctiveness: (None, sharp, abrupt, clear, gradual, diffuse)	Gradual	Abrupt	
Shape: (even, wavy, irregular, tongued, broken)	Even		
Peds			
Pedality Grade (Single Gr/ massive/weak/moderate/strong)	mod.		
Ped Size (mm) & Fabric (Sandy, Earthy, Smooth, Rough)	5 - 10mm	10mm - 20mm	20mm
Shape:	Subangular	Angular	Subangular
Consistence Force: (loose, weak, moderate, firm, strong)	Weak	mod.	Weak
Fragments & Segregations			
Fragments (Type, %, mm)	limestone 5% 2-5mm		Manganese 2% 2-5mm
Segregations (Type, %, Size, Strength, Form)			
pH & Colour			
Field pH	9	8.5	8
Field Colour: (Munsell)	4/1 7.5YR	4/1 7.5YR	5/6 7.5YR
Abundance (%)			
Colour			
Contrast (Fnt, distinct, prominent)			
Roots & Moisture			
Size & Amount (few/common/many/abundant)	< 1mm	1-2 mm	1-2 mm
Field Moisture	Common		
Drainage (V. Poor, Poor, Imperfect, Moderate, Well, Rapid)	Imperfect		
Comments:			

SITE DESCRIPTION

Profile, Analysis

Geology		Slope		Landform Element		Landform Pattern		Land Use		Described By		Date (ddmmyy)		Project		Site											
TSO	M Type	L Meas	Obs Reas	Runoff	Perm	Drainage	M Smp	Aggradn	Depth R Horiz	Type	Height	Width	Length	Pattern	Class	Modal	RMS	LU1	Mgt1	Mgt2							
100	P			123						PLA				PLA													
Location				Map Unit				Air Photos				Substrate				Profile Diagram											
Datum		Zone		Easting / Latitude		Northing / Longitude		Conf		Ord		Sub Ord		GG/ Or2		SG/ SO2		F1		F2		F3		F4		F5	
556653547428218		D E B R																									
Community				Name				Species 1				Species 2				Species 3											
Old Shrubland, bright yellow, RRL																											

Number	Horizon	Depth		Bound	Field Texture		SWS	Colour		Moist	Mottles		Coarse Fragments					Structure		Segregations				Strgth	Cutans			Pans		Samples																					
		Upper	Lower		Shape	Field Texture		Qual	Book		Hue	V	C	Abun	Size	Contr	Col	Abun	Size	Shape	Lth	Str	Alt		Dist	Grade	Size	Type	Compd		Abun	Nat	Form	Size	Eff	Cracks	SWS	Cons	Fabric	Kind	Abund.	Distinct	Type	Cont	Sr						
1	A1	0	10	C	CLS			7.5YR 2.5	10																																			0-10							
2	B21	10	30	G	LMC			7.5YR 3.1	10																																			10-20							
3	B22	30	50	G	AS LMC			7.5YR 3.2	10																																				20-30						
4	B23	50	120		AS LMC			7.5YR 5.4	10																																				50-60						
5																																															80-90				
6																																															110-120				
7																																																			
Test		A1		B21		B22		B23		B24		B25		B26		B27		B28		B29		B30		B31		B32		B33		B34		B35		B36		B37		B38		B39		B40									
pH - RP		6.0		8.0		8.0		8.0		8.0		8.0		8.0		8.0		8.0		8.0		8.0		8.0		8.0		8.0		8.0		8.0		8.0		8.0		8.0		8.0		8.0		8.0							
EC																																																			
Diap																																																			

NOTES:

SITE DESCRIPTION

Public Access

Geology		Slope		Landform Element		Landform Pattern		Land Use		Described By		Date (ddmmyy)		Project	
102		Percent Class		Type Height Width Length		Pattern Class RMS		LU1 Mgt1 Mgt2		CT		250518		FARMHILL	
TSO		Runoff		Type Code		Type Code		Run No		Distance		Depth		Gen T	
M Type		Perim		Type Code		Type Code		Film No		OT		Gr S		Str	
L Meas		Drainage		Type Code		Type Code		Frame No		Conf		Str		Lith	
Obs Reas		M Smp		Type Code		Type Code		Run No		Conf		Str		Lith	
Depth R Horiz		Aggradn		Type Code		Type Code		Film No		Conf		Str		Lith	
Easting / Latitude		Northing / Longitude		Type Code		Type Code		Film No		Conf		Str		Lith	
Zone		Location		Type Code		Type Code		Film No		Conf		Str		Lith	
556651787428070		DIEBR		Type Code		Type Code		Film No		Conf		Str		Lith	
Erosion		Community		Type Code		Type Code		Film No		Conf		Str		Lith	
SHA2		SLTANBARK, POP BOX, RRA, WILGA, CAESAR, PINNACLE, DRIELOW, M3 ASH, RUGGEL, GROSS		Type Code		Type Code		Film No		Conf		Str		Lith	
Ref No		Name		Type Code		Type Code		Film No		Conf		Str		Lith	
1		SLTANBARK, POP BOX, RRA, WILGA, CAESAR, PINNACLE, DRIELOW, M3 ASH, RUGGEL, GROSS		Type Code		Type Code		Film No		Conf		Str		Lith	
2		SLTANBARK, POP BOX, RRA, WILGA, CAESAR, PINNACLE, DRIELOW, M3 ASH, RUGGEL, GROSS		Type Code		Type Code		Film No		Conf		Str		Lith	
3		SLTANBARK, POP BOX, RRA, WILGA, CAESAR, PINNACLE, DRIELOW, M3 ASH, RUGGEL, GROSS		Type Code		Type Code		Film No		Conf		Str		Lith	

Community 1 Details		Species 1		Species 2		Species 3	
Prop		Prop		Prop		Prop	
Strata		Form		Height		Cover	
T		M		L		L	
Horizon		Depth		Field Texture		Bound	
Upper		Lower		Shape		Contd	
1		20		SCL		G	
2		35		SCL		C	
3		35+		SCL		C	
4							
5							
6							
7							

Coarse Fragments		Structure		Segregations		Strgth		Cutans		Pans		Samples	
Shape		Type		Form		SWS		Abund		Cont		0-10	
Size		Size		Size		Size		Kind		Type		10-20	
Abun		Grade		Abun		Abun		Fabric		Str		20-30	
Col		Dist		Comp		Cons		Cons		Type		40-50	
Contr		Alt		Type		Cons		Cons		Type		50-60	
Size		Str		Type		Cons		Cons		Type			
Abun		Lith		Type		Cons		Cons		Type			
Col		Shape		Type		Cons		Cons		Type			
Contr		Size		Type		Cons		Cons		Type			
Size		Abun		Type		Cons		Cons		Type			
Abun		Col		Type		Cons		Cons		Type			
Col		Contr		Type		Cons		Cons		Type			
Contr		Size		Type		Cons		Cons		Type			
Size		Abun		Type		Cons		Cons		Type			
Abun		Col		Type		Cons		Cons		Type			
Col		Contr		Type		Cons		Cons		Type			
Contr		Size		Type		Cons		Cons		Type			
Size		Abun		Type		Cons		Cons		Type			
Abun		Col		Type		Cons		Cons		Type			
Col		Contr		Type		Cons		Cons		Type			
Contr		Size		Type		Cons		Cons		Type			
Size		Abun		Type		Cons		Cons		Type			
Abun		Col		Type		Cons		Cons		Type			
Col		Contr		Type		Cons		Cons		Type			
Contr		Size		Type		Cons		Cons		Type			
Size		Abun		Type		Cons		Cons		Type			
Abun		Col		Type		Cons		Cons		Type			
Col		Contr		Type		Cons		Cons		Type			
Contr		Size		Type		Cons		Cons		Type			
Size		Abun		Type		Cons		Cons		Type			
Abun		Col		Type		Cons		Cons		Type			
Col		Contr		Type		Cons		Cons		Type			
Contr		Size		Type		Cons		Cons		Type			
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Abun		Col		Type		Cons		Cons		Type			
Col		Contr		Type		Cons		Cons		Type			
Contr		Size		Type		Cons		Cons		Type			
Size		Abun		Type		Cons		Cons		Type			
Abun		Col		Type		Cons		Cons		Type			
Col		Contr		Type		Cons		Cons		Type			
Contr		Size		Type		Cons		Cons		Type			
Size		Abun		Type		Cons		Cons		Type			
Abun		Col		Type		Cons		Cons		Type			
Col		Contr		Type		Cons		Cons		Type			
Contr		Size		Type		Cons		Cons		Type			
Size		Abun		Type		Cons		Cons		Type			
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Col		Contr		Type		Cons		Cons		Type			
Contr		Size		Type		Cons		Cons		Type			
Size		Abun		Type		Cons		Cons		Type			
Abun		Col		Type		Cons		Cons		Type			
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Contr		Size		Type		Cons		Cons		Type			
Size		Abun		Type		Cons		Cons		Type			
Abun		Col		Type		Cons		Cons		Type			
Col		Contr		Type		Cons		Cons		Type			
Contr		Size		Type		Cons		Cons		Type			
Size		Abun		Type		Cons		Cons		Type			
Abun		Col		Type		Cons		Cons		Type			
Col		Contr		Type		Cons		Cons		Type			
Contr		Size		Type		Cons		Cons		Type			
Size		Abun		Type		Cons		Cons		Type			
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Col		Contr		Type		Cons		Cons		Type			
Contr		Size		Type		Cons		Cons		Type			
Size		Abun		Type		Cons		Cons		Type			
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Col		Contr		Type		Cons		Cons		Type			
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Size		Abun		Type		Cons		Cons		Type			
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Col		Contr		Type		Cons		Cons		Type			
Contr		Size		Type		Cons		Cons		Type			
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Col		Contr		Type		Cons		Cons		Type			
Contr		Size		Type		Cons		Cons		Type			
Size		Abun		Type		Cons		Cons		Type			
Abun		Col		Type		Cons		Cons		Type			
Col		Contr		Type		Cons		Cons		Type			
Contr		Size		Type		Cons		Cons		Type			
Size		Abun		Type		Cons		Cons		Type			
Abun		Col		Type		Cons		Cons		Type			
Col		Contr		Type		Cons		Cons		Type			
Contr		Size		Type		Cons		Cons		Type			
Size		Abun		Type		Cons		Cons		Type			
Abun		Col		Type		Cons		Cons		Type			
Col		Contr		Type		Cons		Cons		Type			
Contr		Size		Type		Cons		Cons		Type			
Size		Abun		Type		Cons		Cons		Type			
Abun		Col		Type		Cons		Cons		Type			
Col		Contr		Type		Cons		Cons		Type			
Contr		Size		Type		Cons		Cons		Type			
Size		Abun		Type		Cons		Cons		Type			
Abun		Col		Type		Cons		Cons		Type			
Col		Contr		Type		Cons		Cons		Type			
Contr		Size		Type		Cons		Cons		Type			
Size		Abun		Type		Cons		Cons		Type			
Abun		Col		Type		Cons		Cons		Type			
Col		Contr		Type		Cons		Cons		Type			
Contr		Size		Type		Cons		Cons		Type			
Size		Abun		Type		Cons		Cons		Type			
Abun		Col		Type		Cons		Cons		Type			
Col		Contr		Type		Cons		Cons		Type			
Contr		Size		Type		Cons		Cons		Type			
Size		Abun		Type		Cons		Cons		Type			
Abun		Col		Type		Cons		Cons		Type			
Col		Contr		Type		Cons		Cons		Type			
Contr		Size		Type		Cons		Cons		Type			
Size		Abun		Type		Cons		Cons		Type			
Abun		Col		Type		Cons		Cons		Type			
Col		Contr		Type		Cons		Cons		Type			
Contr		Size		Type		Cons		Cons		Type			
Size		Abun		Type		Cons		Cons		Type			
Abun		Col		Type		Cons		Cons		Type			
Col		Contr		Type		Cons		Cons		Type			
Contr		Size		Type		Cons		Cons		Type			
Size		Abun		Type		Cons		Cons		Type			
Abun		Col		Type		Cons		Cons		Type			
Col		Contr		Type		Cons		Cons		Type			
Contr		Size		Type		Cons		Cons		Type			
Size		Abun		Type		Cons		Cons		Type			
Abun		Col		Type		Cons		Cons		Type			
Col		Contr		Type		Cons		Cons		Type			
Contr		Size		Type		Cons		Cons		Type			
Size		Abun		Type									

Pdico. Vol.

NOTES:

Check

895495
SODAD

[illegible]

Test	Meth
pH - RP	
EC	
Disp	

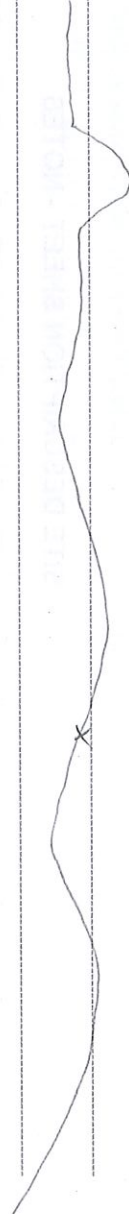
NOTES:

SITE DESCRIPTION

check

Geology		Slope		Landform Element		Landform Pattern		Land Use		Described By		Date (ddmmyy)		Project		Site		S Type		Obs	
DA		Percent		Type		Pattern		LU1		CT		25/05/19		CLAIRBARK		AB32					
TSO		Depth		Tax Unit		Map Unit		Air Photos		Distance		Depth		Gr S		Str		Lith		Gen T	
M Type		Aggrede		Type		Type		Film No		OT		Conf		Gr S		Str		Lith		Gen T	
L Meas		M Samp		Code		Code		Run No		Frame No		Conf		Gr S		Str		Lith		Gen T	
Obs Reas		Perm		Type		Type		Film No		Frame No		Conf		Gr S		Str		Lith		Gen T	
Zone		Easting / Longitude		North / Longitude		Australian Soil Classification		PPF		GSG		Surface Condition		Microrelief		Surface Coarse Fragments		Outcrop		Profile Diagram	
Datum		556652127428373		DE		Col		Ord		Sub		SG		F1		F2		F3		F4	
Ref No		1		2		3		Name		Community		Species 1		Species 2		Species 3		Prop		Prop	
Type		SAR		Erosion		Deg		State		No		GD		No		No		No		No	
Horizon		Upper		Lower		Depth		Bound		Field Texture		Qual		SWS		Book		Colour		Mottles	
Number		1		2		3		4		5		6		7		8		9		10	
Shape		CL5		CL5		CL5		CL5		CL5		CL5		CL5		CL5		CL5		CL5	
Field Texture		CL5		CL5		CL5		CL5		CL5		CL5		CL5		CL5		CL5		CL5	
Qual		CL5		CL5		CL5		CL5		CL5		CL5		CL5		CL5		CL5		CL5	
SWS		CL5		CL5		CL5		CL5		CL5		CL5		CL5		CL5		CL5		CL5	
Book		CL5		CL5		CL5		CL5		CL5		CL5		CL5		CL5		CL5		CL5	
Colour		CL5		CL5		CL5		CL5		CL5		CL5		CL5		CL5		CL5		CL5	
Mottles		CL5		CL5		CL5		CL5		CL5		CL5		CL5		CL5		CL5		CL5	
Coarse Fragments		CL5		CL5		CL5		CL5		CL5		CL5		CL5		CL5		CL5		CL5	
Structure		CL5		CL5		CL5		CL5		CL5		CL5		CL5		CL5		CL5		CL5	
Segregations		CL5		CL5		CL5		CL5		CL5		CL5		CL5		CL5		CL5		CL5	
Strgth		CL5		CL5		CL5		CL5		CL5		CL5		CL5		CL5		CL5		CL5	
Cutans		CL5		CL5		CL5		CL5		CL5		CL5		CL5		CL5		CL5		CL5	
Pans		CL5		CL5		CL5		CL5		CL5		CL5		CL5		CL5		CL5		CL5	
Samples		CL5		CL5		CL5		CL5		CL5		CL5		CL5		CL5		CL5		CL5	
Test		pH-RP		EC		Disp		Meth													

NOTES:



check

NOTES:

Red Poles

NOTES:

SITE DESCRIPTION

P. J. R. Anderson

Geology		Slope		Landform Element		Landform Pattern		Land Use		Described By		Date (ddmmyy)		Project		Site		S Type	
R2		Percent		Type		Pattern		LU1		CT		290519		RAIRAUUC		PR01			
TSO		Runoff		Type		Code		Map Unit		Code		Type		Code		Type		Code	
L Meas		243		Type		Code		Type		Code		Type		Code		Type		Code	
M Type		243		Type		Code		Type		Code		Type		Code		Type		Code	
Obs Reas		243		Type		Code		Type		Code		Type		Code		Type		Code	
Depth R Horiz		243		Type		Code		Type		Code		Type		Code		Type		Code	
Air Photos		243		Type		Code		Type		Code		Type		Code		Type		Code	
Frame No		243		Type		Code		Type		Code		Type		Code		Type		Code	
Run No		243		Type		Code		Type		Code		Type		Code		Type		Code	
Distance		243		Type		Code		Type		Code		Type		Code		Type		Code	
Depth		243		Type		Code		Type		Code		Type		Code		Type		Code	
Gr S		243		Type		Code		Type		Code		Type		Code		Type		Code	
Str		243		Type		Code		Type		Code		Type		Code		Type		Code	
Lith		243		Type		Code		Type		Code		Type		Code		Type		Code	
Gen T		243		Type		Code		Type		Code		Type		Code		Type		Code	
Text		243		Type		Code		Type		Code		Type		Code		Type		Code	
Mass Str		243		Type		Code		Type		Code		Type		Code		Type		Code	
MOS		243		Type		Code		Type		Code		Type		Code		Type		Code	
MC1		243		Type		Code		Type		Code		Type		Code		Type		Code	
MC2		243		Type		Code		Type		Code		Type		Code		Type		Code	
Profile Diagram		243		Type		Code		Type		Code		Type		Code		Type		Code	
PHOTO8		243		Type		Code		Type		Code		Type		Code		Type		Code	
727-748		243		Type		Code		Type		Code		Type		Code		Type		Code	
Community 1 Details		243		Type		Code		Type		Code		Type		Code		Type		Code	
Species 1		243		Type		Code		Type		Code		Type		Code		Type		Code	
Species 2		243		Type		Code		Type		Code		Type		Code		Type		Code	
Species 3		243		Type		Code		Type		Code		Type		Code		Type		Code	
Prop		243		Type		Code		Type		Code		Type		Code		Type		Code	
Height		243		Type		Code		Type		Code		Type		Code		Type		Code	
Cover		243		Type		Code		Type		Code		Type		Code		Type		Code	
Cov Cl		243		Type		Code		Type		Code		Type		Code		Type		Code	
Ht Cl		243		Type		Code		Type		Code		Type		Code		Type		Code	
Form		243		Type		Code		Type		Code		Type		Code		Type		Code	
Strata		243		Type		Code		Type		Code		Type		Code		Type		Code	
T		243		Type		Code		Type		Code		Type		Code		Type		Code	
M		243		Type		Code		Type		Code		Type		Code		Type		Code	
L		243		Type		Code		Type		Code		Type		Code		Type		Code	
Name		243		Type		Code		Type		Code		Type		Code		Type		Code	
Ref No		243		Type		Code		Type		Code		Type		Code		Type		Code	
1		243		Type		Code		Type		Code		Type		Code		Type		Code	
2		243		Type		Code		Type		Code		Type		Code		Type		Code	
3		243		Type		Code		Type		Code		Type		Code		Type		Code	
Type		243		Type		Code		Type		Code		Type		Code		Type		Code	
SAR		243		Type		Code		Type		Code		Type		Code		Type		Code	
Erosion		243		Type		Code		Type		Code		Type		Code		Type		Code	
Deg		243		Type		Code		Type		Code		Type		Code		Type		Code	
State		243		Type		Code		Type		Code		Type		Code		Type		Code	
Type		243		Type		Code		Type		Code		Type		Code		Type		Code	
Horizon		243		Type		Code		Type		Code		Type		Code		Type		Code	
1		243		Type		Code		Type		Code		Type		Code		Type		Code	
2		243		Type		Code		Type		Code		Type		Code		Type		Code	
3		243		Type		Code		Type		Code		Type		Code		Type		Code	
4		243		Type		Code		Type		Code		Type		Code		Type		Code	
5		243		Type		Code		Type		Code		Type		Code		Type		Code	
6		243		Type		Code		Type		Code		Type		Code		Type		Code	
7		243		Type		Code		Type		Code		Type		Code		Type		Code	
Number		243		Type		Code		Type		Code		Type		Code		Type		Code	
Horizon		243		Type		Code		Type		Code		Type		Code		Type		Code	
1		243		Type		Code		Type		Code		Type		Code		Type		Code	
2		243		Type		Code		Type		Code		Type		Code		Type		Code	
3		243		Type		Code		Type		Code		Type		Code		Type		Code	
4		243		Type		Code		Type		Code		Type		Code		Type		Code	
5		243		Type		Code		Type		Code		Type		Code		Type		Code	
6		243		Type		Code		Type		Code		Type		Code		Type		Code	
7		243		Type		Code		Type		Code		Type		Code		Type		Code	
Depth		243		Type		Code		Type		Code		Type		Code		Type		Code	
Upper		243		Type		Code		Type		Code		Type		Code		Type		Code	
Lower		243		Type		Code		Type		Code		Type		Code		Type		Code	
Bound		243		Type		Code		Type		Code		Type		Code		Type		Code	
Shape		243		Type		Code		Type		Code		Type		Code		Type		Code	
Dist		243		Type		Code		Type		Code		Type		Code		Type		Code	
Field Texture		243		Type		Code		Type		Code		Type		Code		Type		Code	
Qual		243		Type		Code		Type		Code		Type		Code		Type		Code	
SWS		243		Type		Code		Type		Code		Type		Code		Type		Code	
Book		243		Type		Code		Type		Code		Type		Code		Type		Code	
Hue		243		Type		Code		Type		Code		Type		Code		Type		Code	
V		243		Type		Code		Type		Code		Type		Code		Type		Code	
C		243		Type		Code		Type		Code		Type		Code		Type		Code	
Moist		243		Type		Code		Type		Code		Type		Code		Type		Code	
Type		243		Type		Code		Type		Code		Type		Code		Type		Code	
Abun		243		Type		Code		Type		Code		Type		Code		Type		Code	
Size		243		Type		Code		Type		Code		Type		Code		Type		Code	
Cont		243		Type		Code		Type		Code		Type		Code		Type		Code	
Col		243		Type		Code		Type		Code		Type		Code		Type		Code	
Abun		243		Type		Code		Type		Code		Type		Code		Type		Code	
Shape		243		Type		Code		Type		Code		Type		Code		Type		Code	
Lith		243		Type		Code		Type		Code		Type		Code		Type		Code	
Str		243		Type		Code		Type		Code		Type		Code		Type		Code	
Alt		243		Type		Code		Type		Code		Type		Code		Type		Code	
Dist		243		Type		Code		Type		Code		Type		Code		Type		Code	
Grade		243		Type		Code		Type		Code		Type		Code		Type		Code	
Size		243		Type		Code		Type		Code		Type		Code		Type		Code	
Type		243		Type		Code		Type		Code		Type		Code		Type		Code	
Comp		243		Type		Code		Type		Code		Type		Code		Type		Code	
Abun		243		Type		Code		Type		Code		Type		Code		Type		Code	
Nat		243		Type		Code		Type		Code		Type		Code		Type		Code	
Form		243		Type		Code		Type		Code		Type		Code		Type		Code	
Size		243		Type		Code		Type		Code		Type		Code		Type		Code	
Eff		243		Type		Code		Type		Code		Type		Code		Type		Code	
Cracks		243		Type		Code		Type		Code		Type		Code		Type		Code	
SWS		243		Type		Code		Type		Code		Type		Code		Type		Code	
Cons		243		Type		Code		Type		Code		Type		Code		Type		Code	
Strgth		243		Type		Code		Type		Code		Type		Code		Type		Code	
Fabric		243		Type		Code		Type		Code		Type		Code		Type		Code	
Kind		243		Type		Code		Type		Code		Type		Code		Type		Code	
Abund		243		Type		Code		Type		Code		Type		Code		Type		Code	
Ostinct		243		Type		Code		Type		Code		Type		Code		Type		Code	
Type		243		Type		Code		Type		Code		Type		Code		Type		Code	
Cont		243		Type		Code		Type		Code		Type		Code		Type		Code	
Str		243		Type		Code		Type		Code		Type		Code		Type		Code	
Samples		243		Type		Code		Type		Code		Type		Code					

SITE DESCRIPTION

Profile

Geology		Slope		Landform Element		Landform Pattern		Land Use		Described By		Date (ddmmyy)		Project		Site		S Type	
10A		Percent		Type		Pattern		LU1		CT		22.05.19		2A1, 2A1L		0303		Obs	
TSO		Depth		Height		Class		Mgt1											
M Type		Aggredn		Loop		Modal		Mgt2											
L Meas		M Samp		Type		RMS		Frame No											
Obs Reas		Drainage		Code		LP		Run No											
Runoff		Perim		Type		Class		Film No											
223		223		Code		LP		Air Photos											
				Type		LP													
				Code		LP													
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Profile

NOTES:

Robert

Profile Diagram

[illegible]

check

NOTES:

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Profile Diagram	
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Test	Meih
pH - RP	
EC	
Disp	

NOTES:

Chuck

945-955
P4075

Test	Method
pH - RP	
EC	
Disp	

NOTES: At foot of slope below transition from put

NOTES:

APPENDIX D

Chain of Custody and Laboratory Certificates

CLIENT DETAILS

Contact Scott Hayes-Stanley
Client NORTHERN RESOURCE CONSULTANTS PTY LTD
Address 12 CANNAN STREET
SOUTH TOWNSVILLE QLD 4810

Telephone 61 7 4772 6500
Facsimile 61 7 4772 2441
Email scotths@northres.com.au

Project Fairhill Soil
Order Number (Not specified)
Samples 33

LABORATORY DETAILS

Manager Jon Dicker
Laboratory SGS Cairns Environmental
Address Unit 2, 58 Comport St
Portsmith QLD 4870

Telephone +61 07 4035 5111
Facsimile +61 07 4035 5122
Email AU.Environmental.Cairns@sgs.com

SGS Reference CE129907 R0
Date Received 16 Oct 2017
Date Reported 10 Nov 2017

COMMENTS

Accredited for compliance with ISO/IEC 17025 - Testing. NATA accredited laboratory 2562(3146).

Particle sizing of soils <75um by Hydrometer not conducted where insufficient sample passes the 75um fraction.

Please see attached report for plant available water subcontracted to Soil Conservation Service, 709 Gundy Road, SCONE NSW 2337, SCO17/175R1.

SIGNATORIES



Anthony Nilsson
Operations Manager



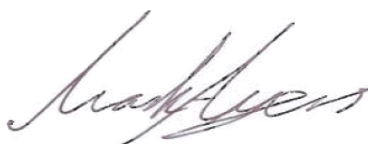
Jon Dicker
Manager Northern QLD



Leanne Orsmond
Quality & Microbiology Coordinator



Maristela Ganzan
Metals Team Leader



Mark Ayers
Team Leader - Agri Plant/Soil

Parameter	Sample Number		CE129907.001	CE129907.002	CE129907.003	CE129907.004
	Sample Matrix		Soil	Soil	Soil	Soil
	Sample Date		26 Sep 2017	26 Sep 2017	27 Sep 2017	27 Sep 2017
	Sample Name		S1_10_20	S1_20_30	S20_0_10	S20_10_20
Units	LOR					

Moisture Content Method: AN002 Tested: 16/10/2017

% Moisture	%w/w	0.5	1.1	3.0	7.7	8.2
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pH in soil (1:5) Method: AN101 Tested: 19/10/2017

pH	pH Units	-	7.2	7.4	8.7	8.8
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Conductivity and TDS by Calculation - Soil Method: AN106 Tested: 19/10/2017

Conductivity of Extract (1:5 dry sample basis)	µS/cm	1	38	56	270	330
Total Dissolved Solids (by calculation)	mg/kg	5	110	170	810	980

Chloride (water extractable) Method: AN274 Tested: 20/10/2017

Chloride (water extractable 1:5)	mg/kg	5	8	23	76	140
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Water Soluble Acidity of Soil Method: AN002/AN140 Tested: 19/10/2017

Water Soluble Acidity as CaCO ₃ to pH 8.3*	mg/kg	25	-	-	-	-
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Colwell Phosphorus Method: AN015 Tested: 18/10/2017

Colwell Phosphorus	mg/kg	1	11	7	12	11
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Parameter	Units	LOR	Sample Number	CE129907.001	CE129907.002	CE129907.003	CE129907.004
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	26 Sep 2017	26 Sep 2017	27 Sep 2017	27 Sep 2017
			Sample Name	S1_10_20	S1_20_30	S20_0_10	S20_10_20

Bicarbonate Extractable (Colwell) Potassium, K Method: AN015/AN320 Tested: 26/10/2017

Bicarbonate Extractable (Colwell) Potassium, K*	mg/kg	10	130	140	370	340
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Nitrate Nitrogen and Nitrite Nitrogen (NOx) by Auto Analyser in Soil Method: AN248 Tested: 20/10/2017

Nitrate/Nitrite Nitrogen, NOx as N	mg/kg	0.1	<0.1	<0.1	3.8	3.2
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Total Kjeldahl Nitrogen and Total Nitrogen in Soil/Sludges Method: AN281 Tested: 19/10/2017

Total Kjeldahl Nitrogen	mg/kg	5	240	400	1300	1000
Total Nitrogen	mg/kg	10	240	400	1300	1000

Total Organic Carbon by Heanes Oxidation Method: AN273 Tested: 19/10/2017

Total Organic Carbon	%w/w	0.05	0.35	0.34	1.4	1.4
Organic Matter	%w/w	0.1	0.60	0.58	2.4	2.4

Emerson Class Number Method: AN009 Tested: 18/10/2017

Emerson Class Number	No unit	1	1	1	5	5
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Exchangeable Cations and Cation Exchange Capacity (CEC/ESP/SAR) Method: AN122 Tested: 20/10/2017

Exchangeable Sodium, Na	mg/kg	2	-	-	-	-
Exchangeable Sodium, Na	meq/100g	0.01	-	-	-	-
Exchangeable Sodium Percentage	%	0.1	-	-	-	-
Exchangeable Potassium, K	mg/kg	2	-	-	-	-
Exchangeable Potassium, K	meq/100g	0.01	-	-	-	-
Exchangeable Potassium Percentage	%	0.1	-	-	-	-
Exchangeable Calcium Percentage	%	0.1	-	-	-	-
Exchangeable Calcium, Ca	mg/kg	2	-	-	-	-
Exchangeable Calcium, Ca	meq/100g	0.01	-	-	-	-
Exchangeable Magnesium, Mg	mg/kg	2	-	-	-	-
Exchangeable Magnesium, Mg	meq/100g	0.02	-	-	-	-
Exchangeable Magnesium Percentage	%	0.1	-	-	-	-
Cation Exchange Capacity	meq/100g	0.02	-	-	-	-
Exchangeable Calcium/Exchangeable Magnesium Ratio	No unit	0.1	-	-	-	-
Monovalent Cations/Divalent Cations Ratio*	No unit	0.1	-	-	-	-
Cation Exchange Capacity (soluble salts removed)	meq/100g	0.02	-	-	-	-
Sodium Adsorption Ratio	No unit	0.1	-	-	-	-
Exchangeable Aluminium, Al	cmol (+)/kg	0.01	-	-	-	-

Parameter	Units	LOR	Sample Number	CE129907.001	CE129907.002	CE129907.003	CE129907.004
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	26 Sep 2017	26 Sep 2017	27 Sep 2017	27 Sep 2017
			Sample Name	S1_10_20	S1_20_30	S20_0_10	S20_10_20

DTPA Extractable Metals in Soil Method: AN025/AN320 Tested: 20/10/2017

Copper, Cu	mg/kg	0.05	0.46	0.73	1.6	1.6
Zinc, Zn	mg/kg	0.05	0.28	0.26	0.45	0.35
Manganese, Mn	mg/kg	0.5	17	15	12	9.6
Iron, Fe	mg/kg	0.5	23	30	17	18

Calcium Chloride Extractable Boron Method: RL 12C2/AN320 Tested: 20/10/2017

CaCl2-extractable Boron, B*	mg/kg	0.05	0.34	0.43	0.95	1.3
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Calcium Chloride Extractable Molybdenum Method: RL 12E1/AN318 Tested: 31/10/2017

CaCl2-extractable Molybdenum, Mo*	mg/kg	0.1	<0.10	<0.10	<0.10	<0.10
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Potassium Chloride Extractable Sulphur Method: RL 10D1/AN320 Tested: 20/10/2017

KCl-40-extractable Sulphur, S*	mg/kg	1	2	2	9	8
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Particle sizing of soils by sieving Method: AN005 Tested: 30/10/2017

Passing 2.00mm	%w/w	1	94	97	92	94
Retained 2.00mm	%w/w	1	6	3	8	6
Passing 600µm	%w/w	1	66	69	87	89
Retained 600µm	%w/w	1	28	27	5	5
Passing 300µm	%w/w	1	36	42	84	86
Retained 300µm	%w/w	1	29	28	3	3
Passing 125µm	%w/w	1	22	25	73	76
Retained 125µm	%w/w	1	15	17	11	10
Passing 63µm	%w/w	1	20	23	70	73
Retained 63µm	%w/w	1	2	2	4	3

Particle sizing of soils <75µm by hydrometer Method: AN005 Tested: 28/10/2017

Sedimentation Diameter 1	mm	0.0001	0.0596	0.0592	0.0525	0.0518
Passing Sedimentation Diameter 1	%w/w	1	19	21	67	72
Retained Sedimentation Diameter 1	%w/w	1	1	2	3	1
Sedimentation Diameter 2	mm	0.0001	0.0424	0.0420	0.0377	0.0372
Passing Sedimentation Diameter 2	%w/w	1	16	20	62	67
Retained Sedimentation Diameter 2	%w/w	1	2	1	5	5
Sedimentation Diameter 3	mm	0.0001	0.0301	0.0298	0.0270	0.0264
Passing Sedimentation Diameter 3	%w/w	1	14	19	58	65
Retained Sedimentation Diameter 3	%w/w	1	2	1	5	2
Sedimentation Diameter 4	mm	0.0001	0.0214	0.0212	0.0193	0.0193
Passing Sedimentation Diameter 4	%w/w	1	12	17	53	53
Retained Sedimentation Diameter 4	%w/w	1	2	2	5	12
Sedimentation Diameter 5	mm	0.0001	0.01570	0.0155	0.0142	0.0143
Passing Sedimentation Diameter 5	%w/w	1	12	16	50	48
Retained Sedimentation Diameter 5	%w/w	1	<1	1	2	5
Sedimentation Diameter 6	mm	0.0001	0.0111	0.0110	0.0102	0.0102
Passing Sedimentation Diameter 6	%w/w	1	11	16	46	44
Retained Sedimentation Diameter 6	%w/w	1	1	<1	5	5
Sedimentation Diameter 7	mm	0.0001	0.0079	0.0078	0.0072	0.0073
Passing Sedimentation Diameter 7	%w/w	1	10	13	43	39
Retained Sedimentation Diameter 7	%w/w	1	1	2	2	5
Sedimentation Diameter 8	mm	0.0001	0.0056	0.0055	0.0052	0.0052
Passing Sedimentation Diameter 8	%w/w	1	8	12	41	37
Retained Sedimentation Diameter 8	%w/w	1	2	1	2	2
Sedimentation Diameter 9	mm	0.0001	0.0040	0.0039	0.0037	0.0037
Passing Sedimentation Diameter 9	%w/w	1	8	11	36	32
Retained Sedimentation Diameter 9	%w/w	1	<1	1	5	5
Sedimentation Diameter 10	mm	0.0001	0.0016	0.0016	0.0015	0.0016
Passing Sedimentation Diameter 10	%w/w	1	5	9	32	25

Parameter	Units	LOR	Sample Number	CE129907.001	CE129907.002	CE129907.003	CE129907.004
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	26 Sep 2017	26 Sep 2017	27 Sep 2017	27 Sep 2017
			Sample Name	S1_10_20	S1_20_30	S20_0_10	S20_10_20

Particle sizing of soils <75µm by hydrometer Method: AN005 Tested: 28/10/2017 (continued)

Retained Sedimentation Diameter 10	%w/w	1	2	2	5	7
Sedimentation Diameter 11	mm	0.0001	0.0012	0.0011	0.0011	0.0011
Passing Sedimentation Diameter 11	%w/w	1	3	8	22	22
Retained Sedimentation Diameter 11	%w/w	1	2	1	9	2
Clay (<0.002mm)	%w/w	0.1	5.0	9.0	32	25
Silt and Clay (<0.005mm)*	%w/w	0.1	8.0	12	41	37
Silt (0.002mm to 0.06mm)*	%w/w	0.1	15	14	38	48
Fine Sand (0.06mm to 0.20mm)*	%w/w	0.1	2.0	2.3	3.6	3.0
Medium and Coarse Sand (0.20mm to 2.0mm)*	%w/w	0.1	72	71	19	18
Gravels (>2.0mm)*	%w/w	0.1	6.3	3.4	7.8	6.2

Parameter	Units	LOR	Sample Number	CE129907.001	CE129907.002	CE129907.003	CE129907.004
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	26 Sep 2017	26 Sep 2017	27 Sep 2017	27 Sep 2017
			Sample Name	S1_10_20	S1_20_30	S20_0_10	S20_10_20

Erodibility Factor of Soil Method: CSIRO Tech Report 13/01 Tested: 26/10/2017

Erodibility Factor (K)*	t.ha.h/ha/MJ/	-	0.02	0.03	0.06	0.07
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Soil Texture (Northcote, 1979) Method: Northcote (1979) Tested: 18/10/2017

Texture Classification*	No unit	1	Sand	Sand	Light Clay	Light Clay
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Sample Subcontracted Method: Tested: 10/11/2017

Sample Subcontracted*	No unit	-	See attached	See attached	See attached	See attached
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Parameter	Units	LOR	Sample Number	CE129907.005	CE129907.006	CE129907.007	CE129907.008
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	27 Sep 2017	27 Sep 2017	28 Sep 2017	28 Sep 2017
			Sample Name	S20_50_70	S20_20_50	S21_0_10	S21_10_20

Moisture Content Method: AN002 Tested: 16/10/2017

% Moisture	%w/w	0.5	14	12	3.8	5.5
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pH in soil (1:5) Method: AN101 Tested: 19/10/2017

pH	pH Units	-	8.4	8.6	7.0	7.2
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Conductivity and TDS by Calculation - Soil Method: AN106 Tested: 19/10/2017

Conductivity of Extract (1:5 dry sample basis)	µS/cm	1	1200	480	41	46
Total Dissolved Solids (by calculation)	mg/kg	5	3500	1400	120	140

Chloride (water extractable) Method: AN274 Tested: 20/10/2017

Chloride (water extractable 1:5)	mg/kg	5	1400	360	15	7
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Water Soluble Acidity of Soil Method: AN002/AN140 Tested: 19/10/2017

Water Soluble Acidity as CaCO ₃ to pH 8.3*	mg/kg	25	<25	<25	-	-
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Colwell Phosphorus Method: AN015 Tested: 18/10/2017

Colwell Phosphorus	mg/kg	1	3	4	8	5
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Parameter	Units	LOR	Sample Number	CE129907.005	CE129907.006	CE129907.007	CE129907.008
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	27 Sep 2017	27 Sep 2017	28 Sep 2017	28 Sep 2017
			Sample Name	S20_50_70	S20_20_50	S21_0_10	S21_10_20

Bicarbonate Extractable (Colwell) Potassium, K Method: AN015/AN320 Tested: 26/10/2017

Bicarbonate Extractable (Colwell) Potassium, K*	mg/kg	10	250	240	160	150
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Nitrate Nitrogen and Nitrite Nitrogen (NOx) by Auto Analyser in Soil Method: AN248 Tested: 20/10/2017

Nitrate/Nitrite Nitrogen, NOx as N	mg/kg	0.1	-	-	0.8	0.6
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Total Kjeldahl Nitrogen and Total Nitrogen in Soil/Sludges Method: AN281 Tested: 17/10/2017

Total Kjeldahl Nitrogen	mg/kg	5	-	-	780	710
Total Nitrogen	mg/kg	10	-	-	780	710

Total Organic Carbon by Heanes Oxidation Method: AN273 Tested: 25/10/2017

Total Organic Carbon	%w/w	0.05	1.0	1.1	0.88	0.87
Organic Matter	%w/w	0.1	1.7	1.9	1.7	1.5

Emerson Class Number Method: AN009 Tested: 18/10/2017

Emerson Class Number	No unit	1	5	5	5	3
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Exchangeable Cations and Cation Exchange Capacity (CEC/ESP/SAR) Method: AN122 Tested: 20/10/2017

Exchangeable Sodium, Na	mg/kg	2	2300	1200	-	-
Exchangeable Sodium, Na	meq/100g	0.01	10	5.0	-	-
Exchangeable Sodium Percentage	%	0.1	17.4	8.7	-	-
Exchangeable Potassium, K	mg/kg	2	420	400	-	-
Exchangeable Potassium, K	meq/100g	0.01	1.1	1.0	-	-
Exchangeable Potassium Percentage	%	0.1	1.9	1.8	-	-
Exchangeable Calcium Percentage	%	0.1	56.0	66.5	-	-
Exchangeable Calcium, Ca	mg/kg	2	6400	7700	-	-
Exchangeable Calcium, Ca	meq/100g	0.01	32	38	-	-
Exchangeable Magnesium, Mg	mg/kg	2	1700	1600	-	-
Exchangeable Magnesium, Mg	meq/100g	0.02	14	13	-	-
Exchangeable Magnesium Percentage	%	0.1	24.7	23.0	-	-
Cation Exchange Capacity	meq/100g	0.02	57	58	-	-
Exchangeable Calcium/Exchangeable Magnesium Ratio	No unit	0.1	2.3	2.9	-	-
Monovalent Cations/Divalent Cations Ratio*	No unit	0.1	0.2	0.1	-	-
Cation Exchange Capacity (soluble salts removed)	meq/100g	0.02	-	-	-	-
Sodium Adsorption Ratio	No unit	0.1	2.1	1.0	-	-
Exchangeable Aluminium, Al	cmol (+)/kg	0.01	-	-	-	-

Parameter	Units	LOR	Sample Number	CE129907.005	CE129907.006	CE129907.007	CE129907.008
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	27 Sep 2017	27 Sep 2017	28 Sep 2017	28 Sep 2017
			Sample Name	S20_50_70	S20_20_50	S21_0_10	S21_10_20

DTPA Extractable Metals in Soil Method: AN025/AN320 Tested: 24/10/2017

Copper, Cu	mg/kg	0.05	-	-	1.2	1.2
Zinc, Zn	mg/kg	0.05	-	-	0.23	0.19
Manganese, Mn	mg/kg	0.5	-	-	25	23
Iron, Fe	mg/kg	0.5	-	-	16	14

Calcium Chloride Extractable Boron Method: RL 12C2/AN320 Tested: 24/10/2017

CaCl ₂ -extractable Boron, B*	mg/kg	0.05	-	-	0.50	0.59
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Calcium Chloride Extractable Molybdenum Method: RL 12E1/AN318 Tested: 31/10/2017

CaCl ₂ -extractable Molybdenum, Mo*	mg/kg	0.1	-	-	<0.10	<0.10
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Potassium Chloride Extractable Sulphur Method: RL 10D1/AN320 Tested: 20/10/2017

KCl-40-extractable Sulphur, S*	mg/kg	1	11	10	4	4
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Particle sizing of soils by sieving Method: AN005 Tested: 30/10/2017

Passing 2.00mm	%w/w	1	96	94	92	91
Retained 2.00mm	%w/w	1	4	6	8	9
Passing 600µm	%w/w	1	92	89	87	86
Retained 600µm	%w/w	1	4	5	5	5
Passing 300µm	%w/w	1	90	87	67	71
Retained 300µm	%w/w	1	2	3	20	14
Passing 125µm	%w/w	1	84	80	43	44
Retained 125µm	%w/w	1	6	7	24	27
Passing 63µm	%w/w	1	82	78	38	40
Retained 63µm	%w/w	1	2	2	5	4

Particle sizing of soils <75µm by hydrometer Method: AN005 Tested: 28/10/2017

Sedimentation Diameter 1	mm	0.0001	0.0511	0.0515	0.0568	0.0568
Passing Sedimentation Diameter 1	%w/w	1	81	77	37	38
Retained Sedimentation Diameter 1	%w/w	1	1	1	1	3
Sedimentation Diameter 2	mm	0.0001	0.0364	0.0368	0.0406	0.0404
Passing Sedimentation Diameter 2	%w/w	1	79	73	33	36
Retained Sedimentation Diameter 2	%w/w	1	3	4	5	2
Sedimentation Diameter 3	mm	0.0001	0.0259	0.0262	0.0288	0.0287
Passing Sedimentation Diameter 3	%w/w	1	76	71	32	33
Retained Sedimentation Diameter 3	%w/w	1	3	2	1	2
Sedimentation Diameter 4	mm	0.0001	0.0185	0.0186	0.0204	0.0203
Passing Sedimentation Diameter 4	%w/w	1	74	68	30	33
Retained Sedimentation Diameter 4	%w/w	1	3	2	1	<1
Sedimentation Diameter 5	mm	0.0001	0.0136	0.0138	0.0149	0.0149
Passing Sedimentation Diameter 5	%w/w	1	71	62	30	31
Retained Sedimentation Diameter 5	%w/w	1	3	6	<1	2
Sedimentation Diameter 6	mm	0.0001	0.0097	0.0098	0.0106	0.0106
Passing Sedimentation Diameter 6	%w/w	1	69	62	28	31
Retained Sedimentation Diameter 6	%w/w	1	3	<1	2	<1
Sedimentation Diameter 7	mm	0.0001	0.0069	0.0070	0.0075	0.0075
Passing Sedimentation Diameter 7	%w/w	1	64	57	28	29
Retained Sedimentation Diameter 7	%w/w	1	5	5	<1	2
Sedimentation Diameter 8	mm	0.0001	0.0049	0.0050	0.0053	0.0053
Passing Sedimentation Diameter 8	%w/w	1	61	52	26	29
Retained Sedimentation Diameter 8	%w/w	1	3	5	2	<1
Sedimentation Diameter 9	mm	0.0001	0.0035	0.0036	0.0038	0.0038
Passing Sedimentation Diameter 9	%w/w	1	56	47	24	26
Retained Sedimentation Diameter 9	%w/w	1	5	5	2	2
Sedimentation Diameter 10	mm	0.0001	0.0015	0.0015	0.0016	0.0015
Passing Sedimentation Diameter 10	%w/w	1	48	40	19	26

Parameter	Units	LOR	Sample Number	CE129907.005	CE129907.006	CE129907.007	CE129907.008
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	27 Sep 2017	27 Sep 2017	28 Sep 2017	28 Sep 2017
			Sample Name	S20_50_70	S20_20_50	S21_0_10	S21_10_20

Particle sizing of soils <75µm by hydrometer Method: AN005 Tested: 28/10/2017 (continued)

Retained Sedimentation Diameter 10	%w/w	1	8	7	5	<1
Sedimentation Diameter 11	mm	0.0001	0.0011	0.0011	0.0011	0.0011
Passing Sedimentation Diameter 11	%w/w	1	43	35	19	24
Retained Sedimentation Diameter 11	%w/w	1	5	5	<1	2
Clay (<0.002mm)	%w/w	0.1	48	40	19	26
Silt and Clay (<0.005mm)*	%w/w	0.1	61	52	26	29
Silt (0.002mm to 0.06mm)*	%w/w	0.1	34	38	19	14
Fine Sand (0.06mm to 0.20mm)*	%w/w	0.1	1.9	2.0	4.6	3.9
Medium and Coarse Sand (0.20mm to 2.0mm)*	%w/w	0.1	12	14	50	47
Gravels (>2.0mm)*	%w/w	0.1	3.9	6.2	7.8	9.2

Parameter	Sample Number		CE129907.005	CE129907.006	CE129907.007	CE129907.008
	Sample Matrix		Soil	Soil	Soil	Soil
	Sample Date		27 Sep 2017	27 Sep 2017	28 Sep 2017	28 Sep 2017
	Sample Name		S20_50_70	S20_20_50	S21_0_10	S21_10_20
Parameter	Units	LOR				

Erodibility Factor of Soil Method: CSIRO Tech Report 13/01 Tested: 26/10/2017

Erodibility Factor (K)*	t.ha.h/ha/MJ/	-	0.08	0.07	0.04	0.04
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Soil Texture (Northcote, 1979) Method: Northcote (1979) Tested: 18/10/2017

Texture Classification*	No unit	1	Medium Heavy Clay	Medium Clay	Sandy Clay	Medium Clay
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Sample Subcontracted Method: Tested: 10/11/2017

Sample Subcontracted*	No unit	-	See attached	See attached	See attached	See attached
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Parameter	Units	LOR	Sample Number	CE129907.009	CE129907.010	CE129907.011	CE129907.012
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	28 Sep 2017	28 Sep 2017	28 Sep 2017	26 Sep 2017
			Sample Name	S21_30_40	S21_40_60	S21_65_75	S1_0_10

Moisture Content Method: AN002 Tested: 16/10/2017

% Moisture	%w/w	0.5	8.9	11	11	1.0
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pH in soil (1:5) Method: AN101 Tested: 19/10/2017

pH	pH Units	-	7.6	8.5	8.9	7.0
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Conductivity and TDS by Calculation - Soil Method: AN106 Tested: 19/10/2017

Conductivity of Extract (1:5 dry sample basis)	µS/cm	1	53	250	720	30
Total Dissolved Solids (by calculation)	mg/kg	5	160	760	2200	90

Chloride (water extractable) Method: AN274 Tested: 20/10/2017

Chloride (water extractable 1:5)	mg/kg	5	7	130	670	6
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Water Soluble Acidity of Soil Method: AN002/AN140 Tested: 19/10/2017

Water Soluble Acidity as CaCO ₃ to pH 8.3*	mg/kg	25	25	<25	<25	-
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Colwell Phosphorus Method: AN015 Tested: 18/10/2017

Colwell Phosphorus	mg/kg	1	3	2	2	12
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Parameter	Units	LOR	Sample Number	CE129907.009	CE129907.010	CE129907.011	CE129907.012
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	28 Sep 2017	28 Sep 2017	28 Sep 2017	26 Sep 2017
			Sample Name	S21_30_40	S21_40_60	S21_65_75	S1_0_10

Bicarbonate Extractable (Colwell) Potassium, K Method: AN015/AN320 Tested: 26/10/2017

Bicarbonate Extractable (Colwell) Potassium, K*	mg/kg	10	110	74	74	130
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Nitrate Nitrogen and Nitrite Nitrogen (NOx) by Auto Analyser in Soil Method: AN248 Tested: 20/10/2017

Nitrate/Nitrite Nitrogen, NOx as N	mg/kg	0.1	-	-	-	<0.1
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Total Kjeldahl Nitrogen and Total Nitrogen in Soil/Sludges Method: AN281 Tested: 17/10/2017

Total Kjeldahl Nitrogen	mg/kg	5	-	-	-	290
Total Nitrogen	mg/kg	10	-	-	-	290

Total Organic Carbon by Heanes Oxidation Method: AN273 Tested: 25/10/2017

Total Organic Carbon	%w/w	0.05	0.68	0.50	0.37	0.40
Organic Matter	%w/w	0.1	1.2	0.87	0.63	0.69

Emerson Class Number Method: AN009 Tested: 18/10/2017

Emerson Class Number	No unit	1	3	5	5	3
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Exchangeable Cations and Cation Exchange Capacity (CEC/ESP/SAR) Method: AN122 Tested: 20/10/2017

Exchangeable Sodium, Na	mg/kg	2	280	760	1000	-
Exchangeable Sodium, Na	meq/100g	0.01	1.2	3.3	4.5	-
Exchangeable Sodium Percentage	%	0.1	4.9	9.6	8.6	-
Exchangeable Potassium, K	mg/kg	2	160	120	100	-
Exchangeable Potassium, K	meq/100g	0.01	0.41	0.30	0.26	-
Exchangeable Potassium Percentage	%	0.1	1.7	0.9	0.5	-
Exchangeable Calcium Percentage	%	0.1	61.1	54.6	66.9	-
Exchangeable Calcium, Ca	mg/kg	2	3000	3800	6900	-
Exchangeable Calcium, Ca	meq/100g	0.01	15	19	35	-
Exchangeable Magnesium, Mg	mg/kg	2	970	1500	1500	-
Exchangeable Magnesium, Mg	meq/100g	0.02	7.9	12	12	-
Exchangeable Magnesium Percentage	%	0.1	32.3	34.9	23.9	-
Cation Exchange Capacity	meq/100g	0.02	25	34	52	-
Exchangeable Calcium/Exchangeable Magnesium Ratio	No unit	0.1	1.9	1.6	2.8	-
Monovalent Cations/Divalent Cations Ratio*	No unit	0.1	<0.1	0.1	0.1	-
Cation Exchange Capacity (soluble salts removed)	meq/100g	0.02	-	-	-	-
Sodium Adsorption Ratio	No unit	0.1	0.4	0.8	0.9	-
Exchangeable Aluminium, Al	cmol (+)/kg	0.01	-	-	-	-

Parameter	Units	LOR	Sample Number	CE129907.009	CE129907.010	CE129907.011	CE129907.012
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	28 Sep 2017	28 Sep 2017	28 Sep 2017	26 Sep 2017
			Sample Name	S21_30_40	S21_40_60	S21_65_75	S1_0_10

DTPA Extractable Metals in Soil Method: AN025/AN320 Tested: 24/10/2017

Copper, Cu	mg/kg	0.05	-	-	-	0.40
Zinc, Zn	mg/kg	0.05	-	-	-	0.29
Manganese, Mn	mg/kg	0.5	-	-	-	15
Iron, Fe	mg/kg	0.5	-	-	-	18

Calcium Chloride Extractable Boron Method: RL 12C2/AN320 Tested: 24/10/2017

CaCl ₂ -extractable Boron, B*	mg/kg	0.05	-	-	-	0.30
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Calcium Chloride Extractable Molybdenum Method: RL 12E1/AN318 Tested: 31/10/2017

CaCl ₂ -extractable Molybdenum, Mo*	mg/kg	0.1	-	-	-	<0.10
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Potassium Chloride Extractable Sulphur Method: RL 10D1/AN320 Tested: 20/10/2017

KCl-40-extractable Sulphur, S*	mg/kg	1	4	8	73	2
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Particle sizing of soils by sieving Method: AN005 Tested: 30/10/2017

Passing 2.00mm	%w/w	1	91	98	89	94
Retained 2.00mm	%w/w	1	9	2	11	6
Passing 600µm	%w/w	1	85	85	81	73
Retained 600µm	%w/w	1	6	13	8	22
Passing 300µm	%w/w	1	72	73	73	41
Retained 300µm	%w/w	1	13	12	8	31
Passing 125µm	%w/w	1	49	55	60	23
Retained 125µm	%w/w	1	24	18	13	19
Passing 63µm	%w/w	1	45	52	58	20
Retained 63µm	%w/w	1	4	3	2	3

Particle sizing of soils <75µm by hydrometer Method: AN005 Tested: 28/10/2017

Sedimentation Diameter 1	mm	0.0001	0.0561	0.0550	0.0543	0.0596
Passing Sedimentation Diameter 1	%w/w	1	44	52	57	19
Retained Sedimentation Diameter 1	%w/w	1	2	1	2	1
Sedimentation Diameter 2	mm	0.0001	0.0399	0.0391	0.0386	0.0424
Passing Sedimentation Diameter 2	%w/w	1	41	50	54	16
Retained Sedimentation Diameter 2	%w/w	1	2	2	2	2
Sedimentation Diameter 3	mm	0.0001	0.0283	0.0278	0.0275	0.0301
Passing Sedimentation Diameter 3	%w/w	1	40	49	52	14
Retained Sedimentation Diameter 3	%w/w	1	1	1	2	2
Sedimentation Diameter 4	mm	0.0001	0.0201	0.0198	0.0196	0.0214
Passing Sedimentation Diameter 4	%w/w	1	38	46	49	12
Retained Sedimentation Diameter 4	%w/w	1	2	2	2	2
Sedimentation Diameter 5	mm	0.0001	0.0147	0.0144	0.0143	0.0157
Passing Sedimentation Diameter 5	%w/w	1	38	46	49	10
Retained Sedimentation Diameter 5	%w/w	1	<1	<1	<1	2
Sedimentation Diameter 6	mm	0.0001	0.0104	0.0102	0.0102	0.0111
Passing Sedimentation Diameter 6	%w/w	1	37	45	47	10
Retained Sedimentation Diameter 6	%w/w	1	1	1	2	<1
Sedimentation Diameter 7	mm	0.0001	0.0074	0.0073	0.0072	0.0079
Passing Sedimentation Diameter 7	%w/w	1	34	42	44	7
Retained Sedimentation Diameter 7	%w/w	1	2	2	2	2
Sedimentation Diameter 8	mm	0.0001	0.0052	0.0052	0.0052	0.0056
Passing Sedimentation Diameter 8	%w/w	1	34	42	42	5
Retained Sedimentation Diameter 8	%w/w	1	<1	<1	2	2
Sedimentation Diameter 9	mm	0.0001	0.0037	0.0037	0.0037	0.0040
Passing Sedimentation Diameter 9	%w/w	1	32	40	40	3
Retained Sedimentation Diameter 9	%w/w	1	2	2	2	2
Sedimentation Diameter 10	mm	0.0001	0.0015	0.0015	0.0015	0.0016
Passing Sedimentation Diameter 10	%w/w	1	28	36	37	1

Parameter	Units	LOR	Sample Number	CE129907.009	CE129907.010	CE129907.011	CE129907.012
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	28 Sep 2017	28 Sep 2017	28 Sep 2017	26 Sep 2017
			Sample Name	S21_30_40	S21_40_60	S21_65_75	S1_0_10

Particle sizing of soils <75µm by hydrometer Method: AN005 Tested: 28/10/2017 (continued)

Retained Sedimentation Diameter 10	%w/w	1	4	4	2	2
Sedimentation Diameter 11	mm	0.0001	0.0011	0.0011	0.0011	0.0012
Passing Sedimentation Diameter 11	%w/w	1	27	35	35	1
Retained Sedimentation Diameter 11	%w/w	1	1	1	2	<1
Clay (<0.002mm)	%w/w	0.1	28	36	37	1.0
Silt and Clay (<0.005mm)*	%w/w	0.1	34	42	42	5.0
Silt (0.002mm to 0.06mm)*	%w/w	0.1	17	16	21	19
Fine Sand (0.06mm to 0.20mm)*	%w/w	0.1	3.5	2.8	2.3	2.6
Medium and Coarse Sand (0.20mm to 2.0mm)*	%w/w	0.1	43	43	29	72
Gravels (>2.0mm)*	%w/w	0.1	8.7	2.3	11	5.8

Parameter	Units	LOR	Sample Number	CE129907.009	CE129907.010	CE129907.011	CE129907.012
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	28 Sep 2017	28 Sep 2017	28 Sep 2017	26 Sep 2017
			Sample Name	S21_30_40	S21_40_60	S21_65_75	S1_0_10

Erodibility Factor of Soil Method: CSIRO Tech Report 13/01 Tested: 26/10/2017

Erodibility Factor (K)*	t.ha.h/ha/MJ/	-	0.05	0.06	0.06	0.02
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Soil Texture (Northcote, 1979) Method: Northcote (1979) Tested: 18/10/2017

Texture Classification*	No unit	1	Medium Clay	Medium Clay	Medium Heavy Clay	Sand
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Sample Subcontracted Method: Tested: 10/11/2017

Sample Subcontracted*	No unit	-	See attached	See attached	See attached	See attached
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Parameter	Units	LOR	Sample Number	CE129907.013	CE129907.014	CE129907.015	CE129907.016
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	26 Sep 2017	26 Sep 2017	26 Sep 2017	28 Sep 2017
			Sample Name	S3_0_10	S3_10_20	S3_20_40	S22_0_10

Moisture Content Method: AN002 Tested: 16/10/2017

% Moisture	%w/w	0.5	4.7	8.1	7.7	3.0
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pH in soil (1:5) Method: AN101 Tested: 19/10/2017

pH	pH Units	-	6.9	7.2	7.6	6.8
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Conductivity and TDS by Calculation - Soil Method: AN106 Tested: 19/10/2017

Conductivity of Extract (1:5 dry sample basis)	µS/cm	1	46	60	160	120
Total Dissolved Solids (by calculation)	mg/kg	5	140	180	490	360

Chloride (water extractable) Method: AN274 Tested: 20/10/2017

Chloride (water extractable 1:5)	mg/kg	5	7	11	12	30
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Water Soluble Acidity of Soil Method: AN002/AN140 Tested: 19/10/2017

Water Soluble Acidity as CaCO ₃ to pH 8.3*	mg/kg	25	-	-	25	-
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Colwell Phosphorus Method: AN015 Tested: 18/10/2017

Colwell Phosphorus	mg/kg	1	8	4	4	59
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Parameter	Units	LOR	Sample Number	CE129907.013	CE129907.014	CE129907.015	CE129907.016
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	26 Sep 2017	26 Sep 2017	26 Sep 2017	28 Sep 2017
			Sample Name	S3_0_10	S3_10_20	S3_20_40	S22_0_10

Bicarbonate Extractable (Colwell) Potassium, K Method: AN015/AN320 Tested: 26/10/2017

Bicarbonate Extractable (Colwell) Potassium, K*	mg/kg	10	240	150	140	500
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Nitrate Nitrogen and Nitrite Nitrogen (NOx) by Auto Analyser in Soil Method: AN248 Tested: 20/10/2017

Nitrate/Nitrite Nitrogen, NOx as N	mg/kg	0.1	1.1	0.6	-	6.4
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Total Kjeldahl Nitrogen and Total Nitrogen in Soil/Sludges Method: AN281 Tested: 17/10/2017

Total Kjeldahl Nitrogen	mg/kg	5	740	670	-	1600
Total Nitrogen	mg/kg	10	750	670	-	1600

Total Organic Carbon by Heanes Oxidation Method: AN273 Tested: 19/10/2017

Total Organic Carbon	%w/w	0.05	0.82	0.76	0.81	2.5
Organic Matter	%w/w	0.1	1.4	1.3	1.4	4.3

Emerson Class Number Method: AN009 Tested: 18/10/2017

Emerson Class Number	No unit	1	5	5	5	3
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Exchangeable Cations and Cation Exchange Capacity (CEC/ESP/SAR) Method: AN122 Tested: 20/10/2017

Exchangeable Sodium, Na	mg/kg	2	-	-	57	-
Exchangeable Sodium, Na	meq/100g	0.01	-	-	0.25	-
Exchangeable Sodium Percentage	%	0.1	-	-	1.0	-
Exchangeable Potassium, K	mg/kg	2	-	-	140	-
Exchangeable Potassium, K	meq/100g	0.01	-	-	0.36	-
Exchangeable Potassium Percentage	%	0.1	-	-	1.4	-
Exchangeable Calcium Percentage	%	0.1	-	-	84.3	-
Exchangeable Calcium, Ca	mg/kg	2	-	-	4400	-
Exchangeable Calcium, Ca	meq/100g	0.01	-	-	22	-
Exchangeable Magnesium, Mg	mg/kg	2	-	-	420	-
Exchangeable Magnesium, Mg	meq/100g	0.02	-	-	3.4	-
Exchangeable Magnesium Percentage	%	0.1	-	-	13.3	-
Cation Exchange Capacity	meq/100g	0.02	-	-	26	-
Exchangeable Calcium/Exchangeable Magnesium Ratio	No unit	0.1	-	-	6.3	-
Monovalent Cations/Divalent Cations Ratio*	No unit	0.1	-	-	<0.1	-
Cation Exchange Capacity (soluble salts removed)	meq/100g	0.02	-	-	-	-
Sodium Adsorption Ratio	No unit	0.1	-	-	<0.1	-
Exchangeable Aluminium, Al	cmol (+)/kg	0.01	-	-	-	-

Parameter	Units	LOR	Sample Number	CE129907.013	CE129907.014	CE129907.015	CE129907.016
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	26 Sep 2017	26 Sep 2017	26 Sep 2017	28 Sep 2017
			Sample Name	S3_0_10	S3_10_20	S3_20_40	S22_0_10

DTPA Extractable Metals in Soil Method: AN025/AN320 Tested: 20/10/2017

Copper, Cu	mg/kg	0.05	0.57	0.43	-	1.6
Zinc, Zn	mg/kg	0.05	0.23	0.11	-	1.1
Manganese, Mn	mg/kg	0.5	23	21	-	32
Iron, Fe	mg/kg	0.5	8.5	6.0	-	48

Calcium Chloride Extractable Boron Method: RL 12C2/AN320 Tested: 20/10/2017

CaCl ₂ -extractable Boron, B*	mg/kg	0.05	0.76	0.88	-	1.0
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Calcium Chloride Extractable Molybdenum Method: RL 12E1/AN318 Tested: 31/10/2017

CaCl ₂ -extractable Molybdenum, Mo*	mg/kg	0.1	<0.10	<0.10	-	<0.10
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Potassium Chloride Extractable Sulphur Method: RL 10D1/AN320 Tested: 20/10/2017

KCl-40-extractable Sulphur, S*	mg/kg	1	8	10	6	8
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Particle sizing of soils by sieving Method: AN005 Tested: 30/10/2017

Passing 2.00mm	%w/w	1	95	99	95	99
Retained 2.00mm	%w/w	1	5	<1	5	<1
Passing 600µm	%w/w	1	94	98	89	98
Retained 600µm	%w/w	1	1	1	6	2
Passing 300µm	%w/w	1	87	92	76	94
Retained 300µm	%w/w	1	8	6	13	4
Passing 125µm	%w/w	1	50	58	49	69
Retained 125µm	%w/w	1	37	33	26	24
Passing 63µm	%w/w	1	46	56	47	64
Retained 63µm	%w/w	1	4	3	3	5

Particle sizing of soils <75µm by hydrometer Method: AN005 Tested: 28/10/2017

Sedimentation Diameter 1	mm	0.0001	0.0554	0.0543	0.0561	0.0529
Passing Sedimentation Diameter 1	%w/w	1	45	56	43	62
Retained Sedimentation Diameter 1	%w/w	1	2	1	3	2
Sedimentation Diameter 2	mm	0.0001	0.0394	0.0388	0.0400	0.0377
Passing Sedimentation Diameter 2	%w/w	1	43	52	40	60
Retained Sedimentation Diameter 2	%w/w	1	2	4	4	2
Sedimentation Diameter 3	mm	0.0001	0.0280	0.0274	0.0284	0.0268
Passing Sedimentation Diameter 3	%w/w	1	41	52	39	58
Retained Sedimentation Diameter 3	%w/w	1	2	<1	1	2
Sedimentation Diameter 4	mm	0.0001	0.0200	0.0196	0.0202	0.0191
Passing Sedimentation Diameter 4	%w/w	1	38	47	36	55
Retained Sedimentation Diameter 4	%w/w	1	3	5	2	2
Sedimentation Diameter 5	mm	0.0001	0.0147	0.0144	0.0148	0.0140
Passing Sedimentation Diameter 5	%w/w	1	36	45	34	53
Retained Sedimentation Diameter 5	%w/w	1	1	2	2	2
Sedimentation Diameter 6	mm	0.0001	0.0104	0.0102	0.0106	0.0100
Passing Sedimentation Diameter 6	%w/w	1	34	44	32	51
Retained Sedimentation Diameter 6	%w/w	1	2	1	2	2
Sedimentation Diameter 7	mm	0.0001	0.0074	0.0073	0.0075	0.0071
Passing Sedimentation Diameter 7	%w/w	1	32	41	29	49
Retained Sedimentation Diameter 7	%w/w	1	2	2	2	2
Sedimentation Diameter 8	mm	0.0001	0.0053	0.0052	0.0053	0.0051
Passing Sedimentation Diameter 8	%w/w	1	30	39	28	44
Retained Sedimentation Diameter 8	%w/w	1	2	2	1	5
Sedimentation Diameter 9	mm	0.0001	0.0038	0.0037	0.0038	0.0036
Passing Sedimentation Diameter 9	%w/w	1	28	32	23	39
Retained Sedimentation Diameter 9	%w/w	1	2	7	5	5
Sedimentation Diameter 10	mm	0.0001	0.0015	0.0015	0.0016	0.0015
Passing Sedimentation Diameter 10	%w/w	1	25	27	19	35

Parameter	Units	LOR	Sample Number	CE129907.013	CE129907.014	CE129907.015	CE129907.016
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	26 Sep 2017	26 Sep 2017	26 Sep 2017	28 Sep 2017
			Sample Name	S3_0_10	S3_10_20	S3_20_40	S22_0_10

Particle sizing of soils <75µm by hydrometer Method: AN005 Tested: 28/10/2017 (continued)

Retained Sedimentation Diameter 10	%w/w	1	2	5	5	5
Sedimentation Diameter 11	mm	0.0001	0.0011	0.0011	0.0011	0.0011
Passing Sedimentation Diameter 11	%w/w	1	23	27	17	33
Retained Sedimentation Diameter 11	%w/w	1	2	<1	1	2
Clay (<0.002mm)	%w/w	0.1	25	27	19	35
Silt and Clay (<0.005mm)*	%w/w	0.1	30	39	28	44
Silt (0.002mm to 0.06mm)*	%w/w	0.1	21	29	28	29
Fine Sand (0.06mm to 0.20mm)*	%w/w	0.1	4.2	2.6	2.7	5.1
Medium and Coarse Sand (0.20mm to 2.0mm)*	%w/w	0.1	46	41	46	30
Gravels (>2.0mm)*	%w/w	0.1	4.7	0.7	4.9	0.7

Parameter	Sample Number		CE129907.013	CE129907.014	CE129907.015	CE129907.016
	Sample Matrix		Soil	Soil	Soil	Soil
	Sample Date		26 Sep 2017	26 Sep 2017	26 Sep 2017	28 Sep 2017
	Sample Name		S3_0_10	S3_10_20	S3_20_40	S22_0_10
Units	LOR					

Erodibility Factor of Soil Method: CSIRO Tech Report 13/01 Tested: 26/10/2017

Erodibility Factor (K)*	t.ha.h/ha/MJ/	-	0.05	0.05	0.05	0.05
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Soil Texture (Northcote, 1979) Method: Northcote (1979) Tested: 18/10/2017

Texture Classification*	No unit	1	Medium Clay	Medium Heavy Clay	Sandy Clay	Medium Clay
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Sample Subcontracted Method: Tested: 10/11/2017

Sample Subcontracted*	No unit	-	See attached	See attached	See attached	See attached
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Parameter	Units	LOR	Sample Number	CE129907.017	CE129907.018	CE129907.019	CE129907.020
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	28 Sep 2017	28 Sep 2017	28 Sep 2017	28 Sep 2017
			Sample Name	S22_10_20	S22_20_30	S22_30_50	S22_50_70

Moisture Content Method: AN002 Tested: 16/10/2017

% Moisture	%w/w	0.5	3.5	3.4	11	11
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pH in soil (1:5) Method: AN101 Tested: 19/10/2017

pH	pH Units	-	7.0	7.0	9.1	9.0
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Conductivity and TDS by Calculation - Soil Method: AN106 Tested: 19/10/2017

Conductivity of Extract (1:5 dry sample basis)	µS/cm	1	90	49	690	1100
Total Dissolved Solids (by calculation)	mg/kg	5	270	150	2100	3400

Chloride (water extractable) Method: AN274 Tested: 20/10/2017

Chloride (water extractable 1:5)	mg/kg	5	27	13	640	1300
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Water Soluble Acidity of Soil Method: AN002/AN140 Tested: 19/10/2017

Water Soluble Acidity as CaCO ₃ to pH 8.3*	mg/kg	25	-	-	<25	<25
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Colwell Phosphorus Method: AN015 Tested: 18/10/2017

Colwell Phosphorus	mg/kg	1	27	13	2	2
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Parameter	Units	LOR	Sample Number	CE129907.017	CE129907.018	CE129907.019	CE129907.020
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	28 Sep 2017	28 Sep 2017	28 Sep 2017	28 Sep 2017
			Sample Name	S22_10_20	S22_20_30	S22_30_50	S22_50_70

Bicarbonate Extractable (Colwell) Potassium, K Method: AN015/AN320 Tested: 26/10/2017

Bicarbonate Extractable (Colwell) Potassium, K*	mg/kg	10	360	270	130	140
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Nitrate Nitrogen and Nitrite Nitrogen (NOx) by Auto Analyser in Soil Method: AN248 Tested: 20/10/2017

Nitrate/Nitrite Nitrogen, NOx as N	mg/kg	0.1	2.8	1.1	-	-
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Total Kjeldahl Nitrogen and Total Nitrogen in Soil/Sludges Method: AN281 Tested: 17/10/2017

Total Kjeldahl Nitrogen	mg/kg	5	1400	900	-	-
Total Nitrogen	mg/kg	10	1400	900	-	-

Total Organic Carbon by Heanes Oxidation Method: AN273 Tested: 19/10/2017

Total Organic Carbon	%w/w	0.05	1.9	1.1	0.95	0.68
Organic Matter	%w/w	0.1	3.3	1.9	1.6	1.2

Emerson Class Number Method: AN009 Tested: 18/10/2017

Emerson Class Number	No unit	1	3	3	5	5
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Exchangeable Cations and Cation Exchange Capacity (CEC/ESP/SAR) Method: AN122 Tested: 20/10/2017

Exchangeable Sodium, Na	mg/kg	2	-	-	1700	2300
Exchangeable Sodium, Na	meq/100g	0.01	-	-	7.5	10
Exchangeable Sodium Percentage	%	0.1	-	-	13.3	17.2
Exchangeable Potassium, K	mg/kg	2	-	-	210	220
Exchangeable Potassium, K	meq/100g	0.01	-	-	0.53	0.57
Exchangeable Potassium Percentage	%	0.1	-	-	0.9	1.0
Exchangeable Calcium Percentage	%	0.1	-	-	63.9	60.7
Exchangeable Calcium, Ca	mg/kg	2	-	-	7200	7100
Exchangeable Calcium, Ca	meq/100g	0.01	-	-	36	35
Exchangeable Magnesium, Mg	mg/kg	2	-	-	1500	1500
Exchangeable Magnesium, Mg	meq/100g	0.02	-	-	12	12
Exchangeable Magnesium Percentage	%	0.1	-	-	21.8	21.1
Cation Exchange Capacity	meq/100g	0.02	-	-	56	58
Exchangeable Calcium/Exchangeable Magnesium Ratio	No unit	0.1	-	-	2.9	2.9
Monovalent Cations/Divalent Cations Ratio*	No unit	0.1	-	-	0.2	0.2
Cation Exchange Capacity (soluble salts removed)	meq/100g	0.02	-	-	-	-
Sodium Adsorption Ratio	No unit	0.1	-	-	1.5	2.1
Exchangeable Aluminium, Al	cmol (+)/kg	0.01	-	-	-	-

Parameter	Units	LOR	Sample Number	CE129907.017	CE129907.018	CE129907.019	CE129907.020
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	28 Sep 2017	28 Sep 2017	28 Sep 2017	28 Sep 2017
			Sample Name	S22_10_20	S22_20_30	S22_30_50	S22_50_70

DTPA Extractable Metals in Soil Method: AN025/AN320 Tested: 20/10/2017

Copper, Cu	mg/kg	0.05	1.4	1.4	-	-
Zinc, Zn	mg/kg	0.05	0.67	0.27	-	-
Manganese, Mn	mg/kg	0.5	22	18	-	-
Iron, Fe	mg/kg	0.5	36	31	-	-

Calcium Chloride Extractable Boron Method: RL 12C2/AN320 Tested: 20/10/2017

CaCl ₂ -extractable Boron, B*	mg/kg	0.05	0.83	0.75	-	-
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Calcium Chloride Extractable Molybdenum Method: RL 12E1/AN318 Tested: 31/10/2017

CaCl ₂ -extractable Molybdenum, Mo*	mg/kg	0.1	<0.10	<0.10	-	-
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Potassium Chloride Extractable Sulphur Method: RL 10D1/AN320 Tested: 20/10/2017

KCl-40-extractable Sulphur, S*	mg/kg	1	7	5	23	86
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Particle sizing of soils by sieving Method: AN005 Tested: 30/10/2017

Passing 2.00mm	%w/w	1	99	100	93	93
Retained 2.00mm	%w/w	1	<1	<1	7	7
Passing 600µm	%w/w	1	98	99	83	78
Retained 600µm	%w/w	1	<1	<1	11	15
Passing 300µm	%w/w	1	83	93	77	73
Retained 300µm	%w/w	1	15	6	6	5
Passing 125µm	%w/w	1	58	63	66	61
Retained 125µm	%w/w	1	26	30	11	12
Passing 63µm	%w/w	1	54	57	63	59
Retained 63µm	%w/w	1	4	6	3	2

Particle sizing of soils <75µm by hydrometer Method: AN005 Tested: 28/10/2017

Sedimentation Diameter 1	mm	0.0001	0.0547	0.0540	0.0536	0.0543
Passing Sedimentation Diameter 1	%w/w	1	51	56	62	57
Retained Sedimentation Diameter 1	%w/w	1	3	2	2	2
Sedimentation Diameter 2	mm	0.0001	0.0389	0.0384	0.0381	0.0389
Passing Sedimentation Diameter 2	%w/w	1	49	53	59	52
Retained Sedimentation Diameter 2	%w/w	1	2	2	2	5
Sedimentation Diameter 3	mm	0.0001	0.0275	0.0273	0.0271	0.0275
Passing Sedimentation Diameter 3	%w/w	1	49	51	58	52
Retained Sedimentation Diameter 3	%w/w	1	<1	2	1	<1
Sedimentation Diameter 4	mm	0.0001	0.0196	0.0194	0.0192	0.0195
Passing Sedimentation Diameter 4	%w/w	1	46	49	57	51
Retained Sedimentation Diameter 4	%w/w	1	2	2	1	1
Sedimentation Diameter 5	mm	0.0001	0.0143	0.0143	0.0141	0.0143
Passing Sedimentation Diameter 5	%w/w	1	46	46	54	48
Retained Sedimentation Diameter 5	%w/w	1	<1	2	2	2
Sedimentation Diameter 6	mm	0.0001	0.0102	0.0102	0.0100	0.0102
Passing Sedimentation Diameter 6	%w/w	1	44	44	52	47
Retained Sedimentation Diameter 6	%w/w	1	2	2	2	1
Sedimentation Diameter 7	mm	0.0001	0.0072	0.0072	0.0071	0.0072
Passing Sedimentation Diameter 7	%w/w	1	42	42	49	45
Retained Sedimentation Diameter 7	%w/w	1	2	2	2	2
Sedimentation Diameter 8	mm	0.0001	0.0052	0.0052	0.0051	0.0052
Passing Sedimentation Diameter 8	%w/w	1	40	38	47	40
Retained Sedimentation Diameter 8	%w/w	1	2	3	2	5
Sedimentation Diameter 9	mm	0.0001	0.0037	0.0037	0.0036	0.0037
Passing Sedimentation Diameter 9	%w/w	1	37	35	42	38
Retained Sedimentation Diameter 9	%w/w	1	2	3	5	2
Sedimentation Diameter 10	mm	0.0001	0.0015	0.0015	0.0015	0.0015
Passing Sedimentation Diameter 10	%w/w	1	33	30	37	34

Parameter	Units	LOR
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Sample Number	CE129907.017	CE129907.018	CE129907.019	CE129907.020
Sample Matrix	Soil	Soil	Soil	Soil
Sample Date	28 Sep 2017	28 Sep 2017	28 Sep 2017	28 Sep 2017
Sample Name	S22_10_20	S22_20_30	S22_30_50	S22_50_70

Particle sizing of soils <75µm by hydrometer Method: AN005 Tested: 28/10/2017 (continued)

Retained Sedimentation Diameter 10	%w/w	1	5	5	5	4
Sedimentation Diameter 11	mm	0.0001	0.0011	0.0011	0.0011	0.0011
Passing Sedimentation Diameter 11	%w/w	1	31	30	35	33
Retained Sedimentation Diameter 11	%w/w	1	2	<1	2	1
Clay (<0.002mm)	%w/w	0.1	33	30	37	34
Silt and Clay (<0.005mm)*	%w/w	0.1	40	38	47	40
Silt (0.002mm to 0.06mm)*	%w/w	0.1	21	27	26	25
Fine Sand (0.06mm to 0.20mm)*	%w/w	0.1	3.9	6.1	3.0	2.4
Medium and Coarse Sand (0.20mm to 2.0mm)*	%w/w	0.1	42	36	27	32
Gravels (>2.0mm)*	%w/w	0.1	0.7	0.4	6.9	6.6

Parameter	Units	LOR	Sample Number	CE129907.017	CE129907.018	CE129907.019	CE129907.020
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	28 Sep 2017	28 Sep 2017	28 Sep 2017	28 Sep 2017
			Sample Name	S22_10_20	S22_20_30	S22_30_50	S22_50_70

Erodibility Factor of Soil Method: CSIRO Tech Report 13/01 Tested: 26/10/2017

Erodibility Factor (K)*	t.ha.h/ha/MJ/	-	0.04	0.06	0.06	0.06
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Soil Texture (Northcote, 1979) Method: Northcote (1979) Tested: 18/10/2017

Texture Classification*	No unit	1	Medium Clay	Light Medium Clay	Medium Clay	Medium Clay
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Sample Subcontracted Method: Tested: 10/11/2017

Sample Subcontracted*	No unit	-	See attached	See attached	See attached	See attached
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Parameter	Sample Number		CE129907.021	CE129907.022	CE129907.023	CE129907.024
	Sample Matrix		Soil	Soil	Soil	Soil
	Sample Date		28 Sep 2017	28 Sep 2017	28 Sep 2017	28 Sep 2017
	Sample Name		S22_70_100	S22_100_130	S23_0_10	S23_10_20
Parameter	Units	LOR				

Moisture Content Method: AN002 Tested: 16/10/2017

% Moisture	%w/w	0.5	3.3	3.0	4.6	7.7
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pH in soil (1:5) Method: AN101 Tested: 19/10/2017

pH	pH Units	-	7.3	7.6	7.7	8.3
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Conductivity and TDS by Calculation - Soil Method: AN106 Tested: 19/10/2017

Conductivity of Extract (1:5 dry sample basis)	µS/cm	1	44	53	86	270
Total Dissolved Solids (by calculation)	mg/kg	5	130	160	260	820

Chloride (water extractable) Method: AN274 Tested: 20/10/2017

Chloride (water extractable 1:5)	mg/kg	5	15	10	20	39
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Water Soluble Acidity of Soil Method: AN002/AN140 Tested: 19/10/2017

Water Soluble Acidity as CaCO ₃ to pH 8.3*	mg/kg	25	25	25	-	-
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Colwell Phosphorus Method: AN015 Tested: 18/10/2017

Colwell Phosphorus	mg/kg	1	19	23	6	5
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Parameter	Units	LOR	Sample Number	CE129907.021	CE129907.022	CE129907.023	CE129907.024
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	28 Sep 2017	28 Sep 2017	28 Sep 2017	28 Sep 2017
			Sample Name	S22_70_100	S22_100_130	S23_0_10	S23_10_20

Bicarbonate Extractable (Colwell) Potassium, K Method: AN015/AN320 Tested: 26/10/2017

Bicarbonate Extractable (Colwell) Potassium, K*	mg/kg	10	230	220	250	220
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Nitrate Nitrogen and Nitrite Nitrogen (NOx) by Auto Analyser in Soil Method: AN248 Tested: 20/10/2017

Nitrate/Nitrite Nitrogen, NOx as N	mg/kg	0.1	-	-	2.4	0.9
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Total Kjeldahl Nitrogen and Total Nitrogen in Soil/Sludges Method: AN281 Tested: 17/10/2017

Total Kjeldahl Nitrogen	mg/kg	5	-	-	900	960
Total Nitrogen	mg/kg	10	-	-	900	960

Total Organic Carbon by Heanes Oxidation Method: AN273 Tested: 25/10/2017

Total Organic Carbon	%w/w	0.05	0.59	0.48	1.2	1.3
Organic Matter	%w/w	0.1	1.0	0.83	2.0	2.2

Emerson Class Number Method: AN009 Tested: 18/10/2017

Emerson Class Number	No unit	1	5	5	5	3
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Exchangeable Cations and Cation Exchange Capacity (CEC/ESP/SAR) Method: AN122 Tested: 20/10/2017

Exchangeable Sodium, Na	mg/kg	2	70	78	-	-
Exchangeable Sodium, Na	meq/100g	0.01	0.30	0.34	-	-
Exchangeable Sodium Percentage	%	0.1	1.8	1.9	-	-
Exchangeable Potassium, K	mg/kg	2	230	210	-	-
Exchangeable Potassium, K	meq/100g	0.01	0.59	0.55	-	-
Exchangeable Potassium Percentage	%	0.1	3.5	3.1	-	-
Exchangeable Calcium Percentage	%	0.1	77.1	78.3	-	-
Exchangeable Calcium, Ca	mg/kg	2	2600	2700	-	-
Exchangeable Calcium, Ca	meq/100g	0.01	13	14	-	-
Exchangeable Magnesium, Mg	mg/kg	2	360	350	-	-
Exchangeable Magnesium, Mg	meq/100g	0.02	3.0	2.9	-	-
Exchangeable Magnesium Percentage	%	0.1	17.6	16.6	-	-
Cation Exchange Capacity	meq/100g	0.02	17	17	-	-
Exchangeable Calcium/Exchangeable Magnesium Ratio	No unit	0.1	4.4	4.7	-	-
Monovalent Cations/Divalent Cations Ratio*	No unit	0.1	<0.1	<0.1	-	-
Cation Exchange Capacity (soluble salts removed)	meq/100g	0.02	-	-	-	-
Sodium Adsorption Ratio	No unit	0.1	0.1	0.1	-	-
Exchangeable Aluminium, Al	cmol (+)/kg	0.01	-	-	-	-

Parameter	Units	LOR	Sample Number	CE129907.021	CE129907.022	CE129907.023	CE129907.024
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	28 Sep 2017	28 Sep 2017	28 Sep 2017	28 Sep 2017
			Sample Name	S22_70_100	S22_100_130	S23_0_10	S23_10_20

DTPA Extractable Metals in Soil Method: AN025/AN320 Tested: 24/10/2017

Copper, Cu	mg/kg	0.05	-	-	1.9	2.2
Zinc, Zn	mg/kg	0.05	-	-	0.23	0.22
Manganese, Mn	mg/kg	0.5	-	-	17	17
Iron, Fe	mg/kg	0.5	-	-	17	19

Calcium Chloride Extractable Boron Method: RL 12C2/AN320 Tested: 24/10/2017

CaCl ₂ -extractable Boron, B*	mg/kg	0.05	-	-	0.63	0.62
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Calcium Chloride Extractable Molybdenum Method: RL 12E1/AN318 Tested: 31/10/2017

CaCl ₂ -extractable Molybdenum, Mo*	mg/kg	0.1	-	-	<0.10	<0.10
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Potassium Chloride Extractable Sulphur Method: RL 10D1/AN320 Tested: 20/10/2017

KCl-40-extractable Sulphur, S*	mg/kg	1	4	4	4	5
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Particle sizing of soils by sieving Method: AN005 Tested: 30/10/2017

Passing 2.00mm	%w/w	1	100	100	89	92
Retained 2.00mm	%w/w	1	<1	<1	11	8
Passing 600µm	%w/w	1	91	95	74	73
Retained 600µm	%w/w	1	9	4	15	19
Passing 300µm	%w/w	1	74	77	61	60
Retained 300µm	%w/w	1	17	18	14	12
Passing 125µm	%w/w	1	49	53	49	52
Retained 125µm	%w/w	1	25	24	12	8
Passing 63µm	%w/w	1	44	48	46	49
Retained 63µm	%w/w	1	5	5	3	3

Particle sizing of soils <75µm by hydrometer Method: AN005 Tested: 28/10/2017

Sedimentation Diameter 1	mm	0.0001	0.0561	0.0557	0.0557	0.0544
Passing Sedimentation Diameter 1	%w/w	1	42	44	44	48
Retained Sedimentation Diameter 1	%w/w	1	2	3	2	1
Sedimentation Diameter 2	mm	0.0001	0.0399	0.0401	0.0396	0.0396
Passing Sedimentation Diameter 2	%w/w	1	40	37	42	43
Retained Sedimentation Diameter 2	%w/w	1	2	7	2	5
Sedimentation Diameter 3	mm	0.0001	0.0286	0.0285	0.0282	0.0284
Passing Sedimentation Diameter 3	%w/w	1	35	36	40	39
Retained Sedimentation Diameter 3	%w/w	1	5	1	2	5
Sedimentation Diameter 4	mm	0.0001	0.0202	0.0203	0.0201	0.0201
Passing Sedimentation Diameter 4	%w/w	1	35	33	38	39
Retained Sedimentation Diameter 4	%w/w	1	<1	3	2	<1
Sedimentation Diameter 5	mm	0.0001	0.0148	0.0148	0.0147	0.0147
Passing Sedimentation Diameter 5	%w/w	1	34	33	35	36
Retained Sedimentation Diameter 5	%w/w	1	1	<1	2	2
Sedimentation Diameter 6	mm	0.0001	0.0105	0.0106	0.0105	0.0105
Passing Sedimentation Diameter 6	%w/w	1	33	30	33	34
Retained Sedimentation Diameter 6	%w/w	1	1	2	2	2
Sedimentation Diameter 7	mm	0.0001	0.0075	0.0075	0.0075	0.0074
Passing Sedimentation Diameter 7	%w/w	1	30	28	31	33
Retained Sedimentation Diameter 7	%w/w	1	2	2	2	1
Sedimentation Diameter 8	mm	0.0001	0.0053	0.0053	0.0053	0.0053
Passing Sedimentation Diameter 8	%w/w	1	28	26	31	29
Retained Sedimentation Diameter 8	%w/w	1	2	2	<1	4
Sedimentation Diameter 9	mm	0.0001	0.0038	0.0038	0.0038	0.0038
Passing Sedimentation Diameter 9	%w/w	1	26	24	28	27
Retained Sedimentation Diameter 9	%w/w	1	2	2	2	2
Sedimentation Diameter 10	mm	0.0001	0.0016	0.0016	0.0016	0.0016
Passing Sedimentation Diameter 10	%w/w	1	24	21	24	24

Parameter	Units	LOR	Sample Number	CE129907.021	CE129907.022	CE129907.023	CE129907.024
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	28 Sep 2017	28 Sep 2017	28 Sep 2017	28 Sep 2017
			Sample Name	S22_70_100	S22_100_130	S23_0_10	S23_10_20

Particle sizing of soils <75µm by hydrometer Method: AN005 Tested: 28/10/2017 (continued)

Retained Sedimentation Diameter 10	%w/w	1	2	2	5	2
Sedimentation Diameter 11	mm	0.0001	0.0011	0.0010	0.0011	0.0011
Passing Sedimentation Diameter 11	%w/w	1	21	21	21	22
Retained Sedimentation Diameter 11	%w/w	1	2	<1	2	2
Clay (<0.002mm)	%w/w	0.1	24	21	24	24
Silt and Clay (<0.005mm)*	%w/w	0.1	28	26	31	29
Silt (0.002mm to 0.06mm)*	%w/w	0.1	20	27	22	25
Fine Sand (0.06mm to 0.20mm)*	%w/w	0.1	5.2	5.2	3.3	3.0
Medium and Coarse Sand (0.20mm to 2.0mm)*	%w/w	0.1	51	47	40	40
Gravels (>2.0mm)*	%w/w	0.1	0.4	0.4	11	8.1

Parameter	Sample Number		CE129907.021	CE129907.022	CE129907.023	CE129907.024
	Sample Matrix		Soil	Soil	Soil	Soil
	Sample Date		28 Sep 2017	28 Sep 2017	28 Sep 2017	28 Sep 2017
	Sample Name		S22_70_100	S22_100_130	S23_0_10	S23_10_20
Units		LOR				

Erodibility Factor of Soil Method: CSIRO Tech Report 13/01 Tested: 26/10/2017

Erodibility Factor (K)*	t.ha.h/ha/MJ/	-	0.05	0.05	0.04	0.04
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Soil Texture (Northcote, 1979) Method: Northcote (1979) Tested: 18/10/2017

Texture Classification*	No unit	1	Light Medium Clay	Sandy Clay	Light Medium Clay	Medium Heavy Clay
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Sample Subcontracted Method: Tested: 10/11/2017

Sample Subcontracted*	No unit	-	See attached	See attached	See attached	See attached
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Parameter	Units	LOR	Sample Number	CE129907.025	CE129907.026	CE129907.027	CE129907.028
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	28 Sep 2017	28 Sep 2017	28 Sep 2017	28 Sep 2017
			Sample Name	S23_20_30	S23_30_60	S25_0_10	S25_10_20

Moisture Content Method: AN002 Tested: 16/10/2017

% Moisture	%w/w	0.5	10	3.8	5.8	8.6
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pH in soil (1:5) Method: AN101 Tested: 19/10/2017

pH	pH Units	-	8.9	7.1	7.4	7.9
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Conductivity and TDS by Calculation - Soil Method: AN106 Tested: 19/10/2017

Conductivity of Extract (1:5 dry sample basis)	µS/cm	1	380	49	180	250
Total Dissolved Solids (by calculation)	mg/kg	5	1100	150	530	740

Chloride (water extractable) Method: AN274 Tested: 20/10/2017

Chloride (water extractable 1:5)	mg/kg	5	160	8	98	180
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Water Soluble Acidity of Soil Method: AN002/AN140 Tested: 19/10/2017

Water Soluble Acidity as CaCO ₃ to pH 8.3*	mg/kg	25	-	25	-	-
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Colwell Phosphorus Method: AN015 Tested: 18/10/2017

Colwell Phosphorus	mg/kg	1	3	15	11	7
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Parameter	Units	LOR	Sample Number	CE129907.025	CE129907.026	CE129907.027	CE129907.028
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	28 Sep 2017	28 Sep 2017	28 Sep 2017	28 Sep 2017
			Sample Name	S23_20_30	S23_30_60	S25_0_10	S25_10_20

Bicarbonate Extractable (Colwell) Potassium, K Method: AN015/AN320 Tested: 26/10/2017

Bicarbonate Extractable (Colwell) Potassium, K*	mg/kg	10	170	230	380	280
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Nitrate Nitrogen and Nitrite Nitrogen (NOx) by Auto Analyser in Soil Method: AN248 Tested: 20/10/2017

Nitrate/Nitrite Nitrogen, NOx as N	mg/kg	0.1	0.9	-	20	22
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Total Kjeldahl Nitrogen and Total Nitrogen in Soil/Sludges Method: AN281 Tested: 17/10/2017

Total Kjeldahl Nitrogen	mg/kg	5	790	-	1300	1300
Total Nitrogen	mg/kg	10	800	-	1300	1400

Total Organic Carbon by Heanes Oxidation Method: AN273 Tested: 19/10/2017

Total Organic Carbon	%w/w	0.05	1.0	0.85	2.1	1.8
Organic Matter	%w/w	0.1	1.8	1.5	3.6	3.0

Emerson Class Number Method: AN009 Tested: 18/10/2017

Emerson Class Number	No unit	1	5	5	3	3
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Exchangeable Cations and Cation Exchange Capacity (CEC/ESP/SAR) Method: AN122 Tested: 20/10/2017

Exchangeable Sodium, Na	mg/kg	2	-	41	-	-
Exchangeable Sodium, Na	meq/100g	0.01	-	0.18	-	-
Exchangeable Sodium Percentage	%	0.1	-	1.0	-	-
Exchangeable Potassium, K	mg/kg	2	-	210	-	-
Exchangeable Potassium, K	meq/100g	0.01	-	0.54	-	-
Exchangeable Potassium Percentage	%	0.1	-	3.1	-	-
Exchangeable Calcium Percentage	%	0.1	-	79.1	-	-
Exchangeable Calcium, Ca	mg/kg	2	-	2800	-	-
Exchangeable Calcium, Ca	meq/100g	0.01	-	14	-	-
Exchangeable Magnesium, Mg	mg/kg	2	-	360	-	-
Exchangeable Magnesium, Mg	meq/100g	0.02	-	2.9	-	-
Exchangeable Magnesium Percentage	%	0.1	-	16.8	-	-
Cation Exchange Capacity	meq/100g	0.02	-	17	-	-
Exchangeable Calcium/Exchangeable Magnesium Ratio	No unit	0.1	-	4.7	-	-
Monovalent Cations/Divalent Cations Ratio*	No unit	0.1	-	<0.1	-	-
Cation Exchange Capacity (soluble salts removed)	meq/100g	0.02	-	-	-	-
Sodium Adsorption Ratio	No unit	0.1	-	<0.1	-	-
Exchangeable Aluminium, Al	cmol (+)/kg	0.01	-	-	-	-

Parameter	Units	LOR	Sample Number	CE129907.025	CE129907.026	CE129907.027	CE129907.028
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	28 Sep 2017	28 Sep 2017	28 Sep 2017	28 Sep 2017
			Sample Name	S23_20_30	S23_30_60	S25_0_10	S25_10_20

DTPA Extractable Metals in Soil Method: AN025/AN320 Tested: 20/10/2017

Copper, Cu	mg/kg	0.05	2.1	-	1.6	1.6
Zinc, Zn	mg/kg	0.05	0.26	-	0.60	0.43
Manganese, Mn	mg/kg	0.5	10	-	35	19
Iron, Fe	mg/kg	0.5	15	-	21	20

Calcium Chloride Extractable Boron Method: RL 12C2/AN320 Tested: 20/10/2017

CaCl ₂ -extractable Boron, B*	mg/kg	0.05	0.92	-	0.82	1.2
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Calcium Chloride Extractable Molybdenum Method: RL 12E1/AN318 Tested: 31/10/2017

CaCl ₂ -extractable Molybdenum, Mo*	mg/kg	0.1	<0.10	-	<0.10	<0.10
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Potassium Chloride Extractable Sulphur Method: RL 10D1/AN320 Tested: 20/10/2017

KCl-40-extractable Sulphur, S*	mg/kg	1	7	4	8	7
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Particle sizing of soils by sieving Method: AN005 Tested: 30/10/2017

Passing 2.00mm	%w/w	1	92	99	97	99
Retained 2.00mm	%w/w	1	8	<1	3	1
Passing 600µm	%w/w	1	67	82	74	68
Retained 600µm	%w/w	1	25	17	23	31
Passing 300µm	%w/w	1	54	53	70	53
Retained 300µm	%w/w	1	13	29	5	15
Passing 125µm	%w/w	1	37	35	58	45
Retained 125µm	%w/w	1	17	18	12	8
Passing 63µm	%w/w	1	36	31	54	42
Retained 63µm	%w/w	1	1	4	4	3

Particle sizing of soils <75µm by hydrometer Method: AN005 Tested: 28/10/2017

Sedimentation Diameter 1	mm	0.0001	0.0575	0.0578	0.0543	0.0568
Passing Sedimentation Diameter 1	%w/w	1	35	31	54	39
Retained Sedimentation Diameter 1	%w/w	1	2	1	<1	3
Sedimentation Diameter 2	mm	0.0001	0.0411	0.0411	0.0389	0.0404
Passing Sedimentation Diameter 2	%w/w	1	30	28	50	37
Retained Sedimentation Diameter 2	%w/w	1	5	2	5	2
Sedimentation Diameter 3	mm	0.0001	0.0293	0.0293	0.0277	0.0287
Passing Sedimentation Diameter 3	%w/w	1	27	26	47	34
Retained Sedimentation Diameter 3	%w/w	1	2	2	2	2
Sedimentation Diameter 4	mm	0.0001	0.0208	0.0208	0.0196	0.0204
Passing Sedimentation Diameter 4	%w/w	1	25	24	47	32
Retained Sedimentation Diameter 4	%w/w	1	2	2	<1	2
Sedimentation Diameter 5	mm	0.0001	0.0153	0.0153	0.0144	0.0149
Passing Sedimentation Diameter 5	%w/w	1	23	21	45	32
Retained Sedimentation Diameter 5	%w/w	1	2	2	2	<1
Sedimentation Diameter 6	mm	0.0001	0.0108	0.0108	0.0102	0.0106
Passing Sedimentation Diameter 6	%w/w	1	23	21	43	30
Retained Sedimentation Diameter 6	%w/w	1	<1	<1	2	2
Sedimentation Diameter 7	mm	0.0001	0.0077	0.0077	0.0073	0.0076
Passing Sedimentation Diameter 7	%w/w	1	20	19	39	27
Retained Sedimentation Diameter 7	%w/w	1	2	2	3	2
Sedimentation Diameter 8	mm	0.0001	0.0055	0.0055	0.0052	0.0054
Passing Sedimentation Diameter 8	%w/w	1	18	17	36	25
Retained Sedimentation Diameter 8	%w/w	1	2	2	3	2
Sedimentation Diameter 9	mm	0.0001	0.0039	0.0039	0.0037	0.0038
Passing Sedimentation Diameter 9	%w/w	1	18	17	31	22
Retained Sedimentation Diameter 9	%w/w	1	<1	<1	5	2
Sedimentation Diameter 10	mm	0.0001	0.0016	0.0016	0.0015	0.0016
Passing Sedimentation Diameter 10	%w/w	1	15	15	26	20

Parameter	Units	LOR	Sample Number	CE129907.025	CE129907.026	CE129907.027	CE129907.028
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	28 Sep 2017	28 Sep 2017	28 Sep 2017	28 Sep 2017
			Sample Name	S23_20_30	S23_30_60	S25_0_10	S25_10_20

Particle sizing of soils <75µm by hydrometer Method: AN005 Tested: 28/10/2017 (continued)

Retained Sedimentation Diameter 10	%w/w	1	2	2	5	2
Sedimentation Diameter 11	mm	0.0001	0.0011	0.0011	0.0011	0.0011
Passing Sedimentation Diameter 11	%w/w	1	15	12	25	18
Retained Sedimentation Diameter 11	%w/w	1	<1	2	1	2
Clay (<0.002mm)	%w/w	0.1	15	15	26	20
Silt and Clay (<0.005mm)*	%w/w	0.1	18	17	36	25
Silt (0.002mm to 0.06mm)*	%w/w	0.1	21	16	28	22
Fine Sand (0.06mm to 0.20mm)*	%w/w	0.1	1.3	3.8	3.8	2.7
Medium and Coarse Sand (0.20mm to 2.0mm)*	%w/w	0.1	55	64	39	54
Gravels (>2.0mm)*	%w/w	0.1	7.7	0.8	3.0	1.2

Parameter	Sample Number		CE129907.025	CE129907.026	CE129907.027	CE129907.028
	Sample Matrix		Soil	Soil	Soil	Soil
	Sample Date		28 Sep 2017	28 Sep 2017	28 Sep 2017	28 Sep 2017
	Sample Name		S23_20_30	S23_30_60	S25_0_10	S25_10_20
Units		LOR				

Erodibility Factor of Soil Method: CSIRO Tech Report 13/01 Tested: 26/10/2017

Erodibility Factor (K)*	t.ha.h/ha/MJ/	-	0.03	0.03	0.04	0.03
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Soil Texture (Northcote, 1979) Method: Northcote (1979) Tested: 18/10/2017

Texture Classification*	No unit	1	Light Clay	Sandy Clay	Light Medium Clay	Light Clay
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Sample Subcontracted Method: Tested: 10/11/2017

Sample Subcontracted*	No unit	-	See attached	See attached	See attached	See attached
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Parameter	Units	LOR	Sample Number	CE129907.029	CE129907.030	CE129907.031	CE129907.032
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	28 Sep 2017	28 Sep 2017	28 Sep 2017	26 Sep 2017
			Sample Name	S25_30_50	S25_50_70	S9_0_10	S9_10_20

Moisture Content Method: AN002 Tested: 16/10/2017

% Moisture	%w/w	0.5	13	13	1.0	1.5
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pH in soil (1:5) Method: AN101 Tested: 19/10/2017

pH	pH Units	-	8.6	8.6	5.8	6.2
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Conductivity and TDS by Calculation - Soil Method: AN106 Tested: 19/10/2017

Conductivity of Extract (1:5 dry sample basis)	µS/cm	1	900	980	36	42
Total Dissolved Solids (by calculation)	mg/kg	5	2700	2900	110	130

Chloride (water extractable) Method: AN274 Tested: 20/10/2017

Chloride (water extractable 1:5)	mg/kg	5	1100	1200	11	21
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Water Soluble Acidity of Soil Method: AN002/AN140 Tested: 19/10/2017

Water Soluble Acidity as CaCO ₃ to pH 8.3*	mg/kg	25	<25	<25	-	-
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Colwell Phosphorus Method: AN015 Tested: 18/10/2017

Colwell Phosphorus	mg/kg	1	3	3	4	3
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Parameter	Units	LOR	Sample Number	CE129907.029	CE129907.030	CE129907.031	CE129907.032
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	28 Sep 2017	28 Sep 2017	28 Sep 2017	26 Sep 2017
			Sample Name	S25_30_50	S25_50_70	S9_0_10	S9_10_20

Bicarbonate Extractable (Colwell) Potassium, K Method: AN015/AN320 Tested: 26/10/2017

Bicarbonate Extractable (Colwell) Potassium, K*	mg/kg	10	180	220	100	110
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Nitrate Nitrogen and Nitrite Nitrogen (NOx) by Auto Analyser in Soil Method: AN248 Tested: 20/10/2017

Nitrate/Nitrite Nitrogen, NOx as N	mg/kg	0.1	-	-	<0.1	<0.1
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Total Kjeldahl Nitrogen and Total Nitrogen in Soil/Sludges Method: AN281 Tested: 17/10/2017

Total Kjeldahl Nitrogen	mg/kg	5	-	-	200	200
Total Nitrogen	mg/kg	10	-	-	200	200

Total Organic Carbon by Heanes Oxidation Method: AN273 Tested: 25/10/2017

Total Organic Carbon	%w/w	0.05	1.5	1.2	0.21	0.21
Organic Matter	%w/w	0.1	2.6	2.0	0.37	0.36

Emerson Class Number Method: AN009 Tested: 18/10/2017

Emerson Class Number	No unit	1	5	5	2	2
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Exchangeable Cations and Cation Exchange Capacity (CEC/ESP/SAR) Method: AN122 Tested: 20/10/2017

Exchangeable Sodium, Na	mg/kg	2	2100	1700	-	-
Exchangeable Sodium, Na	meq/100g	0.01	9.2	7.5	-	-
Exchangeable Sodium Percentage	%	0.1	17.2	13.4	-	-
Exchangeable Potassium, K	mg/kg	2	340	330	-	-
Exchangeable Potassium, K	meq/100g	0.01	0.88	0.85	-	-
Exchangeable Potassium Percentage	%	0.1	1.6	1.5	-	-
Exchangeable Calcium Percentage	%	0.1	52.9	61.4	-	-
Exchangeable Calcium, Ca	mg/kg	2	5600	6900	-	-
Exchangeable Calcium, Ca	meq/100g	0.01	28	34	-	-
Exchangeable Magnesium, Mg	mg/kg	2	1800	1600	-	-
Exchangeable Magnesium, Mg	meq/100g	0.02	15	13	-	-
Exchangeable Magnesium Percentage	%	0.1	28.3	23.7	-	-
Cation Exchange Capacity	meq/100g	0.02	53	56	-	-
Exchangeable Calcium/Exchangeable Magnesium Ratio	No unit	0.1	1.9	2.6	-	-
Monovalent Cations/Divalent Cations Ratio*	No unit	0.1	0.2	0.2	-	-
Cation Exchange Capacity (soluble salts removed)	meq/100g	0.02	-	-	-	-
Sodium Adsorption Ratio	No unit	0.1	2.0	1.5	-	-
Exchangeable Aluminium, Al	cmol (+)/kg	0.01	-	-	-	-

Parameter	Units	LOR	Sample Number	CE129907.029	CE129907.030	CE129907.031	CE129907.032
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	28 Sep 2017	28 Sep 2017	28 Sep 2017	26 Sep 2017
			Sample Name	S25_30_50	S25_50_70	S9_0_10	S9_10_20

DTPA Extractable Metals in Soil Method: AN025/AN320 Tested: 24/10/2017

Copper, Cu	mg/kg	0.05	-	-	0.13	0.13
Zinc, Zn	mg/kg	0.05	-	-	0.18	0.16
Manganese, Mn	mg/kg	0.5	-	-	8.7	6.2
Iron, Fe	mg/kg	0.5	-	-	22	27

Calcium Chloride Extractable Boron Method: RL 12C2/AN320 Tested: 24/10/2017

CaCl ₂ -extractable Boron, B*	mg/kg	0.05	-	-	0.29	0.32
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Calcium Chloride Extractable Molybdenum Method: RL 12E1/AN318 Tested: 31/10/2017

CaCl ₂ -extractable Molybdenum, Mo*	mg/kg	0.1	-	-	<0.10	<0.10
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Potassium Chloride Extractable Sulphur Method: RL 10D1/AN320 Tested: 20/10/2017

KCl-40-extractable Sulphur, S*	mg/kg	1	13	9	4	4
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Particle sizing of soils by sieving Method: AN005 Tested: 30/10/2017

Passing 2.00mm	%w/w	1	98	97	84	85
Retained 2.00mm	%w/w	1	2	3	16	15
Passing 600µm	%w/w	1	80	80	63	67
Retained 600µm	%w/w	1	18	17	21	18
Passing 300µm	%w/w	1	70	73	28	34
Retained 300µm	%w/w	1	11	7	35	34
Passing 125µm	%w/w	1	63	66	12	11
Retained 125µm	%w/w	1	6	7	16	22
Passing 63µm	%w/w	1	62	65	9	9
Retained 63µm	%w/w	1	2	2	3	2

Particle sizing of soils <75µm by hydrometer Method: AN005 Tested: 28/10/2017

Sedimentation Diameter 1	mm	0.0001	0.0540	0.0536	-	-
Passing Sedimentation Diameter 1	%w/w	1	61	63	-	-
Retained Sedimentation Diameter 1	%w/w	1	2	2	-	-
Sedimentation Diameter 2	mm	0.0001	0.0383	0.0381	-	-
Passing Sedimentation Diameter 2	%w/w	1	59	60	-	-
Retained Sedimentation Diameter 2	%w/w	1	1	2	-	-
Sedimentation Diameter 3	mm	0.0001	0.0272	0.0271	-	-
Passing Sedimentation Diameter 3	%w/w	1	58	59	-	-
Retained Sedimentation Diameter 3	%w/w	1	1	1	-	-
Sedimentation Diameter 4	mm	0.0001	0.0193	0.0192	-	-
Passing Sedimentation Diameter 4	%w/w	1	56	58	-	-
Retained Sedimentation Diameter 4	%w/w	1	2	1	-	-
Sedimentation Diameter 5	mm	0.0001	0.0141	0.0141	-	-
Passing Sedimentation Diameter 5	%w/w	1	56	55	-	-
Retained Sedimentation Diameter 5	%w/w	1	<1	2	-	-
Sedimentation Diameter 6	mm	0.0001	0.0100	0.0100	-	-
Passing Sedimentation Diameter 6	%w/w	1	53	53	-	-
Retained Sedimentation Diameter 6	%w/w	1	2	2	-	-
Sedimentation Diameter 7	mm	0.0001	0.0071	0.0071	-	-
Passing Sedimentation Diameter 7	%w/w	1	51	51	-	-
Retained Sedimentation Diameter 7	%w/w	1	2	2	-	-
Sedimentation Diameter 8	mm	0.0001	0.0051	0.0051	-	-
Passing Sedimentation Diameter 8	%w/w	1	48	48	-	-
Retained Sedimentation Diameter 8	%w/w	1	2	2	-	-
Sedimentation Diameter 9	mm	0.0001	0.0036	0.0036	-	-
Passing Sedimentation Diameter 9	%w/w	1	46	46	-	-
Retained Sedimentation Diameter 9	%w/w	1	2	2	-	-
Sedimentation Diameter 10	mm	0.0001	0.0015	0.0015	-	-
Passing Sedimentation Diameter 10	%w/w	1	38	38	-	-

Parameter	Units	LOR	Sample Number	CE129907.029	CE129907.030	CE129907.031	CE129907.032
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	28 Sep 2017	28 Sep 2017	28 Sep 2017	26 Sep 2017
			Sample Name	S25_30_50	S25_50_70	S9_0_10	S9_10_20

Particle sizing of soils <75µm by hydrometer Method: AN005 Tested: 28/10/2017 (continued)

Retained Sedimentation Diameter 10	%w/w	1	7	7	-	-
Sedimentation Diameter 11	mm	0.0001	0.0011	0.0011	-	-
Passing Sedimentation Diameter 11	%w/w	1	34	36	-	-
Retained Sedimentation Diameter 11	%w/w	1	4	2	-	-
Clay (<0.002mm)	%w/w	0.1	38	38	-	-
Silt and Clay (<0.005mm)*	%w/w	0.1	48	48	-	-
Silt (0.002mm to 0.06mm)*	%w/w	0.1	24	27	-	-
Fine Sand (0.06mm to 0.20mm)*	%w/w	0.1	1.6	1.6	-	-
Medium and Coarse Sand (0.20mm to 2.0mm)*	%w/w	0.1	35	31	-	-
Gravels (>2.0mm)*	%w/w	0.1	1.7	3.2	-	-

Parameter	Units	LOR	Sample Number	CE129907.029	CE129907.030	CE129907.031	CE129907.032
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	28 Sep 2017	28 Sep 2017	28 Sep 2017	26 Sep 2017
			Sample Name	S25_30_50	S25_50_70	S9_0_10	S9_10_20

Erodibility Factor of Soil Method: CSIRO Tech Report 13/01 Tested: 26/10/2017

Erodibility Factor (K)*	t.ha.h/ha/MJ/	-	0.05	0.06	0.00	0.00
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Soil Texture (Northcote, 1979) Method: Northcote (1979) Tested: 18/10/2017

Texture Classification*	No unit	1	Medium Heavy Clay	Medium Heavy Clay	Sand	Sand
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Sample Subcontracted Method: Tested: 10/11/2017

Sample Subcontracted*	No unit	-	See attached	See attached	See attached	See attached
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Sample Number CE129907.033
Sample Matrix Soil
Sample Date 26 Sep 2017
Sample Name S9_20_30

Parameter Units LOR

Moisture Content Method: AN002 Tested: 16/10/2017

% Moisture	%w/w	0.5	1.5
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pH in soil (1:5) Method: AN101 Tested: 19/10/2017

pH	pH Units	-	6.2
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Conductivity and TDS by Calculation - Soil Method: AN106 Tested: 19/10/2017

Conductivity of Extract (1:5 dry sample basis)	µS/cm	1	50
Total Dissolved Solids (by calculation)	mg/kg	5	150

Chloride (water extractable) Method: AN274 Tested: 20/10/2017

Chloride (water extractable 1:5)	mg/kg	5	29
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Water Soluble Acidity of Soil Method: AN002/AN140 Tested: 19/10/2017

Water Soluble Acidity as CaCO ₃ to pH 8.3*	mg/kg	25	-
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Colwell Phosphorus Method: AN015 Tested: 18/10/2017

Colwell Phosphorus	mg/kg	1	3
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Sample Number CE129907.033
Sample Matrix Soil
Sample Date 26 Sep 2017
Sample Name S9_20_30

Parameter	Units	LOR
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Bicarbonate Extractable (Colwell) Potassium, K Method: AN015/AN320 Tested: 26/10/2017

Bicarbonate Extractable (Colwell) Potassium, K*	mg/kg	10	110
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Nitrate Nitrogen and Nitrite Nitrogen (NOx) by Auto Analyser in Soil Method: AN248 Tested: 20/10/2017

Nitrate/Nitrite Nitrogen, NOx as N	mg/kg	0.1	<0.1
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Total Kjeldahl Nitrogen and Total Nitrogen in Soil/Sludges Method: AN281 Tested: 19/10/2017

Total Kjeldahl Nitrogen	mg/kg	5	190
Total Nitrogen	mg/kg	10	190

Total Organic Carbon by Heanes Oxidation Method: AN273 Tested: 19/10/2017

Total Organic Carbon	%w/w	0.05	0.12
Organic Matter	%w/w	0.1	0.21

Emerson Class Number Method: AN009 Tested: 18/10/2017

Emerson Class Number	No unit	1	2
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Exchangeable Cations and Cation Exchange Capacity (CEC/ESP/SAR) Method: AN122 Tested: 20/10/2017

Exchangeable Sodium, Na	mg/kg	2	-
Exchangeable Sodium, Na	meq/100g	0.01	-
Exchangeable Sodium Percentage	%	0.1	-
Exchangeable Potassium, K	mg/kg	2	-
Exchangeable Potassium, K	meq/100g	0.01	-
Exchangeable Potassium Percentage	%	0.1	-
Exchangeable Calcium Percentage	%	0.1	-
Exchangeable Calcium, Ca	mg/kg	2	-
Exchangeable Calcium, Ca	meq/100g	0.01	-
Exchangeable Magnesium, Mg	mg/kg	2	-
Exchangeable Magnesium, Mg	meq/100g	0.02	-
Exchangeable Magnesium Percentage	%	0.1	-
Cation Exchange Capacity	meq/100g	0.02	-
Exchangeable Calcium/Exchangeable Magnesium Ratio	No unit	0.1	-
Monovalent Cations/Divalent Cations Ratio*	No unit	0.1	-
Cation Exchange Capacity (soluble salts removed)	meq/100g	0.02	-
Sodium Adsorption Ratio	No unit	0.1	-
Exchangeable Aluminium, Al	cmol (+)/kg	0.01	-

Sample Number CE129907.033
 Sample Matrix Soil
 Sample Date 26 Sep 2017
 Sample Name S9_20_30

Parameter	Units	LOR
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DTPA Extractable Metals in Soil Method: AN025/AN320 Tested: 20/10/2017

Copper, Cu	mg/kg	0.05	0.14
Zinc, Zn	mg/kg	0.05	0.15
Manganese, Mn	mg/kg	0.5	6.7
Iron, Fe	mg/kg	0.5	28

Calcium Chloride Extractable Boron Method: RL 12C2/AN320 Tested: 20/10/2017

CaCl ₂ -extractable Boron, B*	mg/kg	0.05	0.31
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Calcium Chloride Extractable Molybdenum Method: RL 12E1/AN318 Tested: 31/10/2017

CaCl ₂ -extractable Molybdenum, Mo*	mg/kg	0.1	<0.10
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Potassium Chloride Extractable Sulphur Method: RL 10D1/AN320 Tested: 20/10/2017

KCl-40-extractable Sulphur, S*	mg/kg	1	5
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Particle sizing of soils by sieving Method: AN005 Tested: 30/10/2017

Passing 2.00mm	%w/w	1	80
Retained 2.00mm	%w/w	1	20
Passing 600µm	%w/w	1	66
Retained 600µm	%w/w	1	14
Passing 300µm	%w/w	1	35
Retained 300µm	%w/w	1	30
Passing 125µm	%w/w	1	12
Retained 125µm	%w/w	1	24
Passing 63µm	%w/w	1	9
Retained 63µm	%w/w	1	2

		Sample Number	CE129907.033
		Sample Matrix	Soil
		Sample Date	26 Sep 2017
		Sample Name	S9_20_30
Parameter	Units	LOR	

Particle sizing of soils <75µm by hydrometer Method: AN005 Tested: 28/10/2017

Sedimentation Diameter 1	mm	0.0001	-
Passing Sedimentation Diameter 1	%w/w	1	-
Retained Sedimentation Diameter 1	%w/w	1	-
Sedimentation Diameter 2	mm	0.0001	-
Passing Sedimentation Diameter 2	%w/w	1	-
Retained Sedimentation Diameter 2	%w/w	1	-
Sedimentation Diameter 3	mm	0.0001	-
Passing Sedimentation Diameter 3	%w/w	1	-
Retained Sedimentation Diameter 3	%w/w	1	-
Sedimentation Diameter 4	mm	0.0001	-
Passing Sedimentation Diameter 4	%w/w	1	-
Retained Sedimentation Diameter 4	%w/w	1	-
Sedimentation Diameter 5	mm	0.0001	-
Passing Sedimentation Diameter 5	%w/w	1	-
Retained Sedimentation Diameter 5	%w/w	1	-
Sedimentation Diameter 6	mm	0.0001	-
Passing Sedimentation Diameter 6	%w/w	1	-
Retained Sedimentation Diameter 6	%w/w	1	-
Sedimentation Diameter 7	mm	0.0001	-
Passing Sedimentation Diameter 7	%w/w	1	-
Retained Sedimentation Diameter 7	%w/w	1	-
Sedimentation Diameter 8	mm	0.0001	-
Passing Sedimentation Diameter 8	%w/w	1	-
Retained Sedimentation Diameter 8	%w/w	1	-
Sedimentation Diameter 9	mm	0.0001	-
Passing Sedimentation Diameter 9	%w/w	1	-
Retained Sedimentation Diameter 9	%w/w	1	-
Sedimentation Diameter 10	mm	0.0001	-
Passing Sedimentation Diameter 10	%w/w	1	-
Retained Sedimentation Diameter 10	%w/w	1	-
Sedimentation Diameter 11	mm	0.0001	-
Passing Sedimentation Diameter 11	%w/w	1	-
Retained Sedimentation Diameter 11	%w/w	1	-
Clay (<0.002mm)	%w/w	0.1	-
Silt and Clay (<0.005mm)*	%w/w	0.1	-
Silt (0.002mm to 0.06mm)*	%w/w	0.1	-
Fine Sand (0.06mm to 0.20mm)*	%w/w	0.1	-
Medium and Coarse Sand (0.20mm to 2.0mm)*	%w/w	0.1	-
Gravels (>2.0mm)*	%w/w	0.1	-



ANALYTICAL REPORT

CE129907 R0

			Sample Number	CE129907.033
			Sample Matrix	Soil
			Sample Date	26 Sep 2017
			Sample Name	S9_20_30
Parameter	Units	LOR		

Erodibility Factor of Soil Method: CSIRO Tech Report 13/01 Tested: 26/10/2017

Erodibility Factor (K)*	t.ha.h/ha/MJ/	-	0.00
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Soil Texture (Northcote, 1979) Method: Northcote (1979) Tested: 18/10/2017

Texture Classification*	No unit	1	Sand
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Sample Subcontracted Method: Tested: 10/11/2017

Sample Subcontracted*	No unit	-	See attached
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MB blank results are compared to the Limit of Reporting

LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.

DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage*. Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

Bicarbonate Extractable (Colwell) Potassium, K Method: ME-(AU)-[ENV]AN015/AN320

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Bicarbonate Extractable (Colwell) Potassium, K*	LB050497	mg/kg	10	<10	1 - 3%	NA

Calcium Chloride Extractable Boron Method: RL 12C2/AN320

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
CaCl2-extractable Boron, B*	LB050320	mg/kg	0.05	0.19	1 - 6%	NA

Calcium Chloride Extractable Molybdenum Method: RL 12E1/AN318

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
CaCl2-extractable Molybdenum, Mo*	LB050591	mg/kg	0.1	<0.10	0%	NA

Chloride (water extractable) Method: ME-(AU)-[ENV]AN274

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Chloride (water extractable 1:5)	LB050331	mg/kg	5	<5	1 - 3%	104 - 105%

Colwell Phosphorus Method: ME-(AU)-[ENV]AN015

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Colwell Phosphorus	LB050241	mg/kg	1	<1	0 - 3%	88 - 97%

Conductivity and TDS by Calculation - Soil Method: ME-(AU)-[ENV]AN106

Parameter	QC Reference	Units	LOR	MB	LCS %Recovery
Conductivity of Extract (1:5 dry sample basis)	LB050304	µS/cm	1		101%
Total Dissolved Solids (by calculation)	LB050304	mg/kg	5	<5	NA

MB blank results are compared to the Limit of Reporting

LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.

DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage*. Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

DTPA Extractable Metals in Soil Method: ME-(AU)-[ENV]AN025/AN320

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Copper, Cu	LB050316	mg/kg	0.05	<0.05	2 - 12%	NA
Zinc, Zn	LB050316	mg/kg	0.05	<0.05	0 - 12%	NA
Manganese, Mn	LB050316	mg/kg	0.5	<0.5	1 - 4%	NA
Iron, Fe	LB050316	mg/kg	0.5	<0.5	0 - 1%	NA

Exchangeable Cations and Cation Exchange Capacity (CEC/ESP/SAR) Method: ME-(AU)-[ENV]AN122

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Exchangeable Sodium, Na	LB050329	mg/kg	2		2 - 3%	88 - 96%
Exchangeable Sodium, Na	LB050329	meq/100g	0.01	<0.01	2 - 3%	NA
Exchangeable Sodium Percentage	LB050329	%	0.1	<0.1	3%	NA
Exchangeable Potassium, K	LB050329	mg/kg	2		0 - 2%	102 - 104%
Exchangeable Potassium, K	LB050329	meq/100g	0.01	<0.01	0 - 2%	NA
Exchangeable Potassium Percentage	LB050329	%	0.1		1 - 3%	NA
Exchangeable Calcium Percentage	LB050329	%	0.1	<0.1	0 - 1%	NA
Exchangeable Calcium, Ca	LB050329	mg/kg	2		0 - 2%	96 - 102%
Exchangeable Calcium, Ca	LB050329	meq/100g	0.01	<0.01	0 - 2%	NA
Exchangeable Magnesium, Mg	LB050329	mg/kg	2		0%	94 - 98%
Exchangeable Magnesium, Mg	LB050329	meq/100g	0.02	<0.02	0%	NA
Exchangeable Magnesium Percentage	LB050329	%	0.1	<0.1	0 - 1%	NA
Cation Exchange Capacity	LB050329	meq/100g	0.02	<0.02	0 - 1%	NA
Exchangeable Calcium/Exchangeable Magnesium Ratio	LB050329	No unit	0.1		0 - 2%	NA
Monovalent Cations/Divalent Cations Ratio*	LB050329	No unit	0.1		0%	NA
Sodium Adsorption Ratio	LB050329	No unit	0.1		2 - 3%	NA

Nitrate Nitrogen and Nitrite Nitrogen (NOx) by Auto Analyser in Soil Method: ME-(AU)-[ENV]AN248

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Nitrate/Nitrite Nitrogen, NOx as N	LB050326	mg/kg	0.1	<0.1	2%	99 - 101%

pH in soil (1:5) Method: ME-(AU)-[ENV]AN101

Parameter	QC Reference	Units	LOR	MB	LCS %Recovery
pH	LB050304	pH Units	-	5.6	100%

MB blank results are compared to the Limit of Reporting

LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.

DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage*. Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

Potassium Chloride Extractable Sulphur Method: RL 10D1/AN320

Parameter	QC Reference	Units	LOR	DUP %RPD
KCl-40-extractable Sulphur, S*	LB050318	mg/kg	1	2 - 4%

Total Kjeldahl Nitrogen and Total Nitrogen in Soil/Sludges Method: ME-(AU)-[ENV]AN281

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Total Kjeldahl Nitrogen	LB050218	mg/kg	5	<5	0%	99%
	LB050307	mg/kg	5	<5	0 - 1%	99 - 103%

Total Organic Carbon by Heanes Oxidation Method: ME-(AU)-[ENV]AN273

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Total Organic Carbon	LB050306	%w/w	0.05	<0.05	2 - 16%	93 - 94%	109%
	LB050426	%w/w	0.05	<0.05	0 - 4%	95%	101%
Organic Matter	LB050306	%w/w	0.1		2 - 16%		
	LB050426	%w/w	0.1		0 - 4%		

Water Soluble Acidity of Soil Method: ME-(AU)-[ENV]AN002/AN140

Parameter	QC Reference	Units	LOR	MB	LCS %Recovery
Water Soluble Acidity as CaCO ₃ to pH 8.3*	LB050271	mg/kg	25	<25	NA

METHOD

METHODOLOGY SUMMARY

AN002	The test is carried out by drying (at either 40°C or 105°C) a known mass of sample in a weighed evaporating basin. After fully dry the sample is re-weighed. Samples such as sludge and sediment having high percentages of moisture will take some time in a drying oven for complete removal of water.
AN002/AN140	Acidity by Titration: The water extract is titrated with sodium hydroxide to designated pH end point. In a sample containing only carbon dioxide, bicarbonates and carbonates, titration to pH 8.3 at 25°C corresponds to stoichiometric neutralisation of carbonic acid to bicarbonate. Method reference APHA 2310 B.
AN005	The particle size distribution of a soil is determined by wet sieving, using a maximum of 900 mL of deionised water to sieve all fractions down to 75 µm. Referenced to AS1289.3.6.1 and AS1141.11.
AN009	The method follows AS1289 3.8.1 - 2006. Soils are divided into seven classes on the basis of their coherence in water, with one further class being distinguished by the presence of calcium-rich minerals. Class 1: Air-dried crumbs of soil show a strong dispersion reaction, i.e., a colloidal cloud covers nearly the whole of the bottom of the beaker, usually in a very thin layer. The reaction should be evident within 10min. In extreme cases all the water in the beaker becomes cloudy, leaving only a coarse residue in a cloud of clay.
AN009	Class 2: Air-dried crumbs of soil show a moderate to slight reaction. A moderate reaction consists of an easily recognisable cloud of colloids in suspension, usually spreading in thin streaks on the bottom of the beaker. A slight reaction consists of the bare hint of cloud in water at the surface of the crumbs. Class 3: The soil remoulded at the plastic limit disperses in water. Class 4: The remoulded soil does not disperse in water. Calcium carbonate (calcite) or calcium sulfate (gypsum) is present. Class 5: The remoulded soil does not disperse in water and the 1:5 soil/water suspension remains dispersed after 5 min.
AN009	Class 6: The remoulded soil does not disperse in water and the 1:5 soil/water suspension begins to flocculate within 5 min. Class 7: The air-dried crumbs of soil remain coherent in water and swells. Class 8: The air-dried crumbs of soil remain coherent in water and do not swell.
AN015	Soil sample is extracted in an end over end roller in 0.5 N sodium bicarbonate at pH 8.5 with the supernatant liquor analysed for Phosphorous. Orthophosphate anion (PO ₄ ³⁻) is reacted with ammonium molybdate and potassium antimony tartrate in sulfuric acid solution. The resulting phospho-molybdate complex is reduced, using ascorbic acid, to an intense blue coloured complex Molybdenum Blue. The absorbance of this complex is measured at 880 nm by Discrete Analyser, and compared with calibration standards to obtain the concentration of orthophosphate in the sample. Based on Rayment & Higginson 9B1.
AN015/AN320	Soil sample is extracted in an end over end roller in 0.5 N sodium bicarbonate at pH 8.5 with the supernatant liquor analysed for Potassium by ICP OES. Based on Rayment & Higginson 18A1.
AN025/AN320	A chelating agent is used to complex metal ions in solution. The extracted elements are determined by ICP OES.
AN101	pH in Soil Sludge Sediment and Water: pH is measured electrometrically using a combination electrode and is calibrated against 3 buffers purchased commercially. For soils, sediments and sludges, an extract with water (or 0.01M CaCl ₂) is made at a ratio of 1:5 and the pH determined and reported on the extract. Reference APHA 4500-H ⁺ .
AN106	Conductivity and TDS by Calculation: Conductivity is measured by meter with temperature compensation and is calibrated against a standard solution of potassium chloride. Conductivity is generally reported as µmhos/cm or µS/cm @ 25°C. For soils, an extract with water is made at a ratio of 1:5 and the EC determined and reported on the extract, or calculated back to the as-received sample. Salinity can be estimated from conductivity using a conversion factor, which for natural waters, is in the range 0.55 to 0.75. Reference APHA 2510 B.

METHOD

METHODOLOGY SUMMARY

AN122	Exchangeable Cations, CEC and ESP: Soil sample is extracted in 1M Ammonium Acetate at pH=7 (or 1M Ammonium Chloride at pH=7) with cations (Na, K, Ca & Mg) then determined by ICP OES/ICP MS and reported as Exchangeable Cations. For saline soils, these results can be corrected for water soluble cations and reported as Exchangeable cations in meq/100g or soil can be pre-treated (aqueous ethanol/aqueous glycerol) prior to extraction. Cation Exchange Capacity (CEC) is the sum of the exchangeable cations in meq/100g.						
AN122	The Exchangeable Sodium Percentage (ESP) is calculated as the exchangeable sodium divided by the CEC (all in meq/100g) times 100. ESP can be used to categorise the sodicity of the soil as below: <table> <tr> <td>ESP < 6%</td><td>non-sodic</td></tr> <tr> <td>ESP 6-15%</td><td>sodic</td></tr> <tr> <td>ESP >15%</td><td>strongly sodic</td></tr> </table> Method is referenced to Rayment and Higginson, 1992, sections 15D3 and 15N1.-	ESP < 6%	non-sodic	ESP 6-15%	sodic	ESP >15%	strongly sodic
ESP < 6%	non-sodic						
ESP 6-15%	sodic						
ESP >15%	strongly sodic						
AN248	Nitrate / Nitrite in extract by Auto Analyser: In an acidic medium, nitrate is reduced quantitatively to nitrite by cadmium metal. This nitrite plus any original nitrite is determined as an intense red-pink azo dye at 540 nm following diazotisation with sulphanilamide and subsequent coupling with N-(1-naphthyl) ethylenediamine dihydrochloride. Reference APHA 4500-NO3- F.						
AN273	The sample is digested in Dichromate / Sulfuric Acid to oxidise the organic carbon. The determination is completed colourimetrically by Aquakem Discrete Analyser at 600 nm. Based on Rayment & Higginson 6B1.						
AN274	Chloride by Aquakem DA following 1:5 or 1:2 DI water extraction: Chloride reacts with mercuric thiocyanate forming a mercuric chloride complex. In the presence of ferric iron, highly coloured ferric thiocyanate is formed which is proportional to the chloride concentration. Results reported on dry sample basis. Reference APHA 4500Cl-						
AN281	The sample is heated in the presence of Sulphuric acid, K ₂ SO ₄ and CuSO ₄ for two and half hours using a temperature controlled digestion block. Amino Nitrogen of many organic materials is converted to ammonium ion. Free ammonia also is converted to ammonium. The digest is cooled and placed on the Aquakem 250 discrete analyser for Ammonia determination.						
CSIRO Tech Report 13	The soil erodibility factor (K) calculation uses the percentage of soil particles below 125µm, soil organic carbon content and soil permeability class to provide an estimate of soil erodibility used in the universal soil loss equation (USLE) and its derivatives.						
Northcote (1979)	Texture is a measure of the behaviour of a small handful of soil when moistened, worked into a bolus (ball) and then pressed out between thumb and forefinger. It is used mainly as a rough guide to the proportions of gravel, coarse sand, fine sand, silt and clay in the soil.						
RL 10D1/AN320	Air dried <2mm soil is extracted in 0.25M KCl at 40 deg C followed by analysis of filtrate for S by ICP OES. Referenced to Rayment and Lyons method 10D1.						
RL 12C2/AN320	Air dried <2mm soil is extracted in 0.01M CaCl ₂ by refluxing gently for 10 minutes. Extract is then filtered and analysed by ICP OES. Referenced method Rayment and Lyon, 12C2.						
RL12E1/AN318	Air dried <2mm soil is extracted in 0.01M CaCl ₂ by refluxing gently for 10 minutes. Extract is then filtered and analysed by ICP MS. Referenced method Rayment and Lyon, 12E1.						

FOOTNOTES

IS	Insufficient sample for analysis.	LOR	Limit of Reporting
LNR	Sample listed, but not received.	↑↓	Raised or Lowered Limit of Reporting
*	NATA accreditation does not cover the performance of this service.	QFH	QC result is above the upper tolerance
**	Indicative data, theoretical holding time exceeded.	QFL	QC result is below the lower tolerance
		-	The sample was not analysed for this analyte
		NVL	Not Validated

Samples analysed as received.

Solid samples expressed on a dry weight basis.

Where "Total" analyte groups are reported (for example, Total PAHs, Total OC Pesticides) the total will be calculated as the sum of the individual analytes, with those analytes that are reported as <LOR being assumed to be zero. The summed (Total) limit of reporting is calculated by summing the individual analyte LORs and dividing by two. For example, where 16 individual analytes are being summed and each has an LOR of 0.1 mg/kg, the "Totals" LOR will be 1.6 / 2 (0.8 mg/kg). Where only 2 analytes are being summed, the "Total" LOR will be the sum of those two LORs.

Some totals may not appear to add up because the total is rounded after adding up the raw values.

If reported, measurement uncertainty follow the ± sign after the analytical result and is expressed as the expanded uncertainty calculated using a coverage factor of 2, providing a level of confidence of approximately 95%, unless stated otherwise in the comments section of this report.

Results reported for samples tested under test methods with codes starting with ARS-SOP, radionuclide or gross radioactivity concentrations are expressed in becquerel (Bq) per unit of mass or volume or per wipe as stated on the report. Becquerel is the SI unit for activity and equals one nuclear transformation per second.

Note that in terms of units of radioactivity:

- 1 Bq is equivalent to 27 pCi
- 37 MBq is equivalent to 1 mCi

For results reported for samples tested under test methods with codes starting with ARS-SOP, less than (<) values indicate the detection limit for each radionuclide or parameter for the measurement system used. The respective detection limits have been calculated in accordance with ISO 11929.

The QC criteria are subject to internal review according to the SGS QAQC plan and may be provided on request or alternatively can be found here : <http://www.sgs.com.au/~media/Local/Australia/Documents/Technical%20Documents/MP-AU-ENV-QU-022%20QA%20QC%20Plan.pdf>

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Environmental

SAMPLE RECEIPT NOTIFICATION (SRN)

Work Order : **EB1913756**

Client	: SLR Consulting Australia Pty Ltd	Laboratory	: Environmental Division Brisbane
Contact	: CAMERON TRAILL	Contact	: Tyler Cachia
Address	:	Address	: 2 Byth Street Stafford QLD Australia 4053
E-mail	: ctrail@slrconsulting.com	E-mail	: Tyler.Cachia@ALSGlobal.com
Telephone	: ----	Telephone	: +61 2 8784 8555
Facsimile	: ----	Facsimile	: +61-7-3243 7218
Project	: 623.17171 Fairhill Coking Coal	Page	: 1 of 3
Order number	:	Quote number	: EM2018HEGAUS0001 (EN/032/18 Primary work only BQ)
C-O-C number	: ----	QC Level	: NEPM 2013 B3 & ALS QC Standard
Site	: ----		
Sampler	: CAMERON TRAILL		

Dates

Date Samples Received	: 28-May-2019 09:00	Issue Date	: 29-May-2019
Client Requested Due Date	: 10-Jun-2019	Scheduled Reporting Date	: 10-Jun-2019

Delivery Details

Mode of Delivery	: Carrier	Security Seal	: Intact.
No. of coolers/boxes	: 6	Temperature	: 18.2/17.8/19.1/19.8/19.5/18.7°C
Receipt Detail	: MEDIUM HARD ESKY	No. of samples received / analysed	: 6 / 6

General Comments

- This report contains the following information:
 - Sample Container(s)/Preservation Non-Compliances
 - Summary of Sample(s) and Requested Analysis
 - Proactive Holding Time Report
 - Requested Deliverables
- Please be advised that ALS is unable to accommodate the fast turnaround requested on the Chain of Custody. If you wish to discuss this further, please contact Client Services at **ALSEnviro.Brisbane@alsglobal.com**.
- Discounted Package Prices apply only when specific ALS Group Codes ('W', 'S', 'NT' suites) are referenced on COCs.
- Please direct any turn around / technical queries to the laboratory contact designated above.
- Sample Disposal - Aqueous (3 weeks), Solid (2 months ± 1 week) from receipt of samples.
- Analysis will be conducted by ALS Environmental, Brisbane, NATA accreditation no. 825, Site No. 818 (Micro site no. 18958).
- Breaches in recommended extraction / analysis holding times (if any) are displayed overleaf in the Proactive Holding Time Report table.**
- Please be aware that APHA/NEPM recommends water and soil samples be chilled to less than or equal to 6°C for chemical analysis, and less than or equal to 10°C but unfrozen for Microbiological analysis. Where samples are received above this temperature, it should be taken into consideration when interpreting results. Refer to ALS EnviroMail 85 for ALS recommendations of the best practice for chilling samples after sampling and for maintaining a cool temperature during transit.



Sample Container(s)/Preservation Non-Compliances

All comparisons are made against pretreatment/preservation AS, APHA, USEPA standards.

- No sample container / preservation non-compliance exists.

Summary of Sample(s) and Requested Analysis

Some items described below may be part of a laboratory process necessary for the execution of client requested tasks. Packages may contain additional analyses, such as the determination of moisture content and preparation tasks, that are included in the package.

If no sampling time is provided, the sampling time will default 00:00 on the date of sampling. If no sampling date is provided, the sampling date will be assumed by the laboratory and displayed in brackets without a time component

Matrix: **SOIL**

Laboratory sample ID	Client sampling date / time	Client sample ID	
EB1913756-001	23-May-2019 14:00	PR04 / 0.0-0.1	✓
EB1913756-002	23-May-2019 14:00	PR04 / 0.1-0.2	✓
EB1913756-003	23-May-2019 14:00	PR04 / 0.2-0.3	✓
EB1913756-004	23-May-2019 14:00	PR04 / 0.5-0.6	✓
EB1913756-005	23-May-2019 14:00	PR04 / 0.8-0.9	✓
EB1913756-006	23-May-2019 14:00	PR04 / 1.1-1.2	✓

SOIL - EA055-103 Moisture Content	✓
SOIL - ED045G (solids) Chloride Soluble by Discrete Analyser	✓
SOIL - ED091 Calcium Chloride Extractable Boron	✓
SOIL - ED092 DTPA Extractable Metals	✓
SOIL - EK067G (Solids) Total Phosphorus as P by Discrete Analyser	✓
SOIL - EK080 Bicarbonate Extractable P (Colwell)	✓
SOIL - EP004 (Carbon) Organic Matter & Total Organic Carbon (Calc.)	✓

Matrix: **SOIL**

Laboratory sample ID	Client sampling date / time	Client sample ID	
EB1913756-001	23-May-2019 14:00	PR04 / 0.0-0.1	✓
EB1913756-002	23-May-2019 14:00	PR04 / 0.1-0.2	✓
EB1913756-003	23-May-2019 14:00	PR04 / 0.2-0.3	✓
EB1913756-004	23-May-2019 14:00	PR04 / 0.5-0.6	✓
EB1913756-005	23-May-2019 14:00	PR04 / 0.8-0.9	✓
EB1913756-006	23-May-2019 14:00	PR04 / 1.1-1.2	✓

SOIL - AG-1 EB Only Agricultural Soil Suite 1 EB Only	✓
SOIL - EA013 Acid Neutralising Capacity (ANC)	✓
SOIL - EA058 Emerson Aggregate Test	✓
SOIL - EA150H-Y Particle Size Analysis by Hydrometer: Yellow	✓
SOIL - ED042T Sulfur - Total as S (high temperature furnace	✓
SOIL - NT-6S Nitrogen, TKN, NO2, NO3	✓

Proactive Holding Time Report

Sample(s) have been received within the recommended holding times for the requested analysis.



Requested Deliverables

ACCOUNTS PAYABLE AU	
- A4 - AU Tax Invoice (INV)	Email
	accounts payable@slrconsulting.com
CAMERON TRAILL	
- *AU Certificate of Analysis - NATA (COA)	Email
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep) (QCI)	Email
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA (QC)	Email
- A4 - AU Sample Receipt Notification - Environmental HT (SRN)	Email
- A4 - AU Tax Invoice (INV)	Email
- Attachment - Report (SUBCO)	Email
- Chain of Custody (CoC) (COC)	Email
- EDI Format - ENMRG (ENMRG)	Email
- EDI Format - ESDAT (ESDAT)	Email
D TAYLOR	
- A4 - AU Tax Invoice (INV)	Email
	dtaylor@slrconsulting.com



Environmental

CERTIFICATE OF ANALYSIS

Work Order

: **EB1913756**

Client

: **SLR Consulting Australia Pty Ltd**

Contact

: **CAMERON TRAILL**

Address

:

Telephone

: ----

Project

: **623.17171 Fairhill Coking Coal**

Order number

:

C-O-C number

: ----

Sampler

: **CAMERON TRAILL**

Site

: ----

Quote number

: **EN/032/18 Primary work only BQ**

No. of samples received

: **6**

No. of samples analysed

: **6**

Page

: **1 of 7**

Laboratory

: **Environmental Division Brisbane**

Contact

: **Tyler Cachia**

Address

: **2 Byth Street Stafford QLD Australia 4053**

Telephone

: **+61 2 8784 8555**

Date Samples Received

: **28-May-2019 09:00**

Date Analysis Commenced

: **30-May-2019**

Issue Date

: **11-Jun-2019 17:37**



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. 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

Ben Felgendreijens

Senior Acid Sulfate Soil Chemist

Brisbane Acid Sulphate Soils, Stafford, QLD

Kim McCabe

Senior Inorganic Chemist

Brisbane Acid Sulphate Soils, Stafford, QLD

Kim McCabe

Senior Inorganic Chemist

Brisbane Inorganics, Stafford, QLD

Satishkumar Trivedi

Senior Acid Sulfate Soil Chemist

Brisbane Acid Sulphate Soils, Stafford, QLD



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by 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 Contact 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.

- ED006 (Exchangeable Cations on Alkaline Soils): Unable to calculate Magnesium/Potassium Ratio for some samples as the required results for Magnesium/Potassium are below LOR.
- ED008 (Exchangeable Cations with pre-treatment): Unable to calculate Magnesium/Potassium Ratio for some samples as the required results for Magnesium/Potassium are below LOR.
- ALS is not NATA accredited for the analysis of Exchangeable Aluminium and Exchange Acidity in soils when performed under ALS Method ED005.
- ALS is not NATA accredited for the analysis of Exchangeable Cations on Alkaline Soils when performed under ALS Method ED006.
- ASS: EA013 (ANC) Fizz Rating: 0- None; 1- Slight; 2- Moderate; 3- Strong; 4- Very Strong; 5- Lime.
- EA058 Emerson: V. = Very, D. = Dark, L. = Light, VD. = Very Dark
- ED007 and ED008: When Exchangeable Al is reported from these methods, it should be noted that Rayment & Lyons (2011) suggests Exchange Acidity by 1M KCl - Method 15G1 (ED005) is a more suitable method for the determination of exchange acidity (H⁺ + Al³⁺).



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)		Client sample ID		PR04 / 0.0-0.1	PR04 / 0.1-0.2	PR04 / 0.2-0.3	PR04 / 0.5-0.6	PR04 / 0.8-0.9
Client sampling date / time				23-May-2019 14:00	23-May-2019 14:00	23-May-2019 14:00	23-May-2019 14:00	23-May-2019 14:00
Compound	CAS Number	LOR	Unit	EB1913756-001	EB1913756-002	EB1913756-003	EB1913756-004	EB1913756-005
Result				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	---	0.1	pH Unit	7.8	9.1	9.1	8.2	5.6
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	---	1	µS/cm	115	820	852	728	681
EA013: Acid Neutralising Capacity								
ANC as H2SO4	---	0.5	kg H2SO4 equiv./t	----	16.4	16.7	4.1	2.3
ANC as CaCO3	---	0.1	% CaCO3	----	1.7	1.7	0.4	0.2
Fizz Rating	---	0	Fizz Unit	----	1	1	0	0
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	---	1.0	%	5.8	9.7	----	----	----
EA058: Emerson Aggregate Test								
Color (Munsell)	---	-	-	----	Dark Gray (10YR 4/1)	Dark Gray (10YR 4/1)	Gray (10YR 5/1)	Dark Gray (10YR 4/1)
Texture	---	-	-	----	Medium Clay	Medium Clay	Medium Clay	Medium Clay
Emerson Class Number	EC/TC	-	-	----	3	2	2	1
EA150: Soil Classification - National Committee on Soil and Terrain (2009)								
Clay (<2 µm)	---	1	%	57	57	58	61	61
Silt (2-20 µm)	---	1	%	13	12	13	16	15
Fine Sand (0.02-0.2 mm)	---	1	%	9	7	8	4	7
Coarse Sand (0.2-2.0 mm)	---	1	%	17	15	14	18	17
Gravel (>2mm)	---	1	%	4	9	7	1	<1
EA152: Soil Particle Density								
Soil Particle Density (Clay/Silt/Sand)	---	0.01	g/cm3	2.34	2.39	2.54	2.22	2.17
ED005: Exchange Acidity								
Ø Exchange Acidity	---	0.1	meq/100g	----	----	----	----	0.2
Ø Exchangeable Aluminium	---	0.1	meq/100g	----	----	----	----	<0.1
ED006: Exchangeable Cations on Alkaline Soils								
Ø Exchangeable Calcium	---	0.2	meq/100g	5.1	5.0	6.1	3.8	----
Ø Exchangeable Magnesium	---	0.2	meq/100g	4.8	5.5	7.3	6.0	----
Ø Exchangeable Potassium	---	0.2	meq/100g	0.2	<0.2	<0.2	<0.2	----
Ø Exchangeable Sodium	---	0.2	meq/100g	1.8	2.8	4.0	4.1	----
Ø Cation Exchange Capacity	---	0.2	meq/100g	11.9	13.3	17.6	14.1	----
Ø Exchangeable Sodium Percent	---	0.2	%	14.9	20.8	22.7	29.2	----
Ø Calcium/Magnesium Ratio	---	0.2	-	1.0	0.9	0.8	0.6	----
Ø Magnesium/Potassium Ratio	---	0.2	-	19.9	----	----	----	----



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)		Client sample ID	PR04 / 0.0-0.1	PR04 / 0.1-0.2	PR04 / 0.2-0.3	PR04 / 0.5-0.6	PR04 / 0.8-0.9
Compound		Client sampling date / time	23-May-2019 14:00	23-May-2019 14:00	23-May-2019 14:00	23-May-2019 14:00	23-May-2019 14:00
CAS Number	LOR	Unit	EB1913756-001	EB1913756-002	EB1913756-003	EB1913756-004	EB1913756-005
ED008: Exchangeable Cations		Result	Result	Result	Result	Result	Result
Exchangeable Calcium	0.1	meq/100g	-----	-----	-----	-----	2.7
Exchangeable Magnesium	0.1	meq/100g	-----	-----	-----	-----	4.4
Exchangeable Potassium	0.1	meq/100g	-----	-----	-----	-----	0.1
Exchangeable Sodium	0.1	meq/100g	-----	-----	-----	-----	2.8
Cation Exchange Capacity	0.1	meq/100g	-----	-----	-----	-----	10.2
Exchangeable Sodium Percent	0.1	%	-----	-----	-----	-----	27.5
Calcium/Magnesium Ratio	0.1	-	-----	-----	-----	-----	0.6
ED042T: Total Sulfur by LECO							
Sulfur - Total as S (LECO)	0.01	%	0.02	0.02	0.02	<0.01	<0.01
ED045G: Chloride by Discrete Analyser							
Chloride	16887-00-6	10	mg/kg	120	1260	1360	1250
ED091 : Calcium Chloride Extractable Boron							
ø Boron	7440-42-8	0.2	mg/kg	0.3	0.4	-----	-----
ED092: DTPA Extractable Metals							
ø Copper	7440-50-8	1.00	mg/kg	<1.00	<1.00	-----	-----
ø Iron	7439-89-6	1.00	mg/kg	13.9	8.89	-----	-----
ø Manganese	7439-96-5	1.00	mg/kg	22.0	11.0	-----	-----
ø Zinc	7440-66-6	1.00	mg/kg	<1.00	<1.00	-----	-----
EK057G: Nitrite as N by Discrete Analyser							
Nitrite as N (Sol)	14797-65-0	0.1	mg/kg	0.4	0.3	-----	-----
EK058G: Nitrate as N by Discrete Analyser							
Nitrate as N (Sol)	14797-55-8	0.1	mg/kg	0.9	0.8	-----	-----
EK059G: Nitrite plus Nitrate as N (NOX) by Discrete Analyser							
Nitrite + Nitrate as N (Sol)	-----	0.1	mg/kg	1.3	1.1	-----	-----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser							
Total Kjeldahl Nitrogen as N	-----	20	mg/kg	1490	890	-----	-----
EK062: Total Nitrogen as N (TKN + NOx)							
^ Total Nitrogen as N	-----	20	mg/kg	1490	890	-----	-----
EK067G: Total Phosphorus as P by Discrete Analyser							
Total Phosphorus as P	-----	2	mg/kg	222	147	-----	-----
EK080: Bicarbonate Extractable Phosphorus (Colwell)							
Bicarbonate Ext. P (Colwell)	-----	5	mg/kg	<5	<5	-----	-----
EP004: Organic Matter							



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)		Client sample ID		PR04 / 0.0-0.1	PR04 / 0.1-0.2	PR04 / 0.2-0.3	PR04 / 0.5-0.6	PR04 / 0.8-0.9
		Client sampling date / time		23-May-2019 14:00	23-May-2019 14:00	23-May-2019 14:00	23-May-2019 14:00	23-May-2019 14:00
Compound	CAS Number	LOR	Unit	EB1913756-001	EB1913756-002	EB1913756-003	EB1913756-004	EB1913756-005
EP004: Organic Matter - Continued				Result	Result	Result	Result	Result
Organic Matter	-----	0.5	%	2.7	1.4	-----	-----	-----
Total Organic Carbon	-----	0.5	%	1.6	0.8	-----	-----	-----



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)		Client sample ID			PR04 / 1.1-1.2						
		Client sampling date / time			23-May-2019 14:00						
Compound	CAS Number	LOR	Unit	EB1913756-006							
				Result							
EA002: pH 1:5 (Soils)											
pH Value		0.1	pH Unit	5.5							
EA010: Conductivity (1:5)											
Electrical Conductivity @ 25°C		1	µS/cm	480							
EA013: Acid Neutralising Capacity											
ANC as H2SO4		0.5	kg H2SO4 equiv./t	1.9							
ANC as CaCO3		0.1	% CaCO3	0.2							
Fizz Rating		0	Fizz Unit	0							
EA058: Emerson Aggregate Test											
Color (Munsell)		-	-	Grayish Brown (10YR 5/2)							
Texture		-	-	Medium Clay							
Emerson Class Number	EC/TC	-	-	1							
EA150: Soil Classification - National Committee on Soil and Terrain (2009)											
Clay (<2 µm)		1	%	59							
Silt (2-20 µm)		1	%	13							
Fine Sand (0.02-0.2 mm)		1	%	5							
Coarse Sand (0.2-2.0 mm)		1	%	23							
Gravel (>2mm)		1	%	<1							
EA152: Soil Particle Density											
Soil Particle Density (Clay/Silt/Sand)		0.01	g/cm3	2.35							
ED005: Exchange Acidity											
Ø Exchange Acidity		0.1	meq/100g	0.2							
Ø Exchangeable Aluminium		0.1	meq/100g	0.1							
ED008: Exchangeable Cations											
Exchangeable Calcium		0.1	meq/100g	1.7							
Exchangeable Magnesium		0.1	meq/100g	2.9							
Exchangeable Potassium		0.1	meq/100g	<0.1							
Exchangeable Sodium		0.1	meq/100g	2.1							
Cation Exchange Capacity		0.1	meq/100g	6.9							
Exchangeable Sodium Percent		0.1	%	30.2							
Calcium/Magnesium Ratio		0.1	-	0.6							
ED042T: Total Sulfur by LECO											
Sulfur - Total as S (LECO)		0.01	%	<0.01							



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)		Client sample ID		PR04 / 1.1-1.2							
		Client sampling date / time		23-May-2019 14:00							
Compound	CAS Number	LOR	Unit	EB1913756-006							
				Result							
ED045G: Chloride by Discrete Analyser											
Chloride	16887-00-6	10	mg/kg	770							



Environmental

QUALITY CONTROL REPORT

Work Order : **EB1913756**

Page : 1 of 6

Client	: SLR Consulting Australia Pty Ltd	Laboratory	: Environmental Division Brisbane
Contact	: CAMERON TRAILL	Contact	: Tyler Cachia
Address	:	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: ----	Telephone	: +61 2 8784 8555
Project	: 623.17171 Fairhill Coking Coal	Date Samples Received	: 28-May-2019
Order number	:	Date Analysis Commenced	: 30-May-2019
C-O-C number	: ----	Issue Date	: 11-Jun-2019
Sampler	: CAMERON TRAILL		
Site	: ----		
Quote number	: EN/032/18 Primary work only BQ		
No. of samples received	: 6		
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. 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
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Satishkumar Trivedi	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by 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

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**

Sub-Matrix: SOIL				Laboratory Duplicate (DUP) Report					
Laboratory Sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EA002: pH 1:5 (Soils) (QC Lot: 2377071)									
EB1913756-005	PR04 / 0.8-0.9	EA002: pH Value	----	0.1	pH Unit	5.6	5.6	0.00	0% - 20%
EB1913749-001	Anonymous	EA002: pH Value	----	0.1	pH Unit	8.0	8.0	0.00	0% - 20%
EA010: Conductivity (1:5) (QC Lot: 2377072)									
EB1913756-005	PR04 / 0.8-0.9	EA010: Electrical Conductivity @ 25°C	----	1	µS/cm	681	634	7.15	0% - 20%
EB1913749-001	Anonymous	EA010: Electrical Conductivity @ 25°C	----	1	µS/cm	33	30	7.57	0% - 20%
EA013: Acid Neutralising Capacity (QC Lot: 2393313)									
EB1913749-002	Anonymous	EA013: ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	17.8	15.8	11.9	0% - 20%
EB1913759-003	Anonymous	EA013: ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	5.2	5.1	1.94	0% - 50%
EA055: Moisture Content (Dried @ 105-110°C) (QC Lot: 2377073)									
EB1913749-001	Anonymous	EA055: Moisture Content	----	0.1	%	13.9	13.8	0.730	0% - 50%
EB1913756-005	PR04 / 0.8-0.9	EA055: Moisture Content	----	0.1	%	10.0	9.9	1.21	0% - 50%
ED006: Exchangeable Cations on Alkaline Soils (QC Lot: 2392368)									
EB1913749-001	Anonymous	ED006: Exchangeable Calcium	----	0.2	meq/100g	22.9	25.1	9.18	0% - 20%
		ED006: Exchangeable Magnesium	----	0.2	meq/100g	4.4	4.7	6.73	0% - 20%
		ED006: Exchangeable Potassium	----	0.2	meq/100g	0.3	0.3	0.00	No Limit
		ED006: Exchangeable Sodium	----	0.2	meq/100g	0.7	0.7	0.00	No Limit
		ED006: Cation Exchange Capacity	----	0.2	meq/100g	28.4	30.9	8.41	0% - 20%
		ED006: Exchangeable Calcium	----	0.2	meq/100g	2.3	2.5	8.50	0% - 50%
		ED006: Exchangeable Magnesium	----	0.2	meq/100g	3.2	3.4	7.98	0% - 50%
		ED006: Exchangeable Potassium	----	0.2	meq/100g	0.8	0.8	0.00	No Limit
		ED006: Exchangeable Sodium	----	0.2	meq/100g	1.9	2.0	7.75	0% - 50%
		ED006: Cation Exchange Capacity	----	0.2	meq/100g	8.1	8.8	8.01	0% - 20%
EB1913759-003	Anonymous								



Sub-Matrix: **SOIL**

Sub-Matrix: SOIL				Laboratory Duplicate (DUP) Report						
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)	
ED008: Exchangeable Cations (QC Lot: 2392365)										
EB1913756-005	PR04 / 0.8-0.9	ED008: Exchangeable Calcium	----	0.1	meq/100g	2.7	2.8	4.56	0% - 20%	
		ED008: Exchangeable Magnesium	----	0.1	meq/100g	4.4	4.6	5.01	0% - 20%	
		ED008: Exchangeable Potassium	----	0.1	meq/100g	0.1	<0.1	0.00	No Limit	
		ED008: Exchangeable Sodium	----	0.1	meq/100g	2.8	2.8	0.00	0% - 20%	
ED042T: Total Sulfur by LECO (QC Lot: 2392714)										
EB1913749-001	Anonymous	ED042T: Sulfur - Total as S (LECO)	----	0.01	%	<0.01	0.02	0.00	No Limit	
EB1913756-004	PR04 / 0.5-0.6	ED042T: Sulfur - Total as S (LECO)	----	0.01	%	<0.01	<0.01	0.00	No Limit	
ED045G: Chloride by Discrete Analyser (QC Lot: 2377070)										
EB1913756-005	PR04 / 0.8-0.9	ED045G: Chloride	16887-00-6	10	mg/kg	1120	1030	8.21	0% - 20%	
EB1913749-001	Anonymous	ED045G: Chloride	16887-00-6	10	mg/kg	<10	<10	0.00	No Limit	
ED091: Calcium Chloride Extractable Boron (QC Lot: 2376985)										
EB1913749-001	Anonymous	ED091: Boron	7440-42-8	0.2	mg/kg	0.4	0.4	0.00	No Limit	
ED092: DTPA Extractable Metals (QC Lot: 2376984)										
EB1913749-001	Anonymous	ED092: Copper	7440-50-8	1	mg/kg	2.24	2.22	0.969	No Limit	
		ED092: Iron	7439-89-6	1	mg/kg	11.0	10.8	1.57	0% - 50%	
		ED092: Manganese	7439-96-5	1	mg/kg	19.8	19.9	0.442	0% - 50%	
		ED092: Zinc	7440-66-6	1	mg/kg	<1.00	<1.00	0.00	No Limit	
EK057G: Nitrite as N by Discrete Analyser (QC Lot: 2377068)										
EB1913749-001	Anonymous	EK057G: Nitrite as N (Sol.)	14797-65-0	0.1	mg/kg	0.3	0.4	0.00	No Limit	
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QC Lot: 2377069)										
EB1913749-001	Anonymous	EK059G: Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	1.2	1.4	14.8	0% - 50%	
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QC Lot: 2377066)										
EB1913749-001	Anonymous	EK061G: Total Kjeldahl Nitrogen as N	----	20	mg/kg	1050	1010	3.59	0% - 20%	
EK067G: Total Phosphorus as P by Discrete Analyser (QC Lot: 2377067)										
EB1913749-001	Anonymous	EK067G: Total Phosphorus as P	----	2	mg/kg	246	245	0.00	0% - 20%	
EK080: Bicarbonate Extractable Phosphorus (Colwell) (QC Lot: 2376988)										
EB1913749-001	Anonymous	EK080: Bicarbonate Ext. P (Colwell)	----	5	mg/kg	<5	<5	0.00	No Limit	
EP004: Organic Matter (QC Lot: 2376987)										
EB1913749-001	Anonymous	EP004: Organic Matter	----	0.5	%	1.9	2.1	12.5	No Limit	
		EP004: Total Organic Carbon	----	0.5	%	1.1	1.2	12.3	No Limit	



Method Blank (MB) and Laboratory Control Spike (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 Spike (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

Sub-Matrix: SOIL				Method Blank (MB) Report		Laboratory Control Spike (LCS) Report			
Method: Compound	CAS Number	LOR	Unit	Result	Spike Concentration	Spike Recovery (%)	Low	High	
EA002: pH 1:5 (Soils) (QCLOt: 2377071)									
EA002: pH Value	----	----	pH Unit	----	4 pH Unit 7 pH Unit	100 100	98 98	102 102	
EA010: Conductivity (1:5) (QCLOt: 2377072)									
EA010: Electrical Conductivity @ 25°C	----	1	µS/cm	<1	1412 µS/cm	99.6	97	103	
EA013: Acid Neutralising Capacity (QCLOt: 2393313)									
EA013: ANC as H2SO4	----	----	kg H2SO4 equiv./t	----	9.9 kg H2SO4 equiv./t	103	82	120	
ED005: Exchange Acidity (QCLOt: 2392364)									
ED005: Exchange Acidity	----	0.1	meq/100g	<0.1	----	----	----	----	
ED005: Exchangeable Aluminium	----	0.1	meq/100g	<0.1	----	----	----	----	
ED006: Exchangeable Cations on Alkaline Soils (QCLOt: 2392368)									
ED006: Exchangeable Calcium	----	0.2	meq/100g	<0.2	7.0676 meq/100g	114	70	130	
ED006: Exchangeable Magnesium	----	0.2	meq/100g	<0.2	5.5895 meq/100g	75.5	70	130	
ED006: Exchangeable Potassium	----	0.2	meq/100g	<0.2	1.15 meq/100g	75.4	70	130	
ED006: Exchangeable Sodium	----	0.2	meq/100g	<0.2	2.0578 meq/100g	121	70	130	
ED006: Cation Exchange Capacity	----	0.2	meq/100g	<0.2	16.0654 meq/100g	97.2	70	130	
ED008: Exchangeable Cations (QCLOt: 2392365)									
ED008: Exchangeable Calcium	----	0.1	meq/100g	<0.1	9.8115 meq/100g	101	91	109	
ED008: Exchangeable Magnesium	----	0.1	meq/100g	<0.1	6.0172 meq/100g	96.6	89	111	
ED008: Exchangeable Potassium	----	0.1	meq/100g	<0.1	0.7819 meq/100g	87.1	79	116	
ED008: Exchangeable Sodium	----	0.1	meq/100g	<0.1	0.653 meq/100g	97.3	75	118	
ED008: Cation Exchange Capacity	----	0.1	meq/100g	<0.1	17.2959 meq/100g	98.3	88	110	
ED042T: Total Sulfur by LECO (QCLOt: 2392714)									
ED042T: Sulfur - Total as S (LECO)	----	0.01	%	<0.01	0.16 %	110	70	130	
ED045G: Chloride by Discrete Analyser (QCLOt: 2377070)									
ED045G: Chloride	16887-00-6	10	mg/kg	<10 <10	50 mg/kg 5000 mg/kg	91.3 96.3	83 83	119 119	
ED091 : Calcium Chloride Extractable Boron (QCLOt: 2376985)									
ED091: Boron	7440-42-8	0.2	mg/kg	<0.2	100 mg/kg	97.4	85	117	
ED092: DTPA Extractable Metals (QCLOt: 2376984)									
ED092: Copper	7440-50-8	1	mg/kg	<1.00	1.2 mg/kg	106	84	122	
ED092: Iron	7439-89-6	1	mg/kg	<1.00	46.5 mg/kg	105	70	130	
ED092: Manganese	7439-96-5	1	mg/kg	<1.00	6 mg/kg	107	70	130	
ED092: Zinc	7440-66-6	1	mg/kg	<1.00	5.4 mg/kg	104	79	122	



Sub-Matrix: SOIL

Sub-Matrix: SOIL									
Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report		Laboratory Control Spike (LCS) Report			
				Result	Spike Concentration	Spike Recovery (%)		Recovery Limits (%)	
EKO57G: Nitrite as N by Discrete Analyser (QCLot: 2377068)									
EKO57G: Nitrite as N (Sol)	14797-65-0	0.1	mg/kg	<0.1	2.5 mg/kg	103		83	111
EKO59G: Nitrite plus Nitrate as N (NOX) by Discrete Analyser (QCLot: 2377069)									
EKO59G: Nitrite + Nitrate as N (Sol)	-----	0.1	mg/kg	<0.1	2.5 mg/kg	89.0		89	155
EKO61G: Total Kjeldahl Nitrogen By Discrete Analyser (QCLot: 2377066)									
EKO61G: Total Kjeldahl Nitrogen as N	-----	20	mg/kg	<20 <20	848 mg/kg 3644 mg/kg	87.7 95.4		73 73	121 121
EKO67G: Total Phosphorus as P by Discrete Analyser (QCLot: 2377067)									
EKO67G: Total Phosphorus as P	-----	2	mg/kg	<2 <2	939 mg/kg 1200 mg/kg	81.6 87.7		80 80	115 115
EKO80: Bicarbonate Extractable Phosphorus (Colwell) (QCLot: 2376988)									
EKO80: Bicarbonate Ext. P (Colwell)	-----	5	mg/kg	<5 <5 <5	100 mg/kg 44.9 mg/kg 58.07 mg/kg	98.3 103 91.8		70 87 80	130 113 120
EP004: Organic Matter (QCLot: 2376987)									
EP004: Organic Matter	-----	0.5	%	<0.5	80 %	94.5		83	115
EP004: Total Organic Carbon	-----	0.5	%	<0.5	46.4 %	94.5		85	115

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: SOIL

Sub-Matrix: SOIL			Matrix Spike (MS) Report				
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Spike	SpikeRecovery(%)	Recovery Limits (%)	
				Concentration	MS	Low	High
EK057G: Nitrite as N by Discrete Analyser (QCLot: 2377068)							
EB1913749-002	Anonymous	EK057G: Nitrite as N (Sol.)	14797-65-0	2 mg/kg	98.8	70	130
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 2377069)							
EB1913749-002	Anonymous	EK059G: Nitrite + Nitrate as N (Sol.)	---	2 mg/kg	91.3	70	130
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QCLot: 2377066)							
EB1913749-002	Anonymous	EK061G: Total Kjeldahl Nitrogen as N	---	500 mg/kg	93.4	70	130
EK067G: Total Phosphorus as P by Discrete Analyser (QCLot: 2377067)							
EB1913749-002	Anonymous	EK067G: Total Phosphorus as P	---	100 mg/kg	83.9	70	130
EK080: Bicarbonate Extractable Phosphorus (Colwell) (QCLot: 2376988)							
EB1913749-002	Anonymous	EK080: Bicarbonate Ext. P (Colwell)	---	40 mg/kg	108	70	130
EP004: Organic Matter (QCLot: 2376987)							
EB1913749-002	Anonymous	EP004: Organic Matter	---	2 %	91.5	70	130



Sub-Matrix: **SOIL**

Sub-Matrix: SOIL		Matrix Spike (MS) Report					
		Spike Concentration		SpikeRecovery(%) MS		Recovery Limits (%)	
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number				
EP004: Organic Matter (QCLot: 2376987) - continued							
EB1913749-002	Anonymous	EP004: Total Organic Carbon	----	1.16 %	91.4	70	130



QA/QC Compliance Assessment to assist with Quality Review

Work Order	: EB1913756	Page	: 1 of 9
Client	: SLR Consulting Australia Pty Ltd	Laboratory	: Environmental Division Brisbane
Contact	: CAMERON TRAILL	Telephone	: +61 2 8784 8555
Project	: 623.17171 Fairhill Coking Coal	Date Samples Received	: 28-May-2019
Site	: ----	Issue Date	: 11-Jun-2019
Sampler	: CAMERON TRAILL	No. of samples received	: 6
Order number	:	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

- 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.



Matrix: **SOIL**

Evaluation: **x** = 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
EA010: Conductivity (1:5)							
Snap Lock Bag (EA010)							
PR04 / 0.0-0.1,	23-May-2019	06-Jun-2019	30-May-2019	✖	06-Jun-2019	04-Jul-2019	✔
PR04 / 0.2-0.3,							
PR04 / 0.8-0.9,							
EA013: Acid Neutralising Capacity							
Snap Lock Bag (EA013)							
PR04 / 0.1-0.2,	23-May-2019	10-Jun-2019	22-May-2020	✔	10-Jun-2019	07-Dec-2019	✔
PR04 / 0.5-0.6,							
PR04 / 1.1-1.2							
EA055: Moisture Content (Dried @ 105-110°C)							
Snap Lock Bag (EA055)							
PR04 / 0.0-0.1,	23-May-2019	-----	-----	-----	30-May-2019	06-Jun-2019	✔
EA058: Emerson Aggregate Test							
Snap Lock Bag (EA058)							
PR04 / 0.1-0.2,	23-May-2019	-----	-----	-----	06-Jun-2019	19-Nov-2019	✔
PR04 / 0.5-0.6,							
PR04 / 1.1-1.2							
EA150: Soil Classification - National Committee on Soil and Terrain (2009)							
Snap Lock Bag (EA150H)							
PR04 / 0.0-0.1,	23-May-2019	-----	-----	-----	06-Jun-2019	19-Nov-2019	✔
PR04 / 0.2-0.3,							
PR04 / 0.8-0.9,							
EA152: Soil Particle Density							
Snap Lock Bag (EA152)							
PR04 / 0.0-0.1,	23-May-2019	-----	-----	-----	06-Jun-2019	19-Nov-2019	✔
PR04 / 0.2-0.3,							
PR04 / 0.8-0.9,							
ED005: Exchange Acidity							
Snap Lock Bag (ED005)							
PR04 / 0.0-0.1,	23-May-2019	07-Jun-2019	20-Jun-2019	✔	10-Jun-2019	20-Jun-2019	✔
PR04 / 0.2-0.3,							
PR04 / 0.8-0.9,							
ED006: Exchangeable Cations on Alkaline Soils							
Snap Lock Bag (ED006)							
PR04 / 0.0-0.1,	23-May-2019	07-Jun-2019	20-Jun-2019	✔	10-Jun-2019	20-Jun-2019	✔
PR04 / 0.2-0.3,							
PR04 / 0.8-0.9,							



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
ED007: Exchangeable Cations							
Snap Lock Bag (ED007)							
PR04 / 0.0-0.1,	23-May-2019	07-Jun-2019	20-Jun-2019	✓	10-Jun-2019	20-Jun-2019	✓
PR04 / 0.2-0.3,							
PR04 / 0.8-0.9,							
ED008: Exchangeable Cations							
Snap Lock Bag (ED008)							
PR04 / 0.0-0.1,	23-May-2019	07-Jun-2019	20-Jun-2019	✓	10-Jun-2019	20-Jun-2019	✓
PR04 / 0.2-0.3,							
PR04 / 0.8-0.9,							
ED042T: Total Sulfur by LECO							
Pulp Bag (ED042T)							
PR04 / 0.0-0.1,	23-May-2019	07-Jun-2019	20-Jun-2019	✓	07-Jun-2019	20-Jun-2019	✓
PR04 / 0.2-0.3,							
PR04 / 0.8-0.9,							
ED045G: Chloride by Discrete Analyser							
Snap Lock Bag (ED045G)							
PR04 / 0.0-0.1,	23-May-2019	06-Jun-2019	20-Jun-2019	✓	07-Jun-2019	04-Jul-2019	✓
PR04 / 0.2-0.3,							
PR04 / 0.8-0.9,							
ED091 : Calcium Chloride Extractable Boron							
Snap Lock Bag (ED091)							
PR04 / 0.0-0.1,	23-May-2019	06-Jun-2019	19-Nov-2019	✓	07-Jun-2019	19-Nov-2019	✓
ED092: DTPA Extractable Metals							
Snap Lock Bag (ED092)							
PR04 / 0.0-0.1,	23-May-2019	06-Jun-2019	19-Nov-2019	✓	07-Jun-2019	19-Nov-2019	✓
EK057G: Nitrite as N by Discrete Analyser							
Snap Lock Bag (EK057G)							
PR04 / 0.0-0.1,	23-May-2019	06-Jun-2019	19-Nov-2019	✓	07-Jun-2019	19-Nov-2019	✓
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser							
Snap Lock Bag (EK059G)							
PR04 / 0.0-0.1,	23-May-2019	06-Jun-2019	19-Nov-2019	✓	07-Jun-2019	19-Nov-2019	✓
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser							
Snap Lock Bag (EK061G)							
PR04 / 0.0-0.1,	23-May-2019	05-Jun-2019	19-Nov-2019	✓	05-Jun-2019	19-Nov-2019	✓
EK067G: Total Phosphorus as P by Discrete Analyser							
Snap Lock Bag (EK067G)							
PR04 / 0.0-0.1,	23-May-2019	05-Jun-2019	19-Nov-2019	✓	05-Jun-2019	19-Nov-2019	✓
EK080: Bicarbonate Extractable Phosphorus (Colwell)							
Snap Lock Bag (EK080)							
PR04 / 0.0-0.1,	23-May-2019	07-Jun-2019	19-Nov-2019	✓	07-Jun-2019	19-Nov-2019	✓



Matrix: **SOIL**

Evaluation: **x** = 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	Evaluation
EP004: Organic Matter					
Snap Lock Bag (EP004)					
PR04 / 0.0-0.1,					
PR04 / 0.1-0.2	23-May-2019	10-Jun-2019	30-May-2019	10-Jun-2019	08-Jul-2019
			✖		✔



Matrix: SOIL

Evaluation: ✖ = Quality Control frequency not within specification ; ✔ = Quality Control frequency within specification.

Quality Control Sample Type	Count		Rate (%)		Evaluation	Quality Control Specification	
Analytical Methods	Method	QC	Regular	Actual			Expected
Method Blanks (MB) - Continued							
Bicarbonate Extractable P (Colwell)	EK080	1	8	12.50	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Calcium Chloride Extractable Boron	ED091	1	8	12.50	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Chloride Soluble By Discrete Analyser	ED045G	1	20	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
DTPA Extractable Metals	ED092	1	8	12.50	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Electrical Conductivity (1:5)	EA010	1	20	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Exchange Acidity by 1M Potassium Chloride	ED005	1	2	50.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations on Alkaline Soils	ED006	1	15	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations with pre-treatment	ED008	1	2	50.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx)- Soluble by Discrete Analyser	EK059G	1	8	12.50	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite as N - Soluble by Discrete Analyser	EK057G	1	8	12.50	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Organic Matter	EP004	1	8	12.50	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Sulfur - Total as S (LECO)	ED042T	1	20	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
TKN as N By Discrete Analyser	EK061G	1	8	12.50	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus By Discrete Analyser	EK067G	1	8	12.50	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)							
Bicarbonate Extractable P (Colwell)	EK080	1	8	12.50	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx)- Soluble by Discrete Analyser	EK059G	1	8	12.50	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite as N - Soluble by Discrete Analyser	EK057G	1	8	12.50	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Organic Matter	EP004	1	8	12.50	5.00	✓	NEPM 2013 B3 & ALS QC Standard
TKN as N By Discrete Analyser	EK061G	1	8	12.50	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus By Discrete Analyser	EK067G	1	8	12.50	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 (1:5)	EA002	SOIL	In house: Referenced to Rayment and Lyons 4A1 and APHA 4500H+. pH is determined on soil samples after a 1:5 soil/water leach. This method is compliant with NEPM (2013) Schedule B(3)
Electrical Conductivity (1:5)	EA010	SOIL	In house: Referenced to Rayment and Lyons 3A1 and APHA 2510. Conductivity is determined on soil samples using a 1:5 soil/water leach. This method is compliant with NEPM (2013) Schedule B(3)
Acid Neutralising Capacity (ANC)	EA013	SOIL	In house: Referenced to USEPA 600/2-78-054, I. Miller (2000). A fizz test is done to semiquantitatively estimate the likely reactivity. The soil is then reacted with a known excess quantity of an appropriate acid. Titration determines the acid remaining, and the ANC can be calculated from comparison with a blank titration.
Moisture Content	EA055	SOIL	In house: A gravimetric procedure based on weight loss over a 12 hour drying period at 105-110 degrees C. This method is compliant with NEPM (2013) Schedule B(3) Section 7.1 and Table 1 (14 day holding time).
Emerson Aggregate Test	EA058	SOIL	In house: Referenced to AS1289.3.8.1. Testing is performed only on soils with suitable aggregates; sands and gravels are usually unsuitable for this test. The test classifies the behaviour of soil aggregates, when immersed, on their coherence in water.
Particle Size Analysis by Hydrometer	EA150H	SOIL	Particle Size Analysis by Hydrometer according to AS1289.3.6.3 - 2003
Soil Particle Density	EA152	SOIL	Soil Particle Density by AS 1289.3.5.1-2006. Methods of testing soils for engineering purposes - Soil classification tests - Determination of the soil particle density of a soil - Standard method
Exchange Acidity by 1M Potassium Chloride	* ED005	SOIL	In house: referenced to Rayment and Lyons. (2011), method 15G1. This method is unsuitable for near neutral and alkaline soils. NATA accreditation does not cover performance of this service.
Exchangeable Cations on Alkaline Soils	* ED006	SOIL	In house: Referenced to Soil Survey Test Method C5. Soluble salts are removed from the sample prior to analysis. Cations are exchanged from the sample by contact with alcoholic ammonium chloride at pH 8.5. They are then quantitated in the final solution by ICPAES and reported as meq/100g of original soil.
Exchangeable Cations	ED007	SOIL	In house: Referenced to Rayment & Lyons (2011) Method 15A1. Cations are exchanged from the sample by contact with Ammonium Chloride. They are then quantitated in the final solution by ICPAES and reported as meq/100g of original soil. This method is compliant with NEPM (2013) Schedule B(3) (Method 301)
Exchangeable Cations with pre-treatment	ED008	SOIL	In house: Referenced to Rayment & Higginson (2011) Method 15A2. Soluble salts are removed from the sample prior to analysis. Cations are exchanged from the sample by contact with Ammonium Chloride. They are then quantitated in the final solution by ICPAES and reported as meq/100g of original soil. This method is compliant with NEPM (2013) Schedule B(3) (Method 301)
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 SO ₂) is measured by infra-red detector
Chloride Soluble By Discrete Analyser	ED045G	SOIL	In house: Referenced to APHA 4500-Cl- E. 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 thiocyanate forms highly coloured ferric thiocyanate which is measured at 480 nm. Analysis is performed on a 1:5 soil / water leachate.
Calcium Chloride Extractable Boron	* ED091	SOIL	In house: Referenced to Rayment & Higginson (2011) method 12C2. Soil is extracted with hot 0.01M CaCl ₂ solution at a 1:2 ratio. Extracts can be run on ICP.
DTPA Extractable Metals	* ED092	SOIL	In house: Referenced to Rayment and Higginson (2011) 12A1



Analytical Methods			
	Method	Matrix	Method Descriptions
Nitrite as N - Soluble by Discrete Analyser	EK057G	SOIL	In house: Referenced to APHA 4500-NO3- B. Nitrite in a water extract is determined by direct colourimetry by Discrete Analyser.
Nitrate as N - Soluble by Discrete Analyser	EK058G	SOIL	In house: Referenced to APHA 4500-NO3- F. Nitrate in the 1:5 soil:water extract is reduced to nitrite by way of a chemical reduction followed by quantification by Discrete Analyser. Nitrite is determined seperately by direct colourimetry and result for Nitrate calculated as the difference between the two results.
Nitrite and Nitrate as N (NOx)- Soluble by Discrete Analyser	EK059G	SOIL	In house: Thermo Scientific Method D08727 and NEMI (National Environmental Method Index) Method ID: 91771. This method covers the determination of total oxidised nitrogen (NOx-N) and nitrate (NO3-N) by calculation, Combined oxidised Nitrogen (NO2+NO3) in a water extract is determined by direct colourimetry by Discrete Analyser.
TKN as N By Discrete Analyser	EK061G	SOIL	In house: Referenced to APHA 4500-Norg-D Soil samples are digested using Kjeldahl digestion followed by determination by Discrete Analyser.
Total Nitrogen as N (TKN + NOx) By Discrete Analyser	EK062G	SOIL	In house: Referenced to APHA 4500 Norg/NO3- Total Nitrogen is determined as the sum of TKN and Oxidised Nitrogen, each determined seperately as N.
Total Phosphorus By Discrete Analyser	EK067G	SOIL	In house: Referenced to APHA 4500 P-B&F This procedure involves sulfuric acid digestion and quantification using Discrete Analyser.
Bicarbonate Extractable P (Colwell)	EK080	SOIL	In house: Referenced to Rayment & Higginson (2011) Method 9B1 Phosphorus is extracted from the soil using 0.5M NaHCO3 at a 1:100 soil:solution ratio and determined by FIA.
Organic Matter	EP004	SOIL	In house: Referenced to AS1289.4.1.1 - 1997. Dichromate oxidation method after Walkley and Black. This method is compliant with NEPM (2013) Schedule B(3).
Preparation Methods			
	Method	Matrix	Method Descriptions
Exchangeable Cations Preparation Method (Alkaline Soils)	ED006PR	SOIL	In house: Referenced to Rayment and Lyons 2011 method 15C1.
Exchangeable Cations Preparation Method	ED007PR	SOIL	In house: Referenced to Rayment & Higginson (1992) method 15A1. A 1M NH4Cl extraction by end over end tumbling at a ratio of 1:20. There is no pretreatment for soluble salts. Extracts can be run by ICP for cations.
Hot Water CaCl2 Extraction for Boron	ED091PR	SOIL	In house: Referenced to Rayment & Higginson (1992) method 12C2. Soil is extracted with hot 0.01M CaCl2 solution at a 1:2 ratio. Extracts can be run on ICP.
DTPA Extraction for Cu, Zn, Mn, Fe (2 hour leach)	ED092PR	SOIL	In house: Referenced to Rayment & Higginson (1992) Method 12A1 2 hour end over end tumbler extraction with 0.005M DTPA at a ratio of 1:2. Extracts can be run by ICP for metals.
TKN/TP Digestion	EK061/EK067	SOIL	In house: Referenced to APHA 4500 Norg- D; APHA 4500 P - H. Macro Kjeldahl digestion.
Sample Preparation for Bicarbonate Extractable P (Colwell)	EK080-PR	SOIL	In house: Referenced to Rayment & Higginson (2011) Method 9B1 Phosphorus is extracted from the soil using 0.5M NaHCO3 at a 1:100 soil:solution ratio.
Drying at 85 degrees, bagging and labelling (ASS)	EN020PR	SOIL	In house
1:5 solid / water leach for soluble analytes	EN34	SOIL	10 g of soil is mixed with 50 mL of reagent grade water and tumbled end over end for 1 hour. Water soluble salts are leached from the soil by the continuous suspension. Samples are settled and the water filtered off for analysis.
Organic Matter	EP004-PR	SOIL	In house: Referenced to AS1289.4.1.1 - 1997. Dichromate oxidation method after Walkley and Black. This method is compliant with NEPM (2013) Schedule B(3) (Method 105)
Dry and Pulverise (up to 100g)	GEO30	SOIL	#



CHAIN OF CUSTODY

ALS Laboratory - please tick ✓
LABORATORY: 21 Burns Road, Pineside SA 5506
Ph: 08 9559 0800 E: als@als.com.au
DUNEDIN: 2 Burns Road, Pineside SA 5506
Ph: 07 3257 7222 E: samples@als.com.au
DUNEDIN: 2 Burns Road, Pineside SA 5506
Ph: 07 3257 7222 E: samples@als.com.au

LABORATORY: 21 Burns Road, Pineside SA 5506
Ph: 07 3257 7222 E: samples@als.com.au
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DUNEDIN: 2 Burns Road, Pineside SA 5506
Ph: 07 3257 7222 E: samples@als.com.au
DUNEDIN: 2 Burns Road, Pineside SA 5506
Ph: 07 3257 7222 E: samples@als.com.au

CLIENT: SLR Consulting

OFFICE: 15 Astor Terrace, Spring Hill, QLD 4000

PROJECT: Fairhill Coking Coal

ORDER NUMBER: PURCHASE ORDER NO.:

PROJECT MANAGER: Damien Taylor

SAMPLER: Cameron Trail

COC: Enabled to ALS? YES / NO YES

Email Reports to (will default to PM if no other addresses are listed): d.taylor@slrconsulting.com

Email Invoice to (will default to PM if no other addresses are listed): d.taylor@slrconsulting.com

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

TURNAROUND REQUIREMENTS:

Office: 15 Astor Terrace, Spring Hill, QLD 4000

PROJECT: Fairhill Coking Coal

ORDER NUMBER: PURCHASE ORDER NO.:

PROJECT MANAGER: Damien Taylor

SAMPLER: Cameron Trail

COC: Enabled to ALS? YES / NO YES

Email Reports to (will default to PM if no other addresses are listed): d.taylor@slrconsulting.com

Email Invoice to (will default to PM if no other addresses are listed): d.taylor@slrconsulting.com

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

FOR LABORATORY USE ONLY (Check)

Canopy Seal Intact? Yes No N/A

Freeze frozen ice bricks present upon receipt? Yes No N/A

Random Sample Temperature on Receipt: °C

Other comment:

RECEIVED BY: DATE/TIME:

RECEIVED BY: DATE/TIME:

RECEIVED BY: DATE/TIME:

RECEIVED BY: DATE/TIME:

RECEIVED BY: DATE/TIME:

ANALYSIS REQUIRED INCLUDING SUITES (NB: Suite Codes must be listed to attract suite price)

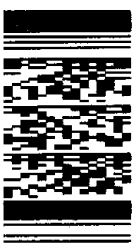
Where Metals are required, specify Total (certified bottles required) or Dissolved (fish filtered bottles required).

MATRIX: Solid(S) Water(W)			INFORMATION		TOPSOIL ONLY					TOPSOIL AND SUBSOIL					SUBSOIL	Information			
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE (refer to codes below)	TOTAL BOTTLES	Nitrogen, nitrite, nitrate, NOx, total Kjeldahl nitrogen (TKN) as N and Total N (ALS code NT- 6S)	Bicarbonate extractable P (Colwell) and Total P (ALS code EK080/EK087)	Organic Carbon (Calc from Organic Matter) - Walkley Black (ALS code EP004)	Boron - CaCl2 Extractable (ALS code ED091)	DTFA Extractable micronutrients (Cu, Fe, Mn, Zn) (ALS code ED092)	pH Plus EC (1:5 soil/water leach) (ALS code IN-4S)	Cl- [1:5] Soluble (ALS code ED045G)	Exch Cations and CEC or ECEC (ALS code ED006 (alkaline soils) or ED007 (no pre-wash) or ED008 (prewash))	Sulfur - Total as S (LECO) (ALS code ED042T)	Carbonate - ANC (ALS code EA013)	PSD + Hydrometer for ranges <2µm, 2-20µm, 20-200µm, 0.2- 2.0mm (ALS code EA150-H-Y)	Emerson Dispersion (ALS code EA058)		
1	PR06 / 0.0-0.1	24/05/2019 / 12:45pm	S			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		HOLD
2	PR06 / 0.1-0.2	24/05/2019 / 12:45pm	S			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
3	PR06 / 0.2-0.3	24/05/2019 / 12:45pm	S			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
4	PR06 / 0.5-0.6	24/05/2019 / 12:45pm	S			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
5	PR06 / 0.8-0.9	24/05/2019 / 12:45pm	S			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
6	PR06 / 1.0-1.1	24/05/2019 / 12:45pm	S			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
TOTAL						2	2	2	2	2	2	2	2	2	2	2	2	0	
Comments on likely contaminant levels of samples requiring specific QC analysis etc. Enviro Brisbane Work Or EB1 Telephone : + 																			

Water Containing Codes: P = Unpreserved Plastic, N = Nitric Preserved Plastic, GRG = Sodium Hydroxide Preserved Plastic, AG = Amber Glass Unpreserved Plastic, AP = Airtight Unpreserved Plastic, V = VOA/VIA HCl Preserved, VB = VOA/VIA Sodium Bisulfate Preserved, VS = VOA/VIA Sulfuric Preserved, AV = Airtight Unpreserved Vial SG = Sulfuric Preserved Plastic, HS = HCl Preserved Plastic, F = Formaldehyde Preserved Glass, Z = Zinc Acetate Preserved Bottle, E = EDTA Preserved Bottle, ST = Sterile Bottle, ASS = Plastic Bag for Acid Soluble Solids, B = Unpreserved Bag, L = Lungs for Acid Soluble Solids, STT = Sterile Sodium Thiosulfate Preserved Bottle.

Environmental Division
Brisbane
Work Order Reference
EB1913749

Telephone : + 61-7-3243 7222





Environmental

SAMPLE RECEIPT NOTIFICATION (SRN)

Work Order : **EB1913749**

Client	: SLR Consulting Australia Pty Ltd	Laboratory	: Environmental Division Brisbane
Contact	: CAMERON TRAILL	Contact	: Tyler Cachia
Address	:	Address	: 2 Byth Street Stafford QLD Australia 4053
E-mail	: ctrail@slrconsulting.com	E-mail	: Tyler.Cachia@ALSGlobal.com
Telephone	: ----	Telephone	: +61 2 8784 8555
Facsimile	: ----	Facsimile	: +61-7-3243 7218
Project	: 623.17171 Fairhill Coking Coal	Page	: 1 of 3
Order number	:	Quote number	: EM2018HEGAUS0001 (EN/032/18
			Primary work only BQ)
C-O-C number	: ----	QC Level	: NEPM 2013 B3 & ALS QC Standard
Site	: ----		
Sampler	: CAMERON TRAILL		

Dates

Date Samples Received	: 28-May-2019 09:00	Issue Date	: 29-May-2019
Client Requested Due Date	: 10-Jun-2019	Scheduled Reporting Date	: 10-Jun-2019

Delivery Details

Mode of Delivery	: Carrier	Security Seal	: Intact.
No. of coolers/boxes	: 6	Temperature	: 18.2/17.8/19.1/19.8/19.5/18.7°C
Receipt Detail	: MEDIUM HARD ESKY	No. of samples received / analysed	: 6 / 6

General Comments

- This report contains the following information:
 - Sample Container(s)/Preservation Non-Compliances
 - Summary of Sample(s) and Requested Analysis
 - Proactive Holding Time Report
 - Requested Deliverables
- Please be advised that ALS is unable to accommodate the fast turnaround requested on the Chain of Custody. If you wish to discuss this further, please contact Client Services at **ALSEnviro.Brisbane@alsglobal.com**.
- *SRN Reissued 29/05/2019: Correct receipt date added.**
- Discounted Package Prices apply only when specific ALS Group Codes ('W', 'S', 'NT' suites) are referenced on COCs.
- Please direct any turn around / technical queries to the laboratory contact designated above.
- Sample Disposal - Aqueous (3 weeks), Solid (2 months $\pm$ 1 week) from receipt of samples.
- Analysis will be conducted by ALS Environmental, Brisbane, NATA accreditation no. 825, Site No. 818 (Micro site no. 18958).
- Breaches in recommended extraction / analysis holding times (if any) are displayed overleaf in the Proactive Holding Time Report table.**
- Please be aware that APHANEPM recommends water and soil samples be chilled to less than or equal to 6°C for chemical analysis, and less than or equal to 10°C but unfrozen for Microbiological analysis. Where samples are received above this temperature, it should be taken into consideration when interpreting results. Refer to ALS EnviroMail 85 for ALS recommendations of the best practice for chilling samples after sampling and for maintaining a cool temperature during transit.



Sample Container(s)/Preservation Non-Compliances

All comparisons are made against pretreatment/preservation AS, APHA, USEPA standards.

- No sample container / preservation non-compliance exists.

Summary of Sample(s) and Requested Analysis

Some items described below may be part of a laboratory process necessary for the execution of client requested tasks. Packages may contain additional analyses, such as the determination of moisture content and preparation tasks, that are included in the package.

If no sampling time is provided, the sampling time will default 00:00 on the date of sampling. If no sampling date is provided, the sampling date will be assumed by the laboratory and displayed in brackets without a time component

Matrix: **SOIL**

Laboratory sample ID	Client sampling date / time	Client sample ID							
EB1913749-001	24-May-2019 12:45	PR06 / 0.0-0.1	✓	✓	✓	✓	✓	✓	✓
EB1913749-002	24-May-2019 12:45	PR06 / 0.1-0.2	✓	✓	✓	✓	✓	✓	✓
EB1913749-003	24-May-2019 12:45	PR06 / 0.2-0.3	✓	✓	✓	✓	✓	✓	✓
EB1913749-004	24-May-2019 12:45	PR06 / 0.5-0.6	✓	✓	✓	✓	✓	✓	✓
EB1913749-005	24-May-2019 12:45	PR06 / 0.8-0.9	✓	✓	✓	✓	✓	✓	✓
EB1913749-006	24-May-2019 12:45	PR06 / 1.0-1.1	✓	✓	✓	✓	✓	✓	✓

Laboratory sample ID	Client sampling date / time	Client sample ID							
EB1913749-001	24-May-2019 12:45	PR06 / 0.0-0.1		SOIL - EA013 Acid Neutralising Capacity (ANC)					
EB1913749-002	24-May-2019 12:45	PR06 / 0.1-0.2	✓	SOIL - EA058 Emerson Aggregate Test	✓				
EB1913749-003	24-May-2019 12:45	PR06 / 0.2-0.3	✓	SOIL - EA150H-Y Particle Size Analysis by Hydrometer: Yellow	✓				
EB1913749-004	24-May-2019 12:45	PR06 / 0.5-0.6	✓	SOIL - ED091 Calcium Chloride Extractable Boron	✓				
EB1913749-005	24-May-2019 12:45	PR06 / 0.8-0.9	✓	SOIL - ED092 DTPA Extractable Metals	✓				
EB1913749-006	24-May-2019 12:45	PR06 / 1.0-1.1	✓	SOIL - EK080 Bicarbonate Extractable P (Colwell)	✓				

Proactive Holding Time Report

Sample(s) have been received within the recommended holding times for the requested analysis.



Requested Deliverables

ACCOUNTS PAYABLE AU

- A4 - AU Tax Invoice (INV)

Email	accounts payable@slrconsulting.com
-------	------------------------------------

CAMERON TRAILL

- *AU Certificate of Analysis - NATA (COA)
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep) (QCI)
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA (QC)
- A4 - AU Sample Receipt Notification - Environmental HT (SRN)
- A4 - AU Tax Invoice (INV)
- Attachment - Report (SUBCO)
- Chain of Custody (CoC) (COC)
- EDI Format - ENMRG (ENMRG)
- EDI Format - ESDAT (ESDAT)

Email	ctrail@slrconsulting.com
Email	ctrail@slrconsulting.com
Email	ctrail@slrconsulting.com
Email	ctrail@slrconsulting.com
Email	ctrail@slrconsulting.com
Email	ctrail@slrconsulting.com
Email	ctrail@slrconsulting.com
Email	ctrail@slrconsulting.com
Email	ctrail@slrconsulting.com

D TAYLOR

- A4 - AU Tax Invoice (INV)

Email	dtaylor@slrconsulting.com
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Environmental

CERTIFICATE OF ANALYSIS

Work Order : **EB1913749**

Client : **SLR Consulting Australia Pty Ltd**

Contact : **CAMERON TRAILL**

Address : **-----**

Telephone : **-----**

Project : **623.17171 Fairhill Coking Coal**

Order number : **-----**

C-O-C number : **-----**

Sampler : **CAMERON TRAILL**

Site : **-----**

Quote number : **EN/032/18 Primary work only BQ**

No. of samples received : **6**

No. of samples analysed : **6**

Page : **1 of 5**

Laboratory : **Environmental Division Brisbane**

Contact : **Tyler Cachia**

Address : **2 Byth Street Stafford QLD Australia 4053**

Telephone : **+61 2 8784 8555**

Date Samples Received : **28-May-2019 09:00**

Date Analysis Commenced : **30-May-2019**

Issue Date : **11-Jun-2019 17:33**

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

This Certificate of Analysis contains the following information:

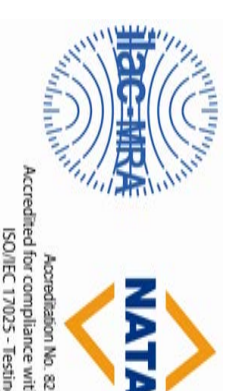
- General Comments
- Analytical Results

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
Ben Felgendreijens	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Satishkumar Trivedi	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Satishkumar Trivedi	Senior Acid Sulfate Soil Chemist	Brisbane Inorganics, Stafford, QLD



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



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by 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 Contact 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.

- ED006 (Exchangeable Cations on Alkaline Soils): Unable to calculate Magnesium/Potassium Ratio for some samples as the required results for Magnesium/Potassium are below LOR.
- ALS is not NATA accredited for the analysis of Exchangeable Aluminium and Exchange Acidity in soils when performed under ALS Method ED005.
- ALS is not NATA accredited for the analysis of Exchangeable Cations on Alkaline Soils when performed under ALS Method ED006.
- ASS: EA013 (ANC) Fizz Rating: 0- None; 1- Slight; 2- Moderate; 3- Strong; 4- Very Strong; 5- Lime.
- EA058 Emerson: V. = Very, D. = Dark, L. = Light, VD. = Very Dark
- ED007 and ED008: When Exchangeable Al is reported from these methods, it should be noted that Rayment & Lyons (2011) suggests Exchange Acidity by 1M KCl - Method 15G1 (ED005) is a more suitable method for the determination of exchange acidity (H+ + Al3+).



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)		Client sample ID		PR06 / 0.0-0.1	PR06 / 0.1-0.2	PR06 / 0.2-0.3	PR06 / 0.5-0.6	PR06 / 0.8-0.9	
Client sampling date / time		24-May-2019 12:45		24-May-2019 12:45		24-May-2019 12:45		24-May-2019 12:45	
Compound	CAS Number	LOR	Unit	EB1913749-001	EB1913749-002	EB1913749-003	EB1913749-004	EB1913749-005	
				Result	Result	Result	Result	Result	
EA002: pH 1:5 (Soils)									
pH Value	----	0.1	pH Unit	8.0	8.3	8.4	8.8	8.5	
EA010: Conductivity (1:5)									
Electrical Conductivity @ 25°C	----	1	µS/cm	33	39	45	101	204	
EA013: Acid Neutralising Capacity									
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	----	17.8	15.3	20.6	18.9	
ANC as CaCO3	----	0.1	% CaCO3	----	1.8	1.6	2.1	1.9	
Fizz Rating	----	0	Fizz Unit	----	1	1	1	1	
EA055: Moisture Content (Dried @ 105-110°C)									
Moisture Content	----	1.0	%	13.9	20.4	----	----	----	
EA058: Emerson Aggregate Test									
Color (Munsell)	----	-	-	----	Very Dark Gray (2.5Y 3/1)	Very Dark Gray (2.5Y 3/1)	Very Dark Gray (2.5Y 3/1)	Dark Gray (2.5Y 4/1)	
Texture	----	-	-	----	Heavy Clay	Heavy Clay	Heavy Clay	Medium Clay	
Emerson Class Number	EC/TC	-	-	----	4	4	3	3	
EA150: Soil Classification - National Committee on Soil and Terrain (2009)									
Clay (<2 µm)	----	1	%	70	63	71	72	69	
Silt (2-20 µm)	----	1	%	19	16	17	19	13	
Fine Sand (0.02-0.2 mm)	----	1	%	5	15	6	3	12	
Coarse Sand (0.2-2.0 mm)	----	1	%	5	5	6	5	5	
Gravel (>2mm)	----	1	%	1	1	<1	1	1	
EA152: Soil Particle Density									
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	2.26	2.52	2.44	2.42	2.34	
ED006: Exchangeable Cations on Alkaline Soils									
Ø Exchangeable Calcium	----	0.2	meq/100g	22.9	23.4	19.3	20.7	19.4	
Ø Exchangeable Magnesium	----	0.2	meq/100g	4.4	4.4	3.8	4.3	4.4	
Ø Exchangeable Potassium	----	0.2	meq/100g	0.3	0.3	0.2	<0.2	<0.2	
Ø Exchangeable Sodium	----	0.2	meq/100g	0.7	1.0	1.2	2.2	2.8	
Ø Cation Exchange Capacity	----	0.2	meq/100g	28.4	29.1	24.5	27.4	26.8	
Ø Exchangeable Sodium Percent	----	0.2	%	2.4	3.6	4.8	8.1	10.4	
Ø Calcium/Magnesium Ratio	----	0.2	-	5.2	5.3	5.1	4.8	4.4	
Ø Magnesium/Potassium Ratio	----	0.2	-	13.3	15.2	17.0	----	----	
ED042T: Total Sulfur by LECO									
Sulfur - Total as S (LECO)	----	0.01	%	<0.01	0.02	0.02	<0.01	<0.01	



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)		Client sample ID	PR06 / 0.0-0.1	PR06 / 0.1-0.2	PR06 / 0.2-0.3	PR06 / 0.5-0.6	PR06 / 0.8-0.9
Compound		Client sampling date / time	24-May-2019 12:45	24-May-2019 12:45	24-May-2019 12:45	24-May-2019 12:45	24-May-2019 12:45
CAS Number	LOR	Unit	EB1913749-001	EB1913749-002	EB1913749-003	EB1913749-004	EB1913749-005
ED045G: Chloride by Discrete Analyser			Result	Result	Result	Result	Result
Chloride	16887-00-6	10	mg/kg	<10	<10	60	240
ED091 : Calcium Chloride Extractable Boron							
Ø Boron	7440-42-8	0.2	mg/kg	0.4	0.4		
ED092: DTPA Extractable Metals							
Ø Copper	7440-50-8	1.00	mg/kg	2.24	2.27		
Ø Iron	7439-89-6	1.00	mg/kg	11.0	11.3		
Ø Manganese	7439-96-5	1.00	mg/kg	19.8	15.0		
Ø Zinc	7440-66-6	1.00	mg/kg	<1.00	<1.00		
EK057G: Nitrite as N by Discrete Analyser							
Nitrite as N (Sol.)	14797-65-0	0.1	mg/kg	0.3	0.1		
EK058G: Nitrate as N by Discrete Analyser							
Nitrate as N (Sol.)	14797-55-8	0.1	mg/kg	0.9	1.3		
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser							
Nitrite + Nitrate as N (Sol.)		0.1	mg/kg	1.2	1.4		
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser							
Total Kjeldahl Nitrogen as N		20	mg/kg	1050	1000		
EK062: Total Nitrogen as N (TKN + NOx)							
^ Total Nitrogen as N		20	mg/kg	1050	1000		
EK067G: Total Phosphorus as P by Discrete Analyser							
Total Phosphorus as P		2	mg/kg	246	217		
EK080: Bicarbonate Extractable Phosphorus (Colwell)							
Bicarbonate Ext. P (Colwell)		5	mg/kg	<5	<5		
EP004: Organic Matter							
Organic Matter		0.5	%	1.9	1.7		
Total Organic Carbon		0.5	%	1.1	1.0		



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)		Client sample ID			PR06 / 1.0-1.1						
		Client sampling date / time			24-May-2019 12:45						
Compound	CAS Number	LOR	Unit	EB1913749-006							
				Result							
EA002: pH 1:5 (Soils)											
pH Value		0.1	pH Unit		8.5						
EA010: Conductivity (1:5)											
Electrical Conductivity @ 25°C		1	µS/cm		229						
EA013: Acid Neutralising Capacity											
ANC as H2SO4		0.5	kg H2SO4 equiv./t		19.2						
ANC as CaCO3		0.1	% CaCO3		2.0						
Fizz Rating		0	Fizz Unit		1						
EA058: Emerson Aggregate Test											
Color (Munsell)		-	-		Very Dark Grayish Brown (2.5Y 3/2)						
Texture		-	-		Sandy Clay						
Emerson Class Number	EC/TC	-	-		3						
EA150: Soil Classification - National Committee on Soil and Terrain (2009)											
Clay (<2 µm)		1	%		55						
Silt (2-20 µm)		1	%		20						
Fine Sand (0.02-0.2 mm)		1	%		7						
Coarse Sand (0.2-2.0 mm)		1	%		10						
Gravel (>2mm)		1	%		8						
EA152: Soil Particle Density											
Soil Particle Density (Clay/Silt/Sand)		0.01	g/cm3		2.22						
ED006: Exchangeable Cations on Alkaline Soils											
Ø Exchangeable Calcium		0.2	meq/100g		14.9						
Ø Exchangeable Magnesium		0.2	meq/100g		3.4						
Ø Exchangeable Potassium		0.2	meq/100g		<0.2						
Ø Exchangeable Sodium		0.2	meq/100g		2.3						
Ø Cation Exchange Capacity		0.2	meq/100g		20.6						
Ø Exchangeable Sodium Percent		0.2	%		11.2						
Ø Calcium/Magnesium Ratio		0.2	-		4.4						
ED042T: Total Sulfur by LECO											
Sulfur - Total as S (LECO)		0.01	%		<0.01						
ED045G: Chloride by Discrete Analyser											
Chloride	16887-00-6	10	mg/kg		230						



Environmental

QUALITY CONTROL REPORT

Work Order : **EB1913749**

Page : 1 of 5

Client	: SLR Consulting Australia Pty Ltd	Laboratory	: Environmental Division Brisbane
Contact	: CAMERON TRAILL	Contact	: Tyler Cachia
Address	:	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: ----	Telephone	: +61 2 8784 8555
Project	: 623.17171 Fairhill Coking Coal	Date Samples Received	: 28-May-2019
Order number	:	Date Analysis Commenced	: 30-May-2019
C-O-C number	: ----	Issue Date	: 11-Jun-2019
Sampler	: CAMERON TRAILL		
Site	: ----		
Quote number	: EN/032/18 Primary work only BQ		
No. of samples received	: 6		
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. 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
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Satishkumar Trivedi	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Satishkumar Trivedi	Senior Acid Sulfate Soil Chemist	Brisbane Inorganics, Stafford, QLD



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by 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

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 sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EA002: pH 1.5 (Soils) (QC Lot: 2377071)									
EB1913756-005	Anonymous	EA002: pH Value	---	0.1	pH Unit	5.6	5.6	0.00	0% - 20%
EB1913749-001	PR06 / 0-0-0.1	EA002: pH Value	---	0.1	pH Unit	8.0	8.0	0.00	0% - 20%
EA010: Conductivity (1:5) (QC Lot: 2377072)									
EB1913756-005	Anonymous	EA010: Electrical Conductivity @ 25°C	---	1	µS/cm	681	634	7.15	0% - 20%
EB1913749-001	PR06 / 0-0-0.1	EA010: Electrical Conductivity @ 25°C	---	1	µS/cm	33	30	7.57	0% - 20%
EA013: Acid Neutralising Capacity (QC Lot: 2393313)									
EB1913749-002	PR06 / 0.1-0.2	EA013: ANC as H2SO4	---	0.5	kg H2SO4 equiv./t	17.8	15.8	11.9	0% - 20%
EB1913759-003	Anonymous	EA013: ANC as H2SO4	---	0.5	kg H2SO4 equiv./t	5.2	5.1	1.94	0% - 50%
EA055: Moisture Content (Dried @ 105-110°C) (QC Lot: 2377073)									
EB1913749-001	PR06 / 0-0-0.1	EA055: Moisture Content	---	0.1	%	13.9	13.8	0.730	0% - 50%
EB1913756-005	Anonymous	EA055: Moisture Content	---	0.1	%	10.0	9.9	1.21	0% - 50%
ED006: Exchangeable Cations on Alkaline Soils (QC Lot: 2392368)									
EB1913749-001	PR06 / 0-0-0.1	ED006: Exchangeable Calcium	---	0.2	meq/100g	22.9	25.1	9.18	0% - 20%
		ED006: Exchangeable Magnesium	---	0.2	meq/100g	4.4	4.7	6.73	0% - 20%
		ED006: Exchangeable Potassium	---	0.2	meq/100g	0.3	0.3	0.00	No Limit
		ED006: Exchangeable Sodium	---	0.2	meq/100g	0.7	0.7	0.00	No Limit
		ED006: Cation Exchange Capacity	---	0.2	meq/100g	28.4	30.9	8.41	0% - 20%
		ED006: Exchangeable Calcium	---	0.2	meq/100g	2.3	2.5	8.50	0% - 50%
		ED006: Exchangeable Magnesium	---	0.2	meq/100g	3.2	3.4	7.98	0% - 50%
		ED006: Exchangeable Potassium	---	0.2	meq/100g	0.8	0.8	0.00	No Limit
		ED006: Exchangeable Sodium	---	0.2	meq/100g	1.9	2.0	7.75	0% - 50%
		ED006: Cation Exchange Capacity	---	0.2	meq/100g	8.1	8.8	8.01	0% - 20%



Sub-Matrix: **SOIL**

Sub-Matrix: SOIL			Laboratory Duplicate (DUP) Report								
Laboratory sample ID	Client sample ID	Method: <i>Compound</i>	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)		
ED042T: Total Sulfur by LECO (QC Lot: 2392714)											
EB1913749-001	PR06 / 0.0-0.1	ED042T: Sulfur - Total as S (LECO)	----	0.01	%	<0.01	0.02	0.00	No Limit		
EB1913756-004	Anonymous	ED042T: Sulfur - Total as S (LECO)	----	0.01	%	<0.01	<0.01	0.00	No Limit		
ED045G: Chloride by Discrete Analyser (QC Lot: 2377070)											
EB1913756-005	Anonymous	ED045G: Chloride	16887-00-6	10	mg/kg	1120	1030	8.21	0% - 20%		
EB1913749-001	PR06 / 0.0-0.1	ED045G: Chloride	16887-00-6	10	mg/kg	<10	<10	0.00	No Limit		
ED091 : Calcium Chloride Extractable Boron (QC Lot: 2376985)											
EB1913749-001	PR06 / 0.0-0.1	ED091: Boron	7440-42-8	0.2	mg/kg	0.4	0.4	0.00	No Limit		
ED092: DTPA Extractable Metals (QC Lot: 2376984)											
EB1913749-001	PR06 / 0.0-0.1	ED092: Copper	7440-50-8	1	mg/kg	2.24	2.22	0.969	No Limit		
		ED092: Iron	7439-89-6	1	mg/kg	11.0	10.8	1.57	0% - 50%		
		ED092: Manganese	7439-96-5	1	mg/kg	19.8	19.9	0.442	0% - 50%		
		ED092: Zinc	7440-66-6	1	mg/kg	<1.00	<1.00	0.00	No Limit		
EK057G: Nitrite as N by Discrete Analyser (QC Lot: 2377068)											
EB1913749-001	PR06 / 0.0-0.1	EK057G: Nitrite as N (Sol.)	14797-65-0	0.1	mg/kg	0.3	0.4	0.00	No Limit		
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QC Lot: 2377069)											
EB1913749-001	PR06 / 0.0-0.1	EK059G: Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	1.2	1.4	14.8	0% - 50%		
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QC Lot: 2377066)											
EB1913749-001	PR06 / 0.0-0.1	EK061G: Total Kjeldahl Nitrogen as N	----	20	mg/kg	1050	1010	3.59	0% - 20%		
EK067G: Total Phosphorus as P by Discrete Analyser (QC Lot: 2377067)											
EB1913749-001	PR06 / 0.0-0.1	EK067G: Total Phosphorus as P	----	2	mg/kg	246	245	0.00	0% - 20%		
EK080: Bicarbonate Extractable Phosphorus (Colwell) (QC Lot: 2376988)											
EB1913749-001	PR06 / 0.0-0.1	EK080: Bicarbonate Ext. P (Colwell)	----	5	mg/kg	<5	<5	0.00	No Limit		
EP004: Organic Matter (QC Lot: 2376987)											
EB1913749-001	PR06 / 0.0-0.1	EP004: Organic Matter	----	0.5	%	1.9	2.1	12.5	No Limit		
		EP004: Total Organic Carbon	----	0.5	%	1.1	1.2	12.3	No Limit		



Sub-Matrix: SOIL

Sub-Matrix: SOIL									
Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report		Laboratory Control Spike (LCS) Report			
				Result	Spike Concentration	Spike Recovery (%)		Recovery Limits (%)	
EKO67G: Total Phosphorus as P by Discrete Analyser (QCLot: 2377067) - continued									
EKO67G: Total Phosphorus as P	----	2	mg/kg	<2	939 mg/kg 1200 mg/kg	81.6 87.7	80 80	115 115	
EKO80: Bicarbonate Extractable Phosphorus (Colwell) (QCLot: 2376988)									
EKO80: Bicarbonate Ext. P (Colwell)	----	5	mg/kg	<5 <5 <5	100 mg/kg 44.9 mg/kg 58.07 mg/kg	98.3 103 91.8	70 87 80	130 113 120	
EP004: Organic Matter (QCLot: 2376987)									
EP004: Organic Matter	----	0.5	%	<0.5	80 %	94.5	83	115	
EP004: Total Organic Carbon	----	0.5	%	<0.5	46.4 %	94.5	85	115	

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: SOIL

Sub-Matrix: SOIL			Matrix Spike (MS) Report				
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Spike Concentration	Recovery Limits (%)		
					Spike Recovery(%) MS	Low	High
EK057G: Nitrite as N by Discrete Analyser (QCLot: 2377068)							
EB1913749-002	PR06 / 0.1-0.2	EK057G: Nitrite as N (Sol.)	14797-65-0	2 mg/kg	98.8	70	130
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 2377069)							
EB1913749-002	PR06 / 0.1-0.2	EK059G: Nitrite + Nitrate as N (Sol.)	---	2 mg/kg	91.3	70	130
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QCLot: 2377066)							
EB1913749-002	PR06 / 0.1-0.2	EK061G: Total Kjeldahl Nitrogen as N	---	500 mg/kg	93.4	70	130
EK067G: Total Phosphorus as P by Discrete Analyser (QCLot: 2377067)							
EB1913749-002	PR06 / 0.1-0.2	EK067G: Total Phosphorus as P	---	100 mg/kg	83.9	70	130
EK080: Bicarbonate Extractable Phosphorus (Colwell) (QCLot: 2376988)							
EB1913749-002	PR06 / 0.1-0.2	EK080: Bicarbonate Ext. P (Colwell)	---	40 mg/kg	108	70	130
EP004: Organic Matter (QCLot: 2376987)							
EB1913749-002	PR06 / 0.1-0.2	EP004: Organic Matter	---	2 %	91.5	70	130
		EP004: Total Organic Carbon	---	1.16 %	91.4	70	130



QA/QC Compliance Assessment to assist with Quality Review

Work Order	: EB1913749	Page	: 1 of 8
Client	: SLR Consulting Australia Pty Ltd	Laboratory	: Environmental Division Brisbane
Contact	: CAMERON TRAILL	Telephone	: +61 2 8784 8555
Project	: 623.17171 Fairhill Coking Coal	Date Samples Received	: 28-May-2019
Site	: ----	Issue Date	: 11-Jun-2019
Sampler	: CAMERON TRAILL	No. of samples received	: 6
Order number	:	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

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

Outliers : Frequency of Quality Control Samples

- NO Quality Control Sample Frequency Outliers exist.

Outliers : Analysis Holding Time Compliance

Matrix: SOIL

Method		Extraction / Preparation			Analysis		
Container / Client Sample ID(s)		Date extracted	Due for extraction	Days overdue	Date analysed	Due for analysis	Days overdue
EA002: pH 1:5 (Soils)							
Snap Lock Bag							
PR06 / 0.0-0.1,		06-Jun-2019	31-May-2019	6	06 Jun 2019	06 Jun 2019	06 Jun 2019
PR06 / 0.2-0.3,							
PR06 / 0.8-0.9,							
EA010: Conductivity (1:5)							
Snap Lock Bag							
PR06 / 0.0-0.1,		06-Jun-2019	31-May-2019	6	06 Jun 2019	06 Jun 2019	06 Jun 2019
PR06 / 0.2-0.3,							
PR06 / 0.8-0.9,							
EP004: Organic Matter							
Snap Lock Bag							
PR06 / 0.0-0.1,		10-Jun-2019	31-May-2019	10	06 Jun 2019	06 Jun 2019	06 Jun 2019

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
EA002: pH 1.5 (Soils)									
Snap Lock Bag (EA002)									
PR06 / 0.0-0.1,		PR06 / 0.1-0.2,	24-May-2019	06-Jun-2019	31-May-2019	✖	06-Jun-2019	06-Jun-2019	✔
PR06 / 0.2-0.3,		PR06 / 0.5-0.6,							
PR06 / 0.8-0.9,		PR06 / 1.0-1.1							
EA010: Conductivity (1:5)									
Snap Lock Bag (EA010)									
PR06 / 0.0-0.1,		PR06 / 0.1-0.2,	24-May-2019	06-Jun-2019	31-May-2019	✖	06-Jun-2019	04-Jul-2019	✔
PR06 / 0.2-0.3,		PR06 / 0.5-0.6,							
PR06 / 0.8-0.9,		PR06 / 1.0-1.1							



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
EA013: Acid Neutralising Capacity							
Snap Lock Bag (EA013)							
PR06 / 0.1-0.2,	24-May-2019	10-Jun-2019	23-May-2020	✓	10-Jun-2019	07-Dec-2019	✓
PR06 / 0.5-0.6,							
PR06 / 1.0-1.1							
EA055: Moisture Content (Dried @ 105-110°C)							
Snap Lock Bag (EA055)							
PR06 / 0.0-0.1,	24-May-2019	-----	-----	-----	30-May-2019	07-Jun-2019	✓
EA058: Emerson Aggregate Test							
Snap Lock Bag (EA058)							
PR06 / 0.1-0.2,	24-May-2019	-----	-----	-----	06-Jun-2019	20-Nov-2019	✓
PR06 / 0.5-0.6,							
PR06 / 1.0-1.1							
EA150: Soil Classification - National Committee on Soil and Terrain (2009)							
Snap Lock Bag (EA150H)							
PR06 / 0.0-0.1,	24-May-2019	-----	-----	-----	06-Jun-2019	20-Nov-2019	✓
PR06 / 0.2-0.3,							
PR06 / 0.8-0.9,							
EA152: Soil Particle Density							
Snap Lock Bag (EA152)							
PR06 / 0.0-0.1,	24-May-2019	-----	-----	-----	06-Jun-2019	20-Nov-2019	✓
PR06 / 0.2-0.3,							
PR06 / 0.8-0.9,							
ED005: Exchange Acidity							
Snap Lock Bag (ED005)							
PR06 / 0.0-0.1,	24-May-2019	07-Jun-2019	21-Jun-2019	✓	10-Jun-2019	21-Jun-2019	✓
PR06 / 0.2-0.3,							
PR06 / 0.8-0.9,							
ED006: Exchangeable Cations on Alkaline Soils							
Snap Lock Bag (ED006)							
PR06 / 0.0-0.1,	24-May-2019	07-Jun-2019	21-Jun-2019	✓	10-Jun-2019	21-Jun-2019	✓
PR06 / 0.2-0.3,							
PR06 / 0.8-0.9,							
ED007: Exchangeable Cations							
Snap Lock Bag (ED007)							
PR06 / 0.0-0.1,	24-May-2019	07-Jun-2019	21-Jun-2019	✓	10-Jun-2019	21-Jun-2019	✓
PR06 / 0.2-0.3,							
PR06 / 0.8-0.9,							



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
ED008: Exchangeable Cations							
Snap Lock Bag (ED008)							
PR06 / 0.0-0.1,	24-May-2019	07-Jun-2019	21-Jun-2019	✔	10-Jun-2019	21-Jun-2019	✔
PR06 / 0.2-0.3,							
PR06 / 0.8-0.9,							
ED042T: Total Sulfur by LECO							
Pulp Bag (ED042T)							
PR06 / 0.0-0.1,	24-May-2019	07-Jun-2019	21-Jun-2019	✔	07-Jun-2019	21-Jun-2019	✔
PR06 / 0.2-0.3,							
PR06 / 0.8-0.9,							
ED045G: Chloride by Discrete Analyser							
Snap Lock Bag (ED045G)							
PR06 / 0.0-0.1,	24-May-2019	06-Jun-2019	21-Jun-2019	✔	07-Jun-2019	04-Jul-2019	✔
PR06 / 0.2-0.3,							
PR06 / 0.8-0.9,							
ED091 : Calcium Chloride Extractable Boron							
Snap Lock Bag (ED091)							
PR06 / 0.0-0.1,	24-May-2019	06-Jun-2019	20-Nov-2019	✔	07-Jun-2019	20-Nov-2019	✔
ED092: DTPA Extractable Metals							
Snap Lock Bag (ED092)							
PR06 / 0.0-0.1,	24-May-2019	06-Jun-2019	20-Nov-2019	✔	07-Jun-2019	20-Nov-2019	✔
EK057G: Nitrite as N by Discrete Analyser							
Snap Lock Bag (EK057G)							
PR06 / 0.0-0.1,	24-May-2019	06-Jun-2019	20-Nov-2019	✔	07-Jun-2019	20-Nov-2019	✔
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser							
Snap Lock Bag (EK059G)							
PR06 / 0.0-0.1,	24-May-2019	06-Jun-2019	20-Nov-2019	✔	07-Jun-2019	20-Nov-2019	✔
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser							
Snap Lock Bag (EK061G)							
PR06 / 0.0-0.1,	24-May-2019	05-Jun-2019	20-Nov-2019	✔	05-Jun-2019	20-Nov-2019	✔
EK067G: Total Phosphorus as P by Discrete Analyser							
Snap Lock Bag (EK067G)							
PR06 / 0.0-0.1,	24-May-2019	05-Jun-2019	20-Nov-2019	✔	05-Jun-2019	20-Nov-2019	✔
EK080: Bicarbonate Extractable Phosphorus (Colwell)							
Snap Lock Bag (EK080)							
PR06 / 0.0-0.1,	24-May-2019	07-Jun-2019	20-Nov-2019	✔	07-Jun-2019	20-Nov-2019	✔
EP004: Organic Matter							
Snap Lock Bag (EP004)							
PR06 / 0.0-0.1,	24-May-2019	10-Jun-2019	31-May-2019	✘	10-Jun-2019	08-Jul-2019	✔



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 (%)		Evaluation	Quality Control Specification
Method	QC	Regular	Actual	Expected		
Laboratory Duplicates (DUP)						
Acid Neutralising Capacity (ANC)	EA013	2	16	12.50	10.00	NEPM 2013 B3 & ALS QC Standard
Bicarbonate Extractable P (Colwell)	EK080	1	8	12.50	10.00	NEPM 2013 B3 & ALS QC Standard
Calcium Chloride Extractable Boron	ED091	1	8	12.50	10.00	NEPM 2013 B3 & ALS QC Standard
Chloride Soluble By Discrete Analyser	ED045G	2	20	10.00	10.00	NEPM 2013 B3 & ALS QC Standard
DTPA Extractable Metals	ED092	1	8	12.50	10.00	NEPM 2013 B3 & ALS QC Standard
Electrical Conductivity (1:5)	EA010	2	20	10.00	10.00	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations on Alkaline Soils	ED006	2	15	13.33	10.00	NEPM 2013 B3 & ALS QC Standard
Moisture Content	EA055	2	8	25.00	10.00	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NO _x -) Soluble by Discrete Analyser	EK059G	1	8	12.50	10.00	NEPM 2013 B3 & ALS QC Standard
Nitrite as N - Soluble by Discrete Analyser	EK057G	1	8	12.50	10.00	NEPM 2013 B3 & ALS QC Standard
Organic Matter	EP004	1	8	12.50	10.00	NEPM 2013 B3 & ALS QC Standard
pH (1:5)	EA002	2	20	10.00	10.00	NEPM 2013 B3 & ALS QC Standard
Sulfur - Total as S (LECO)	ED042T	1	20	5.00	5.00	NEPM 2013 B3 & ALS QC Standard
TKN as N By Discrete Analyser	EK061G	2	8	25.00	10.00	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus By Discrete Analyser	EK067G	2	8	25.00	10.00	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)						
Bicarbonate Extractable P (Colwell)	EK080	1	8	12.50	5.00	NEPM 2013 B3 & ALS QC Standard
Calcium Chloride Extractable Boron	ED091	1	8	12.50	5.00	NEPM 2013 B3 & ALS QC Standard
Chloride Soluble By Discrete Analyser	ED045G	1	20	5.00	5.00	NEPM 2013 B3 & ALS QC Standard

Matrix: SOIL

Evaluation: ✖ = Quality Control frequency not within specification ; ✔ = Quality Control frequency within specification.

Quality Control Sample Type	Count		Rate (%)		Evaluation	Quality Control Specification
Analytical Methods	Method	QC	Regular	Actual		
Method Blanks (MB) - Continued						
DTPA Extractable Metals	ED092	1	8	12.50	5.00	✓ NEPM 2013 B3 & ALS QC Standard
Electrical Conductivity (1:5)	EA010	1	20	5.00	5.00	✓ NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations on Alkaline Soils	ED006	1	15	6.67	5.00	✓ NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx)- Soluble by Discrete Analyser	EK059G	1	8	12.50	5.00	✓ NEPM 2013 B3 & ALS QC Standard
Nitrite as N - Soluble by Discrete Analyser	EK057G	1	8	12.50	5.00	✓ NEPM 2013 B3 & ALS QC Standard
Organic Matter	EP004	1	8	12.50	5.00	✓ NEPM 2013 B3 & ALS QC Standard
Sulfur - Total as S (LECO)	ED042T	1	20	5.00	5.00	✓ NEPM 2013 B3 & ALS QC Standard
TKN as N By Discrete Analyser	EK061G	1	8	12.50	5.00	✓ NEPM 2013 B3 & ALS QC Standard
Total Phosphorus By Discrete Analyser	EK067G	1	8	12.50	5.00	✓ NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)						
Bicarbonate Extractable P (Colwell)	EK080	1	8	12.50	5.00	✓ NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx)- Soluble by Discrete Analyser	EK059G	1	8	12.50	5.00	✓ NEPM 2013 B3 & ALS QC Standard
Nitrite as N - Soluble by Discrete Analyser	EK057G	1	8	12.50	5.00	✓ NEPM 2013 B3 & ALS QC Standard
Organic Matter	EP004	1	8	12.50	5.00	✓ NEPM 2013 B3 & ALS QC Standard
TKN as N By Discrete Analyser	EK061G	1	8	12.50	5.00	✓ NEPM 2013 B3 & ALS QC Standard
Total Phosphorus By Discrete Analyser	EK067G	1	8	12.50	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 (1:5)	EA002	SOIL	In house: Referenced to Rayment and Lyons 4A1 and APHA 4500H+. pH is determined on soil samples after a 1:5 soil/water leach. This method is compliant with NEPM (2013) Schedule B(3)
Electrical Conductivity (1:5)	EA010	SOIL	In house: Referenced to Rayment and Lyons 3A1 and APHA 2510. Conductivity is determined on soil samples using a 1:5 soil/water leach. This method is compliant with NEPM (2013) Schedule B(3)
Acid Neutralising Capacity (ANC)	EA013	SOIL	In house: Referenced to USEPA 600/2-78-054, I. Miller (2000). A fizz test is done to semiquantitatively estimate the likely reactivity. The soil is then reacted with a known excess quantity of an appropriate acid. Titration determines the acid remaining, and the ANC can be calculated from comparison with a blank titration.
Moisture Content	EA055	SOIL	In house: A gravimetric procedure based on weight loss over a 12 hour drying period at 105-110 degrees C. This method is compliant with NEPM (2013) Schedule B(3) Section 7.1 and Table 1 (14 day holding time).
Emerson Aggregate Test	EA058	SOIL	In house: Referenced to AS1289.3.8.1. Testing is performed only on soils with suitable aggregates; sands and gravels are usually unsuitable for this test. The test classifies the behaviour of soil aggregates, when immersed, on their coherence in water.
Particle Size Analysis by Hydrometer	EA150H	SOIL	Particle Size Analysis by Hydrometer according to AS1289.3.6.3 - 2003
Soil Particle Density	EA152	SOIL	Soil Particle Density by AS 1289.3.5.1-2006. Methods of testing soils for engineering purposes - Soil classification tests - Determination of the soil particle density of a soil - Standard method
Exchange Acidity by 1M Potassium Chloride	* ED005	SOIL	In house: referenced to Rayment and Lyons. (2011), method 15G1. This method is unsuitable for near neutral and alkaline soils. NATA accreditation does not cover performance of this service.
Exchangeable Cations on Alkaline Soils	* ED006	SOIL	In house: Referenced to Soil Survey Test Method C5. Soluble salts are removed from the sample prior to analysis. Cations are exchanged from the sample by contact with alcoholic ammonium chloride at pH 8.5. They are then quantitated in the final solution by ICPAES and reported as meq/100g of original soil.
Exchangeable Cations	ED007	SOIL	In house: Referenced to Rayment & Lyons (2011) Method 15A1. Cations are exchanged from the sample by contact with Ammonium Chloride. They are then quantitated in the final solution by ICPAES and reported as meq/100g of original soil. This method is compliant with NEPM (2013) Schedule B(3) (Method 301)
Exchangeable Cations with pre-treatment	ED008	SOIL	In house: Referenced to Rayment & Higginson (2011) Method 15A2. Soluble salts are removed from the sample prior to analysis. Cations are exchanged from the sample by contact with Ammonium Chloride. They are then quantitated in the final solution by ICPAES and reported as meq/100g of original soil. This method is compliant with NEPM (2013) Schedule B(3) (Method 301)
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 SO ₂) is measured by infra-red detector
Chloride Soluble By Discrete Analyser	ED045G	SOIL	In house: Referenced to APHA 4500-Cl- E. 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 thiocyanate forms highly coloured ferric thiocyanate which is measured at 480 nm. Analysis is performed on a 1:5 soil / water leachate.
Calcium Chloride Extractable Boron	* ED091	SOIL	In house: Referenced to Rayment & Higginson (2011) method 12C2. Soil is extracted with hot 0.01M CaCl ₂ solution at a 1:2 ratio. Extracts can be run on ICP.
DTPA Extractable Metals	* ED092	SOIL	In house: Referenced to Rayment and Higginson (2011) 12A1



Analytical Methods			
	Method	Matrix	Method Descriptions
Nitrite as N - Soluble by Discrete Analyser	EK057G	SOIL	In house: Referenced to APHA 4500-NO3- B. Nitrite in a water extract is determined by direct colourimetry by Discrete Analyser.
Nitrate as N - Soluble by Discrete Analyser	EK058G	SOIL	In house: Referenced to APHA 4500-NO3- F. Nitrate in the 1:5 soil:water extract is reduced to nitrite by way of a chemical reduction followed by quantification by Discrete Analyser. Nitrite is determined seperately by direct colourimetry and result for Nitrate calculated as the difference between the two results.
Nitrite and Nitrate as N (NOx)- Soluble by Discrete Analyser	EK059G	SOIL	In house: Thermo Scientific Method D08727 and NEMI (National Environmental Method Index) Method ID: 91771. This method covers the determination of total oxidised nitrogen (NOx-N) and nitrate (NO3-N) by calculation, Combined oxidised Nitrogen (NO2+NO3) in a water extract is determined by direct colourimetry by Discrete Analyser.
TKN as N By Discrete Analyser	EK061G	SOIL	In house: Referenced to APHA 4500-Norg-D Soil samples are digested using Kjeldahl digestion followed by determination by Discrete Analyser.
Total Nitrogen as N (TKN + NOx) By Discrete Analyser	EK062G	SOIL	In house: Referenced to APHA 4500 Norg/NO3- Total Nitrogen is determined as the sum of TKN and Oxidised Nitrogen, each determined seperately as N.
Total Phosphorus By Discrete Analyser	EK067G	SOIL	In house: Referenced to APHA 4500 P-B&F This procedure involves sulfuric acid digestion and quantification using Discrete Analyser.
Bicarbonate Extractable P (Colwell)	EK080	SOIL	In house: Referenced to Rayment & Higginson (2011) Method 9B1 Phosphorus is extracted from the soil using 0.5M NaHCO3 at a 1:100 soil:solution ratio and determined by FLA.
Organic Matter	EP004	SOIL	In house: Referenced to AS1289.4.1.1 - 1997. Dichromate oxidation method after Walkley and Black. This method is compliant with NEPM (2013) Schedule B(3).
Preparation Methods			
	Method	Matrix	Method Descriptions
Exchangeable Cations Preparation Method (Alkaline Soils)	ED006PR	SOIL	In house: Referenced to Rayment and Lyons 2011 method 15C1.
Exchangeable Cations Preparation Method	ED007PR	SOIL	In house: Referenced to Rayment & Higginson (1992) method 15A1. A 1M NH4Cl extraction by end over end tumbling at a ratio of 1:20. There is no pretreatment for soluble salts. Extracts can be run by ICP for cations.
Hot Water CaCl2 Extraction for Boron	ED091PR	SOIL	In house: Referenced to Rayment & Higginson (1992) method 12C2. Soil is extracted with hot 0.01M CaCl2 solution at a 1:2 ratio. Extracts can be run on ICP.
DTPA Extraction for Cu, Zn, Mn, Fe (2 hour leach)	ED092PR	SOIL	In house: Referenced to Rayment & Higginson (1992) Method 12A1 2 hour end over end tumbler extraction with 0.005M DTPA at a ratio of 1:2. Extracts can be run by ICP for metals.
TKN/TP Digestion	EK061/EK067	SOIL	In house: Referenced to APHA 4500 Norg- D; APHA 4500 P - H. Macro Kjeldahl digestion.
Sample Preparation for Bicarbonate Extractable P (Colwell)	EK080-PR	SOIL	In house: Referenced to Rayment & Higginson (2011) Method 9B1 Phosphorus is extracted from the soil using 0.5M NaHCO3 at a 1:100 soil:solution ratio.
Drying at 85 degrees, bagging and labelling (ASS)	EN020PR	SOIL	In house
1:5 solid / water leach for soluble analytes	EN34	SOIL	10 g of soil is mixed with 50 mL of reagent grade water and tumbled end over end for 1 hour. Water soluble salts are leached from the soil by the continuous suspension. Samples are settled and the water filtered off for analysis.
Organic Matter	EP004-PR	SOIL	In house: Referenced to AS1289.4.1.1 - 1997. Dichromate oxidation method after Walkley and Black. This method is compliant with NEPM (2013) Schedule B(3) (Method 105)
Dry and Pulverise (up to 100g)	GEO30	SOIL	#



Environmental

SAMPLE RECEIPT NOTIFICATION (SRN)

Work Order : **EB1913817**

Client : **SLR Consulting Australia Pty Ltd**
Contact : **CAMERON TRAILL**
Address :

Laboratory : **Environmental Division Brisbane**
Contact : **Tyler Cachia**
Address : **2 Byth Street Stafford QLD Australia 4053**

E-mail : **ctrail@slrconsulting.com**
Telephone : **----**
Facsimile : **----**

E-mail : **Tyler.Cachia@ALSGlobal.com**
Telephone : **+61 2 8784 8555**
Facsimile : **+61-7-3243 7218**

Project : **623.17171 Fairhill Coking Coal**
Order number : **----**

Page : **1 of 3**
Quote number : **EM2018HEGAUS0001 (EN/032/18**

C-O-C number : **----**

QC Level

Primary work only BQ)
NEPM 2013 B3 & ALS QC Standard

Site : **----**

Sampler : **----**

Dates

Date Samples Received : **30-May-2019 13:22**
Client Requested Due : **11-Jun-2019**

Issue Date : **30-May-2019**
Scheduled Reporting Date : **11-Jun-2019**

Delivery Details

Mode of Delivery : **Carrier**
No. of coolers/boxes : **----**
Receipt Detail : **MEDIUM ESKY**

Security Seal : **Not Available**
Temperature : **----**
No. of samples received / analysed : **5 / 5**

General Comments

- This report contains the following information:
 - Sample Container(s)/Preservation Non-Compliances
 - Summary of Sample(s) and Requested Analysis
 - Proactive Holding Time Report
 - Requested Deliverables
- Discounted Package Prices apply only when specific ALS Group Codes ('W', 'S', 'NT' suites) are referenced on COCs.
- Please direct any turn around / technical queries to the laboratory contact designated above.
- Sample Disposal - Aqueous (3 weeks), Solid (2 months ± 1 week) from receipt of samples.
- Analysis will be conducted by ALS Environmental, Brisbane, NATA accreditation no. 825, Site No. 818 (Micro site no. 18958).
- **Breaches in recommended extraction / analysis holding times (if any) are displayed overleaf in the Proactive Holding Time Report table.**
- Please be aware that APHA/NEPM recommends water and soil samples be chilled to less than or equal to 6°C for chemical analysis, and less than or equal to 10°C but unfrozen for Microbiological analysis. Where samples are received above this temperature, it should be taken into consideration when interpreting results. Refer to ALS EnviroMail 85 for ALS recommendations of the best practice for chilling samples after sampling and for maintaining a cool temperature during transit.



Sample Container(s)/Preservation Non-Compliances

All comparisons are made against pretreatment/preservation AS, APHA, USEPA standards.

- No sample container / preservation non-compliance exists.

Summary of Sample(s) and Requested Analysis

Some items described below may be part of a laboratory process necessary for the execution of client requested tasks. Packages may contain additional analyses, such as the determination of moisture content and preparation tasks, that are included in the package.

If no sampling time is provided, the sampling time will default 00:00 on the date of sampling. If no sampling date is provided, the sampling date will be assumed by the laboratory and displayed in brackets without a time component

Matrix: **SOIL**

Laboratory sample ID	Client sampling date / time	Client sample ID	SOIL - AG-1 EB Only Agricultural Soil Suite 1 EB Only	SOIL - EA055-103 Moisture Content	SOIL - ED092 DTPA Extractable Metals	SOIL - EK067G (Solids) Total Phosphorus as P by Discrete Analyser	SOIL - EK080 Bicarbonate Extractable P (Colwell)	SOIL - EP004 Organic Matter in Soil (Walkley Black)	SOIL - NT-6S Nitrogen, TKN, NO2, NO3
EB1913817-001	24-May-2019 09:30	PR07/0.0-0.1	✓	✓	✓	✓	✓	✓	✓
EB1913817-002	24-May-2019 09:30	PR07/0.1-0.2	✓	✓	✓	✓	✓	✓	✓
EB1913817-003	24-May-2019 09:30	PR07/0.2-0.3	✓	✓					
EB1913817-004	24-May-2019 09:30	PR07/0.5-0.6	✓	✓					
EB1913817-005	24-May-2019 09:30	PR07/0.7-0.8	✓	✓					

Matrix: **SOIL**

Laboratory sample ID	Client sampling date / time	Client sample ID	SOIL - EA013 Acid Neutralising Capacity (ANC)	SOIL - EA058 Emerson Aggregate Test	SOIL - EA150H/EA152 Particle Sizing with Hydrometer + Soil Particle	SOIL - ED042T Sulfur - Total as S (high temperature furnace)	SOIL - ED045G (solids) Chloride Soluble by Discrete Analyser	SOIL - ED091 Calcium Chloride Extractable Boron
EB1913817-001	24-May-2019 09:30	PR07/0.0-0.1			✓	✓	✓	✓
EB1913817-002	24-May-2019 09:30	PR07/0.1-0.2	✓	✓	✓	✓	✓	✓
EB1913817-003	24-May-2019 09:30	PR07/0.2-0.3	✓	✓	✓	✓	✓	
EB1913817-004	24-May-2019 09:30	PR07/0.5-0.6	✓	✓	✓	✓	✓	
EB1913817-005	24-May-2019 09:30	PR07/0.7-0.8	✓	✓	✓	✓	✓	

Proactive Holding Time Report

Sample(s) have been received within the recommended holding times for the requested analysis.



Requested Deliverables

ACCOUNTS PAYABLE AU

- A4 - AU Tax Invoice (INV)

Email	accounts payable@slrconsulting.com
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CAMERON TRAILL

- *AU Certificate of Analysis - NATA (COA)
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep) (QCI)
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA (QC)
- A4 - AU Sample Receipt Notification - Environmental HT (SRN)
- A4 - AU Tax Invoice (INV)
- Attachment - Report (SUBCO)
- Chain of Custody (CoC) (COC)
- EDI Format - ENMRG (ENMRG)
- EDI Format - ESDAT (ESDAT)

Email	ctrail@slrconsulting.com
Email	ctrail@slrconsulting.com
Email	ctrail@slrconsulting.com
Email	ctrail@slrconsulting.com
Email	ctrail@slrconsulting.com
Email	ctrail@slrconsulting.com
Email	ctrail@slrconsulting.com
Email	ctrail@slrconsulting.com
Email	ctrail@slrconsulting.com

Damien Taylor

- A4 - AU Tax Invoice (INV)

Email	djtaylor@slrconsulting.com
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Environmental

CERTIFICATE OF ANALYSIS

Work Order	: EB1913817	Page	: 1 of 4
Amendment	: 1	Laboratory	: Environmental Division Brisbane
Client	: SLR Consulting Australia Pty Ltd	Contact	: Tyler Cachia
Contact	: CAMERON TRAILL	Address	: 2 Byth Street Stafford QLD Australia 4053
Address	:	Telephone	: +61 2 8784 8555
Telephone	: ---	Date Samples Received	: 30-May-2019 13:22
Project	: 623.17171 Fairhill Coking Coal	Date Analysis Commenced	: 31-May-2019
Order number	: ---	Issue Date	: 13-Jun-2019 16:54
C-O-C number	: ---		
Sampler	: ---		
Site	: ---		
Quote number	: EN/03218 Primary work only BQ		
No. of samples received	: 5		
No. of samples analysed	: 5		



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. 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
Ben Felgendreiers	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Tom Maloney	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by 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 Contact 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.

- ED006 (Exchangeable Cations on Alkaline Soils): Unable to calculate Magnesium/Potassium Ratio for some samples as the required results for Magnesium/Potassium are below LOR.
- ALS is not NATA accredited for the analysis of Exchangeable Aluminium and Exchange Acidity in soils when performed under ALS Method ED005.
- ALS is not NATA accredited for the analysis of Exchangeable Cations on Alkaline Soils when performed under ALS Method ED006.
- Amendment (13/06/2019): This report has been amended and re-released to allow the reporting of additional analytical data.
- ASS: EA013 (ANC): Fizz Rating: 0- None; 1- Slight; 2- Moderate; 3- Strong; 4- Very Strong; 5- Lime.
- EA058 Emerson: V. = Very, D. = Dark, L. = Light, VD. = Very Dark
- ED007 and ED008: When Exchangeable Al is reported from these methods, it should be noted that Rayment & Lyons (2011) suggests Exchange Acidity by 1M KCl - Method 15G1 (ED005) is a more suitable method for the determination of exchange acidity (H+ + Al3+).

Ø Calcium/Magnesium Ratio	0.2	-	2.0	1.6	1.3	0.9	0.8
Ø Magnesium/Potassium Ratio	0.2	-	13.3	21.5	30.1	-	-
ED042T: Total Sulfur by LECO							



Analytical Results

Sub-Matrix: SOIL (Matrix: SOL)		Client sample ID		PR07/0.0-0.1	PR07/0.1-0.2	PR07/0.2-0.3	PR07/0.5-0.6	PR07/0.7-0.8
Compound		Client sampling date / time		24-May-2019 09:30	24-May-2019 09:30	24-May-2019 09:30	24-May-2019 09:30	24-May-2019 09:30
CAS Number	LOR	Unit		EB1913817-001	EB1913817-002	EB1913817-003	EB1913817-004	EB1913817-005
		Result		Result		Result		Result
ED042T: Total Sulfur by LECO - Continued								
Sulfur - Total as S (LECO)	0.01	%	0.03	0.02	0.02	0.04	0.02	
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	40	30	360	680	500
ED091 : Calcium Chloride Extractable Boron								
ø Boron	7440-42-8	0.2	mg/kg	0.3	0.4			
ED092: DTPA Extractable Metals								
ø Copper	7440-50-8	1.00	mg/kg	2.18	2.63			
ø Iron	7439-89-6	1.00	mg/kg	18.0	17.5			
ø Manganese	7439-96-5	1.00	mg/kg	11.0	6.48			
ø Zinc	7440-66-6	1.00	mg/kg	<1.00	<1.00			
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N (Sol.)	14797-65-0	0.1	mg/kg	0.6	0.5			
EK058G: Nitrate as N by Discrete Analyser								
Nitrate as N (Sol.)	14797-55-8	0.1	mg/kg	1.9	1.9			
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N (Sol.)		0.1	mg/kg	2.5	2.4			
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N		20	mg/kg	1450	1750			
EK062: Total Nitrogen as N (TKN + NOx)								
^ Total Nitrogen as N		20	mg/kg	1450	1750			
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P		2	mg/kg	277	323			
EK080: Bicarbonate Extractable Phosphorus (Colwell)								
Bicarbonate Ext. P (Colwell)		5	mg/kg	<5	<5			
EP004: Organic Matter								
Organic Matter		0.5	%	2.1	2.0			
Total Organic Carbon		0.5	%	1.2	1.1			



QUALITY CONTROL REPORT

Work Order : **EB1913817**

Page : 1 of 5

Amendment : **1**

Client : **SLR Consulting Australia Pty Ltd**

Contact : **CAMERON TRAILL**

Address :

Telephone :

Project : **623.17171 Faithill Coking Coal**

Order number :

C-O-C number :

Sampler :

Site :

Quote number : **EN/032/18 Primary work only BQ**

No. of samples received : **5**

No. of samples analysed : **5**

Laboratory : **Environmental Division Brisbane**

Contact : **Tyler Cachia**

Address : **2 Byth Street Stafford QLD Australia 4053**

Telephone : **+61 2 8784 8555**

Date Samples Received : **30-May-2019**

Date Analysis Commenced : **31-May-2019**

Issue Date : **13-Jun-2019**



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. 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
Ben Felgendreiers	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Tom Maloney	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by 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

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

Sub-Matrix: SOIL				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EA002: pH 1:5 (Soils) (QC Lot: 2379494)									
EB1913773-001	Anonymous	EA002: pH Value	----	0.1	pH Unit	7.0	7.2	3.25	0% - 20%
EB1913651-001	Anonymous	EA002: pH Value	----	0.1	pH Unit	7.3	7.4	0.00	0% - 20%
EA002: pH 1:5 (Soils) (QC Lot: 2379497)									
EB1913817-003	PR07/0.2-0.3	EA002: pH Value	----	0.1	pH Unit	9.3	9.3	0.00	0% - 20%
EA010: Conductivity (1:5) (QC Lot: 2379493)									
EB1913773-001	Anonymous	EA010: Electrical Conductivity @ 25°C	----	1	µS/cm	18	15	15.3	0% - 50%
EB1913651-001	Anonymous	EA010: Electrical Conductivity @ 25°C	----	1	µS/cm	50	52	4.50	0% - 20%
EA010: Conductivity (1:5) (QC Lot: 2379498)									
EB1913817-003	PR07/0.2-0.3	EA010: Electrical Conductivity @ 25°C	----	1	µS/cm	440	453	2.91	0% - 20%
EA013: Acid Neutralising Capacity (QC Lot: 2395678)									
EB1913655-001	Anonymous	EA013: ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	12.9	13.9	7.24	0% - 20%
EB1913817-003	PR07/0.2-0.3	EA013: ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	46.7	48.8	4.32	0% - 20%
EA055: Moisture Content (Dried @ 105-110°C) (QC Lot: 2379504)									
EB1913793-001	Anonymous	EA055: Moisture Content	----	0.1	%	5.1	5.2	0.00	No Limit
EB1913901-004	Anonymous	EA055: Moisture Content	----	0.1	%	30.4	30.2	0.361	0% - 20%
ED006: Exchangeable Cations on Alkaline Soils (QC Lot: 2390612)									
EB1913651-002	Anonymous	ED006: Exchangeable Calcium	----	0.2	meq/100g	13.8	14.0	1.52	0% - 20%
		ED006: Exchangeable Magnesium	----	0.2	meq/100g	6.3	6.3	0.00	0% - 20%
		ED006: Exchangeable Potassium	----	0.2	meq/100g	1.1	1.1	0.00	No Limit
		ED006: Exchangeable Sodium	----	0.2	meq/100g	2.6	2.6	0.00	0% - 50%
		ED006: Cation Exchange Capacity	----	0.2	meq/100g	23.9	24.0	0.782	0% - 20%
EB1913817-001	PR07/0.0-0.1	ED006: Exchangeable Calcium	----	0.2	meq/100g	12.6	12.1	4.00	0% - 20%



Sub-Matrix: **SOIL**

Sub-Matrix: SOIL				Laboratory Duplicate (DUP) Report							
Laboratory sample ID	Client sample ID	Method/Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)		
ED006: Exchangeable Cations on Alkaline Soils (QC Lot: 2390612) - continued											
EB1913817-001	PR07/0.0-0.1	ED006: Exchangeable Magnesium	----	0.2	meq/100g	6.2	5.9	6.05	0% - 20%		
		ED006: Exchangeable Potassium	----	0.2	meq/100g	0.5	0.5	0.00	No Limit		
		ED006: Exchangeable Sodium	----	0.2	meq/100g	2.0	1.8	12.5	0% - 50%		
		ED006: Cation Exchange Capacity	----	0.2	meq/100g	21.4	20.3	5.28	0% - 20%		
ED042T: Total Sulfur by LECO (QC Lot: 2395051)											
EB1913773-001	Anonymous	ED042T: Sulfur - Total as S (LECO)	----	0.01	%	0.04	0.04	0.00	No Limit		
EB1913817-005	PR07/0.7-0.8	ED042T: Sulfur - Total as S (LECO)	----	0.01	%	0.02	<0.01	0.00	No Limit		
ED045G: Chloride by Discrete Analyser (QC Lot: 2379496)											
EB1913793-002	Anonymous	ED045G: Chloride	16887-00-6	10	mg/kg	10200	10100	0.356	0% - 20%		
ED091 : Calcium Chloride Extractable Boron (QC Lot: 2379428)											
EB1913651-001	Anonymous	ED091: Boron	7440-42-8	0.2	mg/kg	<0.2	<0.2	0.00	No Limit		
ED092: DTPA Extractable Metals (QC Lot: 2379425)											
EB1913651-002	Anonymous	ED092: Copper	7440-50-8	1	mg/kg	<1.00	<1.00	0.00	No Limit		
		ED092: Iron	7439-89-6	1	mg/kg	10.6	10.8	1.38	0% - 50%		
		ED092: Manganese	7439-96-5	1	mg/kg	6.28	6.86	8.76	No Limit		
		ED092: Zinc	7440-66-6	1	mg/kg	<1.00	<1.00	0.00	No Limit		
EK057G: Nitrite as N by Discrete Analyser (QC Lot: 2379491)											
EB1913793-002	Anonymous	EK057G: Nitrite as N (Sol.)	14797-65-0	0.1	mg/kg	4.4	4.6	3.32	0% - 20%		
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QC Lot: 2379490)											
EB1913793-002	Anonymous	EK059G: Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	2320	2330	0.476	0% - 20%		
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QC Lot: 2379486)											
EB1912649-006	Anonymous	EK061G: Total Kjeldahl Nitrogen as N	----	20	mg/kg	26900	26600	1.23	0% - 20%		
EB1913793-002	Anonymous	EK061G: Total Kjeldahl Nitrogen as N	----	20	mg/kg	1390	1330	4.52	0% - 20%		
EK067G: Total Phosphorus as P by Discrete Analyser (QC Lot: 2379487)											
EB1912649-006	Anonymous	EK067G: Total Phosphorus as P	----	2	mg/kg	6260	6250	0.199	0% - 20%		
EB1913793-002	Anonymous	EK067G: Total Phosphorus as P	----	2	mg/kg	599	588	1.90	0% - 20%		
EK080: Bicarbonate Extractable Phosphorus (Colwell) (QC Lot: 2379437)											
EB1913651-001	Anonymous	EK080: Bicarbonate Ext. P (Colwell)	----	5	mg/kg	17	19	8.80	No Limit		
EP004: Organic Matter (QC Lot: 2379421)											
EB1913651-001	Anonymous	EP004: Organic Matter	----	0.5	%	2.3	2.2	0.00	No Limit		
		EP004: Total Organic Carbon	----	0.5	%	1.3	1.3	0.00	No Limit		



Method Blank (MB) and Laboratory Control Spike (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 Spike (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: SOL

Sub-Matrix: SOIL									
Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report		Laboratory Control Spike (LCS) Report			
				Result	Spike Concentration	Spike Recovery (%)	Low	High	
EA002: pH 1:5 (Soils) (QCLOt: 2379494)									
EA002: pH Value	-----	-----	pH Unit	-----	4 pH Unit 7 pH Unit	99.8 100	98 98	102 102	
EA002: pH 1:5 (Soils) (QCLOt: 2379497)									
EA002: pH Value	-----	-----	pH Unit	-----	4 pH Unit 7 pH Unit	99.8 100	98 98	102 102	
EA010: Conductivity (1:5) (QCLOt: 2379493)									
EA010: Electrical Conductivity @ 25°C	-----	1	µS/cm	<1	1412 µS/cm	100	97	103	
EA010: Conductivity (1:5) (QCLOt: 2379498)									
EA010: Electrical Conductivity @ 25°C	-----	1	µS/cm	<1	1412 µS/cm	99.7	97	103	
EA013: Acid Neutralising Capacity (QCLOt: 2395678)									
EA013: ANC as H2SO4	-----	-----	kg H2SO4 equiv./t	-----	49 kg H2SO4 equiv./t	109	82	120	
ED006: Exchangeable Cations on Alkaline Soils (QCLOt: 2390612)									
ED006: Exchangeable Calcium	-----	0.2	meq/100g	<0.2	11.3 meq/100g	116	70	130	
ED006: Exchangeable Magnesium	-----	0.2	meq/100g	<0.2	5.61 meq/100g	104	70	130	
ED006: Exchangeable Potassium	-----	0.2	meq/100g	<0.2	1.15 meq/100g	89.5	70	130	
ED006: Exchangeable Sodium	-----	0.2	meq/100g	<0.2	3.54 meq/100g	101	70	130	
ED006: Cation Exchange Capacity	-----	0.2	meq/100g	<0.2	21.6 meq/100g	109	70	130	
ED042T: Total Sulfur by LECO (QCLOt: 2395051)									
ED042T: Sulfur - Total as S (LECO)	-----	0.01	%	<0.01	0.16 %	106	70	130	
ED045G: Chloride by Discrete Analyser (QCLOt: 2379496)									
ED045G: Chloride	16887-00-6	10	mg/kg	<10 <10	50 mg/kg 5000 mg/kg	91.0 94.3	83 83	119 119	
ED091 : Calcium Chloride Extractable Boron (QCLOt: 2379428)									
ED091: Boron	7440-42-8	0.2	mg/kg	<0.2	100 mg/kg	95.8	85	117	
ED092: DTPA Extractable Metals (QCLOt: 2379425)									
ED092: Copper	7440-50-8	1	mg/kg	<1.00	1.2 mg/kg	106	84	122	
ED092: Iron	7439-89-6	1	mg/kg	<1.00	46.5 mg/kg	105	70	130	
ED092: Manganese	7439-96-5	1	mg/kg	<1.00	6 mg/kg	107	70	130	
ED092: Zinc	7440-66-6	1	mg/kg	<1.00	5.4 mg/kg	104	79	122	
EK057G: Nitrite as N by Discrete Analyser (QCLOt: 2379491)									
EK057G: Nitrite as N (Sol.)	14797-65-0	0.1	mg/kg	<0.1	2.5 mg/kg	102	83	111	
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLOt: 2379490)									
EK059G: Nitrite + Nitrate as N (Sol.)	-----	0.1	mg/kg	<0.1	2.5 mg/kg	92.8	89	155	



Sub-Matrix: **SOIL**

Sub-Matrix: SOIL				Method Blank (MB) Report		Laboratory Control Spike (LCS) Report			
Method: Compound	CAS Number	LOR	Unit	Result	Spike Concentration	Spike Recovery (%)	LCS	Low	High
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QCLot: 2379486)									
EK061G: Total Kjeldahl Nitrogen as N	----	20	mg/kg	<20 <20	848 mg/kg 3644 mg/kg		104 91.0	73 73	121 121
EK067G: Total Phosphorus as P by Discrete Analyser (QCLot: 2379487)									
EK067G: Total Phosphorus as P	----	2	mg/kg	<2 <2	939 mg/kg 1200 mg/kg		83.3 86.7	80 80	115 115
EK080: Bicarbonate Extractable Phosphorus (Colwell) (QCLot: 2379437)									
EK080: Bicarbonate Ext. P (Colwell)	----	5	mg/kg	<5 <5 <5	100 mg/kg 44.9 mg/kg 58.07 mg/kg		96.6 103 87.6	70 87 80	130 113 120
EP004: Organic Matter (QCLot: 2379421)									
EP004: Organic Matter	----	0.5	%	<0.5	80 %		97.4	83	115
EP004: Total Organic Carbon	----	0.5	%	<0.5	46.4 %		97.4	85	115

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: **SOIL**

Sub-Matrix: SOIL			Matrix Spike (MS) Report					
			Spike Concentration	SpikeRecovery(%)	Recovery Limits (%)			
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number			Low	High	
EK057G: Nitrite as N by Discrete Analyser (QCLot: 2379491)								
EB1913651-002	Anonymous	EK057G: Nitrite as N (Sol.)	14797-65-0	2 mg/kg	97.1	70	130	
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 2379490)								
EB1913651-002	Anonymous	EK059G: Nitrite + Nitrate as N (Sol.)	----	2 mg/kg	92.0	70	130	
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QCLot: 2379486)								
EB1912549-007	Anonymous	EK061G: Total Kjeldahl Nitrogen as N	----	500 mg/kg	# Not Determined	70	130	
EK067G: Total Phosphorus as P by Discrete Analyser (QCLot: 2379487)								
EB1912549-007	Anonymous	EK067G: Total Phosphorus as P	----	100 mg/kg	# Not Determined	70	130	
EK080: Bicarbonate Extractable Phosphorus (Colwell) (QCLot: 2379437)								
EB1913651-002	Anonymous	EK080: Bicarbonate Ext. P (Colwell)	----	40 mg/kg	97.5	70	130	
EP004: Organic Matter (QCLot: 2379421)								
EB1913651-002	Anonymous	EP004: Organic Matter	----	2 %	96.0	70	130	
		EP004: Total Organic Carbon	----	1.16 %	95.6	70	130	



QA/QC Compliance Assessment to assist with Quality Review

Work Order	: EB1913817	Page	: 1 of 9
Amendment	: 1		
Client	: SLR Consulting Australia Pty Ltd	Laboratory	: Environmental Division Brisbane
Contact	: CAMERON TRALL	Telephone	: +61 2 8784 8555
Project	: 623.17171 Fairhill Coking Coal	Date Samples Received	: 30-May-2019
Site	: -----	Issue Date	: 13-Jun-2019
Sampler	: -----	No. of samples received	: 5
Order number	: -----	No. of samples analysed	: 5

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.
- Matrix Spike outliers exist - please see following pages for full details.
- 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 : Quality Control Samples

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: SOIL

Compound Group Name	Laboratory Sample ID	Client Sample ID	Analyte	CAS Number	Data	Limits	Comment
Matrix Spike (MS) Recoveries							
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser	EB1912549-007	Anonymous	Total Kjeldahl Nitrogen as N	----	Not Determined	----	MS recovery not determined, background level greater than or equal to 4x spike level.
EK067G: Total Phosphorus as P by Discrete Analyser	EB1912549-007	Anonymous	Total Phosphorus as P	----	Not Determined	----	MS recovery not determined, background level greater than or equal to 4x spike level.

Outliers : Analysis Holding Time Compliance

Matrix: SOIL

Method		Extraction / Preparation				Analysis		
Container / Client Sample ID(s)		Date extracted	Due for extraction	Days overdue	Date analysed	Due for analysis	Days overdue	
EA002: pH 1:5 (Soils)								
Pulp Bag								
PR07/0.2-0.3,		04-Jun-2019	31-May-2019	4	----	----	----	
PR07/0.7-0.8								
Snap Lock Bag								
PR07/0.0-0.1,		04-Jun-2019	31-May-2019	4	----	----	----	
EA010: Conductivity (1:5)								
Pulp Bag								
PR07/0.2-0.3,		04-Jun-2019	31-May-2019	4	----	----	----	
PR07/0.7-0.8								
Snap Lock Bag								
PR07/0.0-0.1,		04-Jun-2019	31-May-2019	4	----	----	----	
EP004: Organic Matter								
Snap Lock Bag								
PR07/0.0-0.1,		11-Jun-2019	31-May-2019	11	----	----	----	

Outliers : Frequency of Quality Control Samples

Matrix: SOIL

Quality Control Sample Type		Count		Rate (%)		Quality Control Specification	
Method		QC	Regular	Actual	Expected		
Laboratory Duplicates (DUP)							
Nitrite and Nitrate as N (NO _x - Soluble by Discrete Analyser		1	13	7.69	10.00	NEPM 2013 B3 & ALS QC Standard	
Nitrite as N - Soluble by Discrete Analyser		1	13	7.69	10.00	NEPM 2013 B3 & ALS QC Standard	



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
EK057G: Nitrite as N by Discrete Analyser							
Snap Lock Bag (EK057G)							
PR07/0.0-0.1,	24-May-2019	04-Jun-2019	20-Nov-2019	✔	04-Jun-2019	20-Nov-2019	✔
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser							
Snap Lock Bag (EK059G)							
PR07/0.0-0.1,	24-May-2019	04-Jun-2019	20-Nov-2019	✔	04-Jun-2019	20-Nov-2019	✔
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser							
Snap Lock Bag (EK061G)							
PR07/0.0-0.1,	24-May-2019	03-Jun-2019	20-Nov-2019	✔	04-Jun-2019	20-Nov-2019	✔
EK067G: Total Phosphorus as P by Discrete Analyser							
Snap Lock Bag (EK067G)							
PR07/0.0-0.1,	24-May-2019	03-Jun-2019	20-Nov-2019	✔	04-Jun-2019	20-Nov-2019	✔
EK080: Bicarbonate Extractable Phosphorus (Colwell)							
Snap Lock Bag (EK080)							
PR07/0.0-0.1,	24-May-2019	11-Jun-2019	20-Nov-2019	✔	11-Jun-2019	20-Nov-2019	✔
EP004: Organic Matter							
Snap Lock Bag (EP004)							
PR07/0.0-0.1,	24-May-2019	11-Jun-2019	31-May-2019	✘	11-Jun-2019	09-Jul-2019	✔



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 (%)		Evaluation	Quality Control Specification	
Analytical Methods	Method	QC	Regular	Actual			Expected
Laboratory Duplicates (DUP)							
Acid Neutralising Capacity (ANC)	EA013	2	16	12.50	10.00	✔	NEPM 2013 B3 & ALS QC Standard
Bicarbonate Extractable P (Colwell)	EK080	1	8	12.50	10.00	✔	NEPM 2013 B3 & ALS QC Standard
Calcium Chloride Extractable Boron	ED091	1	8	12.50	10.00	✔	NEPM 2013 B3 & ALS QC Standard
Chloride Soluble By Discrete Analyser	ED045G	1	10	10.00	10.00	✔	NEPM 2013 B3 & ALS QC Standard
DTPA Extractable Metals	ED092	1	8	12.50	10.00	✔	NEPM 2013 B3 & ALS QC Standard
Electrical Conductivity (1:5)	EA010	3	23	13.04	10.00	✔	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations on Alkaline Soils	ED006	2	15	13.33	10.00	✔	NEPM 2013 B3 & ALS QC Standard
Moisture Content	EA055	2	11	18.18	10.00	✔	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx)- Soluble by Discrete Analyser	EK059G	1	13	7.69	10.00	✗	NEPM 2013 B3 & ALS QC Standard
Nitrite as N - Soluble by Discrete Analyser	EK057G	1	13	7.69	10.00	✗	NEPM 2013 B3 & ALS QC Standard
Organic Matter	EP004	1	8	12.50	10.00	✔	NEPM 2013 B3 & ALS QC Standard
pH (1:5)	EA002	3	27	11.11	10.00	✔	NEPM 2013 B3 & ALS QC Standard
Sulfur - Total as S (LECO)	ED042T	2	20	10.00	10.00	✔	NEPM 2013 B3 & ALS QC Standard
TKN as N By Discrete Analyser	EK061G	2	13	15.38	10.00	✔	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus By Discrete Analyser	EK067G	2	13	15.38	10.00	✔	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Acid Neutralising Capacity (ANC)	EA013	1	16	6.25	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Bicarbonate Extractable P (Colwell)	EK080	3	8	37.50	15.00	✔	NEPM 2013 B3 & ALS QC Standard
Calcium Chloride Extractable Boron	ED091	1	8	12.50	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Chloride Soluble By Discrete Analyser	ED045G	2	10	20.00	10.00	✔	NEPM 2013 B3 & ALS QC Standard
DTPA Extractable Metals	ED092	1	8	12.50	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Electrical Conductivity (1:5)	EA010	2	23	8.70	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations on Alkaline Soils	ED006	1	15	6.67	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx)- Soluble by Discrete Analyser	EK059G	1	13	7.69	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Nitrite as N - Soluble by Discrete Analyser	EK057G	1	13	7.69	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Organic Matter	EP004	1	8	12.50	5.00	✔	NEPM 2013 B3 & ALS QC Standard
pH (1:5)	EA002	4	27	14.81	10.00	✔	NEPM 2013 B3 & ALS QC Standard
Sulfur - Total as S (LECO)	ED042T	1	20	5.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
TKN as N By Discrete Analyser	EK061G	2	13	15.38	10.00	✔	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus By Discrete Analyser	EK067G	2	13	15.38	10.00	✔	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
Bicarbonate Extractable P (Colwell)	EK080	1	8	12.50	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Calcium Chloride Extractable Boron	ED091	1	8	12.50	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Chloride Soluble By Discrete Analyser	ED045G	1	10	10.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard

Matrix: SOIL

Evaluation: ✖ = Quality Control frequency not within specification ; ✔ = Quality Control frequency within specification.

Quality Control Sample Type	Count		Rate (%)		Evaluation	Quality Control Specification	
Analytical Methods	Method	QC	Regular	Actual			Expected
Method Blanks (MB) - Continued							
DTPA Extractable Metals	ED092	1	8	12.50	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Electrical Conductivity (1:5)	EA010	2	23	8.70	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations on Alkaline Soils	ED006	1	15	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx)- Soluble by Discrete Analyser	EK059G	1	13	7.69	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite as N - Soluble by Discrete Analyser	EK057G	1	13	7.69	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Organic Matter	EP004	1	8	12.50	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Sulfur - Total as S (LECO)	ED042T	1	20	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
TKN as N By Discrete Analyser	EK061G	1	13	7.69	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus By Discrete Analyser	EK067G	1	13	7.69	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)							
Bicarbonate Extractable P (Colwell)	EK080	1	8	12.50	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx)- Soluble by Discrete Analyser	EK059G	1	13	7.69	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite as N - Soluble by Discrete Analyser	EK057G	1	13	7.69	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Organic Matter	EP004	1	8	12.50	5.00	✓	NEPM 2013 B3 & ALS QC Standard
TKN as N By Discrete Analyser	EK061G	1	13	7.69	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus By Discrete Analyser	EK067G	1	13	7.69	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 (1:5)	EA002	SOIL	In house: Referenced to Rayment and Lyons 4A1 and APHA 4500H+. pH is determined on soil samples after a 1:5 soil/water leach. This method is compliant with NEPM (2013) Schedule B(3)
Electrical Conductivity (1:5)	EA010	SOIL	In house: Referenced to Rayment and Lyons 3A1 and APHA 2510. Conductivity is determined on soil samples using a 1:5 soil/water leach. This method is compliant with NEPM (2013) Schedule B(3)
Acid Neutralising Capacity (ANC)	EA013	SOIL	In house: Referenced to USEPA 600/2-78-054, I. Miller (2000). A fizz test is done to semiquantitatively estimate the likely reactivity. The soil is then reacted with a known excess quantity of an appropriate acid. Titration determines the acid remaining, and the ANC can be calculated from comparison with a blank titration.
Moisture Content	EA055	SOIL	In house: A gravimetric procedure based on weight loss over a 12 hour drying period at 105-110 degrees C. This method is compliant with NEPM (2013) Schedule B(3) Section 7.1 and Table 1 (14 day holding time).
Emerson Aggregate Test	EA058	SOIL	In house: Referenced to AS1289.3.8.1. Testing is performed only on soils with suitable aggregates; sands and gravels are usually unsuitable for this test. The test classifies the behaviour of soil aggregates, when immersed, on their coherence in water.
Particle Size Analysis by Hydrometer	EA150H	SOIL	Particle Size Analysis by Hydrometer according to AS1289.3.6.3 - 2003
Soil Particle Density	EA152	SOIL	Soil Particle Density by AS 1289.3.5.1-2006. Methods of testing soils for engineering purposes - Soil classification tests - Determination of the soil particle density of a soil - Standard method
Exchange Acidity by 1M Potassium Chloride	* ED005	SOIL	In house: referenced to Rayment and Lyons. (2011), method 15G1. This method is unsuitable for near neutral and alkaline soils. NATA accreditation does not cover performance of this service.
Exchangeable Cations on Alkaline Soils	* ED006	SOIL	In house: Referenced to Soil Survey Test Method C5. Soluble salts are removed from the sample prior to analysis. Cations are exchanged from the sample by contact with alcoholic ammonium chloride at pH 8.5. They are then quantitated in the final solution by ICPAES and reported as meq/100g of original soil.
Exchangeable Cations	ED007	SOIL	In house: Referenced to Rayment & Lyons (2011) Method 15A1. Cations are exchanged from the sample by contact with Ammonium Chloride. They are then quantitated in the final solution by ICPAES and reported as meq/100g of original soil. This method is compliant with NEPM (2013) Schedule B(3) (Method 301)
Exchangeable Cations with pre-treatment	ED008	SOIL	In house: Referenced to Rayment & Higginson (2011) Method 15A2. Soluble salts are removed from the sample prior to analysis. Cations are exchanged from the sample by contact with Ammonium Chloride. They are then quantitated in the final solution by ICPAES and reported as meq/100g of original soil. This method is compliant with NEPM (2013) Schedule B(3) (Method 301)
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 SO ₂) is measured by infra-red detector
Chloride Soluble By Discrete Analyser	ED045G	SOIL	In house: Referenced to APHA 4500-Cl- E. 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 thiocyanate forms highly coloured ferric thiocyanate which is measured at 480 nm. Analysis is performed on a 1:5 soil / water leachate.
Calcium Chloride Extractable Boron	* ED091	SOIL	In house: Referenced to Rayment & Higginson (2011) method 12C2. Soil is extracted with hot 0.01M CaCl ₂ solution at a 1:2 ratio. Extracts can be run on ICP.
DTPA Extractable Metals	* ED092	SOIL	In house: Referenced to Rayment and Higginson (2011) 12A1



Analytical Methods			
	Method	Matrix	Method Descriptions
Nitrite as N - Soluble by Discrete Analyser	EK057G	SOIL	In house: Referenced to APHA 4500-NO3- B. Nitrite in a water extract is determined by direct colourimetry by Discrete Analyser.
Nitrate as N - Soluble by Discrete Analyser	EK058G	SOIL	In house: Referenced to APHA 4500-NO3- F. Nitrate in the 1:5 soil:water extract is reduced to nitrite by way of a chemical reduction followed by quantification by Discrete Analyser. Nitrite is determined seperately by direct colourimetry and result for Nitrate calculated as the difference between the two results.
Nitrite and Nitrate as N (NOx)- Soluble by Discrete Analyser	EK059G	SOIL	In house: Thermo Scientific Method D08727 and NEMI (National Environmental Method Index) Method ID: 91771. This method covers the determination of total oxidised nitrogen (NOx-N) and nitrate (NO3-N) by calculation, Combined oxidised Nitrogen (NO2+NO3) in a water extract is determined by direct colourimetry by Discrete Analyser.
TKN as N By Discrete Analyser	EK061G	SOIL	In house: Referenced to APHA 4500-Norg-D Soil samples are digested using Kjeldahl digestion followed by determination by Discrete Analyser.
Total Nitrogen as N (TKN + NOx) By Discrete Analyser	EK062G	SOIL	In house: Referenced to APHA 4500 Norg/NO3- Total Nitrogen is determined as the sum of TKN and Oxidised Nitrogen, each determined seperately as N.
Total Phosphorus By Discrete Analyser	EK067G	SOIL	In house: Referenced to APHA 4500 P-B&F This procedure involves sulfuric acid digestion and quantification using Discrete Analyser.
Bicarbonate Extractable P (Colwell)	EK080	SOIL	In house: Referenced to Rayment & Higginson (2011) Method 9B1 Phosphorus is extracted from the soil using 0.5M NaHCO3 at a 1:100 soil:solution ratio and determined by FLA.
Organic Matter	EP004	SOIL	In house: Referenced to AS1289.4.1.1 - 1997. Dichromate oxidation method after Walkley and Black. This method is compliant with NEPM (2013) Schedule B(3).
Preparation Methods			
	Method	Matrix	Method Descriptions
Exchangeable Cations Preparation Method (Alkaline Soils)	ED006PR	SOIL	In house: Referenced to Rayment and Lyons 2011 method 15C1.
Exchangeable Cations Preparation Method	ED007PR	SOIL	In house: Referenced to Rayment & Higginson (1992) method 15A1. A 1M NH4Cl extraction by end over end tumbling at a ratio of 1:20. There is no pretreatment for soluble salts. Extracts can be run by ICP for cations.
Hot Water CaCl2 Extraction for Boron	ED091PR	SOIL	In house: Referenced to Rayment & Higginson (1992) method 12C2. Soil is extracted with hot 0.01M CaCl2 solution at a 1:2 ratio. Extracts can be run on ICP.
DTPA Extraction for Cu, Zn, Mn, Fe (2 hour leach)	ED092PR	SOIL	In house: Referenced to Rayment & Higginson (1992) Method 12A1 2 hour end over end tumbler extraction with 0.005M DTPA at a ratio of 1:2. Extracts can be run by ICP for metals.
TKN/TP Digestion	EK061/EK067	SOIL	In house: Referenced to APHA 4500 Norg- D; APHA 4500 P - H. Macro Kjeldahl digestion.
Sample Preparation for Bicarbonate Extractable P (Colwell)	EK080-PR	SOIL	In house: Referenced to Rayment & Higginson (2011) Method 9B1 Phosphorus is extracted from the soil using 0.5M NaHCO3 at a 1:100 soil:solution ratio.
Drying at 85 degrees, bagging and labelling (ASS)	EN020PR	SOIL	In house
1:5 solid / water leach for soluble analytes	EN34	SOIL	10 g of soil is mixed with 50 mL of reagent grade water and tumbled end over end for 1 hour. Water soluble salts are leached from the soil by the continuous suspension. Samples are settled and the water filtered off for analysis.
Organic Matter	EP004-PR	SOIL	In house: Referenced to AS1289.4.1.1 - 1997. Dichromate oxidation method after Walkley and Black. This method is compliant with NEPM (2013) Schedule B(3) (Method 105)
Dry and Pulverise (up to 100g)	GEO30	SOIL	#



Environmental

SAMPLE RECEIPT NOTIFICATION (SRN)

Work Order : **EB1913650**

Client : **SLR Consulting Australia Pty Ltd**
Contact : **CAMERON TRAILL**
Address :

Laboratory : **Environmental Division Brisbane**
Contact : **Tyler Cachia**
Address : **2 Byth Street Stafford QLD Australia 4053**

E-mail : **ctrail@slrconsulting.com**
Telephone : **----**
Facsimile : **----**

E-mail : **Tyler.Cachia@ALSGlobal.com**
Telephone : **+61 2 8784 8555**
Facsimile : **+61-7-3243 7218**

Project : **623.17171 Fairhill Coking Coal**
Order number :

Page : **1 of 3**
Quote number : **EM2018HEGAUS0001 (EN/032/18**
Primary work only BQ)

C-O-C number : **----** QC Level : **NEPM 2013 B3 & ALS QC Standard**
Site : **----**
Sampler : **CAMERON TRAILL**

Dates

Date Samples Received : **28-May-2019 09:00** Issue Date : **29-May-2019**
Client Requested Due Date : **07-Jun-2019** Scheduled Reporting Date : **07-Jun-2019**

Delivery Details

Mode of Delivery : **Carrier** Security Seal : **Intact.**
No. of coolers/boxes : **1** Temperature : **19.1°C**
Receipt Detail : **MEDIUM ESKY** No. of samples received / analysed : **12 / 12**

General Comments

- This report contains the following information:
 - Sample Container(s)/Preservation Non-Compliances
 - Summary of Sample(s) and Requested Analysis
 - Proactive Holding Time Report
 - Requested Deliverables
- Please be advised that ALS is unable to accommodate the fast turnaround requested on the Chain of Custody. If you wish to discuss this further, please contact Client Services at ALSenviro.Brisbane@alsglobal.com.**
- Discounted Package Prices apply only when specific ALS Group Codes ('W', 'S', 'NT' suites) are referenced on COCs.
- Please direct any turn around / technical queries to the laboratory contact designated above.
- Sample Disposal - Aqueous (3 weeks), Solid (2 months ± 1 week) from receipt of samples.
- Analysis will be conducted by ALS Environmental, Brisbane, NATA accreditation no. 825, Site No. 818 (Micro site no. 18956).
- Breaches in recommended extraction / analysis holding times (if any) are displayed overleaf in the Proactive Holding Time Report table.**
- Please be aware that APHA/NEPM recommends water and soil samples be chilled to less than or equal to 6°C for chemical analysis, and less than or equal to 10°C but unfrozen for Microbiological analysis. Where samples are received above this temperature, it should be taken into consideration when interpreting results. Refer to ALS EnviroMail 85 for ALS recommendations of the best practice for chilling samples after sampling and for maintaining a cool temperature during transit.



Sample Container(s)/Preservation Non-Compliances

All comparisons are made against pretreatment/preservation AS, APHA, USEPA standards.

- No sample container / preservation non-compliance exists.

Summary of Sample(s) and Requested Analysis

Some items described below may be part of a laboratory process necessary for the execution of client requested tasks. Packages may contain additional analyses, such as the determination of moisture content and preparation tasks, that are included in the package.

If no sampling time is provided, the sampling time will default 00:00 on the date of sampling. If no sampling date is provided, the sampling date will be assumed by the laboratory and displayed in brackets without a time component

Matrix: **SOIL**

Laboratory sample ID	Client sampling date / time	Client sample ID	SOIL - AG-1 EB Only Agricultural Soil Suite 1 EB Only	SOIL - EA055-103 Moisture Content	SOIL - ED092 DTPA Extractable Metals	SOIL - EK067G (Solids) Total Phosphorus as P by Discrete Analyser	SOIL - EK080 Bicarbonate Extractable P (Colwell)	SOIL - EP004 Organic Matter in Soil (Walkley Black)	SOIL - NT-6S Nitrogen, TKN, NO2, NO3
EB1913650-001	23-May-2019 08:40	PR14/0.0-0.1	✓	✓	✓	✓	✓	✓	✓
EB1913650-002	23-May-2019 08:40	PR14/0.1-0.2	✓	✓	✓	✓	✓	✓	✓
EB1913650-003	23-May-2019 08:40	PR14/0.2-0.3	✓	✓					
EB1913650-004	23-May-2019 08:40	PR14/0.3-0.4		✓					
EB1913650-005	23-May-2019 08:40	PR14/0.4-0.5		✓					
EB1913650-006	23-May-2019 08:40	PR14/0.5-0.6	✓	✓					
EB1913650-007	23-May-2019 08:40	PR14/0.6-0.7		✓					
EB1913650-008	23-May-2019 08:40	PR14/0.7-0.8							
EB1913650-009	23-May-2019 08:40	PR14/0.8-0.9	✓	✓	✓	✓	✓	✓	
EB1913650-010	23-May-2019 08:40	PR14/0.9-1.0			✓	✓	✓	✓	✓
EB1913650-011	23-May-2019 08:40	PR14/1.0-1.1		✓					
EB1913650-012	23-May-2019 08:40	PR14/1.1-1.2	✓	✓					
EB1913650-001	23-May-2019 08:40	PR14/0.0-0.1	SOIL - EA013 Acid Neutralising Capacity (ANC)		✓	✓	✓	✓	
EB1913650-002	23-May-2019 08:40	PR14/0.1-0.2	SOIL - EA058 Emerson Aggregate Test	✓	✓	✓	✓	✓	
EB1913650-003	23-May-2019 08:40	PR14/0.2-0.3	SOIL - EA150H-Y Particle Size Analysis by Hydrometer: Yellow	✓	✓	✓	✓	✓	
EB1913650-004	23-May-2019 08:40	PR14/0.3-0.4	SOIL - ED042T Sulfur - Total as S (high temperature furnace	✓	✓	✓	✓	✓	
EB1913650-005	23-May-2019 08:40	PR14/0.4-0.5	SOIL - ED045G (solids) Chloride Soluble by Discrete Analyser	✓	✓	✓	✓	✓	
EB1913650-006	23-May-2019 08:40	PR14/0.5-0.6	SOIL - ED091 Calcium Chloride Extractable Boron		✓				
EB1913650-007	23-May-2019 08:40	PR14/0.6-0.7	SOIL - IN-4S pH plus EC (1:5)						
EB1913650-008	23-May-2019 08:40	PR14/0.7-0.8							
EB1913650-009	23-May-2019 08:40	PR14/0.8-0.9							
EB1913650-010	23-May-2019 08:40	PR14/0.9-1.0							
EB1913650-011	23-May-2019 08:40	PR14/1.0-1.1							
EB1913650-012	23-May-2019 08:40	PR14/1.1-1.2							

Matrix: **SOIL**



Proactive Holding Time Report

Sample(s) have been received within the recommended holding times for the requested analysis.

Requested Deliverables

ACCOUNTS PAYABLE AU

- A4 - AU Tax Invoice (INV)

Email	accounts payable@slrconsulting.com
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CAMERON TRAILL

- * AU Certificate of Analysis - NATA (COA)
- * AU Interpretive QC Report - DEFAULT (Anon QCI Rep) (QCI)
- * AU QC Report - DEFAULT (Anon QC Rep) - NATA (QC)
- A4 - AU Sample Receipt Notification - Environmental HT (SRN)
- A4 - AU Tax Invoice (INV)
- Chain of Custody (CoC) (COC)
- EDI Format - ENMRG (ENMRG)
- EDI Format - ESDAT (ESDAT)

Email	ctrail@slrconsulting.com
Email	ctrail@slrconsulting.com
Email	ctrail@slrconsulting.com
Email	ctrail@slrconsulting.com
Email	ctrail@slrconsulting.com
Email	ctrail@slrconsulting.com
Email	ctrail@slrconsulting.com

D TAYLOR

- A4 - AU Tax Invoice (INV)

Email	dtaylor@slrconsulting.com
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Environmental

CERTIFICATE OF ANALYSIS

Work Order	: EB1913650	Page	: 1 of 8
Amendment	: 1	Laboratory	: Environmental Division Brisbane
Client	: SLR Consulting Australia Pty Ltd	Contact	: Tyler Cachia
Contact	: CAMERON TRAILL	Address	: 2 Byth Street Stafford QLD Australia 4053
Address	:	Telephone	: +61 2 8784 8555
Telephone	: ----	Date Samples Received	: 28-May-2019 09:00
Project	: 623.17171 Fairhill Coking Coal	Date Analysis Commenced	: 29-May-2019
Order number	:	Issue Date	: 13-Jun-2019 17:04
C-O-C number	: ----		
Sampler	: CAMERON TRAILL		
Site	: ----		
Quote number	: EN/032/18 Primary work only BQ		
No. of samples received	: 12		
No. of samples analysed	: 12		



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. 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
Ben Felgendreiers	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Mark Hallas	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Mark Hallas	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Satishkumar Trivedi	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Satishkumar Trivedi	Senior Acid Sulfate Soil Chemist	Brisbane Inorganics, Stafford, QLD
Tom Maloney	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by 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 Contact 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.

- ALS is not NATA accredited for the analysis of Exchangeable Aluminium and Exchange Acidity in soils when performed under ALS Method ED005.
- ALS is not NATA accredited for the analysis of Exchangeable Cations on Alkaline Soils when performed under ALS Method ED006.
- EK059G (Nitrite and Nitrate as N): Sample EB1913650_001 (PR14/0.0.0.1) shows poor duplicate results due to sample heterogeneity. Confirmed by visual analysis.
- Amendment (13/06/2019): This report has been amended and re-released to allow the reporting of additional analytical data.
- EK067G (Total Phosphorus as P): Poor matrix spike recovery for sample EB1913644_002 due to sample heterogeneity. Confirmed by visual analysis.
- ASS: EA013 (ANC) Fizz Rating: 0- None; 1- Slight; 2- Moderate; 3- Strong; 4- Very Strong; 5- Lime.
- EA058 Emerson: V. = Very, D. = Dark, L. = Light, VD. = Very Dark
- ED007 and ED008: When Exchangeable Al is reported from these methods, it should be noted that Rayment & Lyons (2011) suggests Exchange Acidity by 1M KCl - Method 15G1 (ED005) is a more suitable method for the determination of exchange acidity (H+ + Al3+).



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)		Client sample ID		PR14/0.0-0.1	PR14/0.1-0.2	PR14/0.2-0.3	PR14/0.3-0.4	PR14/0.4-0.5
Compound		Client sampling date / time		23-May-2019 08:40	23-May-2019 08:40	23-May-2019 08:40	23-May-2019 08:40	23-May-2019 08:40
CAS Number	LOR	Unit		EB1913650-001	EB1913650-002	EB1913650-003	EB1913650-004	EB1913650-005
Result								
EA002: pH 1:5 (Soils)								
pH Value	0.1	pH Unit		8.6	9.4	9.3	9.1	8.3
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	1	µS/cm		168	345	563	1020	3230
EA013: Acid Neutralising Capacity								
ANC as H2SO4	0.5	kg H2SO4 equiv./t		----	61.4	46.3	----	----
ANC as CaCO3	0.1	% CaCO3		----	6.3	4.7	----	----
Fizz Rating	0	Fizz Unit		----	2	2	----	----
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	0.1	%		----	----	13.7	13.6	14.0
Moisture Content	1.0	%		10.4	13.7	----	----	----
EA058: Emerson Aggregate Test								
Color (Munsell)	-	-		----	Dark Grayish Brown (10YR 4/2)	Brown (10YR 4/3)	----	----
Texture	-	-		----	Medium Clay	Heavy Clay	----	----
Emerson Class Number	EC/TC	-		----	3	3	----	----
EA150: Soil Classification - National Committee on Soil and Terrain (2009)								
Clay (<2 µm)	1	%		59	52	56	----	----
Silt (2-20 µm)	1	%		18	17	17	----	----
Fine Sand (0.02-0.2 mm)	1	%		12	22	17	----	----
Coarse Sand (0.2-2.0 mm)	1	%		8	9	9	----	----
Gravel (>2mm)	1	%		2	<1	1	----	----
EA152: Soil Particle Density								
Soil Particle Density (Clay/Silt/Sand)	0.01	g/cm3		2.31	2.42	2.52	----	----
ED006: Exchangeable Cations on Alkaline Soils								
Ø Exchangeable Calcium	0.2	meq/100g		21.7	17.5	15.7	----	----
Ø Exchangeable Magnesium	0.2	meq/100g		7.0	8.2	8.6	----	----
Ø Exchangeable Potassium	0.2	meq/100g		1.2	0.7	0.7	----	----
Ø Exchangeable Sodium	0.2	meq/100g		2.1	5.1	6.2	----	----
Ø Cation Exchange Capacity	0.2	meq/100g		31.9	31.5	31.3	----	----
Ø Exchangeable Sodium Percent	0.2	%		6.5	16.2	19.9	----	----
Ø Calcium/Magnesium Ratio	0.2	-		3.1	2.1	1.8	----	----
Ø Magnesium/Potassium Ratio	0.2	-		6.0	12.1	11.8	----	----
ED042T: Total Sulfur by LECO								



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)		Client sample ID	PR14/0.0-0.1	PR14/0.1-0.2	PR14/0.2-0.3	PR14/0.3-0.4	PR14/0.4-0.5
Compound		Client sampling date / time	23-May-2019 08:40	23-May-2019 08:40	23-May-2019 08:40	23-May-2019 08:40	23-May-2019 08:40
CAS Number	LOR	Unit	EB1913650-001	EB1913650-002	EB1913650-003	EB1913650-004	EB1913650-005
ED042T: Total Sulfur by LECO - Continued		Result	Result	Result	Result	Result	Result
Sulfur - Total as S (LECO)	0.01	%	0.02	0.02	0.03	0.04	0.05
ED045G: Chloride by Discrete Analyser							
Chloride	16887-00-6	10	20	70	540	1020	1500
ED091 : Calcium Chloride Extractable Boron							
ø Boron	7440-42-8	0.2	0.3	0.6			
ED092: DTPA Extractable Metals							
ø Copper	7440-50-8	1.00	1.86	1.83			
ø Iron	7439-89-6	1.00	11.0	12.8			
ø Manganese	7439-96-5	1.00	12.0	12.6			
ø Zinc	7440-66-6	1.00	<1.00	<1.00			
EK057G: Nitrite as N by Discrete Analyser							
Nitrite as N (Sol.)	14797-65-0	0.1	0.9	<0.1			
EK058G: Nitrate as N by Discrete Analyser							
Nitrate as N (Sol.)	14797-55-8	0.1	2.2	0.2			
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser							
Nitrite + Nitrate as N (Sol.)		0.1	3.1	0.2			
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser							
Total Kjeldahl Nitrogen as N		20	1880	680			
EK062: Total Nitrogen as N (TKN + NOx)							
^ Total Nitrogen as N		20	1880	680			
EK067G: Total Phosphorus as P by Discrete Analyser							
Total Phosphorus as P		2	411	277			
EK080: Bicarbonate Extractable Phosphorus (Colwell)							
Bicarbonate Ext. P (Colwell)		5	18	<5			
EP004: Organic Matter							
Organic Matter		0.5	3.6	1.7			
Total Organic Carbon		0.5	2.1	1.0			

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)		Client sample ID		PR14/0.5-0.6	PR14/0.6-0.7	PR14/0.7-0.8	PR14/0.8-0.9	PR14/0.9-1.0
Client sampling date / time				23-May-2019 08:40	23-May-2019 08:40	23-May-2019 08:40	23-May-2019 08:40	23-May-2019 08:40
Compound	CAS Number	LOR	Unit	EB1913650-006 Result	EB1913650-007 Result	EB1913650-008 Result	EB1913650-009 Result	EB1913650-010 Result
EA002: pH 1:5 (Soils)								
pH Value		0.1	pH Unit	8.6	8.1	8.6	8.9	8.9
EA010: Conductivity (1:5)								
Electrical Conductivity @25°C		1	µS/cm	2230	3660	2110	1680	1670
EA013: Acid Neutralising Capacity								
ANC as H2SO4		0.5	kg H2SO4 equiv./t	37.7			39.2	
ANC as CaCO3		0.1	% CaCO3	3.8			4.0	
Fizz Rating		0	Fizz Unit	2			2	
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content		0.1	%	13.9	13.3	13.7	13.5	14.7
EA058: Emerson Aggregate Test								
Color (Munsell)		-	-	Brown (10YR 4/3)			Brown (10YR 4/3)	
Texture		-	-	Heavy Clay			Medium Clay	
Emerson Class Number	EC/TC	-	-	3			3	
EA150: Soil Classification - National Committee on Soil and Terrain (2009)								
Clay (<2 µm)		1	%	53			56	
Silt (2-20 µm)		1	%	16			17	
Fine Sand (0.02-0.2 mm)		1	%	21			17	
Coarse Sand (0.2-2.0 mm)		1	%	9			9	
Gravel (>2mm)		1	%	1			1	
EA152: Soil Particle Density								
Soil Particle Density (Clay/Silt/Sand)		0.01	g/cm3	2.57			2.38	
ED006: Exchangeable Cations on Alkaline Soils								
∅ Exchangeable Calcium		0.2	meq/100g	14.0			12.3	
∅ Exchangeable Magnesium		0.2	meq/100g	8.4			9.0	
∅ Exchangeable Potassium		0.2	meq/100g	0.4			0.4	
∅ Exchangeable Sodium		0.2	meq/100g	9.0			9.7	
∅ Cation Exchange Capacity		0.2	meq/100g	31.8			31.4	
∅ Exchangeable Sodium Percent		0.2	%	28.1			30.8	
∅ Calcium/Magnesium Ratio		0.2	-	1.7			1.4	
∅ Magnesium/Potassium Ratio		0.2	-	20.4			22.4	
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)		0.01	%	0.55	0.20	0.06	0.06	0.04
ED045G: Chloride by Discrete Analyser								



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)		Client sample ID		PR14/0.5-0.6	PR14/0.6-0.7	PR14/0.7-0.8	PR14/0.8-0.9	PR14/0.9-1.0
		Client sampling date / time		23-May-2019 08:40	23-May-2019 08:40	23-May-2019 08:40	23-May-2019 08:40	23-May-2019 08:40
Compound	CAS Number	LOR	Unit	EB1913650-006	EB1913650-007	EB1913650-008	EB1913650-009	EB1913650-010
				Result	Result	Result	Result	Result
ED045G: Chloride by Discrete Analyser - Continued								
Chloride	16887-00-6	10	mg/kg	1940	1910	2340	2560	2730

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)		Client sample ID		PR14/1-0-1.1	PR14/1-1-1.2				
Client sampling date / time				23-May-2019 08:40	23-May-2019 08:40				
Compound	CAS Number	LOR	Unit	EB1913650-011	EB1913650-012				
				Result	Result				
EA002: pH 1:5 (Soils)									
pH Value		0.1	pH Unit	9.0	9.0				
EA010: Conductivity (1:5)									
Electrical Conductivity @ 25°C		1	µS/cm	1760	1740				
EA013: Acid Neutralising Capacity									
ANC as H2SO4		0.5	kg H2SO4 equiv./t		32.7				
ANC as CaCO3		0.1	% CaCO3		3.3				
Fizz Rating		0	Fizz Unit		2				
EA055: Moisture Content (Dried @ 105-110°C)									
Moisture Content		0.1	%	13.8	15.2				
EA058: Emerson Aggregate Test									
Color (Munsell)		-	-		Brown (10YR 4/3)				
Texture		-	-		Medium Clay				
Emerson Class Number	EC/TC	-	-		3				
EA150: Soil Classification - National Committee on Soil and Terrain (2009)									
Clay (<2 µm)		1	%		57				
Silt (2-20 µm)		1	%		17				
Fine Sand (0.02-0.2 mm)		1	%		19				
Coarse Sand (0.2-2.0 mm)		1	%		6				
Gravel (>2mm)		1	%		1				
EA152: Soil Particle Density									
Soil Particle Density (Clay/Silt/Sand)		0.01	g/cm3		2.48				
ED006: Exchangeable Cations on Alkaline Soils									
Ø Exchangeable Calcium		0.2	meq/100g		7.8				
Ø Exchangeable Magnesium		0.2	meq/100g		6.2				
Ø Exchangeable Potassium		0.2	meq/100g		0.4				
Ø Exchangeable Sodium		0.2	meq/100g		7.0				
Ø Cation Exchange Capacity		0.2	meq/100g		21.3				
% Exchangeable Sodium Percent		0.2	%		32.8				
Ø Calcium/Magnesium Ratio		0.2	-		1.3				
Ø Magnesium/Potassium Ratio		0.2	-		17.4				
ED042T: Total Sulfur by LECO									
Sulfur - Total as S (LECO)		0.01	%	0.04	0.04				
ED045G: Chloride by Discrete Analyser									



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)		Client sample ID		PR14/1.0-1.1	PR14/1.1-1.2				
		Client sampling date / time		23-May-2019 08:40	23-May-2019 08:40				
Compound	CAS Number	LOR	Unit	EB1913650-011	EB1913650-012				
				Result	Result				
ED045G: Chloride by Discrete Analyser - Continued									
Chloride	16887-00-6	10	mg/kg	2690	2820				



QUALITY CONTROL REPORT

Work Order : **EB1913650**
Amendment : **1**

Page : 1 of 5

Client	: SLR Consulting Australia Pty Ltd	Laboratory	: Environmental Division Brisbane
Contact	: CAMERON TRAILL	Contact	: Tyler Cachia
Address	:	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: ----	Telephone	: +61 2 8784 8555
Project	: 623.17171 Faithill Coking Coal	Date Samples Received	: 28-May-2019
Order number	:	Date Analysis Commenced	: 29-May-2019
C-O-C number	: ----	Issue Date	: 13-Jun-2019
Sampler	: CAMERON TRAILL		
Site	: ----		
Quote number	: EN/032/18 Primary work only BQ		
No. of samples received	: 12		
No. of samples analysed	: 12		



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. 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
Ben Felgendreiers	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Mark Halias	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Mark Halias	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Satishkumar Trivedi	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Satishkumar Trivedi	Senior Acid Sulfate Soil Chemist	Brisbane Inorganics, Stafford, QLD
Tom Maloney	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by 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

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

Sub-Matrix: SOIL				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EA002: pH 1:5 (Soils) (QC Lot: 2374532)									
EB1913649-004	Anonymous	EA002: pH Value	----	0.1	pH Unit	7.5	7.5	0.00	0% - 20%
EB1913650-008	PR14/0.7-0.8	EA002: pH Value	----	0.1	pH Unit	8.6	8.6	0.00	0% - 20%
EA010: Conductivity (1:5) (QC Lot: 2374533)									
EB1913649-004	Anonymous	EA010: Electrical Conductivity @ 25°C	----	1	µS/cm	12	11	0.00	0% - 50%
EB1913650-008	PR14/0.7-0.8	EA010: Electrical Conductivity @ 25°C	----	1	µS/cm	2110	2200	4.26	0% - 20%
EA013: Acid Neutralising Capacity (QC Lot: 2390595)									
EB1913649-004	Anonymous	EA013: ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	8.6	7.8	9.02	0% - 50%
EM1908388-003	Anonymous	EA013: ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	21.6	24.0	10.6	0% - 20%
EA055: Moisture Content (Dried @ 105-110°C) (QC Lot: 2374535)									
EB1913649-004	Anonymous	EA055: Moisture Content	----	0.1	%	8.5	8.1	4.50	0% - 20%
EB1913650-008	PR14/0.7-0.8	EA055: Moisture Content	----	0.1	%	13.7	13.4	2.54	0% - 20%
ED006: Exchangeable Cations on Alkaline Soils (QC Lot: 2387765)									
EB1913649-005	Anonymous	ED006: Exchangeable Calcium	----	0.2	meq/100g	13.1	13.2	0.00	0% - 20%
		ED006: Exchangeable Magnesium	----	0.2	meq/100g	3.0	3.0	0.00	0% - 50%
		ED006: Exchangeable Potassium	----	0.2	meq/100g	0.3	0.4	0.00	No Limit
		ED006: Exchangeable Sodium	----	0.2	meq/100g	1.1	1.1	0.00	No Limit
		ED006: Cation Exchange Capacity	----	0.2	meq/100g	17.5	17.7	1.09	0% - 20%
ED042T: Total Sulfur by LECO (QC Lot: 2389433)									
EB1913650-004	PR14/0.3-0.4	ED042T: Sulfur - Total as S (LECO)	----	0.01	%	0.04	0.03	0.00	No Limit
EB1913337-001	Anonymous	ED042T: Sulfur - Total as S (LECO)	----	0.01	%	0.02	0.02	0.00	No Limit
ED045G: Chloride by Discrete Analyser (QC Lot: 2374531)									
EB1913649-004	Anonymous	ED045G: Chloride	16887-00-6	10	mg/kg	<10	<10	0.00	No Limit



Sub-Matrix: SOIL				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
ED045G: Chloride by Discrete Analyser (QC Lot: 2374531) - continued									
EBI913650-008	PR14/0.7-0.8	ED045G: Chloride	16887-00-6	10	mg/kg	2340	2480	6.06	0% - 20%
ED091 : Calcium Chloride Extractable Boron (QC Lot: 2374841)									
EBI913643-001	Anonymous	ED091: Boron	7440-42-8	0.2	mg/kg	<0.2	<0.2	0.00	No Limit
EBI913649-002	Anonymous	ED091: Boron	7440-42-8	0.2	mg/kg	<0.2	<0.2	0.00	No Limit
ED092: DTPA Extractable Metals (QC Lot: 2374844)									
EBI913643-001	Anonymous	ED092: Copper	7440-50-8	1	mg/kg	<1.00	<1.00	0.00	No Limit
		ED092: Iron	7439-89-6	1	mg/kg	54.0	52.4	3.07	0% - 20%
		ED092: Manganese	7439-96-5	1	mg/kg	12.4	11.9	4.42	0% - 50%
		ED092: Zinc	7440-66-6	1	mg/kg	<1.00	<1.00	0.00	No Limit
EBI913649-001	Anonymous	ED092: Copper	7440-50-8	1	mg/kg	1.74	1.76	1.08	No Limit
		ED092: Iron	7439-89-6	1	mg/kg	44.7	45.2	1.06	0% - 20%
		ED092: Manganese	7439-96-5	1	mg/kg	30.9	32.4	4.80	0% - 20%
		ED092: Zinc	7440-66-6	1	mg/kg	<1.00	<1.00	0.00	No Limit
EK057G: Nitrite as N by Discrete Analyser (QC Lot: 2374526)									
EBI913650-001	PR14/0.0-0.1	EK057G: Nitrite as N (Sol.)	14797-65-0	0.1	mg/kg	0.9	0.6	39.4	No Limit
EBI913644-001	Anonymous	EK057G: Nitrite as N (Sol.)	14797-65-0	0.1	mg/kg	0.1	0.1	0.00	No Limit
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QC Lot: 2374527)									
EBI913650-001	PR14/0.0-0.1	EK059G: Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	3.1	# 1.9	48.4	0% - 20%
EBI913644-001	Anonymous	EK059G: Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	0.5	0.5	0.00	No Limit
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QC Lot: 2374524)									
EBI913644-001	Anonymous	EK061G: Total Kjeldahl Nitrogen as N	----	20	mg/kg	280	280	0.00	0% - 50%
EBI913650-001	PR14/0.0-0.1	EK061G: Total Kjeldahl Nitrogen as N	----	20	mg/kg	1880	1880	0.00	0% - 20%
EK067G: Total Phosphorus as P by Discrete Analyser (QC Lot: 2374525)									
EBI913644-001	Anonymous	EK067G: Total Phosphorus as P	----	2	mg/kg	125	127	1.68	0% - 20%
EBI913650-001	PR14/0.0-0.1	EK067G: Total Phosphorus as P	----	2	mg/kg	411	410	0.00	0% - 20%
EK080: Bicarbonate Extractable Phosphorus (Colwell) (QC Lot: 2374845)									
EBI913643-001	Anonymous	EK080: Bicarbonate Ext. P (Colwell)	----	5	mg/kg	26	26	0.00	No Limit
EBI913649-001	Anonymous	EK080: Bicarbonate Ext. P (Colwell)	----	5	mg/kg	9	8	13.2	No Limit
EP004: Organic Matter (QC Lot: 2374836)									
EBI913643-001	Anonymous	EP004: Organic Matter	----	0.5	%	3.8	3.9	4.41	No Limit
		EP004: Total Organic Carbon	----	0.5	%	2.2	2.3	0.00	No Limit
EBI913648-002	Anonymous	EP004: Organic Matter	EP004: Total Organic Carbon	0.5	%	2.1	2.3	7.67	No Limit
		EP004: Total Organic Carbon	----	0.5	%	1.2	1.3	0.00	No Limit



Sub-Matrix: SOIL

Sub-Matrix: SOIL									
Method: Compound	CAS Number	LOR	Unit	Method Blank (MB)	Laboratory Control Spike (LCS) Report				
				Report Result	Spike Concentration	Spike Recovery (%)		Recovery Limits (%)	
EKO67G: Total Phosphorus as P by Discrete Analyser (QCLot: 2374525) - continued									
EKO67G: Total Phosphorus as P	----	2	mg/kg	<2	939 mg/kg 1200 mg/kg	82.6 84.9	80 80	115 115	
EKO80: Bicarbonate Extractable Phosphorus (Colwell) (QCLot: 2374845)									
EKO80: Bicarbonate Ext. P (Colwell)	----	5	mg/kg	<5 <5 <5	100 mg/kg 44.9 mg/kg 58.07 mg/kg	101 99.9 83.4	70 87 80	130 113 120	
EP004: Organic Matter (QCLot: 2374836)									
EP004: Organic Matter	----	0.5	%	<0.5	80 %	86.9	83	115	
EP004: Total Organic Carbon	----	0.5	%	<0.5	46.4 %	86.9	85	115	

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: SOIL

Sub-Matrix: SOIL			Matrix Spike (MS) Report				
			Spike Concentration	SpikeRecovery(%) MS	Recovery Limits (%)		
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number				
EK057G: Nitrite as N by Discrete Analyser (QCLot: 2374526)							
EB1913644-002	Anonymous	EK057G: Nitrite as N (Sol.)	14797-65-0	2 mg/kg	82.7	70	130
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 2374527)							
EB1913644-002	Anonymous	EK059G: Nitrite + Nitrate as N (Sol.)		10 mg/kg	92.5	70	130
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QCLot: 2374524)							
EB1913644-002	Anonymous	EK061G: Total Kjeldahl Nitrogen as N		500 mg/kg	92.5	70	130
EK067G: Total Phosphorus as P by Discrete Analyser (QCLot: 2374525)							
EB1913644-002	Anonymous	EK067G: Total Phosphorus as P		100 mg/kg	# 58.8	70	130
EK080: Bicarbonate Extractable Phosphorus (Colwell) (QCLot: 2374845)							
EB1913643-002	Anonymous	EK080: Bicarbonate Ext. P (Colwell)		40 mg/kg	100	70	130
EP004: Organic Matter (QCLot: 2374836)							
EB1913643-002	Anonymous	EP004: Organic Matter		2 %	86.0	70	130
		EP004: Total Organic Carbon		1.16 %	86.2	70	130



Environmental

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: EB1913650	Page	: 1 of 9
Amendment	: 1		
Client	: SLR Consulting Australia Pty Ltd	Laboratory	: Environmental Division Brisbane
Contact	: CAMERON TRAILL	Telephone	: +61 2 8784 8555
Project	: 623.17171 Fairhill Coking Coal	Date Samples Received	: 28-May-2019
Site	: -----	Issue Date	: 13-Jun-2019
Sampler	: CAMERON TRAILL	No. of samples received	: 12
Order number	:	No. of samples analysed	: 12

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 Laboratory Control outliers occur.
- Duplicate outliers exist - please see following pages for full details.
- Matrix Spike outliers exist - please see following pages for full details.
- 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

- NO Quality Control Sample Frequency Outliers exist.



Outliers : Quality Control Samples

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: SOIL

Compound Group Name	Laboratory Sample ID	Client Sample ID	Analyte	CAS Number	Data	Limits	Comment
Duplicate (DUP) RPDs							
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Ar	EB1913650-001	PR14/0.0-0.1	Nitrite + Nitrate as N (Sol.)	----	48.4 %	0% - 20%	RPD exceeds LOR based limits
Matrix Spike (MS) Recoveries							
EK067G: Total Phosphorus as P by Discrete Analyser	EB1913644-002	Anonymous	Total Phosphorus as P	----	58.8 %	70-130%	Recovery less than lower data quality objective

Outliers : Analysis Holding Time Compliance

Matrix: SOIL

Method	Container / Client Sample ID(s)	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Days overdue	Date analysed	Due for analysis	Days overdue
EP004: Organic Matter							
Snap Lock Bag PR14/0.0-0.1,		05-Jun-2019	30-May-2019	6			
PR14/0.1-0.2							

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
EA002: pH 1.5 (Soils)								
Snap Lock Bag (EA002)								
PR14/0.0-0.1,		23-May-2019	30-May-2019	30-May-2019	✓	30-May-2019	30-May-2019	✓
PR14/0.2-0.3,								
PR14/0.4-0.5,								
PR14/0.6-0.7,								
PR14/0.8-0.9,								
PR14/1.0-1.1,								
PR14/1.1-1.2								



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
EA010: Conductivity (1:5)							
Snap Lock Bag (EA010)		23-May-2019	30-May-2019	30-May-2019	30-May-2019	27-Jun-2019	✔
PR14/0.0-0.1,				✔			
PR14/0.2-0.3,							
PR14/0.4-0.5,							
PR14/0.6-0.7,							
PR14/0.8-0.9,							
PR14/1.0-1.1,							
EA013: Acid Neutralising Capacity							
Pulp Bag (EA013)		23-May-2019	06-Jun-2019	22-May-2020	06-Jun-2019	03-Dec-2019	✔
PR14/0.1-0.2,				✔			
PR14/0.5-0.6,							
PR14/1.1-1.2							
EA055: Moisture Content (Dried @ 105-110°C)							
Snap Lock Bag (EA055)		23-May-2019	---	---	29-May-2019	06-Jun-2019	✔
PR14/0.0-0.1,				---			
PR14/0.2-0.3,				---			
PR14/0.4-0.5,							
PR14/0.6-0.7,							
PR14/0.8-0.9,							
PR14/1.0-1.1,							
EA058: Emerson Aggregate Test							
Snap Lock Bag (EA058)		23-May-2019	---	---	04-Jun-2019	19-Nov-2019	✔
PR14/0.1-0.2,				---			
PR14/0.5-0.6,							
PR14/1.1-1.2							
EA150: Soil Classification - National Committee on Soil and Terrain (2009)							
Snap Lock Bag (EA150H)		23-May-2019	---	---	06-Jun-2019	19-Nov-2019	✔
PR14/0.0-0.1,				---			
PR14/0.2-0.3,							
PR14/0.8-0.9,							
EA152: Soil Particle Density							
Snap Lock Bag (EA152)		23-May-2019	---	---	06-Jun-2019	19-Nov-2019	✔
PR14/0.0-0.1,				---			
PR14/0.2-0.3,							
PR14/0.8-0.9,							
ED005: Exchange Acidity							
Snap Lock Bag (ED005)		23-May-2019	05-Jun-2019	20-Jun-2019	06-Jun-2019	20-Jun-2019	✔
PR14/0.0-0.1,							
PR14/0.2-0.3,							
PR14/0.8-0.9,							



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	
ED006: Exchangeable Cations on Alkaline Soils								
Snap Lock Bag (ED006)								
PR14/0.0-0.1,	PR14/0.1-0.2,	23-May-2019	05-Jun-2019	20-Jun-2019	✓	06-Jun-2019	20-Jun-2019	✓
PR14/0.2-0.3,	PR14/0.5-0.6,							
PR14/0.8-0.9,	PR14/1.1-1.2							
ED007: Exchangeable Cations								
Snap Lock Bag (ED007)								
PR14/0.0-0.1,	PR14/0.1-0.2,	23-May-2019	05-Jun-2019	20-Jun-2019	✓	06-Jun-2019	20-Jun-2019	✓
PR14/0.2-0.3,	PR14/0.5-0.6,							
PR14/0.8-0.9,	PR14/1.1-1.2							
ED008: Exchangeable Cations								
Snap Lock Bag (ED008)								
PR14/0.0-0.1,	PR14/0.1-0.2,	23-May-2019	05-Jun-2019	20-Jun-2019	✓	06-Jun-2019	20-Jun-2019	✓
PR14/0.2-0.3,	PR14/0.5-0.6,							
PR14/0.8-0.9,	PR14/1.1-1.2							
ED042T: Total Sulfur by LECO								
Pulp Bag (ED042T)								
PR14/0.0-0.1,	PR14/0.1-0.2,	23-May-2019	06-Jun-2019	20-Jun-2019	✓	06-Jun-2019	20-Jun-2019	✓
PR14/0.2-0.3,	PR14/0.3-0.4,							
PR14/0.4-0.5,	PR14/0.5-0.6,							
PR14/0.6-0.7,	PR14/0.7-0.8,							
PR14/0.8-0.9,	PR14/0.9-1.0,							
PR14/1.0-1.1,	PR14/1.1-1.2							
ED045G: Chloride by Discrete Analyser								
Snap Lock Bag (ED045G)								
PR14/0.0-0.1,	PR14/0.1-0.2,	23-May-2019	30-May-2019	20-Jun-2019	✓	31-May-2019	27-Jun-2019	✓
PR14/0.2-0.3,	PR14/0.3-0.4,							
PR14/0.4-0.5,	PR14/0.5-0.6,							
PR14/0.6-0.7,	PR14/0.7-0.8,							
PR14/0.8-0.9,	PR14/0.9-1.0,							
PR14/1.0-1.1,	PR14/1.1-1.2							
ED091 : Calcium Chloride Extractable Boron								
Snap Lock Bag (ED091)								
PR14/0.0-0.1,	PR14/0.1-0.2	23-May-2019	05-Jun-2019	19-Nov-2019	✓	06-Jun-2019	19-Nov-2019	✓
ED092: DTPA Extractable Metals								
Snap Lock Bag (ED092)								
PR14/0.0-0.1,	PR14/0.1-0.2	23-May-2019	05-Jun-2019	19-Nov-2019	✓	07-Jun-2019	19-Nov-2019	✓
EK057G: Nitrite as N by Discrete Analyser								
Snap Lock Bag (EK057G)								
PR14/0.0-0.1,	PR14/0.1-0.2	23-May-2019	30-May-2019	19-Nov-2019	✓	31-May-2019	19-Nov-2019	✓



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
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser							
Snap Lock Bag (EK059G)							
PR14/0.0-0.1,	23-May-2019	30-May-2019	19-Nov-2019	✔	31-May-2019	19-Nov-2019	✔
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser							
Snap Lock Bag (EK061G)							
PR14/0.0-0.1,	23-May-2019	29-May-2019	19-Nov-2019	✔	30-May-2019	19-Nov-2019	✔
EK067G: Total Phosphorus as P by Discrete Analyser							
Snap Lock Bag (EK067G)							
PR14/0.0-0.1,	23-May-2019	29-May-2019	19-Nov-2019	✔	30-May-2019	19-Nov-2019	✔
EK080: Bicarbonate Extractable Phosphorus (Colwell)							
Snap Lock Bag (EK080)							
PR14/0.0-0.1,	23-May-2019	06-Jun-2019	19-Nov-2019	✔	06-Jun-2019	19-Nov-2019	✔
EP004: Organic Matter							
Snap Lock Bag (EP004)							
PR14/0.0-0.1,	23-May-2019	05-Jun-2019	30-May-2019	✖	05-Jun-2019	03-Jul-2019	✔



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 (%)		Evaluation	Quality Control Specification
Analytical Methods	Method	QC	Regular	Actual	Expected		
Laboratory Duplicates (DUP)							
Acid Neutralising Capacity (ANC)	EA013	2	20	10.00	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Bicarbonate Extractable P (Colwell)	EK080	2	14	14.29	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Calcium Chloride Extractable Boron	ED091	2	14	14.29	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Chloride Soluble By Discrete Analyser	ED045G	2	15	13.33	10.00	✓	NEPM 2013 B3 & ALS QC Standard
DTPA Extractable Metals	ED092	2	14	14.29	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Electrical Conductivity (1:5)	EA010	2	15	13.33	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations on Alkaline Soils	ED006	1	8	12.50	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Moisture Content	EA055	2	15	13.33	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx)- Soluble by Discrete Analyser	EK059G	2	12	16.67	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite as N - Soluble by Discrete Analyser	EK057G	2	12	16.67	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Organic Matter	EP004	2	14	14.29	10.00	✓	NEPM 2013 B3 & ALS QC Standard
pH (1:5)	EA002	2	15	13.33	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Sulfur - Total as S (LECO)	ED042T	2	20	10.00	10.00	✓	NEPM 2013 B3 & ALS QC Standard
TKN as N By Discrete Analyser	EK061G	2	12	16.67	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus By Discrete Analyser	EK067G	2	12	16.67	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Acid Neutralising Capacity (ANC)	EA013	1	20	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Bicarbonate Extractable P (Colwell)	EK080	3	14	21.43	15.00	✓	NEPM 2013 B3 & ALS QC Standard
Calcium Chloride Extractable Boron	ED091	1	14	7.14	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Chloride Soluble By Discrete Analyser	ED045G	2	15	13.33	10.00	✓	NEPM 2013 B3 & ALS QC Standard
DTPA Extractable Metals	ED092	1	14	7.14	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Electrical Conductivity (1:5)	EA010	1	15	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations on Alkaline Soils	ED006	1	8	12.50	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx)- Soluble by Discrete Analyser	EK059G	1	12	8.33	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite as N - Soluble by Discrete Analyser	EK057G	1	12	8.33	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Organic Matter	EP004	1	14	7.14	5.00	✓	NEPM 2013 B3 & ALS QC Standard
pH (1:5)	EA002	2	15	13.33	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Sulfur - Total as S (LECO)	ED042T	1	20	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
TKN as N By Discrete Analyser	EK061G	2	12	16.67	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus By Discrete Analyser	EK067G	2	12	16.67	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
Bicarbonate Extractable P (Colwell)	EK080	1	14	7.14	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Calcium Chloride Extractable Boron	ED091	1	14	7.14	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Chloride Soluble By Discrete Analyser	ED045G	1	15	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard



Matrix: SOIL

Evaluation: ✖ = Quality Control frequency not within specification ; ✔ = Quality Control frequency within specification.

Quality Control Sample Type	Count		Rate (%)		Evaluation	Quality Control Specification	
Analytical Methods	Method	QC	Regular	Actual			Expected
Method Blanks (MB) - Continued							
DTPA Extractable Metals	ED092	1	14	7.14	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Electrical Conductivity (1:5)	EA010	1	15	6.67	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations on Alkaline Soils	ED006	1	8	12.50	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx)- Soluble by Discrete Analyser	EK059G	1	12	8.33	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Nitrite as N - Soluble by Discrete Analyser	EK057G	1	12	8.33	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Organic Matter	EP004	1	14	7.14	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Sulfur - Total as S (LECO)	ED042T	1	20	5.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
TKN as N By Discrete Analyser	EK061G	1	12	8.33	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus By Discrete Analyser	EK067G	1	12	8.33	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)							
Bicarbonate Extractable P (Colwell)	EK080	1	14	7.14	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx)- Soluble by Discrete Analyser	EK059G	1	12	8.33	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Nitrite as N - Soluble by Discrete Analyser	EK057G	1	12	8.33	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Organic Matter	EP004	1	14	7.14	5.00	✔	NEPM 2013 B3 & ALS QC Standard
TKN as N By Discrete Analyser	EK061G	1	12	8.33	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus By Discrete Analyser	EK067G	1	12	8.33	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 (1:5)	EA002	SOIL	In house: Referenced to Rayment and Lyons 4A1 and APHA 4500H+. pH is determined on soil samples after a 1:5 soil/water leach. This method is compliant with NEPM (2013) Schedule B(3)
Electrical Conductivity (1:5)	EA010	SOIL	In house: Referenced to Rayment and Lyons 3A1 and APHA 2510. Conductivity is determined on soil samples using a 1:5 soil/water leach. This method is compliant with NEPM (2013) Schedule B(3)
Acid Neutralising Capacity (ANC)	EA013	SOIL	In house: Referenced to USEPA 600/2-78-054, I. Miller (2000). A fizz test is done to semiquantitatively estimate the likely reactivity. The soil is then reacted with a known excess quantity of an appropriate acid. Titration determines the acid remaining, and the ANC can be calculated from comparison with a blank titration.
Moisture Content	EA055	SOIL	In house: A gravimetric procedure based on weight loss over a 12 hour drying period at 105-110 degrees C. This method is compliant with NEPM (2013) Schedule B(3) Section 7.1 and Table 1 (14 day holding time).
Emerson Aggregate Test	EA058	SOIL	In house: Referenced to AS1289.3.8.1. Testing is performed only on soils with suitable aggregates; sands and gravels are usually unsuitable for this test. The test classifies the behaviour of soil aggregates, when immersed, on their coherence in water.
Particle Size Analysis by Hydrometer	EA150H	SOIL	Particle Size Analysis by Hydrometer according to AS1289.3.6.3 - 2003
Soil Particle Density	EA152	SOIL	Soil Particle Density by AS 1289.3.5.1-2006. Methods of testing soils for engineering purposes - Soil classification tests - Determination of the soil particle density of a soil - Standard method
Exchange Acidity by 1M Potassium Chloride	* ED005	SOIL	In house: referenced to Rayment and Lyons. (2011), method 15G1. This method is unsuitable for near neutral and alkaline soils. NATA accreditation does not cover performance of this service.
Exchangeable Cations on Alkaline Soils	* ED006	SOIL	In house: Referenced to Soil Survey Test Method C5. Soluble salts are removed from the sample prior to analysis. Cations are exchanged from the sample by contact with alcoholic ammonium chloride at pH 8.5. They are then quantitated in the final solution by ICPAES and reported as meq/100g of original soil.
Exchangeable Cations	ED007	SOIL	In house: Referenced to Rayment & Lyons (2011) Method 15A1. Cations are exchanged from the sample by contact with Ammonium Chloride. They are then quantitated in the final solution by ICPAES and reported as meq/100g of original soil. This method is compliant with NEPM (2013) Schedule B(3) (Method 301)
Exchangeable Cations with pre-treatment	ED008	SOIL	In house: Referenced to Rayment & Higginson (2011) Method 15A2. Soluble salts are removed from the sample prior to analysis. Cations are exchanged from the sample by contact with Ammonium Chloride. They are then quantitated in the final solution by ICPAES and reported as meq/100g of original soil. This method is compliant with NEPM (2013) Schedule B(3) (Method 301)
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 SO ₂) is measured by infra-red detector
Chloride Soluble By Discrete Analyser	ED045G	SOIL	In house: Referenced to APHA 4500-Cl- E. 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 thiocyanate forms highly coloured ferric thiocyanate which is measured at 480 nm. Analysis is performed on a 1:5 soil / water leachate.
Calcium Chloride Extractable Boron	* ED091	SOIL	In house: Referenced to Rayment & Higginson (2011) method 12C2. Soil is extracted with hot 0.01M CaCl ₂ solution at a 1:2 ratio. Extracts can be run on ICP.
DTPA Extractable Metals	* ED092	SOIL	In house: Referenced to Rayment and Higginson (2011) 12A1



Analytical Methods		Method	Matrix	Method Descriptions
Nitrite as N - Soluble by Discrete Analyser	EK057G	SOIL	In house: Referenced to APHA 4500-NO3- B. Nitrite in a water extract is determined by direct colourimetry by Discrete Analyser.	
Nitrate as N - Soluble by Discrete Analyser	EK058G	SOIL	In house: Referenced to APHA 4500-NO3- F. Nitrate in the 1:5 soil:water extract is reduced to nitrite by way of a chemical reduction followed by quantification by Discrete Analyser. Nitrite is determined seperately by direct colourimetry and result for Nitrate calculated as the difference between the two results.	
Nitrite and Nitrate as N (NOx)- Soluble by Discrete Analyser	EK059G	SOIL	In house: Thermo Scientific Method D08727 and NEMI (National Environmental Method Index) Method ID: 9171. This method covers the determination of total oxidised nitrogen (NOx-N) and nitrate (NO3-N) by calculation, Combined oxidised Nitrogen (NO2+NO3) in a water extract is determined by direct colourimetry by Discrete Analyser.	
TKN as N By Discrete Analyser	EK061G	SOIL	In house: Referenced to APHA 4500-Norg-D Soil samples are digested using Kjeldahl digestion followed by determination by Discrete Analyser.	
Total Nitrogen as N (TKN + NOx) By Discrete Analyser	EK062G	SOIL	In house: Referenced to APHA 4500 Norg/NO3- Total Nitrogen is determined as the sum of TKN and Oxidised Nitrogen, each determined seperately as N.	
Total Phosphorus By Discrete Analyser	EK067G	SOIL	In house: Referenced to APHA 4500 P-B&F This procedure involves sulfuric acid digestion and quantification using Discrete Analyser.	
Bicarbonate Extractable P (Colwell)	EK080	SOIL	In house: Referenced to Rayment & Higginson (2011) Method 9B1 Phosphorus is extracted from the soil using 0.5M NaHCO3 at a 1:100 soil:solution ratio and determined by FIA.	
Organic Matter	EP004	SOIL	In house: Referenced to AS1289.4.1.1 - 1997. Dichromate oxidation method after Walkley and Black. This method is compliant with NEPM (2013) Schedule B(3).	
Preparation Methods		Method	Matrix	Method Descriptions
Exchangeable Cations Preparation Method (Alkaline Soils)	ED006PR	SOIL	In house: Referenced to Rayment and Lyons 2011 method 15C1.	
Exchangeable Cations Preparation Method	ED007PR	SOIL	In house: Referenced to Rayment & Higginson (1992) method 15A1. A 1M NH4Cl extraction by end over end tumbling at a ratio of 1:20. There is no pretreatment for soluble salts. Extracts can be run by ICP for cations.	
Hot Water CaCl2 Extraction for Boron	ED091PR	SOIL	In house: Referenced to Rayment & Higginson (1992) method 12C2. Soil is extracted with hot 0.01M CaCl2 solution at a 1:2 ratio. Extracts can be run on ICP.	
DTPA Extraction for Cu, Zn, Mn, Fe (2 hour leach)	ED092PR	SOIL	In house: Referenced to Rayment & Higginson (1992) Method 12A1 2 hour end over end tumbler extraction with 0.005M DTPA at a ratio of 1:2. Extracts can be run by ICP for metals.	
TKN/TP Digestion	EK061/EK067	SOIL	In house: Referenced to APHA 4500 Norg- D: APHA 4500 P - H. Macro Kjeldahl digestion.	
Sample Preparation for Bicarbonate Extractable P (Colwell)	EK080-PR	SOIL	In house: Referenced to Rayment & Higginson (2011) Method 9B1 Phosphorus is extracted from the soil using 0.5M NaHCO3 at a 1:100 soil:solution ratio.	
Drying at 85 degrees, bagging and labelling (ASS)	EN020PR	SOIL	In house	
1:5 solid /water leach for soluble analytes	EN34	SOIL	10 g of soil is mixed with 50 mL of reagent grade water and tumbled end over end for 1 hour. Water soluble salts are leached from the soil by the continuous suspension. Samples are settled and the water filtered off for analysis.	
Organic Matter	EP004-PR	SOIL	In house: Referenced to AS1289.4.1.1 - 1997. Dichromate oxidation method after Walkley and Black. This method is compliant with NEPM (2013) Schedule B(3) (Method 105)	
Dry and Pulverise (up to 100g)	GEO30	SOIL	#	



Environmental

SAMPLE RECEIPT NOTIFICATION (SRN)

Work Order : **EB1913644**

Client : **SLR Consulting Australia Pty Ltd**
Contact : **CAMERON TRAILL**
Address :

Laboratory : **Environmental Division Brisbane**
Contact : **Tyler Cachia**
Address : **2 Byth Street Stafford QLD Australia 4053**

E-mail : **ctrail@slrconsulting.com**
Telephone : **----**
Facsimile : **----**

E-mail : **Tyler.Cachia@ALSGlobal.com**
Telephone : **+61 2 8784 8555**
Facsimile : **+61-7-3243 7218**

Project : **623.17171 Fairhill Coking Coal**
Order number :

Page : **1 of 3**
Quote number : **EM2018HEGAUS0001 (EN/032/18**

C-O-C number : **----**

QC Level

Primary work only BQ)
: **NEPM 2013 B3 & ALS QC Standard**

Site : **----**
Sampler : **CAMERON TRAILL**

Dates

Date Samples Received : **28-May-2019 09:00**
Client Requested Due : **07-Jun-2019**
Date

Issue Date : **28-May-2019**
Scheduled Reporting Date : **07-Jun-2019**

Delivery Details

Mode of Delivery : **Carrier**
No. of coolers/boxes : **1**
Receipt Detail : **MEDIUM HARD ESKY**

Security Seal : **Intact.**
Temperature : **19.5°C**
No. of samples received / analysed : **6 / 6**

General Comments

- This report contains the following information:
 - Sample Container(s)/Preservation Non-Compliances
 - Summary of Sample(s) and Requested Analysis
 - Proactive Holding Time Report
 - Requested Deliverables
- Please be advised that ALS is unable to accommodate the fast turnaround requested on the Chain of Custody. If you wish to discuss this further, please contact Client Services at ALSEnviro.Brisbane@alsglobal.com.**
- Discounted Package Prices apply only when specific ALS Group Codes ('W', 'S', 'NT' suites) are referenced on COCs.
- Please direct any turn around / technical queries to the laboratory contact designated above.
- Sample Disposal - Aqueous (3 weeks), Solid (2 months ± 1 week) from receipt of samples.
- Analysis will be conducted by ALS Environmental, Brisbane, NATA accreditation no. 825, Site No. 818 (Micro site no. 18956).
- Breaches in recommended extraction / analysis holding times (if any) are displayed overleaf in the Proactive Holding Time Report table.**
- Please be aware that APHA/NEPM recommends water and soil samples be chilled to less than or equal to 6°C for chemical analysis, and less than or equal to 10°C but unfrozen for Microbiological analysis. Where samples are received above this temperature, it should be taken into consideration when interpreting results. Refer to ALS EnviroMail 85 for ALS recommendations of the best practice for chilling samples after sampling and for maintaining a cool temperature during transit.



Sample Container(s)/Preservation Non-Compliances

All comparisons are made against pretreatment/preservation AS, APHA, USEPA standards.

- No sample container / preservation non-compliance exists.

Summary of Sample(s) and Requested Analysis

Some items described below may be part of a laboratory process necessary for the execution of client requested tasks. Packages may contain additional analyses, such as the determination of moisture content and preparation tasks, that are included in the package.

If no sampling time is provided, the sampling time will default 00:00 on the date of sampling. If no sampling date is provided, the sampling date will be assumed by the laboratory and displayed in brackets without a time component

Matrix: **SOIL**

Laboratory sample ID	Client sampling date / time	Client sample ID							
EB1913644-001	23-May-2019 15:15	PR02 / 0.0-0.1	✓	✓	✓	✓	✓	✓	✓
EB1913644-002	23-May-2019 15:15	PR02 / 0.1-0.2	✓	✓	✓	✓	✓	✓	✓
EB1913644-003	23-May-2019 15:15	PR02 / 0.3-0.4	✓	✓	✓	✓	✓	✓	✓
EB1913644-004	23-May-2019 15:15	PR02 / 0.5-0.6	✓	✓	✓	✓	✓	✓	✓
EB1913644-005	23-May-2019 15:15	PR02 / 0.8-0.9	✓	✓	✓	✓	✓	✓	✓
EB1913644-006	23-May-2019 15:15	PR02 / 1.1-1.2	✓	✓	✓	✓	✓	✓	✓

Matrix: **SOIL**

Laboratory sample ID	Client sampling date / time	Client sample ID							
EB1913644-001	23-May-2019 15:15	PR02 / 0.0-0.1	✓	✓	✓	✓	✓	✓	✓
EB1913644-002	23-May-2019 15:15	PR02 / 0.1-0.2	✓	✓	✓	✓	✓	✓	✓
EB1913644-003	23-May-2019 15:15	PR02 / 0.3-0.4	✓	✓	✓	✓	✓	✓	✓
EB1913644-004	23-May-2019 15:15	PR02 / 0.5-0.6	✓	✓	✓	✓	✓	✓	✓
EB1913644-005	23-May-2019 15:15	PR02 / 0.8-0.9	✓	✓	✓	✓	✓	✓	✓
EB1913644-006	23-May-2019 15:15	PR02 / 1.1-1.2	✓	✓	✓	✓	✓	✓	✓

SOIL - EA013
Acid Neutralising Capacity (ANC)

SOIL - EA058
Emerson Aggregate Test

SOIL - EA150H-Y
Particle Size Analysis by Hydrometer: Yellow

SOIL - ED042T
Sulfur - Total as S (high temperature furnace)

SOIL - ED045G (solids)
Chloride Soluble by Discrete Analyser

SOIL - ED091
Calcium Chloride Extractable Boron

SOIL - AG-1 EB Only
Agricultural Soil Suite 1 EB Only

SOIL - EA055-103
Moisture Content

SOIL - ED092
DTPA Extractable Metals

SOIL - EK067G (Solids)
Total Phosphorus as P by Discrete Analyser

SOIL - EK080
Bicarbonate Extractable P (Colwell)

SOIL - EP004 (Carbon)
Organic Matter & Total Organic Carbon (Calc.)

SOIL - NT-6S
Nitrogen, TKN, NO2, NO3

Proactive Holding Time Report

Sample(s) have been received within the recommended holding times for the requested analysis.



Requested Deliverables

ACCOUNTS PAYABLE AU

- A4 - AU Tax Invoice (INV)

Email accountspayableau@slrconsulting.com

CAMERON TRAILL

- *AU Certificate of Analysis - NATA (COA)
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep) (QCI)
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA (QC)
- A4 - AU Sample Receipt Notification - Environmental HT (SRN)
- A4 - AU Tax Invoice (INV)
- Attachment - Report (SUBCO)
- Chain of Custody (CoC) (COC)
- EDI Format - ENMRG (ENMRG)
- EDI Format - ESDAT (ESDAT)

Email ctraill@slrconsulting.com
Email ctraill@slrconsulting.com
Email ctraill@slrconsulting.com
Email ctraill@slrconsulting.com
Email ctraill@slrconsulting.com
Email ctraill@slrconsulting.com
Email ctraill@slrconsulting.com
Email ctraill@slrconsulting.com
Email ctraill@slrconsulting.com

D TAYLOR

- A4 - AU Tax Invoice (INV)

Email dtaylor@slrconsulting.com



Environmental

CERTIFICATE OF ANALYSIS

Work Order

: **EB1913644**

Client

: **SLR Consulting Australia Pty Ltd**

Contact

: **CAMERON TRAILL**

Address

:

Telephone

: ----

Project

: **623.17171 Fairhill Coking Coal**

Order number

:

C-O-C number

: ----

Sampler

: **CAMERON TRAILL**

Site

: ----

Quote number

: **EN/032/18 Primary work only BQ**

No. of samples received

: **6**

No. of samples analysed

: **6**

Page

: **1 of 6**

Laboratory

: **Environmental Division Brisbane**

Contact

: **Tyler Cachia**

Address

: **2 Byth Street Stafford QLD Australia 4053**

Telephone

: **+61 2 8784 8555**

Date Samples Received

: **28-May-2019 09:00**

Date Analysis Commenced

: **29-May-2019**

Issue Date

: **07-Jun-2019 18:51**

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. 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
Ben Felgendreijens	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Mark Hallas	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Mark Hallas	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Satishkumar Trivedi	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Satishkumar Trivedi	Senior Acid Sulfate Soil Chemist	Brisbane Inorganics, Stafford, QLD
Tom Maloney	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by 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 Contact 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.

- ED006 (Exchangeable Cations on Alkaline Soils). Unable to calculate Magnesium/Potassium Ratio for sample EB1913644-004 (PR02 / 0.5-0.6) as the required results for Magnesium/Potassium are below LOR.
- ALS is not NATA accredited for the analysis of Exchangeable Aluminium and Exchange Acidity in soils when performed under ALS Method ED005.
- ALS is not NATA accredited for the analysis of Exchangeable Cations on Alkaline Soils when performed under ALS Method ED006.
- EK067G (Total Phosphorus as P): Poor matrix spike recovery for sample EB1913644_002 (PR02 / 0.1-0.2) due to sample heterogeneity. Confirmed by visual analysis.
- EK059G (Nitrite and Nitrate as N): Sample EB1913650_001 shows poor duplicate results due to sample heterogeneity. Confirmed by visual analysis.
- ASS: EA013 (ANC) Fizz Rating: 0- None; 1- Slight; 2- Moderate; 3- Strong; 4- Very Strong; 5- Lime.
- EA058 Emerson: V. = Very, D. = Dark, L. = Light, VD. = Very Dark
- ED007 and ED008: When Exchangeable Al is reported from these methods, it should be noted that Rayment & Lyons (2011) suggests Exchange Acidity by 1M KCl - Method 15G1 (ED005) is a more suitable method for the determination of exchange acidity (H⁺ + Al³⁺).



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)		Client sample ID		PR02 / 0.0-0.1	PR02 / 0.1-0.2	PR02 / 0.3-0.4	PR02 / 0.5-0.6	PR02 / 0.8-0.9
Compound		CAS Number	LOR	Unit	Result	Result	Result	Result
Client sampling date / time		23-May-2019 15:15		23-May-2019 15:15		23-May-2019 15:15		23-May-2019 15:15
EB1913644-001		EB1913644-002		EB1913644-003		EB1913644-004		EB1913644-005
EA002: pH 1:5 (Soils)								
pH Value	0.1	pH Unit		7.0	6.9	8.0	9.0	9.0
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	1	µS/cm		21	11	100	267	346
EA013: Acid Neutralising Capacity								
ANC as H2SO4	0.5	kg H2SO4 equiv./t		----	6.9	12.1	180	105
ANC as CaCO3	0.1	% CaCO3		----	0.7	1.2	18.4	10.7
Fizz Rating	0	Fizz Unit		----	1	1	3	2
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	1.0	%		4.3	5.7	-----	-----	-----
EA058: Emerson Aggregate Test								
Color (Munsell)	-	-		----	Dark Brown (7.5YR 3/3)	Dark Reddish Brown (5YR 3/4)	Reddish Brown (5YR 4/4)	Dark Yellowish Brown (10YR 4/4)
Texture	-	-		----	Sandy Clay Loam	Heavy Clay	Sandy Clay	Sandy Clay
Emerson Class Number	-	-		----	2	3	4	4
EA150: Soil Classification - National Committee on Soil and Terrain (2009)								
Clay (<2 µm)	1	%		26	22	65	51	40
Silt (2-20 µm)	1	%		21	16	8	11	19
Fine Sand (0.02-0.2 mm)	1	%		31	39	19	15	28
Coarse Sand (0.2-2.0 mm)	1	%		19	21	8	16	8
Gravel (>2mm)	1	%		3	2	<1	7	5
EA152: Soil Particle Density								
Soil Particle Density (Clay/Silt/Sand)	0.01	g/cm3		2.36	2.39	2.28	2.42	2.36
ED006: Exchangeable Cations on Alkaline Soils								
Ø Exchangeable Calcium	0.2	meq/100g		----	----	19.4	16.5	23.9
Ø Exchangeable Magnesium	0.2	meq/100g		----	----	6.4	5.9	9.7
Ø Exchangeable Potassium	0.2	meq/100g		----	----	0.3	<0.2	0.4
Ø Exchangeable Sodium	0.2	meq/100g		----	----	2.3	2.2	4.0
Ø Cation Exchange Capacity	0.2	meq/100g		----	----	28.3	24.9	38.0
Ø Exchangeable Sodium Percent	0.2	%		----	----	8.1	9.0	10.7
Ø Calcium/Magnesium Ratio	0.2	-		----	----	3.0	2.8	2.5
Ø Magnesium/Potassium Ratio	0.2	-		----	----	22.8	-----	23.7
ED007: Exchangeable Cations								
Exchangeable Calcium	0.1	meq/100g		6.5	5.5	-----	-----	-----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)		Client sample ID		PR02 / 0.0-0.1	PR02 / 0.1-0.2	PR02 / 0.3-0.4	PR02 / 0.5-0.6	PR02 / 0.8-0.9
Client sampling date / time				23-May-2019 15:15	23-May-2019 15:15	23-May-2019 15:15	23-May-2019 15:15	23-May-2019 15:15
Compound	CAS Number	LOR	Unit	EB1913644-001	EB1913644-002	EB1913644-003	EB1913644-004	EB1913644-005
Result				Result	Result	Result	Result	Result
ED007: Exchangeable Cations - Continued								
Exchangeable Magnesium	0.1	meq/100g	2.0	1.7	0.0000	0.0000	0.0000	0.0000
Exchangeable Potassium	0.1	meq/100g	0.3	0.2	0.0000	0.0000	0.0000	0.0000
Exchangeable Sodium	0.1	meq/100g	<0.1	0.1	0.0000	0.0000	0.0000	0.0000
Cation Exchange Capacity	0.1	meq/100g	8.9	7.4	0.0000	0.0000	0.0000	0.0000
Exchangeable Sodium Percent	0.1	%	1.1	1.5	0.0000	0.0000	0.0000	0.0000
Calcium/Magnesium Ratio	0.1	-	3.2	3.2	0.0000	0.0000	0.0000	0.0000
Magnesium/Potassium Ratio	0.1	-	6.0	10.2	0.0000	0.0000	0.0000	0.0000
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	0.01	%	0.02	0.02	<0.01	0.02	0.02	0.02
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	<10	100	170	250	
ED091 : Calcium Chloride Extractable Boron								
ø Boron	7440-42-8	0.2	mg/kg	<0.2				0.0000
ED092: DTPA Extractable Metals								
ø Copper	7440-50-8	1.00	mg/kg	<1.00				0.0000
ø Iron	7439-89-6	1.00	mg/kg	22.2	22.8	0.0000	0.0000	0.0000
ø Manganese	7439-96-5	1.00	mg/kg	36.8	16.3	0.0000	0.0000	0.0000
ø Zinc	7440-66-6	1.00	mg/kg	<1.00				0.0000
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N (Sol.)	14797-65-0	0.1	mg/kg	0.1	<0.1	0.0000	0.0000	0.0000
EK058G: Nitrate as N by Discrete Analyser								
Nitrate as N (Sol.)	14797-55-8	0.1	mg/kg	0.4	0.4	0.0000	0.0000	0.0000
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N (Sol.)	0.1	mg/kg	0.5	0.4	0.0000	0.0000	0.0000	0.0000
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	20	mg/kg	280	310	0.0000	0.0000	0.0000	0.0000
EK062: Total Nitrogen as N (TKN + NOx)								
^ Total Nitrogen as N	20	mg/kg	280	310	0.0000	0.0000	0.0000	0.0000
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	2	mg/kg	125	103				0.0000
EK080: Bicarbonate Extractable Phosphorus (Colwell)								
Bicarbonate Ext. P (Colwell)	5	mg/kg	<5	<5	0.0000	0.0000	0.0000	0.0000
EP004: Organic Matter								



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)		Client sample ID		PR02 / 0.0-0.1	PR02 / 0.1-0.2	PR02 / 0.3-0.4	PR02 / 0.5-0.6	PR02 / 0.8-0.9
		Client sampling date / time		23-May-2019 15:15	23-May-2019 15:15	23-May-2019 15:15	23-May-2019 15:15	23-May-2019 15:15
Compound	CAS Number	LOR	Unit	EB1913644-001	EB1913644-002	EB1913644-003	EB1913644-004	EB1913644-005
				Result	Result	Result	Result	Result
EP004: Organic Matter - Continued								
Organic Matter	-----	0.5	%	2.0	1.2	-----	-----	-----
Total Organic Carbon	-----	0.5	%	1.1	0.7	-----	-----	-----



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)		Client sample ID			PR02 / 1.1-1.2					
		Client sampling date / time			23-May-2019 15:15					
Compound	CAS Number	LOR	Unit	EB1913644-006						
				Result						
EA002: pH 1:5 (Soils)										
pH Value		0.1	pH Unit	9.4						
EA010: Conductivity (1:5)										
Electrical Conductivity @ 25°C		1	µS/cm	188						
EA013: Acid Neutralising Capacity										
ANC as H2SO4		0.5	kg H2SO4 equiv./t	39.5						
ANC as CaCO3		0.1	% CaCO3	4.0						
Fizz Rating		0	Fizz Unit	2						
EA058: Emerson Aggregate Test										
Color (Munsell)		-	-	Dark Yellowish Brown (10YR 4/6)						
Texture		-	-	Clayey Sand						
Emerson Class Number	EC/TC	-	-	3						
EA150: Soil Classification - National Committee on Soil and Terrain (2009)										
Clay (<2 µm)		1	%	26						
Silt (2-20 µm)		1	%	10						
Fine Sand (0.02-0.2 mm)		1	%	51						
Coarse Sand (0.2-2.0 mm)		1	%	11						
Gravel (>2mm)		1	%	2						
EA152: Soil Particle Density										
Soil Particle Density (Clay/Silt/Sand)		0.01	g/cm3	2.40						
ED006: Exchangeable Cations on Alkaline Soils										
Ø Exchangeable Calcium		0.2	meq/100g	15.9						
Ø Exchangeable Magnesium		0.2	meq/100g	4.4						
Ø Exchangeable Potassium		0.2	meq/100g	0.2						
Ø Exchangeable Sodium		0.2	meq/100g	2.4						
Ø Cation Exchange Capacity		0.2	meq/100g	22.9						
Ø Exchangeable Sodium Percent		0.2	%	10.4						
Ø Calcium/Magnesium Ratio		0.2	-	3.6						
Ø Magnesium/Potassium Ratio		0.2	-	21.7						
ED042T: Total Sulfur by LECO										
Sulfur - Total as S (LECO)		0.01	%	<0.01						
ED045G: Chloride by Discrete Analyser										
Chloride	16887-00-6	10	mg/kg	20						



Environmental

QUALITY CONTROL REPORT

Work Order : **EB1913644**

Page : 1 of 6

Client	: SLR Consulting Australia Pty Ltd	Laboratory	: Environmental Division Brisbane
Contact	: CAMERON TRAILL	Contact	: Tyler Cachia
Address	:	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: ----	Telephone	: +61 2 8784 8555
Project	: 623.17171 Fairhill Coking Coal	Date Samples Received	: 28-May-2019
Order number	:	Date Analysis Commenced	: 29-May-2019
C-O-C number	: ----	Issue Date	: 07-Jun-2019
Sampler	: CAMERON TRAILL		
Site	: ----		
Quote number	: EN/032/18 Primary work only BQ		
No. of samples received	: 6		
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. 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
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Mark Hallas	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Mark Hallas	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Satishkumar Trivedi	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Satishkumar Trivedi	Senior Acid Sulfate Soil Chemist	Brisbane Inorganics, Stafford, QLD
Tom Maloney	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by 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

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 sample ID		Client sample ID	Method: Compound	CAS Number	Laboratory Duplicate (DUP) Report						
EA002: pH 1.5 (Soils) (QC Lot: 2374529)					LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)	
EB1913646-005	Anonymous		EA002: pH Value	---	0.1	pH Unit	8.6	8.6	0.00	0% - 20%	
EB1913644-001	PR02 / 0-0-0.1		EA002: pH Value	---	0.1	pH Unit	7.0	7.2	2.11	0% - 20%	
EA010: Conductivity (1:5) (QC Lot: 2374528)											
EB1913646-005	Anonymous		EA010: Electrical Conductivity @ 25°C	---	1	µS/cm	294	300	2.02	0% - 20%	
EB1913644-001	PR02 / 0-0-0.1		EA010: Electrical Conductivity @ 25°C	---	1	µS/cm	21	20	8.02	0% - 20%	
EA013: Acid Neutralising Capacity (QC Lot: 2390594)											
EB1913643-002	Anonymous		EA013: ANC as H2SO4	---	0.5	kg H2SO4 equiv./t	12.2	11.0	10.2	0% - 20%	
EB1913646-003	Anonymous		EA013: ANC as H2SO4	---	0.5	kg H2SO4 equiv./t	<0.5	<0.5	0.00	No Limit	
EA055: Moisture Content (Dried @ 105-110°C) (QC Lot: 2374534)											
EB1913644-001	PR02 / 0-0-0.1		EA055: Moisture Content	---	0.1	%	4.3	4.5	4.08	No Limit	
EB1913646-005	Anonymous		EA055: Moisture Content	---	0.1	%	5.6	5.7	0.00	0% - 20%	
ED006: Exchangeable Cations on Alkaline Soils (QC Lot: 2387764)											
EB1913643-002	Anonymous		ED006: Exchangeable Calcium	---	0.2	meq/100g	7.6	7.7	1.62	0% - 20%	
			ED006: Exchangeable Magnesium	---	0.2	meq/100g	5.3	5.4	2.71	0% - 20%	
			ED006: Exchangeable Potassium	---	0.2	meq/100g	0.2	0.2	0.00	No Limit	
			ED006: Exchangeable Sodium	---	0.2	meq/100g	3.7	4.2	13.0	0% - 20%	
			ED006: Cation Exchange Capacity	---	0.2	meq/100g	16.8	17.6	4.62	0% - 20%	
			ED006: Exchangeable Calcium	---	0.2	meq/100g	3.8	3.7	3.75	0% - 50%	
			ED006: Exchangeable Magnesium	---	0.2	meq/100g	3.9	3.8	4.62	0% - 50%	
			ED006: Exchangeable Potassium	---	0.2	meq/100g	0.4	0.2	51.0	No Limit	
			ED006: Exchangeable Sodium	---	0.2	meq/100g	3.7	3.7	0.00	0% - 50%	
			ED006: Cation Exchange Capacity	---	0.2	meq/100g	11.8	11.4	3.65	0% - 20%	



Sub-Matrix: SOIL				Laboratory Duplicate (DUP) Report						
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)	
EP004: Organic Matter (QC Lot: 2374836) - continued										
EB1913643-001	Anonymous	EP004: Organic Matter	----	0.5	%	3.8	3.9	4.41	No Limit	
		EP004: Total Organic Carbon	----	0.5	%	2.2	2.3	0.00	No Limit	
		EP004: Organic Matter	----	0.5	%	2.1	2.3	7.67	No Limit	
EB1913648-002	Anonymous	EP004: Total Organic Carbon	----	0.5	%	1.2	1.3	0.00	No Limit	



Sub-Matrix: SOIL

Sub-Matrix: SOIL				Method Blank (MB) Report		Laboratory Control Spike (LCS) Report			
Method: Compound	CAS Number	LOR	Unit	Result	Spike Concentration	Spike Recovery (%)	LCS	Low	High
EKO59G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 2374527) - continued									
EKO59G: Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	<0.1	2.5 mg/kg		103	89	155
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QCLot: 2374524)									
EK061G: Total Kjeldahl Nitrogen as N	----	20	mg/kg	<20 <20	848 mg/kg 3644 mg/kg		99.1 89.1	73 73	121 121
EK067G: Total Phosphorus as P by Discrete Analyser (QCLot: 2374525)									
EK067G: Total Phosphorus as P	----	2	mg/kg	<2 <2	939 mg/kg 1200 mg/kg		82.6 84.9	80 80	115 115
EK080: Bicarbonate Extractable Phosphorus (Colwell) (QCLot: 2374845)									
EK080: Bicarbonate Ext. P (Colwell)	----	5	mg/kg	<5 <5 <5	100 mg/kg 44.9 mg/kg 58.07 mg/kg		101 99.9 83.4	70 87 80	130 113 120
EP004: Organic Matter (QCLot: 2374836)									
EP004: Organic Matter	----	0.5	%	<0.5	80 %		86.9	83	115
EP004: Total Organic Carbon	----	0.5	%	<0.5	46.4 %		86.9	85	115

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: SOIL

Sub-Matrix: SOIL			Matrix Spike (MS) Report				
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Spike	SpikeRecovery(%)	Recovery Limits (%)	
				Concentration	MS	Low	High
EK057G: Nitrite as N by Discrete Analyser (QCLot: 2374526)							
EB1913644-002	PR02 / 0.1-0.2	EK057G: Nitrite as N (Sol.)	14797-65-0	2 mg/kg	82.7	70	130
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 2374527)							
EB1913644-002	PR02 / 0.1-0.2	EK059G: Nitrite + Nitrate as N (Sol.)	----	10 mg/kg	92.5	70	130
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QCLot: 2374524)							
EB1913644-002	PR02 / 0.1-0.2	EK061G: Total Kjeldahl Nitrogen as N	----	500 mg/kg	92.5	70	130
EK067G: Total Phosphorus as P by Discrete Analyser (QCLot: 2374525)							
EB1913644-002	PR02 / 0.1-0.2	EK067G: Total Phosphorus as P	----	100 mg/kg	# 58.8	70	130
EK080: Bicarbonate Extractable Phosphorus (Colwell) (QCLot: 2374845)							
EB1913643-002	Anonymous	EK080: Bicarbonate Ext. P (Colwell)	----	40 mg/kg	100	70	130
EP004: Organic Matter (QCLot: 2374836)							
EB1913643-002	Anonymous	EP004: Organic Matter	----	2 %	86.0	70	130
		EP004: Total Organic Carbon	----	1.16 %	86.2	70	130



Environmental

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: EB1913644	Page	: 1 of 8
Client	: SLR Consulting Australia Pty Ltd	Laboratory	: Environmental Division Brisbane
Contact	: CAMERON TRAILL	Telephone	: +61 2 8784 8555
Project	: 623.17171 Fairhill Coking Coal	Date Samples Received	: 28-May-2019
Site	: ----	Issue Date	: 07-Jun-2019
Sampler	: CAMERON TRAILL	No. of samples received	: 6
Order number	:	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 Laboratory Control outliers occur.
- Duplicate outliers exist - please see following pages for full details.
- Matrix Spike outliers exist - please see following pages for full details.
- 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

- NO Quality Control Sample Frequency Outliers exist.



Outliers : Quality Control Samples

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: **SOIL**

Compound Group Name	Laboratory Sample ID	Client Sample ID	Analyte	CAS Number	Data	Limits	Comment
Duplicate (DUP) RPDs							
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Ar	EB1913650-001	Anonymous	Nitrite + Nitrate as N (Sol.)	----	48.4 %	0% - 20%	RPD exceeds LOR based limits
Matrix Spike (MS) Recoveries							
EK067G: Total Phosphorus as P by Discrete Analyser	EB1913644-002	PR02 / 0.1-0.2	Total Phosphorus as P	----	58.8 %	70-130%	Recovery less than lower data quality objective

Outliers : Analysis Holding Time Compliance

Matrix: **SOIL**

Method	Container / Client Sample ID(s)	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Days overdue	Date analysed	Due for analysis	Days overdue
EP004: Organic Matter							
Snap Lock Bag							
PR02 / 0.0-0.1,		05-Jun-2019	30-May-2019	6	----	----	----
PR02 / 0.1-0.2							

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		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA002: pH 1.5 (Soils)							
Snap Lock Bag (EA002)							
PR02 / 0.0-0.1,	23-May-2019	30-May-2019	30-May-2019	✓	30-May-2019	30-May-2019	✓
PR02 / 0.3-0.4,							
PR02 / 0.8-0.9,							
EA010: Conductivity (1:5)							
Snap Lock Bag (EA010)							
PR02 / 0.0-0.1,	23-May-2019	30-May-2019	30-May-2019	✓	30-May-2019	27-Jun-2019	✓
PR02 / 0.3-0.4,							
PR02 / 0.8-0.9,							



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
EA013: Acid Neutralising Capacity							
Snap Lock Bag (EA013)							
PR02 / 0.1-0.2,	23-May-2019	06-Jun-2019	22-May-2020	✓	06-Jun-2019	03-Dec-2019	✓
PR02 / 0.5-0.6,							
PR02 / 1.1-1.2							
EA055: Moisture Content (Dried @ 105-110°C)							
Snap Lock Bag (EA055)							
PR02 / 0.0-0.1,	23-May-2019	-----	-----	-----	29-May-2019	06-Jun-2019	✓
EA058: Emerson Aggregate Test							
Snap Lock Bag (EA058)							
PR02 / 0.1-0.2,	23-May-2019	-----	-----	-----	04-Jun-2019	19-Nov-2019	✓
PR02 / 0.5-0.6,							
PR02 / 1.1-1.2							
EA150: Soil Classification - National Committee on Soil and Terrain (2009)							
Snap Lock Bag (EA150H)							
PR02 / 0.0-0.1,	23-May-2019	-----	-----	-----	06-Jun-2019	19-Nov-2019	✓
PR02 / 0.3-0.4,							
PR02 / 0.8-0.9,							
EA152: Soil Particle Density							
Snap Lock Bag (EA152)							
PR02 / 0.0-0.1,	23-May-2019	-----	-----	-----	06-Jun-2019	19-Nov-2019	✓
PR02 / 0.3-0.4,							
PR02 / 0.8-0.9,							
ED005: Exchange Acidity							
Snap Lock Bag (ED005)							
PR02 / 0.0-0.1,	23-May-2019	05-Jun-2019	20-Jun-2019	✓	06-Jun-2019	20-Jun-2019	✓
PR02 / 0.3-0.4,							
PR02 / 0.8-0.9,							
ED006: Exchangeable Cations on Alkaline Soils							
Snap Lock Bag (ED006)							
PR02 / 0.0-0.1,	23-May-2019	05-Jun-2019	20-Jun-2019	✓	06-Jun-2019	20-Jun-2019	✓
PR02 / 0.3-0.4,							
PR02 / 0.8-0.9,							
ED007: Exchangeable Cations							
Snap Lock Bag (ED007)							
PR02 / 0.0-0.1,	23-May-2019	05-Jun-2019	20-Jun-2019	✓	06-Jun-2019	20-Jun-2019	✓
PR02 / 0.3-0.4,							
PR02 / 0.8-0.9,							



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
ED008: Exchangeable Cations							
Snap Lock Bag (ED008)							
PR02 / 0.0-0.1,	23-May-2019	05-Jun-2019	20-Jun-2019	✔	06-Jun-2019	20-Jun-2019	✔
PR02 / 0.3-0.4,							
PR02 / 0.8-0.9,							
ED042T: Total Sulfur by LECO							
Pulp Bag (ED042T)							
PR02 / 0.0-0.1,	23-May-2019	05-Jun-2019	20-Jun-2019	✔	05-Jun-2019	20-Jun-2019	✔
PR02 / 0.3-0.4,							
PR02 / 0.8-0.9,							
ED045G: Chloride by Discrete Analyser							
Snap Lock Bag (ED045G)							
PR02 / 0.0-0.1,	23-May-2019	30-May-2019	20-Jun-2019	✔	31-May-2019	27-Jun-2019	✔
PR02 / 0.3-0.4,							
PR02 / 0.8-0.9,							
ED091 : Calcium Chloride Extractable Boron							
Snap Lock Bag (ED091)							
PR02 / 0.0-0.1,	23-May-2019	05-Jun-2019	19-Nov-2019	✔	06-Jun-2019	19-Nov-2019	✔
ED092: DTPA Extractable Metals							
Snap Lock Bag (ED092)							
PR02 / 0.0-0.1,	23-May-2019	05-Jun-2019	19-Nov-2019	✔	07-Jun-2019	19-Nov-2019	✔
EK057G: Nitrite as N by Discrete Analyser							
Snap Lock Bag (EK057G)							
PR02 / 0.0-0.1,	23-May-2019	30-May-2019	19-Nov-2019	✔	31-May-2019	19-Nov-2019	✔
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser							
Snap Lock Bag (EK059G)							
PR02 / 0.0-0.1,	23-May-2019	30-May-2019	19-Nov-2019	✔	31-May-2019	19-Nov-2019	✔
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser							
Snap Lock Bag (EK061G)							
PR02 / 0.0-0.1,	23-May-2019	29-May-2019	19-Nov-2019	✔	30-May-2019	19-Nov-2019	✔
EK067G: Total Phosphorus as P by Discrete Analyser							
Snap Lock Bag (EK067G)							
PR02 / 0.0-0.1,	23-May-2019	29-May-2019	19-Nov-2019	✔	30-May-2019	19-Nov-2019	✔
EK080: Bicarbonate Extractable Phosphorus (Colwell)							
Snap Lock Bag (EK080)							
PR02 / 0.0-0.1,	23-May-2019	06-Jun-2019	19-Nov-2019	✔	06-Jun-2019	19-Nov-2019	✔
EP004: Organic Matter							
Snap Lock Bag (EP004)							
PR02 / 0.0-0.1,	23-May-2019	05-Jun-2019	30-May-2019	✖	05-Jun-2019	03-Jul-2019	✔



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	Method	Count		Actual	Rate (%)		Evaluation	Quality Control Specification
Analytical Methods		QC	Regular		Expected			
Laboratory Duplicates (DUP)								
Acid Neutralising Capacity (ANC)	EA013	2	20	10.00	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Bicarbonate Extractable P (Colwell)	EK080	2	14	14.29	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Calcium Chloride Extractable Boron	ED091	2	14	14.29	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Chloride Soluble By Discrete Analyser	ED045G	2	20	10.00	10.00		✔	NEPM 2013 B3 & ALS QC Standard
DTPA Extractable Metals	ED092	2	14	14.29	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Electrical Conductivity (1:5)	EA010	2	20	10.00	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations	ED007	1	7	14.29	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations on Alkaline Soils	ED006	2	20	10.00	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Moisture Content	EA055	2	16	12.50	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NO _x -) Soluble by Discrete Analyser	EK059G	2	12	16.67	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Nitrite as N - Soluble by Discrete Analyser	EK057G	2	12	16.67	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Organic Matter	EP004	2	14	14.29	10.00		✔	NEPM 2013 B3 & ALS QC Standard
pH (1:5)	EA002	2	20	10.00	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Sulfur - Total as S (LECO)	ED042T	2	20	10.00	10.00		✔	NEPM 2013 B3 & ALS QC Standard
TKN as N By Discrete Analyser	EK061G	2	12	16.67	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus By Discrete Analyser	EK067G	2	12	16.67	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)								
Acid Neutralising Capacity (ANC)	EA013	1	20	5.00	5.00		✔	NEPM 2013 B3 & ALS QC Standard
Bicarbonate Extractable P (Colwell)	EK080	3	14	21.43	15.00		✔	NEPM 2013 B3 & ALS QC Standard
Calcium Chloride Extractable Boron	ED091	1	14	7.14	5.00		✔	NEPM 2013 B3 & ALS QC Standard
Chloride Soluble By Discrete Analyser	ED045G	2	20	10.00	10.00		✔	NEPM 2013 B3 & ALS QC Standard
DTPA Extractable Metals	ED092	1	14	7.14	5.00		✔	NEPM 2013 B3 & ALS QC Standard
Electrical Conductivity (1:5)	EA010	1	20	5.00	5.00		✔	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations	ED007	1	7	14.29	5.00		✔	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations on Alkaline Soils	ED006	1	20	5.00	5.00		✔	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NO _x -) Soluble by Discrete Analyser	EK059G	1	12	8.33	5.00		✔	NEPM 2013 B3 & ALS QC Standard
Nitrite as N - Soluble by Discrete Analyser	EK057G	1	12	8.33	5.00		✔	NEPM 2013 B3 & ALS QC Standard
Organic Matter	EP004	1	14	7.14	5.00		✔	NEPM 2013 B3 & ALS QC Standard
pH (1:5)	EA002	2	20	10.00	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Sulfur - Total as S (LECO)	ED042T	1	20	5.00	5.00		✔	NEPM 2013 B3 & ALS QC Standard
TKN as N By Discrete Analyser	EK061G	2	12	16.67	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus By Discrete Analyser	EK067G	2	12	16.67	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)								
Bicarbonate Extractable P (Colwell)	EK080	1	14	7.14	5.00		✔	NEPM 2013 B3 & ALS QC Standard



Matrix: SOIL

Evaluation: ✖ = Quality Control frequency not within specification ; ✔ = Quality Control frequency within specification.

Quality Control Sample Type	Count		Rate (%)		Quality Control Specification		
	QC	Reacular	Actual	Expected		Evaluation	
Analytical Methods							
Method Blanks (MB) - Continued							
Calcium Chloride Extractable Boron	ED091	1	14	7.14	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Chloride Soluble By Discrete Analyser	ED045G	1	20	5.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
DTPA Extractable Metals	ED092	1	14	7.14	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Electrical Conductivity (1:5)	EA010	1	20	5.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Exchangeable Catlions	ED007	1	7	14.29	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations on Alkaline Soils	ED006	1	20	5.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx)- Soluble by Discrete Analyser	EK059G	1	12	8.33	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Nitrite as N - Soluble by Discrete Analyser	EK057G	1	12	8.33	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Organic Matter	EP004	1	14	7.14	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Sulfur - Total as S (LECO)	ED042T	1	20	5.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
TKN as N By Discrete Analyser	EK061G	1	12	8.33	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus By Discrete Analyser	EK067G	1	12	8.33	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)							
Bicarbonate Extractable P (Colwell)	EK080	1	14	7.14	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx)- Soluble by Discrete Analyser	EK059G	1	12	8.33	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Nitrite as N - Soluble by Discrete Analyser	EK057G	1	12	8.33	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Organic Matter	EP004	1	14	7.14	5.00	✔	NEPM 2013 B3 & ALS QC Standard
TKN as N By Discrete Analyser	EK061G	1	12	8.33	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus By Discrete Analyser	EK067G	1	12	8.33	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 (1:5)	EA002	SOIL	In house: Referenced to Rayment and Lyons 4A1 and APHA 4500H+. pH is determined on soil samples after a 1:5 soil/water leach. This method is compliant with NEPM (2013) Schedule B(3)
Electrical Conductivity (1:5)	EA010	SOIL	In house: Referenced to Rayment and Lyons 3A1 and APHA 2510. Conductivity is determined on soil samples using a 1:5 soil/water leach. This method is compliant with NEPM (2013) Schedule B(3)
Acid Neutralising Capacity (ANC)	EA013	SOIL	In house: Referenced to USEPA 600/2-78-054, I. Miller (2000). A fizz test is done to semiquantitatively estimate the likely reactivity. The soil is then reacted with a known excess quantity of an appropriate acid. Titration determines the acid remaining, and the ANC can be calculated from comparison with a blank titration.
Moisture Content	EA055	SOIL	In house: A gravimetric procedure based on weight loss over a 12 hour drying period at 105-110 degrees C. This method is compliant with NEPM (2013) Schedule B(3) Section 7.1 and Table 1 (14 day holding time).
Emerson Aggregate Test	EA058	SOIL	In house: Referenced to AS1289.3.8.1. Testing is performed only on soils with suitable aggregates; sands and gravels are usually unsuitable for this test. The test classifies the behaviour of soil aggregates, when immersed, on their coherence in water.
Particle Size Analysis by Hydrometer	EA150H	SOIL	Particle Size Analysis by Hydrometer according to AS1289.3.6.3 - 2003
Soil Particle Density	EA152	SOIL	Soil Particle Density by AS 1289.3.5.1-2006. Methods of testing soils for engineering purposes - Soil classification tests - Determination of the soil particle density of a soil - Standard method
Exchange Acidity by 1M Potassium Chloride	* ED005	SOIL	In house: referenced to Rayment and Lyons. (2011), method 15G1. This method is unsuitable for near neutral and alkaline soils. NATA accreditation does not cover performance of this service.
Exchangeable Cations on Alkaline Soils	* ED006	SOIL	In house: Referenced to Soil Survey Test Method C5. Soluble salts are removed from the sample prior to analysis. Cations are exchanged from the sample by contact with alcoholic ammonium chloride at pH 8.5. They are then quantitated in the final solution by ICPAES and reported as meq/100g of original soil.
Exchangeable Cations	ED007	SOIL	In house: Referenced to Rayment & Lyons (2011) Method 15A1. Cations are exchanged from the sample by contact with Ammonium Chloride. They are then quantitated in the final solution by ICPAES and reported as meq/100g of original soil. This method is compliant with NEPM (2013) Schedule B(3) (Method 301)
Exchangeable Cations with pre-treatment	ED008	SOIL	In house: Referenced to Rayment & Higginson (2011) Method 15A2. Soluble salts are removed from the sample prior to analysis. Cations are exchanged from the sample by contact with Ammonium Chloride. They are then quantitated in the final solution by ICPAES and reported as meq/100g of original soil. This method is compliant with NEPM (2013) Schedule B(3) (Method 301)
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 SO ₂) is measured by infra-red detector
Chloride Soluble By Discrete Analyser	ED045G	SOIL	In house: Referenced to APHA 4500-Cl- E. 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 thiocyanate forms highly coloured ferric thiocyanate which is measured at 480 nm. Analysis is performed on a 1:5 soil / water leachate.
Calcium Chloride Extractable Boron	* ED091	SOIL	In house: Referenced to Rayment & Higginson (2011) method 12C2. Soil is extracted with hot 0.01M CaCl ₂ solution at a 1:2 ratio. Extracts can be run on ICP.
DTPA Extractable Metals	* ED092	SOIL	In house: Referenced to Rayment and Higginson (2011) 12A1

Analytical Methods		Method	Matrix	Method Descriptions
Nitrite as N - Soluble by Discrete Analyser	EK057G	SOIL	In house: Referenced to APHA 4500-NO3- B. Nitrite in a water extract is determined by direct colourimetry by Discrete Analyser.	
Nitrate as N - Soluble by Discrete Analyser	EK058G	SOIL	In house: Referenced to APHA 4500-NO3- F. Nitrate in the 1:5 soil:water extract is reduced to nitrite by way of a chemical reduction followed by quantification by Discrete Analyser. Nitrite is determined seperately by direct colourimetry and result for Nitrate calculated as the difference between the two results.	
Nitrite and Nitrate as N (NOx)- Soluble by Discrete Analyser	EK059G	SOIL	In house: Thermo Scientific Method D08727 and NEMI (National Environmental Method Index) Method ID: 9171. This method covers the determination of total oxidised nitrogen (NOx-N) and nitrate (NO3-N) by calculation, Combined oxidised Nitrogen (NO2+N03) in a water extract is determined by direct colourimetry by Discrete Analyser.	
TKN as N By Discrete Analyser	EK061G	SOIL	In house: Referenced to APHA 4500-Norg-D Soil samples are digested using Kjeldahl digestion followed by determination by Discrete Analyser.	
Total Nitrogen as N (TKN + NOx) By Discrete Analyser	EK062G	SOIL	In house: Referenced to APHA 4500 Norg/NO3- Total Nitrogen is determined as the sum of TKN and Oxidised Nitrogen, each determined seperately as N.	
Total Phosphorus By Discrete Analyser	EK067G	SOIL	In house: Referenced to APHA 4500 P-B&F This procedure involves sulfuric acid digestion and quantification using Discrete Analyser.	
Bicarbonate Extractable P (Colwell)	EK080	SOIL	In house: Referenced to Rayment & Higginson (2011) Method 9B1 Phosphorus is extracted from the soil using 0.5M NaHCO3 at a 1:100 soil:solution ratio and determined by FIA.	
Organic Matter	EP004	SOIL	In house: Referenced to AS1289.4.1.1 - 1997. Dichromate oxidation method after Walkley and Black. This method is compliant with NEPM (2013) Schedule B(3).	
Preparation Methods		Method	Matrix	Method Descriptions
Exchangeable Cations Preparation Method (Alkaline Soils)	ED006PR	SOIL	In house: Referenced to Rayment and Lyons 2011 method 15C1.	
Exchangeable Cations Preparation Method	ED007PR	SOIL	In house: Referenced to Rayment & Higginson (1992) method 15A1. A 1M NH4Cl extraction by end over end tumbling at a ratio of 1:20. There is no pretreatment for soluble salts. Extracts can be run by ICP for cations.	
Hot Water CaCl2 Extraction for Boron	ED091PR	SOIL	In house: Referenced to Rayment & Higginson (1992) method 12C2. Soil is extracted with hot 0.01M CaCl2 solution at a 1:2 ratio. Extracts can be run on ICP.	
DTPA Extraction for Cu, Zn, Mn, Fe (2 hour leach)	ED092PR	SOIL	In house: Referenced to Rayment & Higginson (1992) Method 12A1 2 hour end over end tumbler extraction with 0.005M DTPA at a ratio of 1:2. Extracts can be run by ICP for metals.	
TKN/TP Digestion	EK061/EK067	SOIL	In house: Referenced to APHA 4500 Norg- D; APHA 4500 P - H. Macro Kjeldahl digestion.	
Sample Preparation for Bicarbonate Extractable P (Colwell)	EK080-PR	SOIL	In house: Referenced to Rayment & Higginson (2011) Method 9B1 Phosphorus is extracted from the soil using 0.5M NaHCO3 at a 1:100 soil:solution ratio.	
Drying at 85 degrees, bagging and labelling (ASS)	EN020PR	SOIL	In house	
1:5 solid / water leach for soluble analyes	EN34	SOIL	10 g of soil is mixed with 50 mL of reagent grade water and tumbled end over end for 1 hour. Water soluble salts are leached from the soil by the continuous suspension. Samples are settled and the water filtered off for analysis.	
Organic Matter	EP004-PR	SOIL	In house: Referenced to AS1289.4.1.1 - 1997. Dichromate oxidation method after Walkley and Black. This method is compliant with NEPM (2013) Schedule B(3) (Method 105)	
Dry and Pulverise (up to 100g)	GEO30	SOIL	#	



CHAIN OF CUSTODY

ALS Laboratory please refer to

CANLAB 21 Burns Road, Burnside SA 5066
Ph: 08 8359 9800 E: als@canlab.com.au
CHRISBANE 2 BPA Street, Sturt SA 5043
Ph: 07 3243 7221 E: als@canlab.com.au
C/OA/ADDITIONAL 46 Colman Road, Burnside SA 5066
Ph: 07 3243 7221 E: als@canlab.com.au

UNIVERSITY 78 Nelson Road, Mount Dromedary QLD 4202
Ph: 07 4641 177 E: als@canlab.com.au
DUNBOURNE 24 West Road, Sturt SA 5043
Ph: 08 8359 9800 E: als@canlab.com.au
C/OA/ADDITIONAL 46 Colman Road, Burnside SA 5066
Ph: 07 3243 7221 E: als@canlab.com.au

CHRONICLE 277-289 Macquarie Road, Sydney NSW 2154
Ph: 02 6754 6556 E: als@canlab.com.au
DUNBOURNE 24 West Road, Sturt SA 5043
Ph: 08 8359 9800 E: als@canlab.com.au
C/OA/ADDITIONAL 46 Colman Road, Burnside SA 5066
Ph: 07 3243 7221 E: als@canlab.com.au

CHRONICLE 277-289 Macquarie Road, Sydney NSW 2154
Ph: 02 6754 6556 E: als@canlab.com.au
DUNBOURNE 24 West Road, Sturt SA 5043
Ph: 08 8359 9800 E: als@canlab.com.au
C/OA/ADDITIONAL 46 Colman Road, Burnside SA 5066
Ph: 07 3243 7221 E: als@canlab.com.au

CLIENT SITE CONSULTING

OFFICE: 15 Astor Terrace, Spring Hill, QLD 4000

PROJECT: Fairhill Coking Coal PROJECT NO.: 633.17171

ORDER NUMBER: PURCHASE ORDER NO.: CONTRACT PH: 0429 110 256

PROJECT MANAGER: Damien Taylor COUNTRY OF ORIGIN: Australia

SAMPLER: Cameron Trail SAMPLER MOBILE: 0437 588 619

COC: Email to ALS? (YES / NO) YES EDO FORMAT (or default):

Email Reports to (will default to PM if no other addresses are listed): chall@alsconsulting.com

Email Invoice to (will default to PM if no other addresses are listed): maylor@alsconsulting.com

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

TURNOVER REQUIREMENTS:

(Standard 1A) may be longer for some tests e.g. Urea ☒ Standard 1A (1st due date)

(Fast Turn) - no storage for CEC check

FOR LABORATORY USE ONLY (CHECK)

Custody Seal intact? Yes No N/A

Free for frozen ice bricks present upon receipt? Yes No N/A

Random Sample Temperature on Receipt: °C

RECEIVED BY: DATE/TIME: 28/5/14 9:00

RECEIVED BY: DATE/TIME:

ALS USE ONLY

SAMPLE DETAILS MATRIX: Solid(s) Water(s)

LAB ID SAMPLE ID DATE / TIME MATRIX

1 PR11 / 0.0-0.1 23/05/2019 / 10:00am S

2 PR11 / 0.1-0.2 23/05/2019 / 10:00am S

3 PR11 / 0.2-0.3 23/05/2019 / 10:00am S

4 PR11 / 0.5-0.6 23/05/2019 / 10:00am S

5 PR11 / 0.8-0.9 23/05/2019 / 10:00am S

6 PR11 / 1.1-1.2 23/05/2019 / 10:00am S

TOTAL 2 2 2 2 2 2 2 2 2 2 2 2

TYPE & PRESERVATIVE (refer to codes below)

TOTAL BOTTLES

Nitrogen, nitrite, nitrate, NOx, total Kjeldahl nitrogen (TKN) as N and Total N (ALS code NT-65)

Bicarbonate extractable P (Colwell) and Total P (ALS code EK080/EK067)

Organic Carbon (Calc from Organic Matter) - Walkley Black (ALS code EP004)

Boron - CaCl2 Extractable (ALS code ED091)

DTPA Extractable micronutrients (Cu, Fe, Mn, Zn) (ALS code ED092)

pH Plus EC (1:5 soil/water leach) (ALS code IN-4S)

Cl- (1:5) Soluble (ALS code ED045G)

Exch Cations and CEC or ECCE (ALS code ED006 (alkaline soils) or ED007 (no pre-wash) or ED008 (pre-wash))

Sulfur - Total as S (LECO) (ALS code ED042T)

Carbonate - ANC (ALS code ED013)

PSD - Hydrometer for ranges <2µm, 2-20µm, 20-200µm, 0.2-2.0mm (ALS code EA150-H-Y)

Emerson Dispersion (ALS code EA058)

HOLD

Additional Information

Comments on field, laboratory, or sample, including specific OC analysis etc.

Water Container Codes: P = Unpreserved Plastic, N = Nitric Preserved Plastic, ORC = Sodium Hydroxide Preserved Plastic, SH = Sodium Hydroxide Preserved Plastic, AG = Amber Glass Unpreserved, AP = Amber Glass Unpreserved Plastic

V = VOA With HCl Preserved, VS = VOA With Sodium Borohydride Preserved, VSS = VOA With Sodium Borohydride Preserved, VSS = VOA With Sodium Borohydride Preserved, VSS = VOA With Sodium Borohydride Preserved, VSS = VOA With Sodium Borohydride Preserved

E = Extra Preserved Bottle, ST = Stone Bottle, ASS = Plastic Bag for Acid Soluble Solids, B = Unpreserved Bottle, L = Liquid Bottle Preserved, BOTTLE ST = Stone Bottle, L = Liquid Bottle Preserved, BOTTLE ST = Stone Bottle, L = Liquid Bottle Preserved

2 = Zinc Acetate Preserved Bottle, E = Extra Preserved Bottle, ST = Stone Bottle, ASS = Plastic Bag for Acid Soluble Solids, B = Unpreserved Bottle, L = Liquid Bottle Preserved, BOTTLE ST = Stone Bottle, L = Liquid Bottle Preserved

2 = Zinc Acetate Preserved Bottle, E = Extra Preserved Bottle, ST = Stone Bottle, ASS = Plastic Bag for Acid Soluble Solids, B = Unpreserved Bottle, L = Liquid Bottle Preserved, BOTTLE ST = Stone Bottle, L = Liquid Bottle Preserved

Environmental Division
Brisbane
Work Order Reference
EB1913643



Telephone : +61-7-3243 7222



Environmental

SAMPLE RECEIPT NOTIFICATION (SRN)

Work Order : **EB1913643**

Client : **SLR Consulting Australia Pty Ltd**
Contact : **CAMERON TRAILL**
Address :

Laboratory : **Environmental Division Brisbane**
Contact : **Tyler Cachia**
Address : **2 Byth Street Stafford QLD Australia 4053**

E-mail : **ctrail@slrconsulting.com**
Telephone : **----**
Facsimile : **----**

E-mail : **Tyler.Cachia@ALSGlobal.com**
Telephone : **+61 2 8784 8555**
Facsimile : **+61-7-3243 7218**

Project : **623.17171 Fairhill Coking Coal**
Order number :

Page : **1 of 3**
Quote number : **EM2018HEGAUS0001 (EN/032/18**
Primary work only BQ)

C-O-C number : **----** QC Level : **NEPM 2013 B3 & ALS QC Standard**
Site : **----**
Sampler : **CAMERON TRAILL**

Dates

Date Samples Received : **28-May-2019 09:00** Issue Date : **29-May-2019**
Client Requested Due : **07-Jun-2019** Scheduled Reporting Date : **07-Jun-2019**
Date

Delivery Details

Mode of Delivery : **Carrier** Security Seal : **Intact.**
No. of coolers/boxes : **1** Temperature : **17.8°C**
Receipt Detail : **MEDIUM ESKY** No. of samples received / analysed : **6 / 6**

General Comments

- This report contains the following information:
 - Sample Container(s)/Preservation Non-Compliances
 - Summary of Sample(s) and Requested Analysis
 - Proactive Holding Time Report
 - Requested Deliverables
- Please be advised that ALS is unable to accommodate the fast turnaround requested on the Chain of Custody. If you wish to discuss this further, please contact Client Services at ALSEnviro.Brisbane@alsglobal.com**
 - Discounted Package Prices apply only when specific ALS Group Codes ('W', 'S', 'NT' suites) are referenced on COCs.
 - Please direct any turn around / technical queries to the laboratory contact designated above.
 - Sample Disposal - Aqueous (3 weeks), Solid (2 months ± 1 week) from receipt of samples.
 - Analysis will be conducted by ALS Environmental, Brisbane, NATA accreditation no. 825, Site No. 818 (Micro site no. 18956).
- Breaches in recommended extraction / analysis holding times (if any) are displayed overleaf in the Proactive Holding Time Report table.**
- Please be aware that APHA/NEPM recommends water and soil samples be chilled to less than or equal to 6°C for chemical analysis, and less than or equal to 10°C but unfrozen for Microbiological analysis. Where samples are received above this temperature, it should be taken into consideration when interpreting results. Refer to ALS EnviroMail 85 for ALS recommendations of the best practice for chilling samples after sampling and for maintaining a cool temperature during transit.



Sample Container(s)/Preservation Non-Compliances

All comparisons are made against pretreatment/preservation AS, APHA, USEPA standards.

- No sample container / preservation non-compliance exists.

Summary of Sample(s) and Requested Analysis

Some items described below may be part of a laboratory process necessary for the execution of client requested tasks. Packages may contain additional analyses, such as the determination of moisture content and preparation tasks, that are included in the package.

If no sampling time is provided, the sampling time will default 00:00 on the date of sampling. If no sampling date is provided, the sampling date will be assumed by the laboratory and displayed in brackets without a time component

Matrix: **SOIL**

Laboratory sample ID	Client sampling date / time	Client sample ID	
EB1913643-001	23-May-2019 10:00	PR11 / 0.0-0.1	✓
EB1913643-002	23-May-2019 10:00	PR11 / 0.1-0.2	✓
EB1913643-003	23-May-2019 10:00	PR11 / 0.2-0.3	✓
EB1913643-004	23-May-2019 10:00	PR11 / 0.5-0.6	✓
EB1913643-005	23-May-2019 10:00	PR11 / 0.8-0.9	✓
EB1913643-006	23-May-2019 10:00	PR11 / 1.1-1.2	✓

SOIL - AG-1 EB Only Agricultural Soil Suite 1 EB Only	✓
SOIL - EA055-103 Moisture Content	✓
SOIL - ED045G (solids) Chloride Soluble by Discrete Analyser	✓
SOIL - EK067G (Solids) Total Phosphorus as P by Discrete Analyser	✓
SOIL - EK080 Bicarbonate Extractable P (Colwell)	✓
SOIL - EP004 (Carbon) Organic Matter & Total Organic Carbon (Calc.)	✓
SOIL - NT-6S Nitrogen, TKN, NO2, NO3	✓

Matrix: **SOIL**

Laboratory sample ID	Client sampling date / time	Client sample ID					
EB1913643-001	23-May-2019 10:00	PR11 / 0.0-0.1		✓	✓	✓	✓
EB1913643-002	23-May-2019 10:00	PR11 / 0.1-0.2	✓	✓	✓	✓	✓
EB1913643-003	23-May-2019 10:00	PR11 / 0.2-0.3	✓	✓	✓	✓	✓
EB1913643-004	23-May-2019 10:00	PR11 / 0.5-0.6	✓	✓	✓	✓	✓
EB1913643-005	23-May-2019 10:00	PR11 / 0.8-0.9	✓	✓	✓	✓	✓
EB1913643-006	23-May-2019 10:00	PR11 / 1.1-1.2	✓	✓	✓	✓	✓

SOIL - EA013 Acid Neutralising Capacity (ANC)	✓
SOIL - EA058 Emerson Aggregate Test	✓
SOIL - EA150H-Y Particle Size Analysis by Hydrometer: Yellow	✓
SOIL - ED042T Sulfur - Total as S (high temperature furnace)	✓
SOIL - ED091 Calcium Chloride Extractable Boron	✓
SOIL - ED092 DTPA Extractable Metals	✓

Proactive Holding Time Report

Sample(s) have been received within the recommended holding times for the requested analysis.



Requested Deliverables

ACCOUNTS PAYABLE AU

- A4 - AU Tax Invoice (INV)

Email accountspayableau@slrconsulting.com

CAMERON TRAILL

- *AU Certificate of Analysis - NATA (COA)
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep) (QCI)
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA (QC)
- A4 - AU Sample Receipt Notification - Environmental HT (SRN)
- A4 - AU Tax Invoice (INV)
- Attachment - Report (SUBCO)
- Chain of Custody (CoC) (COC)
- EDI Format - ENMRG (ENMRG)
- EDI Format - ESDAT (ESDAT)

Email ctraill@slrconsulting.com
Email ctraill@slrconsulting.com
Email ctraill@slrconsulting.com
Email ctraill@slrconsulting.com
Email ctraill@slrconsulting.com
Email ctraill@slrconsulting.com
Email ctraill@slrconsulting.com
Email ctraill@slrconsulting.com
Email ctraill@slrconsulting.com

D TAYLOR

- A4 - AU Tax Invoice (INV)

Email dtaylor@slrconsulting.com



Environmental

CERTIFICATE OF ANALYSIS

Work Order

: **EB1913643**

Client

: **SLR Consulting Australia Pty Ltd**

Contact

: CAMERON TRAILL

Address

:

Telephone

: ----

Project

: 623.17171 Fairhill Coking Coal

Order number

:

C-O-C number

: ----

Sampler

: CAMERON TRAILL

Site

: ----

Quote number

: EN/032/18 Primary work only BQ

No. of samples received

: 6

No. of samples analysed

: 6

Page

: 1 of 6

Laboratory

: Environmental Division Brisbane

Contact

: Tyler Cachia

Address

: 2 Byth Street Stafford QLD Australia 4053

Telephone

: +61 2 8784 8555

Date Samples Received

: 28-May-2019 09:00

Date Analysis Commenced

: 29-May-2019

Issue Date

: 07-Jun-2019 19:10



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. 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

Andrew Epps	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Mark Hallas	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Mark Hallas	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Satishkumar Trivedi	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Satishkumar Trivedi	Senior Acid Sulfate Soil Chemist	Brisbane Inorganics, Stafford, QLD
Tom Maloney	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by 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 Contact 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.

- ALS is not NATA accredited for the analysis of Exchangeable Aluminium and Exchange Acidity in soils when performed under ALS Method ED005.
- ALS is not NATA accredited for the analysis of Exchangeable Cations on Alkaline Soils when performed under ALS Method ED006.
- EK061G (Total Kjeldahl Nitrogen as N) / EK067G (Total Phosphorous as P); Sample EB1913643_002 shows poor spike recovery due to sample heterogeneity. This has been confirmed by visual inspection.
- ASS: EA013 (ANC) Fizz Rating: 0- None; 1- Slight; 2- Moderate; 3- Strong; 4- Very Strong; 5- Lime.
- EA058 Emerson: V. = Very, D. = Dark, L. = Light, VD. = Very Dark
- ED007 and ED008: When Exchangeable Al is reported from these methods, it should be noted that Rayment & Lyons (2011) suggests Exchange Acidity by 1M KCl - Method 15G1 (ED005) is a more suitable method for the determination of exchange acidity (H+ + Al3+).



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)		Client sample ID		PR11 / 0.0-0.1	PR11 / 0.1-0.2	PR11 / 0.2-0.3	PR11 / 0.5-0.6	PR11 / 0.8-0.9
Client sampling date / time				23-May-2019 10:00	23-May-2019 10:00	23-May-2019 10:00	23-May-2019 10:00	23-May-2019 10:00
Compound	CAS Number	LOR	Unit	EB1913643-001	EB1913643-002	EB1913643-003	EB1913643-004	EB1913643-005
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	7.1	8.9	9.6	9.6	9.7
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	39	149	661	1330	1340
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	-----	12.2	18.2	35.5	31.8
ANC as CaCO3	----	0.1	% CaCO3	-----	1.2	1.8	3.6	3.2
Fizz Rating	----	0	Fizz Unit	-----	1	1	2	2
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	2.4	7.5	-----	-----	-----
EA058: Emerson Aggregate Test								
Color (Munsell)	----	-	-	-----	Very Dark Gray (10YR 3/1)	Very Dark Grayish Brown (2.5Y 3/2)	Brown (7.5YR 5/3)	Brown (7.5YR 5/4)
Texture	----	-	-	-----	Light Clay	Medium Clay	Sandy Clay	Medium Clay
Emerson Class Number	EC/TC	-	-	-----	2	2	2	2
EA150: Soil Classification - National Committee on Soil and Terrain (2009)								
Clay (<2 µm)	----	1	%	20	40	36	35	35
Silt (2-20 µm)	----	1	%	14	14	13	12	14
Fine Sand (0.02-0.2 mm)	----	1	%	41	28	32	29	30
Coarse Sand (0.2-2.0 mm)	----	1	%	25	18	19	21	17
Gravel (>2mm)	----	1	%	<1	<1	<1	3	4
EA152: Soil Particle Density								
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	2.25	2.24	2.40	2.52	2.44
ED006: Exchangeable Cations on Alkaline Soils								
Ø Exchangeable Calcium	----	0.2	meq/100g	-----	7.6	4.7	1.8	2.1
Ø Exchangeable Magnesium	----	0.2	meq/100g	-----	5.3	5.6	4.7	5.0
Ø Exchangeable Potassium	----	0.2	meq/100g	-----	0.2	0.2	0.3	0.4
Ø Exchangeable Sodium	----	0.2	meq/100g	-----	3.7	6.5	9.3	9.7
Ø Cation Exchange Capacity	----	0.2	meq/100g	-----	16.8	17.0	16.2	17.2
Ø Exchangeable Sodium Percent	----	0.2	%	-----	22.2	38.2	57.6	56.3
Ø Calcium/Magnesium Ratio	----	0.2	-	-----	1.4	0.8	0.4	0.4
Ø Magnesium/Potassium Ratio	----	0.2	-	-----	21.4	24.3	16.7	12.8
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	7.1	----	-----	-----	-----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)		Client sample ID		PR11 / 0.0-0.1	PR11 / 0.1-0.2	PR11 / 0.2-0.3	PR11 / 0.5-0.6	PR11 / 0.8-0.9
Client sampling date / time				23-May-2019 10:00	23-May-2019 10:00	23-May-2019 10:00	23-May-2019 10:00	23-May-2019 10:00
Compound	CAS Number	LOR	Unit	EB1913643-001	EB1913643-002	EB1913643-003	EB1913643-004	EB1913643-005
				Result	Result	Result	Result	Result
ED007: Exchangeable Cations - Continued								
Exchangeable Magnesium	-----	0.1	meq/100g	3.1	-----	-----	-----	-----
Exchangeable Potassium	-----	0.1	meq/100g	0.4	-----	-----	-----	-----
Exchangeable Sodium	-----	0.1	meq/100g	1.0	-----	-----	-----	-----
Cation Exchange Capacity	-----	0.1	meq/100g	11.6	-----	-----	-----	-----
Exchangeable Sodium Percent	-----	0.1	%	8.9	-----	-----	-----	-----
Calcium/Magnesium Ratio	-----	0.1	-	2.3	-----	-----	-----	-----
Magnesium/Potassium Ratio	-----	0.1	-	8.3	-----	-----	-----	-----
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	-----	0.01	%	0.02	0.02	0.02	0.03	0.03
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	20	110	560	1680	1700
ED091 : Calcium Chloride Extractable Boron								
Ø Boron	7440-42-8	0.2	mg/kg	<0.2	0.4	-----	-----	-----
ED092: DTPA Extractable Metals								
Ø Copper	7440-50-8	1.00	mg/kg	<1.00	1.02	-----	-----	-----
Ø Iron	7439-89-6	1.00	mg/kg	54.0	17.0	-----	-----	-----
Ø Manganese	7439-96-5	1.00	mg/kg	12.4	9.35	-----	-----	-----
Ø Zinc	7440-66-6	1.00	mg/kg	<1.00	<1.00	-----	-----	-----
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N (Sol.)	14797-65-0	0.1	mg/kg	0.4	<0.1	-----	-----	-----
EK058G: Nitrate as N by Discrete Analyser								
Nitrate as N (Sol.)	14797-55-8	0.1	mg/kg	0.3	0.1	-----	-----	-----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N (Sol.)	-----	0.1	mg/kg	0.7	0.1	-----	-----	-----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	-----	20	mg/kg	1040	840	-----	-----	-----
EK062: Total Nitrogen as N (TKN + NOx)								
^ Total Nitrogen as N	-----	20	mg/kg	1040	840	-----	-----	-----
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	-----	2	mg/kg	332	248	-----	-----	-----
EK080: Bicarbonate Extractable Phosphorus (Colwell)								
Bicarbonate Ext. P (Colwell)	-----	5	mg/kg	26	<5	-----	-----	-----
EP004: Organic Matter								



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)		Client sample ID		PR11 / 0.0-0.1	PR11 / 0.1-0.2	PR11 / 0.2-0.3	PR11 / 0.5-0.6	PR11 / 0.8-0.9
		Client sampling date / time		23-May-2019 10:00	23-May-2019 10:00	23-May-2019 10:00	23-May-2019 10:00	23-May-2019 10:00
Compound	CAS Number	LOR	Unit	EB1913643-001	EB1913643-002	EB1913643-003	EB1913643-004	EB1913643-005
				Result	Result	Result	Result	Result
EP004: Organic Matter - Continued								
Organic Matter	---	0.5	%	3.8	2.0	-----	-----	-----
Total Organic Carbon	---	0.5	%	2.2	1.2	-----	-----	-----



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)		Client sample ID			PR11 / 1.1-1.2																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
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Environmental

QUALITY CONTROL REPORT

Work Order : **EB1913643**

Page : 1 of 6

Client	: SLR Consulting Australia Pty Ltd	Laboratory	: Environmental Division Brisbane
Contact	: CAMERON TRAILL	Contact	: Tyler Cachia
Address	:	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: ----	Telephone	: +61 2 8784 8555
Project	: 623.17171 Fairhill Coking Coal	Date Samples Received	: 28-May-2019
Order number	:	Date Analysis Commenced	: 29-May-2019
C-O-C number	: ----	Issue Date	: 07-Jun-2019
Sampler	: CAMERON TRAILL		
Site	: ----		
Quote number	: EN/032/18 Primary work only BQ		
No. of samples received	: 6		
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. 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
Andrew Epps	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Ben Fejendrejers	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Mark Hallas	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Mark Hallas	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Satishkumar Trivedi	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Satishkumar Trivedi	Senior Acid Sulfate Soil Chemist	Brisbane Inorganics, Stafford, QLD
Tom Maloney	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD



Sub-Matrix: **SOIL**

Sub-Matrix: SOIL			Laboratory Duplicate (DUP) Report						
Laboratory sample ID	Client sample ID	Method/Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
ED007: Exchangeable Cations (QC Lot: 2387754) - continued									
EB1913643-001	PR11 / 0.0-0.1	ED007: Exchangeable Calcium	----	0.1	meq/100g	7.1	6.8	4.18	0% - 20%
		ED007: Exchangeable Magnesium	----	0.1	meq/100g	3.1	3.0	3.45	0% - 20%
		ED007: Exchangeable Potassium	----	0.1	meq/100g	0.4	0.4	0.00	No Limit
		ED007: Exchangeable Sodium	----	0.1	meq/100g	1.0	1.0	0.00	0% - 50%
ED042T: Total Sulfur by LECO (QC Lot: 2387690)									
EB1913643-001	PR11 / 0.0-0.1	ED042T: Sulfur - Total as S (LECO)	----	0.01	%	0.02	<0.01	0.00	No Limit
EB1913644-004	Anonymous	ED042T: Sulfur - Total as S (LECO)	----	0.01	%	0.02	0.02	0.00	No Limit
ED045G: Chloride by Discrete Analyser (QC Lot: 2374513)									
EB1913643-005	PR11 / 0.8-0.9	ED045G: Chloride	16887-00-6	10	mg/kg	1700	1690	0.00	0% - 20%
EB1913617-001	Anonymous	ED045G: Chloride	16887-00-6	10	mg/kg	<10	<10	0.00	No Limit
ED091 : Calcium Chloride Extractable Boron (QC Lot: 2374841)									
EB1913643-001	PR11 / 0.0-0.1	ED091: Boron	7440-42-8	0.2	mg/kg	<0.2	<0.2	0.00	No Limit
EB1913649-002	Anonymous	ED091: Boron	7440-42-8	0.2	mg/kg	<0.2	<0.2	0.00	No Limit
ED092: DTPA Extractable Metals (QC Lot: 2374844)									
EB1913643-001	PR11 / 0.0-0.1	ED092: Copper	7440-50-8	1	mg/kg	<1.00	<1.00	0.00	No Limit
		ED092: Iron	7439-89-6	1	mg/kg	54.0	52.4	3.07	0% - 20%
		ED092: Manganese	7439-96-5	1	mg/kg	12.4	11.9	4.42	0% - 50%
		ED092: Zinc	7440-66-6	1	mg/kg	<1.00	<1.00	0.00	No Limit
EB1913649-001	Anonymous	ED092: Copper	7440-50-8	1	mg/kg	1.74	1.76	1.08	No Limit
		ED092: Iron	7439-89-6	1	mg/kg	44.7	45.2	1.06	0% - 20%
		ED092: Manganese	7439-96-5	1	mg/kg	30.9	32.4	4.80	0% - 20%
		ED092: Zinc	7440-66-6	1	mg/kg	<1.00	<1.00	0.00	No Limit
EK057G: Nitrite as N by Discrete Analyser (QC Lot: 2374514)									
EB1913632-001	Anonymous	EK057G: Nitrite as N (Sol.)	14797-65-0	0.1	mg/kg	0.2	0.2	0.00	No Limit
EK059G : Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QC Lot: 2374515)									
EB1913632-001	Anonymous	EK059G: Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	28.4	29.4	3.33	0% - 20%
EK061G : Total Kjeldahl Nitrogen By Discrete Analyser (QC Lot: 2374521)									
EB1913643-001	PR11 / 0.0-0.1	EK061G: Total Kjeldahl Nitrogen as N	----	20	mg/kg	1040	1120	7.40	0% - 20%
EK067G: Total Phosphorus as P by Discrete Analyser (QC Lot: 2374522)									
EB1913643-001	PR11 / 0.0-0.1	EK067G: Total Phosphorus as P	----	2	mg/kg	332	376	12.6	0% - 20%
EK080: Bicarbonate Extractable Phosphorus (Colwell) (QC Lot: 2374845)									
EB1913643-001	PR11 / 0.0-0.1	EK080: Bicarbonate Ext. P (Colwell)	----	5	mg/kg	26	26	0.00	No Limit
EB1913649-001	Anonymous	EK080: Bicarbonate Ext. P (Colwell)	----	5	mg/kg	9	8	13.2	No Limit
EP004: Organic Matter (QC Lot: 2374836)									
EB1913643-001	PR11 / 0.0-0.1	EP004: Organic Matter	----	0.5	%	3.8	3.9	4.41	No Limit
EB1913648-002	Anonymous	EP004: Total Organic Carbon	----	0.5	%	2.2	2.3	0.00	No Limit
		EP004: Organic Matter	----	0.5	%	2.1	2.3	7.67	No Limit
		EP004: Total Organic Carbon	----	0.5	%	1.2	1.3	0.00	No Limit



Sub-Matrix: **SOIL**

Sub-Matrix: SOIL				Method Blank (MB) Report		Laboratory Control Spike (LCS) Report			
Method: Compound	CAS Number	LOR	Unit	Result	Spike Concentration	Spike Recovery (%)	Low	High	
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 2374515) - continued									
EK059G: Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	<0.1	2.5 mg/kg	91.8	89	155	
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QCLot: 2374521)									
EK061G: Total Kjeldahl Nitrogen as N	----	20	mg/kg	<20 <20	848 mg/kg 3644 mg/kg	108 94.3	73 73	121 121	
EK067G: Total Phosphorus as P by Discrete Analyser (QCLot: 2374522)									
EK067G: Total Phosphorus as P	----	2	mg/kg	<2 <2	939 mg/kg 1200 mg/kg	93.2 102	80 80	115 115	
EK080: Bicarbonate Extractable Phosphorus (Colwell) (QCLot: 2374845)									
EK080: Bicarbonate Ext. P (Colwell)	----	5	mg/kg	<5 <5 <5	100 mg/kg 44.9 mg/kg 58.07 mg/kg	101 99.9 83.4	70 87 80	130 113 120	
EP004: Organic Matter (QCLot: 2374836)									
EP004: Organic Matter	----	0.5	%	<0.5	80 %	86.9	83	115	
EP004: Total Organic Carbon	----	0.5	%	<0.5	46.4 %	86.9	85	115	

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: **SOIL**

Sub-Matrix: SOIL				Matrix Spike (MS) Report						
Laboratory sample ID		Client sample ID		Method: Compound		CAS Number	Spike Concentration	SpikeRecovery(%) MS	Recovery Limits (%) LowHigh	
EK057G: Nitrite as N by Discrete Analyser (QCLot: 2374514)										
EB1913643-001		PR11 / 0.0-0.1		EK057G: Nitrite as N (Sol.)		14797-65-0	2 mg/kg	88.3	70	130
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 2374515)										
EB1913643-001		PR11 / 0.0-0.1		EK059G: Nitrite + Nitrate as N (Sol.)		---	2 mg/kg	81.0	70	130
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QCLot: 2374521)										
EB1913643-002		PR11 / 0.1-0.2		EK061G: Total Kjeldahl Nitrogen as N		---	500 mg/kg	# Not Determined	70	130
EK067G: Total Phosphorus as P by Discrete Analyser (QCLot: 2374522)										
EB1913643-002		PR11 / 0.1-0.2		EK067G: Total Phosphorus as P		---	100 mg/kg	# 58.5	70	130
EK080: Bicarbonate Extractable Phosphorus (Colwell) (QCLot: 2374845)										
EB1913643-002		PR11 / 0.1-0.2		EK080: Bicarbonate Ext. P (Colwell)		---	40 mg/kg	100	70	130
EP004: Organic Matter (QCLot: 2374836)										
EB1913643-002		PR11 / 0.1-0.2		EP004: Organic Matter		---	2 %	86.0	70	130
				EP004: Total Organic Carbon		---	1.16 %	86.2	70	130





QA/QC Compliance Assessment to assist with Quality Review

Work Order	: EB1913643	Page	: 1 of 9
Client	: SLR Consulting Australia Pty Ltd	Laboratory	: Environmental Division Brisbane
Contact	: CAMERON TRAILL	Telephone	: +61 2 8784 8555
Project	: 623.17171 Fairhill Coking Coal	Date Samples Received	: 28-May-2019
Site	: ----	Issue Date	: 07-Jun-2019
Sampler	: CAMERON TRAILL	No. of samples received	: 6
Order number	:	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.
- Matrix Spike outliers exist - please see following pages for full details.
- 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

- NO Quality Control Sample Frequency Outliers exist.



Matrix: **SOIL**

Evaluation: **x** = 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
EA010: Conductivity (1:5)							
Snap Lock Bag (EA010)							
PR11 / 0.0-0.1,	23-May-2019	31-May-2019	30-May-2019	✖	31-May-2019	28-Jun-2019	✔
PR11 / 0.2-0.3,							
PR11 / 0.8-0.9,							
EA013: Acid Neutralising Capacity							
Snap Lock Bag (EA013)							
PR11 / 0.1-0.2,	23-May-2019	06-Jun-2019	22-May-2020	✔	06-Jun-2019	03-Dec-2019	✔
PR11 / 0.5-0.6,							
PR11 / 1.1-1.2							
EA055: Moisture Content (Dried @ 105-110°C)							
Snap Lock Bag (EA055)							
PR11 / 0.0-0.1,	23-May-2019	-----	-----	-----	29-May-2019	06-Jun-2019	✔
EA058: Emerson Aggregate Test							
Snap Lock Bag (EA058)							
PR11 / 0.1-0.2,	23-May-2019	-----	-----	-----	04-Jun-2019	19-Nov-2019	✔
PR11 / 0.5-0.6,							
PR11 / 1.1-1.2							
EA150: Soil Classification - National Committee on Soil and Terrain (2009)							
Snap Lock Bag (EA150H)							
PR11 / 0.0-0.1,	23-May-2019	-----	-----	-----	04-Jun-2019	19-Nov-2019	✔
PR11 / 0.2-0.3,							
PR11 / 0.8-0.9,							
EA152: Soil Particle Density							
Snap Lock Bag (EA152)							
PR11 / 0.0-0.1,	23-May-2019	-----	-----	-----	04-Jun-2019	19-Nov-2019	✔
PR11 / 0.2-0.3,							
PR11 / 0.8-0.9,							
ED005: Exchange Acidity							
Snap Lock Bag (ED005)							
PR11 / 0.0-0.1,	23-May-2019	05-Jun-2019	20-Jun-2019	✔	06-Jun-2019	20-Jun-2019	✔
PR11 / 0.2-0.3,							
PR11 / 0.8-0.9,							
ED006: Exchangeable Cations on Alkaline Soils							
Snap Lock Bag (ED006)							
PR11 / 0.0-0.1,	23-May-2019	05-Jun-2019	20-Jun-2019	✔	06-Jun-2019	20-Jun-2019	✔
PR11 / 0.2-0.3,							
PR11 / 0.8-0.9,							



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
ED007: Exchangeable Cations							
Snap Lock Bag (ED007) PR11 / 0.0-0.1, PR11 / 0.2-0.3, PR11 / 0.8-0.9,	23-May-2019	05-Jun-2019	20-Jun-2019	✓	06-Jun-2019	20-Jun-2019	✓
ED008: Exchangeable Cations							
Snap Lock Bag (ED008) PR11 / 0.0-0.1, PR11 / 0.2-0.3, PR11 / 0.8-0.9,	23-May-2019	05-Jun-2019	20-Jun-2019	✓	06-Jun-2019	20-Jun-2019	✓
ED042T: Total Sulfur by LECO							
Pulp Bag (ED042T) PR11 / 0.0-0.1, PR11 / 0.2-0.3, PR11 / 0.8-0.9,	23-May-2019	05-Jun-2019	20-Jun-2019	✓	05-Jun-2019	20-Jun-2019	✓
ED045G: Chloride by Discrete Analyser							
Snap Lock Bag (ED045G) PR11 / 0.0-0.1, PR11 / 0.2-0.3, PR11 / 0.8-0.9,	23-May-2019	31-May-2019	20-Jun-2019	✓	31-May-2019	28-Jun-2019	✓
ED091 : Calcium Chloride Extractable Boron							
Snap Lock Bag (ED091) PR11 / 0.0-0.1,	23-May-2019	05-Jun-2019	19-Nov-2019	✓	06-Jun-2019	19-Nov-2019	✓
ED092: DTPA Extractable Metals							
Snap Lock Bag (ED092) PR11 / 0.0-0.1,	23-May-2019	05-Jun-2019	19-Nov-2019	✓	07-Jun-2019	19-Nov-2019	✓
EK057G: Nitrite as N by Discrete Analyser							
Snap Lock Bag (EK057G) PR11 / 0.0-0.1,	23-May-2019	31-May-2019	19-Nov-2019	✓	31-May-2019	19-Nov-2019	✓
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser							
Snap Lock Bag (EK059G) PR11 / 0.0-0.1,	23-May-2019	31-May-2019	19-Nov-2019	✓	31-May-2019	19-Nov-2019	✓
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser							
Snap Lock Bag (EK061G) PR11 / 0.0-0.1,	23-May-2019	30-May-2019	19-Nov-2019	✓	30-May-2019	19-Nov-2019	✓
EK067G: Total Phosphorus as P by Discrete Analyser							
Snap Lock Bag (EK067G) PR11 / 0.0-0.1,	23-May-2019	30-May-2019	19-Nov-2019	✓	30-May-2019	19-Nov-2019	✓
EK080: Bicarbonate Extractable Phosphorus (Colwell)							
Snap Lock Bag (EK080) PR11 / 0.0-0.1,	23-May-2019	06-Jun-2019	19-Nov-2019	✓	06-Jun-2019	19-Nov-2019	✓



Matrix: **SOIL**

Evaluation: **x** = 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	
EP004: Organic Matter							
Snap Lock Bag (EP004)							
PR11 / 0.0-0.1,							
PR11 / 0.1-0.2	23-May-2019	05-Jun-2019	30-May-2019	✗	05-Jun-2019	03-Jul-2019	✓



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	Method	Count		Actual	Rate (%)		Evaluation	Quality Control Specification
Analytical Methods		QC	Regular		Expected			
Laboratory Duplicates (DUP)								
Acid Neutralising Capacity (ANC)	EA013	2	20	10.00	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Bicarbonate Extractable P (Colwell)	EK080	2	14	14.29	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Calcium Chloride Extractable Boron	ED091	2	14	14.29	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Chloride Soluble By Discrete Analyser	ED045G	2	12	16.67	10.00		✔	NEPM 2013 B3 & ALS QC Standard
DTPA Extractable Metals	ED092	2	14	14.29	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Electrical Conductivity (1:5)	EA010	1	10	10.00	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations	ED007	1	7	14.29	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations on Alkaline Soils	ED006	2	20	10.00	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Moisture Content	EA055	2	9	22.22	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NO _x -) Soluble by Discrete Analyser	EK059G	1	3	33.33	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Nitrite as N - Soluble by Discrete Analyser	EK057G	1	3	33.33	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Organic Matter	EP004	2	14	14.29	10.00		✔	NEPM 2013 B3 & ALS QC Standard
pH (1:5)	EA002	2	17	11.76	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Sulfur - Total as S (LECO)	ED042T	2	20	10.00	10.00		✔	NEPM 2013 B3 & ALS QC Standard
TKN as N By Discrete Analyser	EK061G	1	2	50.00	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus By Discrete Analyser	EK067G	1	2	50.00	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)								
Acid Neutralising Capacity (ANC)	EA013	1	20	5.00	5.00		✔	NEPM 2013 B3 & ALS QC Standard
Bicarbonate Extractable P (Colwell)	EK080	3	14	21.43	15.00		✔	NEPM 2013 B3 & ALS QC Standard
Calcium Chloride Extractable Boron	ED091	1	14	7.14	5.00		✔	NEPM 2013 B3 & ALS QC Standard
Chloride Soluble By Discrete Analyser	ED045G	2	12	16.67	10.00		✔	NEPM 2013 B3 & ALS QC Standard
DTPA Extractable Metals	ED092	1	14	7.14	5.00		✔	NEPM 2013 B3 & ALS QC Standard
Electrical Conductivity (1:5)	EA010	1	10	10.00	5.00		✔	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations	ED007	1	7	14.29	5.00		✔	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations on Alkaline Soils	ED006	1	20	5.00	5.00		✔	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NO _x -) Soluble by Discrete Analyser	EK059G	1	3	33.33	5.00		✔	NEPM 2013 B3 & ALS QC Standard
Nitrite as N - Soluble by Discrete Analyser	EK057G	1	3	33.33	5.00		✔	NEPM 2013 B3 & ALS QC Standard
Organic Matter	EP004	1	14	7.14	5.00		✔	NEPM 2013 B3 & ALS QC Standard
pH (1:5)	EA002	2	17	11.76	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Sulfur - Total as S (LECO)	ED042T	1	20	5.00	5.00		✔	NEPM 2013 B3 & ALS QC Standard
TKN as N By Discrete Analyser	EK061G	2	2	100.00	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus By Discrete Analyser	EK067G	2	2	100.00	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)								
Bicarbonate Extractable P (Colwell)	EK080	1	14	7.14	5.00		✔	NEPM 2013 B3 & ALS QC Standard



Matrix: SOIL

Evaluation: ✖ = Quality Control frequency not within specification ; ✔ = Quality Control frequency within specification.

Quality Control Sample Type	Count		Rate (%)		Quality Control Specification		
	QC	Reacular	Actual	Expected			
Analytical Methods							
Method Blanks (MB) - Continued							
Calcium Chloride Extractable Boron	ED091	1	14	7.14	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Chloride Soluble By Discrete Analyser	ED045G	1	12	8.33	5.00	✔	NEPM 2013 B3 & ALS QC Standard
DTPA Extractable Metals	ED092	1	14	7.14	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Electrical Conductivity (1:5)	EA010	1	10	10.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Exchangeable Catlons	ED007	1	7	14.29	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations on Alkaline Soils	ED006	1	20	5.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx)- Soluble by Discrete Analyser	EK059G	1	3	33.33	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Nitrite as N - Soluble by Discrete Analyser	EK057G	1	3	33.33	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Organic Matter	EP004	1	14	7.14	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Sulfur - Total as S (LECO)	ED042T	1	20	5.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
TKN as N By Discrete Analyser	EK061G	1	2	50.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus By Discrete Analyser	EK067G	1	2	50.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)							
Bicarbonate Extractable P (Colwell)	EK080	1	14	7.14	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx)- Soluble by Discrete Analyser	EK059G	1	3	33.33	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Nitrite as N - Soluble by Discrete Analyser	EK057G	1	3	33.33	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Organic Matter	EP004	1	14	7.14	5.00	✔	NEPM 2013 B3 & ALS QC Standard
TKN as N By Discrete Analyser	EK061G	1	2	50.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus By Discrete Analyser	EK067G	1	2	50.00	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 (1:5)	EA002	SOIL	In house: Referenced to Rayment and Lyons 4A1 and APHA 4500H+. pH is determined on soil samples after a 1:5 soil/water leach. This method is compliant with NEPM (2013) Schedule B(3)
Electrical Conductivity (1:5)	EA010	SOIL	In house: Referenced to Rayment and Lyons 3A1 and APHA 2510. Conductivity is determined on soil samples using a 1:5 soil/water leach. This method is compliant with NEPM (2013) Schedule B(3)
Acid Neutralising Capacity (ANC)	EA013	SOIL	In house: Referenced to USEPA 600/2-78-054, I. Miller (2000). A fizz test is done to semiquantitatively estimate the likely reactivity. The soil is then reacted with an known excess quantity of an appropriate acid. Titration determines the acid remaining, and the ANC can be calculated from comparison with a blank titration.
Moisture Content	EA055	SOIL	In house: A gravimetric procedure based on weight loss over a 12 hour drying period at 105-110 degrees C. This method is compliant with NEPM (2013) Schedule B(3) Section 7.1 and Table 1 (14 day holding time).
Emerson Aggregate Test	EA058	SOIL	In house: Referenced to AS1289.3.8.1. Testing is performed only on soils with suitable aggregates; sands and gravels are usually unsuitable for this test. The test classifies the behaviour of soil aggregates, when immersed, on their coherence in water.
Particle Size Analysis by Hydrometer	EA150H	SOIL	Particle Size Analysis by Hydrometer according to AS1289.3.6.3 - 2003
Soil Particle Density	EA152	SOIL	Soil Particle Density by AS 1289.3.5.1-2006. Methods of testing soils for engineering purposes - Soil classification tests - Determination of the soil particle density of a soil - Standard method
Exchange Acidity by 1M Potassium Chloride	* ED005	SOIL	In house: referenced to Rayment and Lyons. (2011), method 15G1. This method is unsuitable for near neutral and alkaline soils. NATA accreditation does not cover performance of this service.
Exchangeable Cations on Alkaline Soils	* ED006	SOIL	In house: Referenced to Soil Survey Test Method C5. Soluble salts are removed from the sample prior to analysis. Cations are exchanged from the sample by contact with alcoholic ammonium chloride at pH 8.5. They are then quantitated in the final solution by ICPAES and reported as meq/100g of original soil.
Exchangeable Cations	ED007	SOIL	In house: Referenced to Rayment & Lyons (2011) Method 15A1. Cations are exchanged from the sample by contact with Ammonium Chloride. They are then quantitated in the final solution by ICPAES and reported as meq/100g of original soil. This method is compliant with NEPM (2013) Schedule B(3) (Method 301)
Exchangeable Cations with pre-treatment	ED008	SOIL	In house: Referenced to Rayment & Higginson (2011) Method 15A2. Soluble salts are removed from the sample prior to analysis. Cations are exchanged from the sample by contact with Ammonium Chloride. They are then quantitated in the final solution by ICPAES and reported as meq/100g of original soil. This method is compliant with NEPM (2013) Schedule B(3) (Method 301)
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 SO ₂) is measured by infra-red detector
Chloride Soluble By Discrete Analyser	ED045G	SOIL	In house: Referenced to APHA 4500-Cl- E. 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 thiocyanate forms highly coloured ferric thiocyanate which is measured at 480 nm. Analysis is performed on a 1:5 soil / water leachate.
Calcium Chloride Extractable Boron	* ED091	SOIL	In house: Referenced to Rayment & Higginson (2011) method 12C2. Soil is extracted with hot 0.01M CaCl ₂ solution at a 1:2 ratio. Extracts can be run on ICP.
DTPA Extractable Metals	* ED092	SOIL	In house: Referenced to Rayment and Higginson (2011) 12A1

Analytical Methods		Method	Matrix	Method Descriptions
Nitrite as N - Soluble by Discrete Analyser	EK057G	SOIL	In house: Referenced to APHA 4500-NO3- B. Nitrite in a water extract is determined by direct colourimetry by Discrete Analyser.	
Nitrate as N - Soluble by Discrete Analyser	EK058G	SOIL	In house: Referenced to APHA 4500-NO3- F. Nitrate in the 1:5 soil:water extract is reduced to nitrite by way of a chemical reduction followed by quantification by Discrete Analyser. Nitrite is determined seperately by direct colourimetry and result for Nitrate calculated as the difference between the two results.	
Nitrite and Nitrate as N (NOx)- Soluble by Discrete Analyser	EK059G	SOIL	In house: Thermo Scientific Method D08727 and NEMI (National Environmental Method Index) Method ID: 91771. This method covers the determination of total oxidised nitrogen (NOx-N) and nitrate (NO3-N) by calculation, Combined oxidised Nitrogen (NO2+NO3) in a water extract is determined by direct colourimetry by Discrete Analyser.	
TKN as N By Discrete Analyser	EK061G	SOIL	In house: Referenced to APHA 4500-Norg-D Soil samples are digested using Kjeldahl digestion followed by determination by Discrete Analyser.	
Total Nitrogen as N (TKN + NOx) By Discrete Analyser	EK062G	SOIL	In house: Referenced to APHA 4500 Norg/NO3- Total Nitrogen is determined as the sum of TKN and Oxidised Nitrogen, each determined seperately as N.	
Total Phosphorus By Discrete Analyser	EK067G	SOIL	In house: Referenced to APHA 4500 P-B&F This procedure involves sulfuric acid digestion and quantification using Discrete Analyser.	
Bicarbonate Extractable P (Colwell)	EK080	SOIL	In house: Referenced to Rayment & Higginson (2011) Method 9B1 Phosphorus is extracted from the soil using 0.5M NaHCO3 at a 1:100 soil:solution ratio and determined by FLA.	
Organic Matter	EP004	SOIL	In house: Referenced to AS1289.4.1.1 - 1997. Dichromate oxidation method after Walkley and Black. This method is compliant with NEPM (2013) Schedule B(3).	
Preparation Methods		Method	Matrix	Method Descriptions
Exchangeable Cations Preparation Method (Alkaline Soils)	ED006PR	SOIL	In house: Referenced to Rayment and Lyons 2011 method 15C1.	
Exchangeable Cations Preparation Method	ED007PR	SOIL	In house: Referenced to Rayment & Higginson (1992) method 15A1. A 1M NH4Cl extraction by end over end tumbling at a ratio of 1:20. There is no pretreatment for soluble salts. Extracts can be run by ICP for cations.	
Hot Water CaCl2 Extraction for Boron	ED091PR	SOIL	In house: Referenced to Rayment & Higginson (1992) method 12C2. Soil is extracted with hot 0.01M CaCl2 solution at a 1:2 ratio. Extracts can be run on ICP.	
DTPA Extraction for Cu, Zn, Mn, Fe (2 hour leach)	ED092PR	SOIL	In house: Referenced to Rayment & Higginson (1992) Method 12A1 2 hour end over end tumbler extraction with 0.005M DTPA at a ratio of 1:2. Extracts can be run by ICP for metals.	
TKN/TP Digestion	EK061/EK067	SOIL	In house: Referenced to APHA 4500 Norg- D; APHA 4500 P - H. Macro Kjeldahl digestion.	
Sample Preparation for Bicarbonate Extractable P (Colwell)	EK080-PR	SOIL	In house: Referenced to Rayment & Higginson (2011) Method 9B1 Phosphorus is extracted from the soil using 0.5M NaHCO3 at a 1:100 soil:solution ratio.	
Drying at 85 degrees, bagging and labelling (ASS)	EN020PR	SOIL	In house	
1:5 solid / water leach for soluble analytes	EN34	SOIL	10 g of soil is mixed with 50 mL of reagent grade water and tumbled end over end for 1 hour. Water soluble salts are leached from the soil by the continuous suspension. Samples are settled and the water filtered off for analysis.	
Organic Matter	EP004-PR	SOIL	In house: Referenced to AS1289.4.1.1 - 1997. Dichromate oxidation method after Walkley and Black. This method is compliant with NEPM (2013) Schedule B(3) (Method 105)	
Dry and Pulverise (up to 100g)	GEO30	SOIL	#	



Environmental

SAMPLE RECEIPT NOTIFICATION (SRN)

Work Order : **EB1913646**

Client : **SLR Consulting Australia Pty Ltd**
Contact : **CAMERON TRAILL**
Address :

Laboratory : **Environmental Division Brisbane**
Contact : **Tyler Cachia**
Address : **2 Byth Street Stafford QLD Australia 4053**

E-mail : **ctrail@slrconsulting.com**
Telephone : **----**
Facsimile : **----**

E-mail : **Tyler.Cachia@ALSGlobal.com**
Telephone : **+61 2 8784 8555**
Facsimile : **+61-7-3243 7218**

Project : **623.17171 Fairhill Coking Coal**
Order number :

Page : **1 of 3**
Quote number : **EM2018HEGAUS0001 (EN/032/18**
Primary work only BQ)

C-O-C number : **----** QC Level : **NEPM 2013 B3 & ALS QC Standard**
Site : **----**
Sampler : **CAMERON TRAILL**

Dates

Date Samples Received : **28-May-2019 09:00** Issue Date : **28-May-2019**
Client Requested Due : **07-Jun-2019** Scheduled Reporting Date : **07-Jun-2019**
Date

Delivery Details

Mode of Delivery : **Carrier** Security Seal : **Intact.**
No. of coolers/boxes : **1** Temperature : **19.5°C**
Receipt Detail : **Medium Esky** No. of samples received / analysed : **5 / 5**

General Comments

- This report contains the following information:
 - Sample Container(s)/Preservation Non-Compliances
 - Summary of Sample(s) and Requested Analysis
 - Proactive Holding Time Report
 - Requested Deliverables
- Please be advised that ALS is unable to accommodate the fast turnaround requested on the Chain of Custody. If you wish to discuss this further, please contact Client Services at ALSEnviro.Brisbane@alsglobal.com.**
 - Discounted Package Prices apply only when specific ALS Group Codes ('W', 'S', 'NT' suites) are referenced on COCs.
 - Please direct any turn around / technical queries to the laboratory contact designated above.
 - Sample Disposal - Aqueous (3 weeks), Solid (2 months ± 1 week) from receipt of samples.
 - Analysis will be conducted by ALS Environmental, Brisbane, NATA accreditation no. 825, Site No. 818 (Micro site no. 18956).
- Breaches in recommended extraction / analysis holding times (if any) are displayed overleaf in the Proactive Holding Time Report table.**
 - Please be aware that APHA/NEPM recommends water and soil samples be chilled to less than or equal to 6°C for chemical analysis, and less than or equal to 10°C but unfrozen for Microbiological analysis. Where samples are received above this temperature, it should be taken into consideration when interpreting results. Refer to ALS EnviroMail 85 for ALS recommendations of the best practice for chilling samples after sampling and for maintaining a cool temperature during transit.



Sample Container(s)/Preservation Non-Compliances

All comparisons are made against pretreatment/preservation AS, APHA, USEPA standards.

- No sample container / preservation non-compliance exists.

Summary of Sample(s) and Requested Analysis

Some items described below may be part of a laboratory process necessary for the execution of client requested tasks. Packages may contain additional analyses, such as the determination of moisture content and preparation tasks, that are included in the package.

If no sampling time is provided, the sampling time will default 00:00 on the date of sampling. If no sampling date is provided, the sampling date will be assumed by the laboratory and displayed in brackets without a time component

Matrix: **SOIL**

Laboratory sample ID	Client sampling date / time	Client sample ID	SOIL - AG-1 EB Only Agricultural Soil Suite 1 EB Only	SOIL - EA055-103 Moisture Content	SOIL - ED091 Calcium Chloride Extractable Boron	SOIL - EK067G (Solids) Total Phosphorus as P by Discrete Analyser	SOIL - EK080 Bicarbonate Extractable P (Colwell)	SOIL - EP004 (Carbon) Organic Matter & Total Organic Carbon (Calc.)	SOIL - NT-6S Nitrogen, TKN, NO2, NO3
EB1913646-001	25-May-2019 08:30	OB30 / 0.0-0.1	✓	✓	✓	✓	✓	✓	✓
EB1913646-002	25-May-2019 08:30	OB30 / 0.1-0.2	✓	✓	✓	✓	✓	✓	✓
EB1913646-003	25-May-2019 08:30	OB30 / 0.2-0.3	✓	✓					
EB1913646-004	25-May-2019 08:30	OB30 / 0.4-0.5	✓	✓					
EB1913646-005	25-May-2019 08:30	OB30 / 0.5-0.6	✓	✓					

Matrix: **SOIL**

Laboratory sample ID	Client sampling date / time	Client sample ID	SOIL - EA013 Acid Neutralising Capacity (ANC)	SOIL - EA058 Emerson Aggregate Test	SOIL - EA150H-Y Particle Size Analysis by Hydrometer: Yellow	SOIL - ED042T Sulfur - Total as S (high temperature furnace)	SOIL - ED045G (solids) Chloride Soluble by Discrete Analyser	SOIL - ED092 DTPA Extractable Metals
EB1913646-001	25-May-2019 08:30	OB30 / 0.0-0.1			✓	✓	✓	✓
EB1913646-002	25-May-2019 08:30	OB30 / 0.1-0.2	✓	✓	✓	✓	✓	✓
EB1913646-003	25-May-2019 08:30	OB30 / 0.2-0.3	✓	✓	✓	✓	✓	
EB1913646-004	25-May-2019 08:30	OB30 / 0.4-0.5	✓	✓	✓	✓	✓	
EB1913646-005	25-May-2019 08:30	OB30 / 0.5-0.6	✓	✓	✓	✓	✓	

Proactive Holding Time Report

Sample(s) have been received within the recommended holding times for the requested analysis.



Requested Deliverables

ACCOUNTS PAYABLE AU	
- A4 - AU Tax Invoice (INV)	Email
	accounts payable@slrconsulting.com
CAMERON TRAILL	
- *AU Certificate of Analysis - NATA (COA)	Email
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep) (QCI)	Email
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA (QC)	Email
- A4 - AU Sample Receipt Notification - Environmental HT (SRN)	Email
- A4 - AU Tax Invoice (INV)	Email
- Chain of Custody (CoC) (COC)	Email
- EDI Format - ENMRG (ENMRG)	Email
- EDI Format - ESDAT (ESDAT)	Email
D TAYLOR	
- A4 - AU Tax Invoice (INV)	Email
	dtaylor@slrconsulting.com



Environmental

CERTIFICATE OF ANALYSIS

Work Order

: **EB1913646**

Client

: **SLR Consulting Australia Pty Ltd**

Contact

: **CAMERON TRAILL**

Address

:

Telephone

: ----

Project

: **623.17171 Fairhill Coking Coal**

Order number

:

C-O-C number

: ----

Sampler

: **CAMERON TRAILL**

Site

: ----

Quote number

: **EN/032/18 Primary work only BQ**

No. of samples received

: **5**

No. of samples analysed

: **5**

Page

: **1 of 5**

Laboratory

: **Environmental Division Brisbane**

Contact

: **Tyler Cachia**

Address

: **2 Byth Street Stafford QLD Australia 4053**

Telephone

: **+61 2 8784 8555**

Date Samples Received

: **28-May-2019 09:00**

Date Analysis Commenced

: **29-May-2019**

Issue Date

: **07-Jun-2019 18:59**

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. 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
Ben Felgendreijens	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Mark Hallas	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Mark Hallas	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Satishkumar Trivedi	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Satishkumar Trivedi	Senior Acid Sulfate Soil Chemist	Brisbane Inorganics, Stafford, QLD
Tom Maloney	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by 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 Contact 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.

- ALS is not NATA accredited for the analysis of Exchangeable Aluminium and Exchange Acidity in soils when performed under ALS Method ED005.
- ALS is not NATA accredited for the analysis of Exchangeable Cations on Alkaline Soils when performed under ALS Method ED006.
- EK067G (Total Phosphorus as P): Poor matrix spike recovery for sample EB1913644_002 due to sample heterogeneity. Confirmed by visual analysis.
- EK059G (Nitrite and Nitrate as N): Sample EB1913650_001 shows poor duplicate results due to sample heterogeneity. Confirmed by visual analysis.
- ASS: EA013 (ANC) Fizz Rating: 0- None; 1- Slight; 2- Moderate; 3- Strong; 4- Very Strong; 5- Lime.
- EA058 Emerson: V. = Very, D. = Dark, L. = Light, VD. = Very Dark
- ED007 and ED008: When Exchangeable Al is reported from these methods, it should be noted that Rayment & Lyons (2011) suggests Exchange Acidity by 1M KCl - Method 15G1 (ED005) is a more suitable method for the determination of exchange acidity (H+ + Al3+).



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)		Client sample ID		OB30 / 0.0-0.1	OB30 / 0.1-0.2	OB30 / 0.2-0.3	OB30 / 0.4-0.5	OB30 / 0.5-0.6
		Client sampling date / time		25-May-2019 08:30	25-May-2019 08:30	25-May-2019 08:30	25-May-2019 08:30	25-May-2019 08:30
Compound	CAS Number	LOR	Unit	EB1913646-001	EB1913646-002	EB1913646-003	EB1913646-004	EB1913646-005
				Result	Result	Result	Result	Result
ED007: Exchangeable Cations - Continued								
Exchangeable Calcium	0.1	meq/100g	2.8	2.6	1.7	-----	-----	-----
Exchangeable Magnesium	0.1	meq/100g	1.2	1.3	1.2	-----	-----	-----
Exchangeable Potassium	0.1	meq/100g	0.4	0.3	0.1	-----	-----	-----
Exchangeable Sodium	0.1	meq/100g	<0.1	0.1	0.4	-----	-----	-----
Cation Exchange Capacity	0.1	meq/100g	4.5	4.4	3.5	-----	-----	-----
Exchangeable Sodium Percent	0.1	%	1.3	2.3	13.4	-----	-----	-----
Calcium/Magnesium Ratio	0.1	-	2.3	2.0	1.4	-----	-----	-----
Magnesium/Potassium Ratio	0.1	-	2.8	4.4	8.8	-----	-----	-----
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	0.01	%	0.02	0.02	<0.01	<0.01	0.02	
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	10	<10	20	150	360
ED091 : Calcium Chloride Extractable Boron								
Ø Boron	7440-42-8	0.2	mg/kg	<0.2	<0.2	-----	-----	-----
ED092: DTPA Extractable Metals								
Ø Copper	7440-50-8	1.00	mg/kg	<1.00	<1.00	-----	-----	-----
Ø Iron	7439-89-6	1.00	mg/kg	39.2	37.3	-----	-----	-----
Ø Manganese	7439-96-5	1.00	mg/kg	24.5	17.5	-----	-----	-----
Ø Zinc	7440-66-6	1.00	mg/kg	<1.00	<1.00	-----	-----	-----
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N (Sol.)	14797-65-0	0.1	mg/kg	0.2	0.1	-----	-----	-----
EK058G: Nitrate as N by Discrete Analyser								
Nitrate as N (Sol.)	14797-55-8	0.1	mg/kg	0.6	0.2	-----	-----	-----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N (Sol.)	0.1	mg/kg	0.8	0.3	-----	-----	-----	-----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	20	mg/kg	750	490	-----	-----	-----	-----
EK062: Total Nitrogen as N (TKN + NOx)								
^ Total Nitrogen as N	20	mg/kg	750	490	-----	-----	-----	-----
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	2	mg/kg	214	401	-----	-----	-----	-----
EK080: Bicarbonate Extractable Phosphorus (Colwell)								
Bicarbonate Ext. P (Colwell)	5	mg/kg	28	<5	-----	-----	-----	-----



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)		Client sample ID		OB30 / 0.0-0.1	OB30 / 0.1-0.2	OB30 / 0.2-0.3	OB30 / 0.4-0.5	OB30 / 0.5-0.6
		Client sampling date / time		25-May-2019 08:30	25-May-2019 08:30	25-May-2019 08:30	25-May-2019 08:30	25-May-2019 08:30
Compound	CAS Number	LOR	Unit	EB1913646-001	EB1913646-002	EB1913646-003	EB1913646-004	EB1913646-005
				Result	Result	Result	Result	Result
EP004: Organic Matter								
Organic Matter	----	0.5	%	1.8	1.1	-----	-----	-----
Total Organic Carbon	-----	0.5	%	1.0	0.6	-----	-----	-----



Environmental

QUALITY CONTROL REPORT

Work Order : **EB1913646**

Page : 1 of 6

Client	: SLR Consulting Australia Pty Ltd	Laboratory	: Environmental Division Brisbane
Contact	: CAMERON TRAILL	Contact	: Tyler Cachia
Address	:	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: -----	Telephone	: +61 2 8784 8555
Project	: 623.17171 Fairhill Coking Coal	Date Samples Received	: 28-May-2019
Order number	:	Date Analysis Commenced	: 29-May-2019
C-O-C number	: -----	Issue Date	: 07-Jun-2019
Sampler	: CAMERON TRAILL		
Site	: -----		
Quote number	: EN/032/18 Primary work only BQ		
No. of samples received	: 5		
No. of samples analysed	: 5		



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. 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
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Mark Hallas	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Mark Hallas	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Satishkumar Trivedi	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Satishkumar Trivedi	Senior Acid Sulfate Soil Chemist	Brisbane Inorganics, Stafford, QLD
Tom Maloney	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by 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

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**

Sub-Matrix: SOIL				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EA002: pH 1:5 (Soils) (QC Lot: 2374529)									
EB1913646-005	OB30 / 0.5-0.6	EA002: pH Value	----	0.1	pH Unit	8.6	8.6	0.00	0% - 20%
EB1913644-001	Anonymous	EA002: pH Value	----	0.1	pH Unit	7.0	7.2	2.11	0% - 20%
EA010: Conductivity (1:5) (QC Lot: 2374528)									
EB1913646-005	OB30 / 0.5-0.6	EA010: Electrical Conductivity @ 25°C	----	1	µS/cm	294	300	2.02	0% - 20%
EB1913644-001	Anonymous	EA010: Electrical Conductivity @ 25°C	----	1	µS/cm	21	20	8.02	0% - 20%
EA013: Acid Neutralising Capacity (QC Lot: 2390594)									
EB1913643-002	Anonymous	EA013: ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	12.2	11.0	10.2	0% - 20%
EB1913646-003	OB30 / 0.2-0.3	EA013: ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	<0.5	<0.5	0.00	No Limit
EA055: Moisture Content (Dried @ 105-110°C) (QC Lot: 2374534)									
EB1913644-001	Anonymous	EA055: Moisture Content	----	0.1	%	4.3	4.5	4.08	No Limit
EB1913646-005	OB30 / 0.5-0.6	EA055: Moisture Content	----	0.1	%	5.6	5.7	0.00	0% - 20%
ED006: Exchangeable Cations on Alkaline Soils (QC Lot: 2387764)									
EB1913643-002	Anonymous	ED006: Exchangeable Calcium	----	0.2	meq/100g	7.6	7.7	1.62	0% - 20%
		ED006: Exchangeable Magnesium	----	0.2	meq/100g	5.3	5.4	2.71	0% - 20%
		ED006: Exchangeable Potassium	----	0.2	meq/100g	0.2	0.2	0.00	No Limit
		ED006: Exchangeable Sodium	----	0.2	meq/100g	3.7	4.2	13.0	0% - 20%
		ED006: Cation Exchange Capacity	----	0.2	meq/100g	16.8	17.6	4.62	0% - 20%
		ED006: Exchangeable Calcium	----	0.2	meq/100g	3.8	3.7	3.75	0% - 50%
		ED006: Exchangeable Magnesium	----	0.2	meq/100g	3.9	3.8	4.62	0% - 50%
		ED006: Exchangeable Potassium	----	0.2	meq/100g	0.4	0.2	51.0	No Limit
		ED006: Exchangeable Sodium	----	0.2	meq/100g	3.7	3.7	0.00	0% - 50%
		ED006: Cation Exchange Capacity	----	0.2	meq/100g	11.8	11.4	3.65	0% - 20%
EB1913646-005	OB30 / 0.5-0.6								



Sub-Matrix: SOIL				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EP004: Organic Matter (QC Lot: 2374836) - continued									
EB1913643-001	Anonymous	EP004: Organic Matter	----	0.5	%	3.8	3.9	4.41	No Limit
		EP004: Total Organic Carbon	----	0.5	%	2.2	2.3	0.00	No Limit
		EP004: Organic Matter	----	0.5	%	2.1	2.3	7.67	No Limit
EB1913648-002	Anonymous	EP004: Total Organic Carbon	----	0.5	%	1.2	1.3	0.00	No Limit



Sub-Matrix: SOIL

Sub-Matrix: SOIL		Method Blank (MB) Report		Laboratory Control Spike (LCS) Report				
Method: Compound	CAS Number	LOR	Unit	Result	Spike Concentration	Spike Recovery (%)	Recovery Limits (%)	
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 2374527) - continued								
EK059G: Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	<0.1	2.5 mg/kg	103	89	155
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QCLot: 2374524)								
EK061G: Total Kjeldahl Nitrogen as N	----	20	mg/kg	<20 <20	848 mg/kg 3644 mg/kg	99.1 89.1	73 73	121 121
EK067G: Total Phosphorus as P by Discrete Analyser (QCLot: 2374525)								
EK067G: Total Phosphorus as P	----	2	mg/kg	<2 <2	939 mg/kg 1200 mg/kg	82.6 84.9	80 80	115 115
EK080: Bicarbonate Extractable Phosphorus (Colwell) (QCLot: 2374845)								
EK080: Bicarbonate Ext. P (Colwell)	----	5	mg/kg	<5 <5 <5	100 mg/kg 44.9 mg/kg 58.07 mg/kg	101 99.9 83.4	70 87 80	130 113 120
EP004: Organic Matter (QCLot: 2374836)								
EP004: Organic Matter	----	0.5	%	<0.5	80 %	86.9	83	115
EP004: Total Organic Carbon	----	0.5	%	<0.5	46.4 %	86.9	85	115

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: SOIL

Sub-Matrix: SOIL			Matrix Spike (MS) Report					
			Spike Concentration	SpikeRecovery(%) MS	Recovery Limits (%)			
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number			Low	High	
EK057G: Nitrite as N by Discrete Analyser (QCLot: 2374526)								
EB1913644-002	Anonymous	EK057G: Nitrite as N (Sol.)	14797-65-0	2 mg/kg	82.7	70	130	
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 2374527)								
EB1913644-002	Anonymous	EK059G: Nitrite + Nitrate as N (Sol.)	***	10 mg/kg	92.5	70	130	
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QCLot: 2374524)								
EB1913644-002	Anonymous	EK061G: Total Kjeldahl Nitrogen as N	***	500 mg/kg	92.5	70	130	
EK067G: Total Phosphorus as P by Discrete Analyser (QCLot: 2374525)								
EB1913644-002	Anonymous	EK067G: Total Phosphorus as P	***	100 mg/kg	# 58.8	70	130	
EK080: Bicarbonate Extractable Phosphorus (Colwell) (QCLot: 2374845)								
EB1913643-002	Anonymous	EK080: Bicarbonate Ext. P (Colwell)	***	40 mg/kg	100	70	130	
EP004: Organic Matter (QCLot: 2374836)								
EB1913643-002	Anonymous	EP004: Organic Matter	***	2 %	86.0	70	130	
		EP004: Total Organic Carbon	***	1.16 %	86.2	70	130	



QA/QC Compliance Assessment to assist with Quality Review

Work Order	: EB1913646	Page	: 1 of 8
Client	: SLR Consulting Australia Pty Ltd	Laboratory	: Environmental Division Brisbane
Contact	: CAMERON TRAILL	Telephone	: +61 2 8784 8555
Project	: 623.17171 Fairhill Coking Coal	Date Samples Received	: 28-May-2019
Site	: ----	Issue Date	: 07-Jun-2019
Sampler	: CAMERON TRAILL	No. of samples received	: 5
Order number	:	No. of samples analysed	: 5

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 Laboratory Control outliers occur.
- Duplicate outliers exist - please see following pages for full details.
- Matrix Spike outliers exist - please see following pages for full details.
- 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

- NO Quality Control Sample Frequency Outliers exist.



Outliers : Quality Control Samples

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: **SOIL**

Compound Group Name	Laboratory Sample ID	Client Sample ID	Analyte	CAS Number	Data	Limits	Comment
Duplicate (DUP) RPDs							
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Ar	EB1913650-001	Anonymous	Nitrite + Nitrate as N (Sol.)	----	48.4 %	0% - 20%	RPD exceeds LOR based limits
Matrix Spike (MS) Recoveries							
EK067G: Total Phosphorus as P by Discrete Analyser	EB1913644-002	Anonymous	Total Phosphorus as P	----	58.8 %	70-130%	Recovery less than lower data quality objective

Outliers : Analysis Holding Time Compliance

Matrix: **SOIL**

Method	Container / Client Sample ID(s)	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Days overdue	Date analysed	Due for analysis	Days overdue
EP004: Organic Matter							
Snap Lock Bag							
OB30 / 0.0-0.1,		05-Jun-2019	01-Jun-2019	4			
OB30 / 0.1-0.2							

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
EA002: pH 1:5 (Soils)								
Snap Lock Bag (EA002)								
OB30 / 0.0-0.1,		25-May-2019	30-May-2019	01-Jun-2019	✔	30-May-2019	30-May-2019	✔
OB30 / 0.2-0.3,								
OB30 / 0.5-0.6								
EA010: Conductivity (1:5)								
Snap Lock Bag (EA010)								
OB30 / 0.0-0.1,		25-May-2019	30-May-2019	01-Jun-2019	✔	30-May-2019	27-Jun-2019	✔
OB30 / 0.2-0.3,								
OB30 / 0.5-0.6								



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
EA013: Acid Neutralising Capacity							
Pulp Bag (EA013)							
OB30 / 0.1-0.2,	25-May-2019	06-Jun-2019	24-May-2020	✓	06-Jun-2019	03-Dec-2019	✓
OB30 / 0.4-0.5,							
EA055: Moisture Content (Dried @ 105-110°C)							
Snap Lock Bag (EA055)							
OB30 / 0.0-0.1,	25-May-2019	----	----	----	29-May-2019	08-Jun-2019	✓
OB30 / 0.2-0.3,							
OB30 / 0.5-0.6							
EA058: Emerson Aggregate Test							
Snap Lock Bag (EA058)							
OB30 / 0.1-0.2,	25-May-2019	----	----	----	04-Jun-2019	21-Nov-2019	✓
OB30 / 0.4-0.5,							
EA150: Soil Classification - National Committee on Soil and Terrain (2009)							
Snap Lock Bag (EA150H)							
OB30 / 0.0-0.1,	25-May-2019	----	----	----	04-Jun-2019	21-Nov-2019	✓
OB30 / 0.2-0.3,							
OB30 / 0.5-0.6							
EA152: Soil Particle Density							
Snap Lock Bag (EA152)							
OB30 / 0.0-0.1,	25-May-2019	----	----	----	04-Jun-2019	21-Nov-2019	✓
OB30 / 0.2-0.3,							
OB30 / 0.5-0.6							
ED005: Exchange Acidity							
Snap Lock Bag (ED005)							
OB30 / 0.0-0.1,	25-May-2019	05-Jun-2019	22-Jun-2019	✓	06-Jun-2019	22-Jun-2019	✓
OB30 / 0.2-0.3,							
OB30 / 0.5-0.6							
ED006: Exchangeable Cations on Alkaline Soils							
Snap Lock Bag (ED006)							
OB30 / 0.0-0.1,	25-May-2019	05-Jun-2019	22-Jun-2019	✓	06-Jun-2019	22-Jun-2019	✓
OB30 / 0.2-0.3,							
OB30 / 0.5-0.6							
ED007: Exchangeable Cations							
Snap Lock Bag (ED007)							
OB30 / 0.0-0.1,	25-May-2019	05-Jun-2019	22-Jun-2019	✓	06-Jun-2019	22-Jun-2019	✓
OB30 / 0.2-0.3,							
OB30 / 0.5-0.6							



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
ED008: Exchangeable Cations							
Snap Lock Bag (ED008)	25-May-2019	05-Jun-2019	22-Jun-2019	✔	06-Jun-2019	22-Jun-2019	✔
OB30 / 0.0-0.1,							
OB30 / 0.2-0.3,							
OB30 / 0.5-0.6							
ED042T: Total Sulfur by LECO							
Pulp Bag (ED042T)	25-May-2019	05-Jun-2019	22-Jun-2019	✔	05-Jun-2019	22-Jun-2019	✔
OB30 / 0.0-0.1,							
OB30 / 0.2-0.3,							
OB30 / 0.5-0.6							
ED045G: Chloride by Discrete Analyser							
Snap Lock Bag (ED045G)	25-May-2019	30-May-2019	22-Jun-2019	✔	31-May-2019	27-Jun-2019	✔
OB30 / 0.0-0.1,							
OB30 / 0.2-0.3,							
OB30 / 0.5-0.6							
ED091 : Calcium Chloride Extractable Boron							
Snap Lock Bag (ED091)	25-May-2019	05-Jun-2019	21-Nov-2019	✔	06-Jun-2019	21-Nov-2019	✔
OB30 / 0.0-0.1,							
ED092: DTPA Extractable Metals							
Snap Lock Bag (ED092)	25-May-2019	05-Jun-2019	21-Nov-2019	✔	07-Jun-2019	21-Nov-2019	✔
OB30 / 0.0-0.1,							
EK057G: Nitrite as N by Discrete Analyser							
Snap Lock Bag (EK057G)	25-May-2019	30-May-2019	21-Nov-2019	✔	31-May-2019	21-Nov-2019	✔
OB30 / 0.0-0.1,							
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser							
Snap Lock Bag (EK059G)	25-May-2019	30-May-2019	21-Nov-2019	✔	31-May-2019	21-Nov-2019	✔
OB30 / 0.0-0.1,							
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser							
Snap Lock Bag (EK061G)	25-May-2019	29-May-2019	21-Nov-2019	✔	30-May-2019	21-Nov-2019	✔
OB30 / 0.0-0.1,							
EK067G: Total Phosphorus as P by Discrete Analyser							
Snap Lock Bag (EK067G)	25-May-2019	29-May-2019	21-Nov-2019	✔	30-May-2019	21-Nov-2019	✔
OB30 / 0.0-0.1,							
EK080: Bicarbonate Extractable Phosphorus (Colwell)							
Snap Lock Bag (EK080)	25-May-2019	06-Jun-2019	21-Nov-2019	✔	06-Jun-2019	21-Nov-2019	✔
OB30 / 0.0-0.1,							
EP004: Organic Matter							
Snap Lock Bag (EP004)	25-May-2019	05-Jun-2019	01-Jun-2019	✖	05-Jun-2019	03-Jul-2019	✔
OB30 / 0.0-0.1,							
OB30 / 0.1-0.2							



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	Method	Count		Actual	Rate (%)		Evaluation	Quality Control Specification
Analytical Methods		QC	Regular		Expected			
Laboratory Duplicates (DUP)								
Acid Neutralising Capacity (ANC)	EA013	2	20	10.00	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Bicarbonate Extractable P (Colwell)	EK080	2	14	14.29	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Calcium Chloride Extractable Boron	ED091	2	14	14.29	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Chloride Soluble By Discrete Analyser	ED045G	2	20	10.00	10.00		✔	NEPM 2013 B3 & ALS QC Standard
DTPA Extractable Metals	ED092	2	14	14.29	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Electrical Conductivity (1:5)	EA010	2	20	10.00	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations	ED007	1	7	14.29	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations on Alkaline Soils	ED006	2	20	10.00	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Moisture Content	EA055	2	16	12.50	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NO _x -) Soluble by Discrete Analyser	EK059G	2	12	16.67	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Nitrite as N - Soluble by Discrete Analyser	EK057G	2	12	16.67	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Organic Matter	EP004	2	14	14.29	10.00		✔	NEPM 2013 B3 & ALS QC Standard
pH (1:5)	EA002	2	20	10.00	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Sulfur - Total as S (LECO)	ED042T	2	20	10.00	10.00		✔	NEPM 2013 B3 & ALS QC Standard
TKN as N By Discrete Analyser	EK061G	2	12	16.67	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus By Discrete Analyser	EK067G	2	12	16.67	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)								
Acid Neutralising Capacity (ANC)	EA013	1	20	5.00	5.00		✔	NEPM 2013 B3 & ALS QC Standard
Bicarbonate Extractable P (Colwell)	EK080	3	14	21.43	15.00		✔	NEPM 2013 B3 & ALS QC Standard
Calcium Chloride Extractable Boron	ED091	1	14	7.14	5.00		✔	NEPM 2013 B3 & ALS QC Standard
Chloride Soluble By Discrete Analyser	ED045G	2	20	10.00	10.00		✔	NEPM 2013 B3 & ALS QC Standard
DTPA Extractable Metals	ED092	1	14	7.14	5.00		✔	NEPM 2013 B3 & ALS QC Standard
Electrical Conductivity (1:5)	EA010	1	20	5.00	5.00		✔	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations	ED007	1	7	14.29	5.00		✔	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations on Alkaline Soils	ED006	1	20	5.00	5.00		✔	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NO _x -) Soluble by Discrete Analyser	EK059G	1	12	8.33	5.00		✔	NEPM 2013 B3 & ALS QC Standard
Nitrite as N - Soluble by Discrete Analyser	EK057G	1	12	8.33	5.00		✔	NEPM 2013 B3 & ALS QC Standard
Organic Matter	EP004	1	14	7.14	5.00		✔	NEPM 2013 B3 & ALS QC Standard
pH (1:5)	EA002	2	20	10.00	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Sulfur - Total as S (LECO)	ED042T	1	20	5.00	5.00		✔	NEPM 2013 B3 & ALS QC Standard
TKN as N By Discrete Analyser	EK061G	2	12	16.67	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus By Discrete Analyser	EK067G	2	12	16.67	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)								
Bicarbonate Extractable P (Colwell)	EK080	1	14	7.14	5.00		✔	NEPM 2013 B3 & ALS QC Standard



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
Method Blanks (MB) - Continued							
Calcium Chloride Extractable Boron	ED091	1	14	7.14	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Chloride Soluble By Discrete Analyser	ED045G	1	20	5.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
DTPA Extractable Metals	ED092	1	14	7.14	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Electrical Conductivity (1:5)	EA010	1	20	5.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations	ED007	1	7	14.29	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations on Alkaline Soils	ED006	1	20	5.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx)- Soluble by Discrete Analyser	EK059G	1	12	8.33	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Nitrite as N - Soluble by Discrete Analyser	EK057G	1	12	8.33	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Organic Matter	EP004	1	14	7.14	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Sulfur - Total as S (LECO)	ED042T	1	20	5.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
TKN as N By Discrete Analyser	EK061G	1	12	8.33	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus By Discrete Analyser	EK067G	1	12	8.33	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)							
Bicarbonate Extractable P (Colwell)	EK080	1	14	7.14	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx)- Soluble by Discrete Analyser	EK059G	1	12	8.33	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Nitrite as N - Soluble by Discrete Analyser	EK057G	1	12	8.33	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Organic Matter	EP004	1	14	7.14	5.00	✔	NEPM 2013 B3 & ALS QC Standard
TKN as N By Discrete Analyser	EK061G	1	12	8.33	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus By Discrete Analyser	EK067G	1	12	8.33	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 (1:5)	EA002	SOIL	In house: Referenced to Rayment and Lyons 4A1 and APHA 4500H+. pH is determined on soil samples after a 1:5 soil/water leach. This method is compliant with NEPM (2013) Schedule B(3)
Electrical Conductivity (1:5)	EA010	SOIL	In house: Referenced to Rayment and Lyons 3A1 and APHA 2510. Conductivity is determined on soil samples using a 1:5 soil/water leach. This method is compliant with NEPM (2013) Schedule B(3)
Acid Neutralising Capacity (ANC)	EA013	SOIL	In house: Referenced to USEPA 600/2-78-054, I. Miller (2000). A fizz test is done to semiquantitatively estimate the likely reactivity. The soil is then reacted with a known excess quantity of an appropriate acid. Titration determines the acid remaining, and the ANC can be calculated from comparison with a blank titration.
Moisture Content	EA055	SOIL	In house: A gravimetric procedure based on weight loss over a 12 hour drying period at 105-110 degrees C. This method is compliant with NEPM (2013) Schedule B(3) Section 7.1 and Table 1 (14 day holding time).
Emerson Aggregate Test	EA058	SOIL	In house: Referenced to AS1289.3.8.1. Testing is performed only on soils with suitable aggregates; sands and gravels are usually unsuitable for this test. The test classifies the behaviour of soil aggregates, when immersed, on their coherence in water.
Particle Size Analysis by Hydrometer	EA150H	SOIL	Particle Size Analysis by Hydrometer according to AS1289.3.6.3 - 2003
Soil Particle Density	EA152	SOIL	Soil Particle Density by AS 1289.3.5.1-2006. Methods of testing soils for engineering purposes - Soil classification tests - Determination of the soil particle density of a soil - Standard method
Exchange Acidity by 1M Potassium Chloride	* ED005	SOIL	In house: referenced to Rayment and Lyons. (2011), method 15G1. This method is unsuitable for near neutral and alkaline soils. NATA accreditation does not cover performance of this service.
Exchangeable Cations on Alkaline Soils	* ED006	SOIL	In house: Referenced to Soil Survey Test Method C5. Soluble salts are removed from the sample prior to analysis. Cations are exchanged from the sample by contact with alcoholic ammonium chloride at pH 8.5. They are then quantitated in the final solution by ICPAES and reported as meq/100g of original soil.
Exchangeable Cations	ED007	SOIL	In house: Referenced to Rayment & Lyons (2011) Method 15A1. Cations are exchanged from the sample by contact with Ammonium Chloride. They are then quantitated in the final solution by ICPAES and reported as meq/100g of original soil. This method is compliant with NEPM (2013) Schedule B(3) (Method 301)
Exchangeable Cations with pre-treatment	ED008	SOIL	In house: Referenced to Rayment & Higginson (2011) Method 15A2. Soluble salts are removed from the sample prior to analysis. Cations are exchanged from the sample by contact with Ammonium Chloride. They are then quantitated in the final solution by ICPAES and reported as meq/100g of original soil. This method is compliant with NEPM (2013) Schedule B(3) (Method 301)
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 SO ₂) is measured by infra-red detector
Chloride Soluble By Discrete Analyser	ED045G	SOIL	In house: Referenced to APHA 4500-Cl- E. 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 thiocyanate forms highly coloured ferric thiocyanate which is measured at 480 nm. Analysis is performed on a 1:5 soil / water leachate.
Calcium Chloride Extractable Boron	* ED091	SOIL	In house: Referenced to Rayment & Higginson (2011) method 12C2. Soil is extracted with hot 0.01M CaCl ₂ solution at a 1:2 ratio. Extracts can be run on ICP.
DTPA Extractable Metals	* ED092	SOIL	In house: Referenced to Rayment and Higginson (2011) 12A1



Analytical Methods			
	Method	Matrix	Method Descriptions
Nitrite as N - Soluble by Discrete Analyser	EK057G	SOIL	In house: Referenced to APHA 4500-NO3- B. Nitrite in a water extract is determined by direct colourimetry by Discrete Analyser.
Nitrate as N - Soluble by Discrete Analyser	EK058G	SOIL	In house: Referenced to APHA 4500-NO3- F. Nitrate in the 1:5 soil:water extract is reduced to nitrite by way of a chemical reduction followed by quantification by Discrete Analyser. Nitrite is determined seperately by direct colourimetry and result for Nitrate calculated as the difference between the two results.
Nitrite and Nitrate as N (NOx)- Soluble by Discrete Analyser	EK059G	SOIL	In house: Thermo Scientific Method D08727 and NEMI (National Environmental Method Index) Method ID: 91771. This method covers the determination of total oxidised nitrogen (NOx-N) and nitrate (NO3-N) by calculation, Combined oxidised Nitrogen (NO2+NO3) in a water extract is determined by direct colourimetry by Discrete Analyser.
TKN as N By Discrete Analyser	EK061G	SOIL	In house: Referenced to APHA 4500-Norg-D Soil samples are digested using Kjeldahl digestion followed by determination by Discrete Analyser.
Total Nitrogen as N (TKN + NOx) By Discrete Analyser	EK062G	SOIL	In house: Referenced to APHA 4500 Norg/NO3- Total Nitrogen is determined as the sum of TKN and Oxidised Nitrogen, each determined seperately as N.
Total Phosphorus By Discrete Analyser	EK067G	SOIL	In house: Referenced to APHA 4500 P-B&F This procedure involves sulfuric acid digestion and quantification using Discrete Analyser.
Bicarbonate Extractable P (Colwell)	EK080	SOIL	In house: Referenced to Rayment & Higginson (2011) Method 9B1 Phosphorus is extracted from the soil using 0.5M NaHCO3 at a 1:100 soil:solution ratio and determined by FLA.
Organic Matter	EP004	SOIL	In house: Referenced to AS1289.4.1.1 - 1997. Dichromate oxidation method after Walkley and Black. This method is compliant with NEPM (2013) Schedule B(3).
Preparation Methods			
	Method	Matrix	Method Descriptions
Exchangeable Cations Preparation Method (Alkaline Soils)	ED006PR	SOIL	In house: Referenced to Rayment and Lyons 2011 method 15C1.
Exchangeable Cations Preparation Method	ED007PR	SOIL	In house: Referenced to Rayment & Higginson (1992) method 15A1. A 1M NH4Cl extraction by end over end tumbling at a ratio of 1:20. There is no pretreatment for soluble salts. Extracts can be run by ICP for cations.
Hot Water CaCl2 Extraction for Boron	ED091PR	SOIL	In house: Referenced to Rayment & Higginson (1992) method 12C2. Soil is extracted with hot 0.01M CaCl2 solution at a 1:2 ratio. Extracts can be run on ICP.
DTPA Extraction for Cu, Zn, Mn, Fe (2 hour leach)	ED092PR	SOIL	In house: Referenced to Rayment & Higginson (1992) Method 12A1 2 hour end over end tumbler extraction with 0.005M DTPA at a ratio of 1:2. Extracts can be run by ICP for metals.
TKN/TP Digestion	EK061/EK067	SOIL	In house: Referenced to APHA 4500 Norg- D; APHA 4500 P - H. Macro Kjeldahl digestion.
Sample Preparation for Bicarbonate Extractable P (Colwell)	EK080-PR	SOIL	In house: Referenced to Rayment & Higginson (2011) Method 9B1 Phosphorus is extracted from the soil using 0.5M NaHCO3 at a 1:100 soil:solution ratio.
Drying at 85 degrees, bagging and labelling (ASS)	EN020PR	SOIL	In house
1:5 solid / water leach for soluble analytes	EN34	SOIL	10 g of soil is mixed with 50 mL of reagent grade water and tumbled end over end for 1 hour. Water soluble salts are leached from the soil by the continuous suspension. Samples are settled and the water filtered off for analysis.
Organic Matter	EP004-PR	SOIL	In house: Referenced to AS1289.4.1.1 - 1997. Dichromate oxidation method after Walkley and Black. This method is compliant with NEPM (2013) Schedule B(3) (Method 105)
Dry and Pulverise (up to 100g)	GEO30	SOIL	#



Environmental

SAMPLE RECEIPT NOTIFICATION (SRN)

Work Order : **EB1913649**

Client : **SLR Consulting Australia Pty Ltd**
Contact : **CAMERON TRAILL**
Address :

Laboratory : **Environmental Division Brisbane**
Contact : **Tyler Cachia**
Address : **2 Byth Street Stafford QLD Australia 4053**

E-mail : **ctrail@slrconsulting.com**
Telephone : **----**
Facsimile : **----**

E-mail : **Tyler.Cachia@ALSGlobal.com**
Telephone : **+61 2 8784 8555**
Facsimile : **+61-7-3243 7218**

Project : **623.17171 Fairhill Coking Coal**
Order number :

Page : **1 of 3**
Quote number : **EM2018HEGAUS0001 (EN/032/18**
Primary work only BQ)

C-O-C number : **----** QC Level : **NEPM 2013 B3 & ALS QC Standard**
Site : **----**
Sampler : **CAMERON TRAILL**

Dates

Date Samples Received : **28-May-2019 09:00** Issue Date : **28-May-2019**
Client Requested Due : **07-Jun-2019** Scheduled Reporting Date : **07-Jun-2019**
Date

Delivery Details

Mode of Delivery : **Carrier** Security Seal : **Intact.**
No. of coolers/boxes : **1** Temperature : **19.5°C**
Receipt Detail : **Medium Esky** No. of samples received / analysed : **6 / 6**

General Comments

- This report contains the following information:
 - Sample Container(s)/Preservation Non-Compliances
 - Summary of Sample(s) and Requested Analysis
 - Proactive Holding Time Report
 - Requested Deliverables
- Please be advised that ALS is unable to accommodate the fast turnaround requested on the Chain of Custody. If you wish to discuss this further, please contact Client Services at ALSenviro.Brisbane@alsglobal.com.**
 - Discounted Package Prices apply only when specific ALS Group Codes ('W', 'S', 'NT' suites) are referenced on COCs.
 - Please direct any turn around / technical queries to the laboratory contact designated above.
 - Sample Disposal - Aqueous (3 weeks), Solid (2 months ± 1 week) from receipt of samples.
 - Analysis will be conducted by ALS Environmental, Brisbane, NATA accreditation no. 825, Site No. 818 (Micro site no. 18956).
- Breaches in recommended extraction / analysis holding times (if any) are displayed overleaf in the Proactive Holding Time Report table.**
- Please be aware that APHA/NEPM recommends water and soil samples be chilled to less than or equal to 6°C for chemical analysis, and less than or equal to 10°C but unfrozen for Microbiological analysis. Where samples are received above this temperature, it should be taken into consideration when interpreting results. Refer to ALS EnviroMail 85 for ALS recommendations of the best practice for chilling samples after sampling and for maintaining a cool temperature during transit.



Sample Container(s)/Preservation Non-Compliances

All comparisons are made against pretreatment/preservation AS, APHA, USEPA standards.

- No sample container / preservation non-compliance exists.

Summary of Sample(s) and Requested Analysis

Some items described below may be part of a laboratory process necessary for the execution of client requested tasks. Packages may contain additional analyses, such as the determination of moisture content and preparation tasks, that are included in the package.

If no sampling time is provided, the sampling time will default 00:00 on the date of sampling. If no sampling date is provided, the sampling date will be assumed by the laboratory and displayed in brackets without a time component

Matrix: **SOIL**

Laboratory sample ID	Client sampling date / time	Client sample ID							
EB1913649-001	24-May-2019 14:00	PR01 / 0.0-0.1	✓	✓	✓	✓	✓	✓	✓
EB1913649-002	24-May-2019 14:00	PR01 / 0.1-0.2	✓	✓	✓	✓	✓	✓	✓
EB1913649-003	24-May-2019 14:00	PR01 / 0.2-0.3	✓	✓	✓	✓	✓	✓	✓
EB1913649-004	24-May-2019 14:00	PR01 / 0.5-0.6	✓	✓	✓	✓	✓	✓	✓
EB1913649-005	24-May-2019 14:00	PR01 / 0.8-0.9	✓	✓	✓	✓	✓	✓	✓
EB1913649-006	24-May-2019 14:00	PR01 / 1.1-1.2	✓	✓	✓	✓	✓	✓	✓

Laboratory sample ID	Client sampling date / time	Client sample ID							
EB1913649-001	24-May-2019 14:00	PR01 / 0.0-0.1		SOIL - EA013 Acid Neutralising Capacity (ANC)					
EB1913649-002	24-May-2019 14:00	PR01 / 0.1-0.2	✓	SOIL - EA058 Emerson Aggregate Test	✓				
EB1913649-003	24-May-2019 14:00	PR01 / 0.2-0.3	✓	SOIL - EA150H-Y Particle Size Analysis by Hydrometer: Yellow	✓				
EB1913649-004	24-May-2019 14:00	PR01 / 0.5-0.6	✓	SOIL - ED042T Sulfur - Total as S (high temperature furnace)	✓				
EB1913649-005	24-May-2019 14:00	PR01 / 0.8-0.9	✓	SOIL - ED045G (solids) Chloride Soluble by Discrete Analyser	✓				
EB1913649-006	24-May-2019 14:00	PR01 / 1.1-1.2	✓	SOIL - ED091 Calcium Chloride Extractable Boron	✓				

Proactive Holding Time Report

Sample(s) have been received within the recommended holding times for the requested analysis.



Requested Deliverables

ACCOUNTS PAYABLE AU	
- A4 - AU Tax Invoice (INV)	Email
	accounts payable@slrconsulting.com
CAMERON TRAILL	
- *AU Certificate of Analysis - NATA (COA)	Email
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep) (QCI)	Email
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA (QC)	Email
- A4 - AU Sample Receipt Notification - Environmental HT (SRN)	Email
- A4 - AU Tax Invoice (INV)	Email
- Chain of Custody (CoC) (COC)	Email
- EDI Format - ENMRG (ENMRG)	Email
- EDI Format - ESDAT (ESDAT)	Email
D TAYLOR	
- A4 - AU Tax Invoice (INV)	Email
	dtaylor@slrconsulting.com



Environmental

CERTIFICATE OF ANALYSIS

Work Order

: **EB1913649**

Client

: **SLR Consulting Australia Pty Ltd**

Contact

: **CAMERON TRAILL**

Address

:

Telephone

: ----

Project

: **623.17171 Fairhill Coking Coal**

Order number

:

C-O-C number

: ----

Sampler

: **CAMERON TRAILL**

Site

: ----

Quote number

: **EN/032/18 Primary work only BQ**

No. of samples received

: **6**

No. of samples analysed

: **6**

Page

: **1 of 7**

Laboratory

: **Environmental Division Brisbane**

Contact

: **Tyler Cachia**

Address

: **2 Byth Street Stafford QLD Australia 4053**

Telephone

: **+61 2 8784 8555**

Date Samples Received

: **28-May-2019 09:00**

Date Analysis Commenced

: **29-May-2019**

Issue Date

: **07-Jun-2019 19:15**

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. 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
Ben Felgendreijens	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Mark Hallas	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Mark Hallas	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Satishkumar Trivedi	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Satishkumar Trivedi	Senior Acid Sulfate Soil Chemist	Brisbane Inorganics, Stafford, QLD
Tom Maloney	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by 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 Contact 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

Δ = 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.

- ALS is not NATA accredited for the analysis of Exchangeable Aluminium and Exchange Acidity in soils when performed under ALS Method ED005.
- ALS is not NATA accredited for the analysis of Exchangeable Cations on Alkaline Soils when performed under ALS Method ED006.
- EK067G (Total Phosphorus as P): Poor matrix spike recovery for sample EB1913644_002 due to sample heterogeneity. Confirmed by visual analysis.
- EK059G (Nitrite and Nitrate as N): Sample EB1913650_001 shows poor duplicate results due to sample heterogeneity. Confirmed by visual analysis.
- ASS: EA013 (ANC) Fizz Rating: 0- None; 1- Slight; 2- Moderate; 3- Strong; 4- Very Strong; 5- Lime.
- EA058 Emerson: V. = Very, D. = Dark, L. = Light, VD. = Very Dark
- ED007 and ED008: When Exchangeable Al is reported from these methods, it should be noted that Rayment & Lyons (2011) suggests Exchange Acidity by 1M KCl - Method 15G1 (ED005) is a more suitable method for the determination of exchange acidity (H+ + Al3+).

ED007: Exchangeable Cations



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)		Client sample ID	PR01 / 0.0-0.1	PR01 / 0.1-0.2	PR01 / 0.2-0.3	PR01 / 0.5-0.6	PR01 / 0.8-0.9
Compound		Client sampling date / time	24-May-2019 14:00	24-May-2019 14:00	24-May-2019 14:00	24-May-2019 14:00	24-May-2019 14:00
CAS Number	LOR	Unit	EB1913649-001	EB1913649-002	EB1913649-003	EB1913649-004	EB1913649-005
ED007: Exchangeable Cations - Continued		Result	Result	Result	Result	Result	Result
Exchangeable Calcium	0.1	meq/100g	15.3	-----	-----	-----	-----
Exchangeable Magnesium	0.1	meq/100g	5.1	-----	-----	-----	-----
Exchangeable Potassium	0.1	meq/100g	0.6	-----	-----	-----	-----
Exchangeable Sodium	0.1	meq/100g	0.3	-----	-----	-----	-----
Cation Exchange Capacity	0.1	meq/100g	21.4	-----	-----	-----	-----
Exchangeable Sodium Percent	0.1	%	1.2	-----	-----	-----	-----
Calcium/Magnesium Ratio	0.1	-	3.0	-----	-----	-----	-----
Magnesium/Potassium Ratio	0.1	-	7.9	-----	-----	-----	-----
ED042T: Total Sulfur by LECO							
Sulfur - Total as S (LECO)	0.01	%	<0.01	<0.01	<0.01	<0.01	<0.01
ED045G: Chloride by Discrete Analyser							
Chloride	16887-00-6	10	mg/kg	<10	<10	<10	110
ED091: Calcium Chloride Extractable Boron							
Ø Boron	7440-42-8	0.2	mg/kg	<0.2	-----	-----	-----
ED092: DTPA Extractable Metals							
Ø Copper	7440-50-8	1.00	mg/kg	1.74	1.18	-----	-----
Ø Iron	7439-89-6	1.00	mg/kg	44.7	22.6	-----	-----
Ø Manganese	7439-96-5	1.00	mg/kg	30.9	24.8	-----	-----
Ø Zinc	7440-66-6	1.00	mg/kg	<1.00	<1.00	-----	-----
EK057G: Nitrite as N by Discrete Analyser							
Nitrite as N (Sol)	14797-65-0	0.1	mg/kg	0.3	<0.1	-----	-----
EK058G: Nitrate as N by Discrete Analyser							
Nitrate as N (Sol)	14797-55-8	0.1	mg/kg	1.6	0.7	-----	-----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser							
Nitrite + Nitrate as N (Sol)	-----	0.1	mg/kg	1.9	0.7	-----	-----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser							
Total Kjeldahl Nitrogen as N	-----	20	mg/kg	1100	450	-----	-----
EK062: Total Nitrogen as N (TKN + NOx)							
^ Total Nitrogen as N	-----	20	mg/kg	1100	450	-----	-----
EK067G: Total Phosphorus as P by Discrete Analyser							
Total Phosphorus as P	-----	2	mg/kg	290	176	-----	-----
EK080: Bicarbonate Extractable Phosphorus (Colwell)							
Bicarbonate Ext. P (Colwell)	-----	5	mg/kg	9	<5	-----	-----



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)		Client sample ID		PR01 / 0.0-0.1	PR01 / 0.1-0.2	PR01 / 0.2-0.3	PR01 / 0.5-0.6	PR01 / 0.8-0.9
		Client sampling date / time		24-May-2019 14:00	24-May-2019 14:00	24-May-2019 14:00	24-May-2019 14:00	24-May-2019 14:00
Compound	CAS Number	LOR	Unit	EB1913649-001	EB1913649-002	EB1913649-003	EB1913649-004	EB1913649-005
EP004: Organic Matter				Result	Result	Result	Result	Result
Organic Matter	-----	0.5	%	2.9	1.3	-----	-----	-----
Total Organic Carbon	-----	0.5	%	1.7	0.8	-----	-----	-----



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)		Client sample ID			PR01 / 1.1-1.2						
		Client sampling date / time			24-May-2019 14:00						
Compound	CAS Number	LOR	Unit	EB1913649-006							
				Result							
EA002: pH 1:5 (Soils)											
pH Value		0.1	pH Unit		8.0						
EA010: Conductivity (1:5)											
Electrical Conductivity @ 25°C		1	µS/cm		301						
EA013: Acid Neutralising Capacity											
ANC as H2SO4		0.5	kg H2SO4 equiv./t		8.6						
ANC as CaCO3		0.1	% CaCO3		0.9						
Fizz Rating		0	Fizz Unit		0						
EA055: Moisture Content (Dried @ 105-110°C)											
Moisture Content		0.1	%		9.2						
EA058: Emerson Aggregate Test											
Color (Munsell)		-	-	Very Dark Gray (2.5Y 3/1)							
Texture		-	-	Medium Clay							
Emerson Class Number	EC/TC	-	-	3							
EA150: Soil Classification - National Committee on Soil and Terrain (2009)											
Clay (<2 µm)		1	%		37						
Silt (2-20 µm)		1	%		19						
Fine Sand (0.02-0.2 mm)		1	%		36						
Coarse Sand (0.2-2.0 mm)		1	%		8						
Gravel (>2mm)		1	%		<1						
EA152: Soil Particle Density											
Soil Particle Density (Clay/Silt/Sand)		0.01	g/cm3		2.66						
ED006: Exchangeable Cations on Alkaline Soils											
Ø Exchangeable Calcium		0.2	meq/100g		15.1						
Ø Exchangeable Magnesium		0.2	meq/100g		3.5						
Ø Exchangeable Potassium		0.2	meq/100g		0.4						
Ø Exchangeable Sodium		0.2	meq/100g		1.3						
Ø Cation Exchange Capacity		0.2	meq/100g		20.3						
Ø Exchangeable Sodium Percent		0.2	%		6.4						
Ø Calcium/Magnesium Ratio		0.2	-		4.3						
Ø Magnesium/Potassium Ratio		0.2	-		8.7						
ED042T: Total Sulfur by LECO											
Sulfur - Total as S (LECO)		0.01	%		<0.01						



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)		Client sample ID		PR01 / 1.1-1.2							
		Client sampling date / time		24-May-2019 14:00							
Compound	CAS Number	LOR	Unit	EB1913649-006							
				Result							
ED045G: Chloride by Discrete Analyser											
Chloride	16887-00-6	10	mg/kg	410							



Environmental

QUALITY CONTROL REPORT

Work Order : **EB1913649**

Page : 1 of 7

Client	: SLR Consulting Australia Pty Ltd	Laboratory	: Environmental Division Brisbane
Contact	: CAMERON TRAILL	Contact	: Tyler Cachia
Address	:	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: ----	Telephone	: +61 2 8784 8555
Project	: 623.17171 Fairhill Coking Coal	Date Samples Received	: 28-May-2019
Order number	:	Date Analysis Commenced	: 29-May-2019
C-O-C number	: ----	Issue Date	: 07-Jun-2019
Sampler	: CAMERON TRAILL		
Site	: ----		
Quote number	: EN/032/18 Primary work only BQ		
No. of samples received	: 6		
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. 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
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Mark Hallas	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Mark Hallas	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Satishkumar Trivedi	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Satishkumar Trivedi	Senior Acid Sulfate Soil Chemist	Brisbane Inorganics, Stafford, QLD
Tom Maloney	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by 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

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 sample ID		Client sample ID	Method: Compound	CAS Number	Laboratory Duplicate (DUP) Report						
EA002: pH 1.5 (Soils) (QC Lot: 2374529)					LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)	
EB1913646-005	Anonymous		EA002: pH Value	---	0.1	pH Unit	8.6	8.6	0.00	0% - 20%	
EB1913644-001	Anonymous		EA002: pH Value	---	0.1	pH Unit	7.0	7.2	2.11	0% - 20%	
EA002: pH 1.5 (Soils) (QC Lot: 2374532)											
EB1913649-004	PR01 / 0.5-0.6		EA002: pH Value	---	0.1	pH Unit	7.5	7.5	0.00	0% - 20%	
EB1913650-008	Anonymous		EA002: pH Value	---	0.1	pH Unit	8.6	8.6	0.00	0% - 20%	
EA010: Conductivity (1:5) (QC Lot: 2374528)											
EB1913646-005	Anonymous		EA010: Electrical Conductivity @ 25°C	---	1	µS/cm	294	300	2.02	0% - 20%	
EB1913644-001	Anonymous		EA010: Electrical Conductivity @ 25°C	---	1	µS/cm	21	20	8.02	0% - 20%	
EA010: Conductivity (1:5) (QC Lot: 2374533)											
EB1913649-004	PR01 / 0.5-0.6		EA010: Electrical Conductivity @ 25°C	---	1	µS/cm	12	11	0.00	0% - 50%	
EB1913650-008	Anonymous		EA010: Electrical Conductivity @ 25°C	---	1	µS/cm	2110	2200	4.26	0% - 20%	
EA013: Acid Neutralising Capacity (QC Lot: 2390594)											
EB1913643-002	Anonymous		EA013: ANC as H2SO4	---	0.5	kg H2SO4 equiv./t	12.2	11.0	10.2	0% - 20%	
EB1913646-003	Anonymous		EA013: ANC as H2SO4	---	0.5	kg H2SO4 equiv./t	<0.5	<0.5	0.00	No Limit	
EA013: Acid Neutralising Capacity (QC Lot: 2390595)											
EB1913649-004	PR01 / 0.5-0.6		EA013: ANC as H2SO4	---	0.5	kg H2SO4 equiv./t	8.6	7.8	9.02	0% - 50%	
EM1908388-003	Anonymous		EA013: ANC as H2SO4	---	0.5	kg H2SO4 equiv./t	21.6	24.0	10.6	0% - 20%	
EA055: Moisture Content (Dried @ 105-110°C) (QC Lot: 2374534)											
EB1913644-001	Anonymous		EA055: Moisture Content	---	0.1	%	4.3	4.5	4.08	No Limit	
EB1913646-005	Anonymous		EA055: Moisture Content	---	0.1	%	5.6	5.7	0.00	0% - 20%	



Sub-Matrix: SOIL				Laboratory Duplicate (DUP) Report						
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)	
EA055: Moisture Content (Dried @ 105-110°C) (QC Lot: 2374535)										
EB1913649-004	PR01 / 0.5-0.6	EA055: Moisture Content	----	0.1	%	8.5	8.1	4.50	0% - 20%	
EB1913650-008	Anonymous	EA055: Moisture Content	----	0.1	%	13.7	13.4	2.54	0% - 20%	
ED006: Exchangeable Cations on Alkaline Soils (QC Lot: 2387764)										
EB1913643-002	Anonymous	ED006: Exchangeable Calcium	----	0.2	meq/100g	7.6	7.7	1.62	0% - 20%	
		ED006: Exchangeable Magnesium	----	0.2	meq/100g	5.3	5.4	2.71	0% - 20%	
		ED006: Exchangeable Potassium	----	0.2	meq/100g	0.2	0.2	0.00	No Limit	
		ED006: Exchangeable Sodium	----	0.2	meq/100g	3.7	4.2	13.0	0% - 20%	
		ED006: Cation Exchange Capacity	----	0.2	meq/100g	16.8	17.6	4.62	0% - 20%	
EB1913646-005	Anonymous	ED006: Exchangeable Calcium	----	0.2	meq/100g	3.8	3.7	3.75	0% - 50%	
		ED006: Exchangeable Magnesium	----	0.2	meq/100g	3.9	3.8	4.62	0% - 50%	
		ED006: Exchangeable Potassium	----	0.2	meq/100g	0.4	0.2	51.0	No Limit	
		ED006: Exchangeable Sodium	----	0.2	meq/100g	3.7	3.7	0.00	0% - 50%	
ED006: Cation Exchange Capacity										
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ED006: Cation Exchange										



Sub-Matrix: **SOIL**

Sub-Matrix: SOIL				Laboratory Duplicate (DUP) Report							
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)		
ED092: DTPA Extractable Metals (QC Lot: 2374844) - continued											
EB1913643-001	Anonymous	ED092: Zinc	7440-66-6	1	mg/kg	<1.00	<1.00	0.00	No Limit		
EB1913649-001	PR01 / 0.0-0.1	ED092: Copper	7440-50-8	1	mg/kg	1.74	1.76	1.08	No Limit		
		ED092: Iron	7439-89-6	1	mg/kg	44.7	45.2	1.06	0% - 20%		
		ED092: Manganese	7439-96-5	1	mg/kg	30.9	32.4	4.80	0% - 20%		
		ED092: Zinc	7440-66-6	1	mg/kg	<1.00	<1.00	0.00	No Limit		
EK057G: Nitrite as N by Discrete Analyser (QC Lot: 2374526)											
EB1913650-001	Anonymous	EK057G: Nitrite as N (Sol.)	14797-65-0	0.1	mg/kg	0.9	0.6	39.4	No Limit		
EB1913644-001	Anonymous	EK057G: Nitrite as N (Sol.)	14797-65-0	0.1	mg/kg	0.1	0.1	0.00	No Limit		
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QC Lot: 2374527)											
EB1913650-001	Anonymous	EK059G: Nitrite + Nitrate as N (Sol.)	---	0.1	mg/kg	3.1	# 1.9	48.4	0% - 20%		
EB1913644-001	Anonymous	EK059G: Nitrite + Nitrate as N (Sol.)	---	0.1	mg/kg	0.5	0.5	0.00	No Limit		
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QC Lot: 2374524)											
EB1913644-001	Anonymous	EK061G: Total Kjeldahl Nitrogen as N	---	20	mg/kg	280	280	0.00	0% - 50%		
EB1913650-001	Anonymous	EK061G: Total Kjeldahl Nitrogen as N	---	20	mg/kg	1880	1880	0.00	0% - 20%		
EK067G: Total Phosphorus as P by Discrete Analyser (QC Lot: 2374525)											
EB1913644-001	Anonymous	EK067G: Total Phosphorus as P	---	2	mg/kg	125	127	1.68	0% - 20%		
EB1913650-001	Anonymous	EK067G: Total Phosphorus as P	---	2	mg/kg	411	410	0.00	0% - 20%		
EK080: Bicarbonate Extractable Phosphorus (Colwell) (QC Lot: 2374845)											
EB1913643-001	Anonymous	EK080: Bicarbonate Ext. P (Colwell)	---	5	mg/kg	26	26	0.00	No Limit		
EB1913649-001	PR01 / 0.0-0.1	EK080: Bicarbonate Ext. P (Colwell)	---	5	mg/kg	9	8	13.2	No Limit		
EP004: Organic Matter (QC Lot: 2374836)											
EB1913643-001	Anonymous	EP004: Organic Matter	---	0.5	%	3.8	3.9	4.41	No Limit		
		EP004: Total Organic Carbon	---	0.5	%	2.2	2.3	0.00	No Limit		
EB1913648-002	Anonymous	EP004: Organic Matter	---	0.5	%	2.1	2.3	7.67	No Limit		
		EP004: Total Organic Carbon	---	0.5	%	1.2	1.3	0.00	No Limit		



Method Blank (MB) and Laboratory Control Spike (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 Spike (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

Sub-Matrix: SOIL				Method Blank (MB) Report		Laboratory Control Spike (LCS) Report			
Method: Compound	CAS Number	LOR	Unit	Result	Spike Concentration	Spike Recovery (%)	Low	High	
EA002: pH 1:5 (Soils) (QCLOt: 2374529)									
EA002: pH Value	----	----	pH Unit	----	4 pH Unit 7 pH Unit	100 100	98 98	102 102	
EA002: pH 1:5 (Soils) (QCLOt: 2374532)									
EA002: pH Value	----	----	pH Unit	----	4 pH Unit 7 pH Unit	99.8 100	98 98	102 102	
EA010: Conductivity (1:5) (QCLOt: 2374528)									
EA010: Electrical Conductivity @ 25°C	----	1	µS/cm	<1	1412 µS/cm	100	97	103	
EA010: Conductivity (1:5) (QCLOt: 2374533)									
EA010: Electrical Conductivity @ 25°C	----	1	µS/cm	<1	1412 µS/cm	101	97	103	
EA013: Acid Neutralising Capacity (QCLOt: 2390594)									
EA013: ANC as H2SO4	----	----	kg H2SO4 equiv./t	----	9.9 kg H2SO4 equiv./t	106	82	120	
EA013: Acid Neutralising Capacity (QCLOt: 2390595)									
EA013: ANC as H2SO4	----	----	kg H2SO4 equiv./t	----	9.9 kg H2SO4 equiv./t	106	82	120	
ED006: Exchangeable Cations on Alkaline Soils (QCLOt: 2387764)									
ED006: Exchangeable Calcium	----	0.2	meq/100g	<0.2	11.3 meq/100g	109	70	130	
ED006: Exchangeable Magnesium	----	0.2	meq/100g	<0.2	5.61 meq/100g	100	70	130	
ED006: Exchangeable Potassium	----	0.2	meq/100g	<0.2	1.15 meq/100g	89.3	70	130	
ED006: Exchangeable Sodium	----	0.2	meq/100g	<0.2	3.54 meq/100g	96.8	70	130	
ED006: Cation Exchange Capacity	----	0.2	meq/100g	<0.2	21.6 meq/100g	104	70	130	
ED006: Exchangeable Cations on Alkaline Soils (QCLOt: 2387765)									
ED006: Exchangeable Calcium	----	0.2	meq/100g	<0.2	11.3 meq/100g	103	70	130	
ED006: Exchangeable Magnesium	----	0.2	meq/100g	<0.2	5.61 meq/100g	94.0	70	130	
ED006: Exchangeable Potassium	----	0.2	meq/100g	<0.2	1.15 meq/100g	85.8	70	130	
ED006: Exchangeable Sodium	----	0.2	meq/100g	<0.2	3.54 meq/100g	92.8	70	130	
ED006: Cation Exchange Capacity	----	0.2	meq/100g	<0.2	21.6 meq/100g	97.9	70	130	
ED007: Exchangeable Cations (QCLOt: 2387754)									
ED007: Exchangeable Calcium	----	0.1	meq/100g	<0.1	10.9967 meq/100g	92.5	79	113	
ED007: Exchangeable Magnesium	----	0.1	meq/100g	<0.1	6.9112 meq/100g	93.1	85	115	
ED007: Exchangeable Potassium	----	0.1	meq/100g	<0.1	0.9423 meq/100g	86.6	70	122	
ED007: Exchangeable Sodium	----	0.1	meq/100g	<0.1	1.5785 meq/100g	99.5	76	112	
ED007: Cation Exchange Capacity	----	0.1	meq/100g	<0.1	20.4287 meq/100g	93.0	82	112	
ED042T: Total Sulfur by LECO (QCLOt: 2387691)									
ED042T: Sulfur - Total as S (LECO)	----	0.01	%	<0.01	0.51 %	97.9	70	130	



Sub-Matrix: **SOIL**

Sub-Matrix: SOIL				Method Blank (MB) Report		Laboratory Control Spike (LCS) Report				
Method: Compound	CAS Number	LOR	Unit	Result	Spike Concentration	Spike Recovery (%)		Recovery Limits (%)		
						LCS	Low	High		
ED045G: Chloride by Discrete Analyser (QCLot: 2374530)										
ED045G: Chloride	16887-00-6	10	mg/kg	<10	50 mg/kg	96.8	83	119		
				<10	5000 mg/kg	107	83	119		
ED045G: Chloride by Discrete Analyser (QCLot: 2374531)										
ED045G: Chloride	16887-00-6	10	mg/kg	<10	50 mg/kg	97.5	83	119		
				<10	5000 mg/kg	106	83	119		
ED091 : Calcium Chloride Extractable Boron (QCLot: 2374841)										
ED091: Boron	7440-42-8	0.2	mg/kg	<0.2	100 mg/kg	97.1	85	117		
ED092: DTPA Extractable Metals (QCLot: 2374844)										
ED092: Copper	7440-50-8	1	mg/kg	<1.00	1.2 mg/kg	106	84	122		
ED092: Iron	7439-89-6	1	mg/kg	<1.00	46.5 mg/kg	119	70	130		
ED092: Manganese	7439-96-5	1	mg/kg	<1.00	6 mg/kg	114	70	130		
ED092: Zinc	7440-66-6	1	mg/kg	<1.00	5.4 mg/kg	106	79	122		
EKO57G: Nitrite as N by Discrete Analyser (QCLot: 2374526)										
EKO57G: Nitrite as N (Sol.)	14797-65-0	0.1	mg/kg	<0.1	2.5 mg/kg	101	83	111		
EKO59G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 2374527)										
EKO59G: Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	<0.1	2.5 mg/kg	103	89	155		
EKO61G: Total Kjeldahl Nitrogen By Discrete Analyser (QCLot: 2374524)										
EKO61G: Total Kjeldahl Nitrogen as N	----	20	mg/kg	<20	848 mg/kg	99.1	73	121		
				<20	3644 mg/kg	89.1	73	121		
EKO67G: Total Phosphorus as P by Discrete Analyser (QCLot: 2374525)										
EKO67G: Total Phosphorus as P	----	2	mg/kg	<2	939 mg/kg	82.6	80	115		
				<2	1200 mg/kg	84.9	80	115		
EKO80: Bicarbonate Extractable Phosphorus (Colwell) (QCLot: 2374845)										
EKO80: Bicarbonate Ext. P (Colwell)	----	5	mg/kg	<5	100 mg/kg	101	70	130		
				<5	44.9 mg/kg	99.9	87	113		
				<5	58.07 mg/kg	83.4	80	120		
EP004: Organic Matter (QCLot: 2374836)										
EP004: Organic Matter	----	0.5	%	<0.5	80 %	86.9	83	115		
EP004: Total Organic Carbon	----	0.5	%	<0.5	46.4 %	86.9	85	115		

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: **SOIL**

Laboratory sample ID	Client sample ID	Method: Compound	Matrix Spike (MS) Report				
			Spike		Spike Recovery (%)		Recovery Limits (%)
			Concentration	MS	Low	High	



Sub-Matrix: **SOIL**

Sub-Matrix: SOIL			Matrix Spike (MS) Report						
			Spike Concentration	SpikeRecovery(%) MS	Recovery Limits (%)		Low	High	
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number						
EK057G: Nitrite as N by Discrete Analyser (QCLot: 2374526)									
EB1913644-002	Anonymous	EK057G: Nitrite as N (Sol.)	14797-65-0	2 mg/kg	82.7	70	130		
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 2374527)									
EB1913644-002	Anonymous	EK059G: Nitrite + Nitrate as N (Sol.)	***	10 mg/kg	92.5	70	130		
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QCLot: 2374524)									
EB1913644-002	Anonymous	EK061G: Total Kjeldahl Nitrogen as N	***	500 mg/kg	92.5	70	130		
EK067G: Total Phosphorus as P by Discrete Analyser (QCLot: 2374525)									
EB1913644-002	Anonymous	EK067G: Total Phosphorus as P	***	100 mg/kg	# 58.8	70	130		
EK080: Bicarbonate Extractable Phosphorus (Colwell) (QCLot: 2374845)									
EB1913643-002	Anonymous	EK080: Bicarbonate Ext. P (Colwell)	***	40 mg/kg	100	70	130		
EP004: Organic Matter (QCLot: 2374836)									
EB1913643-002	Anonymous	EP004: Organic Matter	***	2 %	86.0	70	130		
		EP004: Total Organic Carbon	***	1.16 %	86.2	70	130		



QA/QC Compliance Assessment to assist with Quality Review

Work Order	: EB1913649	Page	: 1 of 8
Client	: SLR Consulting Australia Pty Ltd	Laboratory	: Environmental Division Brisbane
Contact	: CAMERON TRAILL	Telephone	: +61 2 8784 8555
Project	: 623.17171 Fairhill Coking Coal	Date Samples Received	: 28-May-2019
Site	: ----	Issue Date	: 07-Jun-2019
Sampler	: CAMERON TRAILL	No. of samples received	: 6
Order number	:	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 Laboratory Control outliers occur.
- Duplicate outliers exist - please see following pages for full details.
- Matrix Spike outliers exist - please see following pages for full details.
- 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

- NO Quality Control Sample Frequency Outliers exist.



Outliers : Quality Control Samples

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: **SOIL**

Compound Group Name	Laboratory Sample ID	Client Sample ID	Analyte	CAS Number	Data	Limits	Comment
Duplicate (DUP) RPDs							
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Ar	EB1913650-001	Anonymous	Nitrite + Nitrate as N (Sol.)	----	48.4 %	0% - 20%	RPD exceeds LOR based limits
Matrix Spike (MS) Recoveries							
EK067G: Total Phosphorus as P by Discrete Analyser	EB1913644-002	Anonymous	Total Phosphorus as P	----	58.8 %	70-130%	Recovery less than lower data quality objective

Outliers : Analysis Holding Time Compliance

Matrix: **SOIL**

Method	Container / Client Sample ID(s)	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Days overdue	Date analysed	Due for analysis	Days overdue
EP004: Organic Matter							
Snap Lock Bag							
PR01 / 0.0-0.1,		05-Jun-2019	31-May-2019	5			
PR01 / 0.1-0.2							

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
EA002: pH 1:5 (Soils)							
Snap Lock Bag (EA002)							
PR01 / 0.0-0.1,	24-May-2019	30-May-2019	31-May-2019	✓	30-May-2019	30-May-2019	✓
PR01 / 0.2-0.3,							
PR01 / 0.8-0.9,							
EA010: Conductivity (1:5)							
Snap Lock Bag (EA010)							
PR01 / 0.0-0.1,	24-May-2019	30-May-2019	31-May-2019	✓	30-May-2019	27-Jun-2019	✓
PR01 / 0.2-0.3,							
PR01 / 0.8-0.9,							



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
EA013: Acid Neutralising Capacity							
Pulp Bag (EA013)							
PR01 / 0.1-0.2,							
PR01 / 0.5-0.6,							
PR01 / 1.1-1.2							
EA055: Moisture Content (Dried @ 105-110°C)							
Snap Lock Bag (EA055)							
PR01 / 0.0-0.1,	24-May-2019	----	-----	-----	29-May-2019	07-Jun-2019	✓
PR01 / 0.2-0.3,							
PR01 / 0.8-0.9,							
EA058: Emerson Aggregate Test							
Snap Lock Bag (EA058)							
PR01 / 0.1-0.2,	24-May-2019	----	-----	-----	04-Jun-2019	20-Nov-2019	✓
PR01 / 0.5-0.6,							
PR01 / 1.1-1.2							
EA150: Soil Classification - National Committee on Soil and Terrain (2009)							
Snap Lock Bag (EA150H)							
PR01 / 0.0-0.1,	24-May-2019	----	-----	-----	04-Jun-2019	20-Nov-2019	✓
PR01 / 0.2-0.3,							
PR01 / 0.8-0.9,							
EA152: Soil Particle Density							
Snap Lock Bag (EA152)							
PR01 / 0.0-0.1,	24-May-2019	----	-----	-----	04-Jun-2019	20-Nov-2019	✓
PR01 / 0.2-0.3,							
PR01 / 0.8-0.9,							
ED005: Exchange Acidity							
Snap Lock Bag (ED005)							
PR01 / 0.0-0.1,	24-May-2019	05-Jun-2019	21-Jun-2019	✓	06-Jun-2019	21-Jun-2019	✓
PR01 / 0.2-0.3,							
PR01 / 0.8-0.9,							
ED006: Exchangeable Cations on Alkaline Soils							
Snap Lock Bag (ED006)							
PR01 / 0.0-0.1,	24-May-2019	05-Jun-2019	21-Jun-2019	✓	06-Jun-2019	21-Jun-2019	✓
PR01 / 0.2-0.3,							
PR01 / 0.8-0.9,							
ED007: Exchangeable Cations							
Snap Lock Bag (ED007)							
PR01 / 0.0-0.1,	24-May-2019	05-Jun-2019	21-Jun-2019	✓	06-Jun-2019	21-Jun-2019	✓
PR01 / 0.2-0.3,							
PR01 / 0.8-0.9,							



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
ED008: Exchangeable Cations							
Snap Lock Bag (ED008)							
PR01 / 0.0-0.1,	24-May-2019	05-Jun-2019	21-Jun-2019	✔	06-Jun-2019	21-Jun-2019	✔
PR01 / 0.2-0.3,							
PR01 / 0.8-0.9,							
ED042T: Total Sulfur by LECO							
Pulp Bag (ED042T)							
PR01 / 0.0-0.1,	24-May-2019	05-Jun-2019	21-Jun-2019	✔	05-Jun-2019	21-Jun-2019	✔
PR01 / 0.2-0.3,							
PR01 / 0.8-0.9,							
ED045G: Chloride by Discrete Analyser							
Snap Lock Bag (ED045G)							
PR01 / 0.0-0.1,	24-May-2019	30-May-2019	21-Jun-2019	✔	31-May-2019	27-Jun-2019	✔
PR01 / 0.2-0.3,							
PR01 / 0.8-0.9,							
ED091 : Calcium Chloride Extractable Boron							
Snap Lock Bag (ED091)							
PR01 / 0.0-0.1,	24-May-2019	05-Jun-2019	20-Nov-2019	✔	06-Jun-2019	20-Nov-2019	✔
ED092: DTPA Extractable Metals							
Snap Lock Bag (ED092)							
PR01 / 0.0-0.1,	24-May-2019	05-Jun-2019	20-Nov-2019	✔	07-Jun-2019	20-Nov-2019	✔
EK057G: Nitrite as N by Discrete Analyser							
Snap Lock Bag (EK057G)							
PR01 / 0.0-0.1,	24-May-2019	30-May-2019	20-Nov-2019	✔	31-May-2019	20-Nov-2019	✔
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser							
Snap Lock Bag (EK059G)							
PR01 / 0.0-0.1,	24-May-2019	30-May-2019	20-Nov-2019	✔	31-May-2019	20-Nov-2019	✔
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser							
Snap Lock Bag (EK061G)							
PR01 / 0.0-0.1,	24-May-2019	29-May-2019	20-Nov-2019	✔	30-May-2019	20-Nov-2019	✔
EK067G: Total Phosphorus as P by Discrete Analyser							
Snap Lock Bag (EK067G)							
PR01 / 0.0-0.1,	24-May-2019	29-May-2019	20-Nov-2019	✔	30-May-2019	20-Nov-2019	✔
EK080: Bicarbonate Extractable Phosphorus (Colwell)							
Snap Lock Bag (EK080)							
PR01 / 0.0-0.1,	24-May-2019	06-Jun-2019	20-Nov-2019	✔	06-Jun-2019	20-Nov-2019	✔
EP004: Organic Matter							
Snap Lock Bag (EP004)							
PR01 / 0.0-0.1,	24-May-2019	05-Jun-2019	31-May-2019	✘	05-Jun-2019	03-Jul-2019	✔



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	Method	Count		Actual	Rate (%)		Evaluation	Quality Control Specification
Analytical Methods		QC	Regular		Expected			
Laboratory Duplicates (DUP)								
Acid Neutralising Capacity (ANC)	EA013	4	40	10.00	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Bicarbonate Extractable P (Colwell)	EK080	2	14	14.29	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Calcium Chloride Extractable Boron	ED091	2	14	14.29	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Chloride Soluble By Discrete Analyser	ED045G	4	35	11.43	10.00		✔	NEPM 2013 B3 & ALS QC Standard
DTPA Extractable Metals	ED092	2	14	14.29	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Electrical Conductivity (1:5)	EA010	4	35	11.43	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations	ED007	1	7	14.29	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations on Alkaline Soils	ED006	3	28	10.71	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Moisture Content	EA055	4	31	12.90	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NO _x -) Soluble by Discrete Analyser	EK059G	2	12	16.67	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Nitrite as N - Soluble by Discrete Analyser	EK057G	2	12	16.67	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Organic Matter	EP004	2	14	14.29	10.00		✔	NEPM 2013 B3 & ALS QC Standard
pH (1:5)	EA002	4	35	11.43	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Sulfur - Total as S (LECO)	ED042T	1	9	11.11	10.00		✔	NEPM 2013 B3 & ALS QC Standard
TKN as N By Discrete Analyser	EK061G	2	12	16.67	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus By Discrete Analyser	EK067G	2	12	16.67	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)								
Acid Neutralising Capacity (ANC)	EA013	2	40	5.00	5.00		✔	NEPM 2013 B3 & ALS QC Standard
Bicarbonate Extractable P (Colwell)	EK080	3	14	21.43	15.00		✔	NEPM 2013 B3 & ALS QC Standard
Calcium Chloride Extractable Boron	ED091	1	14	7.14	5.00		✔	NEPM 2013 B3 & ALS QC Standard
Chloride Soluble By Discrete Analyser	ED045G	4	35	11.43	10.00		✔	NEPM 2013 B3 & ALS QC Standard
DTPA Extractable Metals	ED092	1	14	7.14	5.00		✔	NEPM 2013 B3 & ALS QC Standard
Electrical Conductivity (1:5)	EA010	2	35	5.71	5.00		✔	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations	ED007	1	7	14.29	5.00		✔	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations on Alkaline Soils	ED006	2	28	7.14	5.00		✔	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NO _x -) Soluble by Discrete Analyser	EK059G	1	12	8.33	5.00		✔	NEPM 2013 B3 & ALS QC Standard
Nitrite as N - Soluble by Discrete Analyser	EK057G	1	12	8.33	5.00		✔	NEPM 2013 B3 & ALS QC Standard
Organic Matter	EP004	1	14	7.14	5.00		✔	NEPM 2013 B3 & ALS QC Standard
pH (1:5)	EA002	4	35	11.43	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Sulfur - Total as S (LECO)	ED042T	1	9	11.11	5.00		✔	NEPM 2013 B3 & ALS QC Standard
TKN as N By Discrete Analyser	EK061G	2	12	16.67	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus By Discrete Analyser	EK067G	2	12	16.67	10.00		✔	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)								
Bicarbonate Extractable P (Colwell)	EK080	1	14	7.14	5.00		✔	NEPM 2013 B3 & ALS QC Standard



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	
Method Blanks (MB) - Continued							
Calcium Chloride Extractable Boron	ED091	1	14	7.14	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Chloride Soluble By Discrete Analyser	ED045G	2	35	5.71	5.00	✓	NEPM 2013 B3 & ALS QC Standard
DTPA Extractable Metals	ED092	1	14	7.14	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Electrical Conductivity (1:5)	EA010	2	35	5.71	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations	ED007	1	7	14.29	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Exchangeable Cations on Alkaline Soils	ED006	2	28	7.14	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx)- Soluble by Discrete Analyser	EK059G	1	12	8.33	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite as N - Soluble by Discrete Analyser	EK057G	1	12	8.33	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Organic Matter	EP004	1	14	7.14	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Sulfur - Total as S (LECO)	ED042T	1	9	11.11	5.00	✓	NEPM 2013 B3 & ALS QC Standard
TKN as N By Discrete Analyser	EK061G	1	12	8.33	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus By Discrete Analyser	EK067G	1	12	8.33	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)							
Bicarbonate Extractable P (Colwell)	EK080	1	14	7.14	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx)- Soluble by Discrete Analyser	EK059G	1	12	8.33	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite as N - Soluble by Discrete Analyser	EK057G	1	12	8.33	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Organic Matter	EP004	1	14	7.14	5.00	✓	NEPM 2013 B3 & ALS QC Standard
TKN as N By Discrete Analyser	EK061G	1	12	8.33	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus By Discrete Analyser	EK067G	1	12	8.33	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 (1:5)	EA002	SOIL	In house: Referenced to Rayment and Lyons 4A1 and APHA 4500H+. pH is determined on soil samples after a 1:5 soil/water leach. This method is compliant with NEPM (2013) Schedule B(3)
Electrical Conductivity (1:5)	EA010	SOIL	In house: Referenced to Rayment and Lyons 3A1 and APHA 2510. Conductivity is determined on soil samples using a 1:5 soil/water leach. This method is compliant with NEPM (2013) Schedule B(3)
Acid Neutralising Capacity (ANC)	EA013	SOIL	In house: Referenced to USEPA 600/2-78-054, I. Miller (2000). A fizz test is done to semiquantitatively estimate the likely reactivity. The soil is then reacted with a known excess quantity of an appropriate acid. Titration determines the acid remaining, and the ANC can be calculated from comparison with a blank titration.
Moisture Content	EA055	SOIL	In house: A gravimetric procedure based on weight loss over a 12 hour drying period at 105-110 degrees C. This method is compliant with NEPM (2013) Schedule B(3) Section 7.1 and Table 1 (14 day holding time).
Emerson Aggregate Test	EA058	SOIL	In house: Referenced to AS1289.3.8.1. Testing is performed only on soils with suitable aggregates; sands and gravels are usually unsuitable for this test. The test classifies the behaviour of soil aggregates, when immersed, on their coherence in water.
Particle Size Analysis by Hydrometer	EA150H	SOIL	Particle Size Analysis by Hydrometer according to AS1289.3.6.3 - 2003
Soil Particle Density	EA152	SOIL	Soil Particle Density by AS 1289.3.5.1-2006. Methods of testing soils for engineering purposes - Soil classification tests - Determination of the soil particle density of a soil - Standard method
Exchange Acidity by 1M Potassium Chloride	* ED005	SOIL	In house: referenced to Rayment and Lyons. (2011), method 15G1. This method is unsuitable for near neutral and alkaline soils. NATA accreditation does not cover performance of this service.
Exchangeable Cations on Alkaline Soils	* ED006	SOIL	In house: Referenced to Soil Survey Test Method C5. Soluble salts are removed from the sample prior to analysis. Cations are exchanged from the sample by contact with alcoholic ammonium chloride at pH 8.5. They are then quantitated in the final solution by ICPAES and reported as meq/100g of original soil.
Exchangeable Cations	ED007	SOIL	In house: Referenced to Rayment & Lyons (2011) Method 15A1. Cations are exchanged from the sample by contact with Ammonium Chloride. They are then quantitated in the final solution by ICPAES and reported as meq/100g of original soil. This method is compliant with NEPM (2013) Schedule B(3) (Method 301)
Exchangeable Cations with pre-treatment	ED008	SOIL	In house: Referenced to Rayment & Higginson (2011) Method 15A2. Soluble salts are removed from the sample prior to analysis. Cations are exchanged from the sample by contact with Ammonium Chloride. They are then quantitated in the final solution by ICPAES and reported as meq/100g of original soil. This method is compliant with NEPM (2013) Schedule B(3) (Method 301)
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 SO ₂) is measured by infra-red detector
Chloride Soluble By Discrete Analyser	ED045G	SOIL	In house: Referenced to APHA 4500-Cl- E. 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 thiocyanate forms highly coloured ferric thiocyanate which is measured at 480 nm. Analysis is performed on a 1:5 soil / water leachate.
Calcium Chloride Extractable Boron	* ED091	SOIL	In house: Referenced to Rayment & Higginson (2011) method 12C2. Soil is extracted with hot 0.01M CaCl ₂ solution at a 1:2 ratio. Extracts can be run on ICP.
DTPA Extractable Metals	* ED092	SOIL	In house: Referenced to Rayment and Higginson (2011) 12A1



Analytical Methods			
	Method	Matrix	Method Descriptions
Nitrite as N - Soluble by Discrete Analyser	EK057G	SOIL	In house: Referenced to APHA 4500-NO3- B. Nitrite in a water extract is determined by direct colourimetry by Discrete Analyser.
Nitrate as N - Soluble by Discrete Analyser	EK058G	SOIL	In house: Referenced to APHA 4500-NO3- F. Nitrate in the 1:5 soil:water extract is reduced to nitrite by way of a chemical reduction followed by quantification by Discrete Analyser. Nitrite is determined seperately by direct colourimetry and result for Nitrate calculated as the difference between the two results.
Nitrite and Nitrate as N (NOx)- Soluble by Discrete Analyser	EK059G	SOIL	In house: Thermo Scientific Method D08727 and NEMI (National Environmental Method Index) Method ID: 91771. This method covers the determination of total oxidised nitrogen (NOx-N) and nitrate (NO3-N) by calculation, Combined oxidised Nitrogen (NO2+NO3) in a water extract is determined by direct colourimetry by Discrete Analyser.
TKN as N By Discrete Analyser	EK061G	SOIL	In house: Referenced to APHA 4500-Norg-D Soil samples are digested using Kjeldahl digestion followed by determination by Discrete Analyser.
Total Nitrogen as N (TKN + NOx) By Discrete Analyser	EK062G	SOIL	In house: Referenced to APHA 4500 Norg/NO3- Total Nitrogen is determined as the sum of TKN and Oxidised Nitrogen, each determined seperately as N.
Total Phosphorus By Discrete Analyser	EK067G	SOIL	In house: Referenced to APHA 4500 P-B&F This procedure involves sulfuric acid digestion and quantification using Discrete Analyser.
Bicarbonate Extractable P (Colwell)	EK080	SOIL	In house: Referenced to Rayment & Higginson (2011) Method 9B1 Phosphorus is extracted from the soil using 0.5M NaHCO3 at a 1:100 soil:solution ratio and determined by FLA.
Organic Matter	EP004	SOIL	In house: Referenced to AS1289.4.1.1 - 1997. Dichromate oxidation method after Walkley and Black. This method is compliant with NEPM (2013) Schedule B(3).
Preparation Methods			
	Method	Matrix	Method Descriptions
Exchangeable Cations Preparation Method (Alkaline Soils)	ED006PR	SOIL	In house: Referenced to Rayment and Lyons 2011 method 15C1.
Exchangeable Cations Preparation Method	ED007PR	SOIL	In house: Referenced to Rayment & Higginson (1992) method 15A1. A 1M NH4Cl extraction by end over end tumbling at a ratio of 1:20. There is no pretreatment for soluble salts. Extracts can be run by ICP for cations.
Hot Water CaCl2 Extraction for Boron	ED091PR	SOIL	In house: Referenced to Rayment & Higginson (1992) method 12C2. Soil is extracted with hot 0.01M CaCl2 solution at a 1:2 ratio. Extracts can be run on ICP.
DTPA Extraction for Cu, Zn, Mn, Fe (2 hour leach)	ED092PR	SOIL	In house: Referenced to Rayment & Higginson (1992) Method 12A1 2 hour end over end tumbler extraction with 0.005M DTPA at a ratio of 1:2. Extracts can be run by ICP for metals.
TKN/TP Digestion	EK061/EK067	SOIL	In house: Referenced to APHA 4500 Norg- D; APHA 4500 P - H. Macro Kjeldahl digestion.
Sample Preparation for Bicarbonate Extractable P (Colwell)	EK080-PR	SOIL	In house: Referenced to Rayment & Higginson (2011) Method 9B1 Phosphorus is extracted from the soil using 0.5M NaHCO3 at a 1:100 soil:solution ratio.
Drying at 85 degrees, bagging and labelling (ASS)	EN020PR	SOIL	In house
1:5 solid / water leach for soluble analytes	EN34	SOIL	10 g of soil is mixed with 50 mL of reagent grade water and tumbled end over end for 1 hour. Water soluble salts are leached from the soil by the continuous suspension. Samples are settled and the water filtered off for analysis.
Organic Matter	EP004-PR	SOIL	In house: Referenced to AS1289.4.1.1 - 1997. Dichromate oxidation method after Walkley and Black. This method is compliant with NEPM (2013) Schedule B(3) (Method 105)
Dry and Pulverise (up to 100g)	GEO30	SOIL	#

Appendix D contents here

ASIA PACIFIC OFFICES

BRISBANE

Level 2, 15 Astor Terrace
Spring Hill QLD 4000
Australia
T: +61 7 3858 4800
F: +61 7 3858 4801

MACKAY

21 River Street
Mackay QLD 4740
Australia
T: +61 7 3181 3300

SYDNEY

2 Lincoln Street
Lane Cove NSW 2066
Australia
T: +61 2 9427 8100
F: +61 2 9427 8200

AUCKLAND

68 Beach Road
Auckland 1010
New Zealand
T: +64 27 441 7849

CANBERRA

GPO 410
Canberra ACT 2600
Australia
T: +61 2 6287 0800
F: +61 2 9427 8200

MELBOURNE

Suite 2, 2 Domville Avenue
Hawthorn VIC 3122
Australia
T: +61 3 9249 9400
F: +61 3 9249 9499

TOWNSVILLE

Level 1, 514 Sturt Street
Townsville QLD 4810
Australia
T: +61 7 4722 8000
F: +61 7 4722 8001

NELSON

6/A Cambridge Street
Richmond, Nelson 7020
New Zealand
T: +64 274 898 628

DARWIN

5 Foelsche Street
Darwin NT 0800
Australia
T: +61 8 8998 0100
F: +61 2 9427 8200

NEWCASTLE

10 Kings Road
New Lambton NSW 2305
Australia
T: +61 2 4037 3200
F: +61 2 4037 3201

TOWNSVILLE SOUTH

12 Cannan Street
Townsville South QLD 4810
Australia
T: +61 7 4772 6500

GOLD COAST

Level 2, 194 Varsity Parade
Varsity Lakes QLD 4227
Australia
M: +61 438 763 516

PERTH

Ground Floor, 503 Murray Street
Perth WA 6000
Australia
T: +61 8 9422 5900
F: +61 8 9422 5901



Northern Resource
CONSULTANTS

Fairhill Coal Project

Terrestrial Flora and Fauna Technical Report

July 2019, Rev3

prepared for

Futura Resources Pty Ltd

Contact Information	Details
Contact Person	Dave Hall
Phone	07 4772 6500
Email	Dhall@slrconsulting.com
Mail	12 Cannan Street, South Townsville QLD, 4810

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1. Introduction

1.1 Background

The Fairhill project is a proposed coal mine in central Queensland located approximately 50 km northeast of Emerald on mining lease (ML) 700043.

Futura Resources Pty Ltd commissioned flora and fauna surveys as part of baseline environmental studies to support environmental approvals for the development of a coal mine on ML 700043.

The study area for this report incorporates sites across the Fairhill ML and encompasses an area of approximately 1000 ha. It incorporates the proposed disturbance area for the project and additional disturbance sites within the ML.

1.2 Purpose

This report details a flora and fauna assessment conducted by Northern Resource Consultants Pty Ltd (NRC) within the study area including:

- Methodologies employed for assessing the terrestrial flora and fauna biodiversity values within the study area
- The presence and status of species and communities within the local area, and
- Potential ecological impacts of the project and recommendations for mitigating impacts, with a focus on species and communities of conservation concern, such as those listed under State and Commonwealth legislation.

2. Regulatory Framework

2.1 Commonwealth Legislation

2.1.1 Environment Protection and Biodiversity Conservation Act 1999

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) is administered by the Australian Government Department of the Environment and Energy (DEE). The EPBC Act provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places, which are defined in the EPBC Act as matters of national environmental significance (MNES). The MNES listed in the EPBC Act that are relevant to this report are:

- Nationally threatened species and ecological communities
- Migratory species.

Database searches and field assessments should be conducted as part of any flora and fauna impact assessment. The results of these assessments can then be used to determine the presence (or likelihood of the presence) of any MNES within a proposed project area. If any species or communities listed under the EPBC Act are present or likely to be present, an assessment of significance is required. If the proposed action may have a significant impact on a MNES, it must be referred to DEE for assessment. If DEE determines that the proposed action is likely to have significant impacts, the project will be considered as a controlled action and will require formal assessment and approval. If the proposed action is not likely to be significant, approval is not required if the action is taken in accordance with the referral. Consequently, the action can proceed, subject to any state or local government requirements.

2.2 State Legislation

Environmental Protection Act 1994

The *Environmental Protection Act 1994* (EP Act) is intended 'to protect Queensland's environment while allowing for development that improves total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends (ecologically sustainable development)'. The EP Act regulates environmentally relevant activities (ERAs). The Queensland Department of Environment and Science (DES) assesses applications to undertake ERAs, and issues environmental authorities (EAs) that identify environmental conditions to be met to ensure the prevention or minimisation of environmental harm caused by the authorised ERAs. An assessment of environmental impacts on identified environmental values is required as part of the EA application.

When making an application to DES for an EA for mining activities, the applicant is required under the Environmental Protection Regulation 1998 to identify environmentally sensitive areas (ESAs) within or adjacent to the proposed ML. An ESA is defined as a location that:

- Has environmental values that contribute to maintaining biological diversity and integrity
- Has intrinsic or attributed scientific, historical or cultural heritage value, and
- Is important to providing amenity, harmony or sense of community.

Three categories of ESA exist:

- Category A: areas that have significant ecological values including national parks, marine parks, conservation parks, the Wet Tropics World Heritage Area and the Great Barrier Reef Marine Park Region.
- Category B: areas that include regional ecosystems (REs) with an endangered status, Ramsar wetlands (as per the Ramsar Convention on wetlands of international importance, especially as waterfowl habitat), forest reserves, wilderness areas, areas seaward of the highest astronomical tide, fish habitat areas and areas containing marine plants.
- Category C: areas that include nature refuges, state forests, timber reserves, declared catchment areas, river improvement areas and resource reserves.

Vegetation Management Act 1999

The *Vegetation Management Act 1999* (VM Act) is administered by the Queensland Department of Natural Resources, Mines and Energy (DNRME) and protects Queensland's biodiversity by conserving native vegetation and addressing land degradation issues.

Queensland's vegetation management framework regulates the clearing of certain native vegetation by incorporating the RE classification scheme. REs are remnant vegetation communities in a bioregion that are consistently associated with a particular combination of geology, landform and soil. Remnant vegetation is defined under the VM Act as vegetation where the dominant canopy layer has greater than 70% of the height and greater than 50% of the cover relative to the undisturbed height and cover of that stratum and is dominated by species characteristic of the vegetation's undisturbed canopy.

The Queensland Herbarium has mapped the remnant extent of REs for most of Queensland using a combination of satellite imagery, aerial photography and on-ground studies (ground-truthing). RE maps published by DNRME describe the extent and conservation status of remnant vegetation as REs. REs are classified in the following vegetation management class and biodiversity status categories depending on the percentage of original cover remaining and extent of degradation:

- Endangered
- Of concern
- Least concern/not of concern.

The classification of REs is relevant to identifying vegetation communities of conservation significance in a regional context and potential environmental offset requirements under the Queensland environmental offsets framework.

In association with the VM Act, essential habitat mapping is available for protected flora and fauna, encompassing areas that the chief executive reasonably believes are areas of essential habitat. Mapped areas are usually characterised by a 2.5 km radius buffer around a reported location of a threatened species within areas of remnant vegetation containing essential habitat factors for protected flora and fauna. To be deemed essential habitat for protected flora and fauna, an area must contain at least three essential habitat parameters determined as mandatory for a species at any stage of its life cycle. Essential habitat factors for protected flora and fauna incorporate components of a species habitat and can be characterised by a landform, RE, vegetation structure, soil type and water body that is necessary or desirable for the species at any stage of its life cycle.

Nature Conservation Act 1992

The *Nature Conservation Act 1992* (NC Act) is administered by DES and provides the framework for the declaration and management of protected areas, and protection of wildlife listed under the Nature Conservation (Wildlife) Regulation 2006 (NC Regulation).

Protected Areas

Protected areas are declared under the NC Act for the conservation of Queensland's natural and cultural resources. Classes of protected areas under the NC Act include national parks, regional parks and nature refuges. An environmental offset may be required for actions resulting in significant residual impacts within a protected area.

Under the Queensland environmental offsets framework, an impact on a protected area is significant if a prescribed activity results, or is likely to result, in one or more of the following:

- Authorised clearing or inundation of all or part of the protected area for the construction of private or publicly owned infrastructure on the area.
- The exclusion of, or reduction in, public use or enjoyment of all or part of the protected area.
- A reduction in the natural or cultural values of all or part of the protected area.

Protected Wildlife

The purpose of the NC Regulation is to prescribe wildlife as one of the following classes of wildlife:

- Extinct in the wild
- Endangered
- Vulnerable
- Near threatened, or
- Least concern.

Threatened wildlife under the NC Act is wildlife that is prescribed as extinct in the wild, endangered or vulnerable. Additional levels of protection are also given to near threatened species. All native flora and fauna species are protected under the NC Act and 'permits to take' protected wildlife are required from DES.

DES provides the Wildlife Online (WO) database, which can be searched to generate a list of all species recorded within a specified area. This tool is useful for determining the presence or likelihood of occurrence of threatened species in an area.

A Protected Plants Flora Survey Trigger Map is available, which shows high-risk areas for protected plants (those considered as endangered, vulnerable and near threatened (EVNT) species) and is used to help determine flora survey and clearing permit requirements for a specified area. If the study area is

located within a high-risk area, a comprehensive flora survey is required to be undertaken before any clearing of protected plants can occur. This survey will need to comply with Queensland's *Flora Survey Guidelines – Protected Plants* (Department of Environment and Heritage Protection (EHP), 2014a).

If threatened plants are found to occur within the high-risk area during the field survey, and these are likely to be cleared or impacted by the proposed project, an application for a clearing permit from DES will be required. This application will need to be accompanied by the flora survey results and potential impact management options for the protected plants that include appropriate avoidance, mitigation and/or offsetting measures.

In addition to this, if threatened plants are found outside a high-risk area during the field survey, and these plants are likely to be cleared or impacted by the proposed project, a clearing permit will also be required. Where a flora survey identifies that there are no protected plants present or impacts can be avoided, clearing will be exempt from requiring a permit under the NC Act.

Biosecurity Act 2014

The *Biosecurity Act 2014* commenced on 1 July 2016, with the aim to ensure a consistent, modern, risk-based and less prescriptive approach to biosecurity in Queensland. The *Biosecurity Act 2014* replaced the many separate pieces of legislation that were previously applied to manage biosecurity, particularly the *Land Protection (Pest and Stock Route Management) Act 2002*. The Biosecurity Regulation 2016 sets out how the *Biosecurity Act 2014* is implemented and applied.

Under the *Biosecurity Act 2014*, there are three types of invasive flora and fauna species:

- Prohibited invasive species
- Restricted invasive species, and
- Invasive species.

Invasive animals are classified in a similar manner to plants and include prohibited and restricted classifications. Prohibited invasive species are not considered to be present in Queensland; however, if they were, they would seriously threaten Queensland's primary industries, natural environment, livestock, human health and people's livelihoods. If a prohibited invasive species is found in Queensland, it must be reported to Biosecurity Queensland within 24 h of the sighting.

Restricted invasive species also seriously threaten Queensland's primary industries, natural environment, livestock, human health and people's livelihoods, but are already established in Queensland. Under the *Biosecurity Act 2014*, restricted invasive species may fall into one or more categories, each with different restrictions:

- Category 2: the invasive species must be reported within 24 h to Biosecurity Queensland.
- Category 3: the invasive species must not be distributed or released into the environment.
- Category 4: the invasive species must not be moved.
- Category 5: the invasive species must not be kept.

Landholder responsibilities and restrictions pertaining to these classifications are specific for each category and an invasive species may be listed under multiple categories. Invasive species include those that are not listed as prohibited or restricted invasive species, but that have, or are likely to have, an adverse impact on a biosecurity consideration because of the introduction, spread or increase in population size of the species in an area. Everyone is obligated to take all reasonable and practical steps to minimise the risks associated with invasive species under their control. Local governments and Biosecurity Queensland provide weed control support services but may also enforce landowner responsibilities if necessary.

Queensland environmental offsets framework

The Queensland environmental offsets framework includes an Act, a regulation and a single policy, which replaces the five previous single-issue policies.

The Environmental Offsets Regulation 2014 provides details of the prescribed activities regulated under legislation and the prescribed environmental matters (known as matters of state environmental significance or MSES) to which the framework applies. Examples of MSES include:

- Wetlands and watercourses
- Endangered and of concern REs
- Connectivity areas, and
- Protected wildlife habitat.

For any new development, all impacts to MSES must be avoided or minimised where possible. Where there is a *significant residual impact* to MSES, an environmental offset may be required in accordance with the Queensland Environmental Offsets Policy.

3. Flora and Fauna Assessment Methodology

3.1 Overall Assessment Methodology

NRC employed a joint approach of desktop analysis and field surveys in this study. The desktop analysis and scoping phase encompassed:

- Project planning and definition of objectives
- Detailed desktop studies
- Review of previous studies, particularly:
 - Collation of existing records, and
 - Literature review of species and potential threats and impacts.

The field survey phase encompassed:

- Systematic, targeted and incidental flora surveys
- Vegetation community mapping and assessments, and
- Systematic, targeted and incidental fauna surveys.

The study team implemented best practice recommendations from sources such as:

- Terrestrial Vertebrate Fauna Survey Guidelines for Queensland (Eyre *et al.*, 2018)
- Methodology for Survey and Mapping of REs and Vegetation Communities in Queensland (Neldner *et al.*, 2017), and
- Flora Survey Guidelines – Protected Plants (EHP, 2014a).

SLR is a registered scientific user with ethics approval to conduct fauna studies from the Department of Agriculture and Fisheries Animal Ethics Committee. The survey work involved in this report was conducted under Scientific Purposes Permit number WISP14046014.

3.2 Desktop Analysis

3.2.1 Literature Review and Previous Studies

There are no known previous flora and fauna studies of the study area but there are several other studies within the local area. An environmental impact statement (EIS) process was conducted for the Curragh North Mine (2004), located approximately 20 km to the east of the Fairhill site, and in the receiving catchment of Fairhill. A flora and fauna survey was undertaken at Curragh between 1998 and 2003 and is included as Appendix J to that EIS. A flora and fauna technical report for the Wilton Coal project by Saunders Havill Group (SHG, 2011) was conducted in November 2011. The study area for this survey was adjacent to the Fairhill project. Another baseline flora and fauna assessment has been conducted at the Wilton Coal Project located approximately 14 km southwest of the Fairhill site by NRC in 2017 with additional vegetation mapping undertaken for that report in 2018.

Field guides and scientific publications were also reviewed prior to field surveys to determine species likely to be present within the study area and preferred habitat. Focus was given to threatened species identified as having a high potential to occur within the study area. Given the lack of previous studies relevant to the study area, the desktop assessment relied primarily on database searches to determine species, communities and species habitat relevant to the study area.

3.2.2 Database Searches

The DEE Protected Matters Search Tool and the Queensland Government WO database were utilised to determine species, communities and areas of conservation significance with potential relevance to the proposed action. Both searches included a 30 km buffer around a central co-ordinate within the study area (-23.2442° S, 148.5733° E), which includes the entire study area and a large buffer incorporating similar habitat in the surrounding landscape.

The results of the database searches and their relevance to the proposed development are discussed in the Desktop Analysis Results section of this report. NRC has developed an approach for ranking threatened species and communities recorded from the desktop searches in terms of their likelihood of occurring within the study area. This approach is based on the presence of local records and the habitat requirements for each species, which are recommended criteria for desktop impact assessments in state published survey guideline documents, such as Eyre *et al.* (2018). Details of the criteria used to assess the likelihood of occurrence for threatened and near threatened species are provided in Table 1. The potential impacts to threatened species that may occur within the study area are discussed in the Impact Assessment and Management section of this report.

It is possible that some locally occurring near threatened or threatened species may not be recorded in the State and Commonwealth databases. The comprehensive field survey component of this assessment is therefore an important aspect of the impact assessment process to determine the presence of any threatened species that have not been previously recorded in the local area.

Table 1: Key assessment criteria for occurrence or likelihood of threatened and near threatened species

LIKELIHOOD OF OCCURRING	KEY CRITERIA	DEFINITION
Present	Present during survey or historical records in the study area	Species was recorded during field surveys or a historical record of the species was located in the study area
High	Known records (<30 km) or within species known range AND Suitable habitat of high quality is present	Historical records of the species occur within a 30 km radius of the study area or the study area is within the species known range Suitable habitat of high quality exists with the study area
Moderate	Known records (<30 km) or within species known range AND Suitable habitat is present, but degraded	Historical records of the species occur within a 30 km radius of the study area or the study area is within the species known range Suitable habitat is present but is significantly degraded or fragmented
Low	No records (<30 km) and not within species known range OR Habitat present is unsuitable, absent, or highly degraded	No historical records of this species occur within a 30 km radius of the study area or within the known range for this species or: OR The habitat within the study area is not suitable and/or is in extremely poor condition, or is absent for the species

3.2.3 Mapping

The following mapping sources were reviewed as part of the desktop analysis:

- Regulated Vegetation Management Map (DNRME, 2018).
- ESAs Map (DES, 2018a).
- Referable wetlands (DES, 2018b).
- Protected Plants Flora Survey Trigger Map (DES, 2018c).
- Essential habitat mapping as shown on the Regulated Vegetation Management Map (DNRME, 2018).
- Geoscience Australia (GA) online interactive maps – Australian and Region Surface Geology (GA, 2018).
- Groundwater Dependent Ecosystem (GDE) Atlas (BOM, 2019).
- Queensland Globe, GDE mapping (DNRME, 2019).

3.3 Nomenclature and Taxonomy

Except for technical descriptions and tables, all flora and fauna species are referred to by their common names throughout this report, with their scientific names shown in brackets only after the first reference. Scientific names for flora species within this report follow Bostock and Holland (2017). Where no common name is provided in reference texts, a search was conducted for other accepted common names and, if none were found, then the species name only was used. An asterisk is used to denote species that are not native to Australia.

The use of scientific and common names for fauna species is in accordance with the following references:

- Birds: Pizzey and Knight (2012)
- Amphibians: Vanderduys (2012)
- Reptiles: Wilson (2015)
- Mammals (except bats): Van Dyck *et al.* (2013), and
- Bats: Reardon *et al.* (2015).

3.4 Flora Survey Methodology

3.4.1 Overall Methodology

Techniques described in the *Methodology for Survey and Mapping of Regional Ecosystems and Vegetation Communities in Queensland* (Neldner *et al.*, 2017) were used to collect sufficient data during the field vegetation assessments to verify the RE codes of the remnant vegetation in the assessment area. The key features recorded in the field relevant to this report are:

- Vegetation structure including height of each stratum and cover density
- Key species within each stratum, and
- Geology, landform and other land zone characteristics.

The species composition and structure for each community were compared to the technical descriptions provided in the Regional Ecosystem Description Database (REDD; Queensland Herbarium, 2018). The land zone characteristics of each site were compared to the descriptions provided in Wilson and Taylor (2012). This information provided the basis for determining the appropriate RE code for each community. The information in these documents was also used in conjunction with site observations to determine appropriate values for the factors relating to remnant status.

Vegetation surveys were conducted between 26 and 30 September 2017 and 14 and 19 May 2018. The purpose of the surveys was to:

- Determine the appropriate RE code, extent and remnant status of vegetation communities throughout the study area
- Identify threatened plant species. Although the study area is not within a 'high risk area', NRC performed targeted searches for threatened flora species identified in the local area during desktop analyses, including 'meander' searches in accordance with the *Flora Survey Guidelines – Protected Plants* (EHP, 2014a), and
- Compile a flora species inventory for the study area.

3.4.2 Vegetation Assessment Sites

Site selection

Ground-truthing of the remnant vegetation mapping involved detailed assessments of vegetation characteristics at multiple transect locations within the study area. Assessment sites were selected where they would provide representative data for the vegetation type that was the subject of the assessment.

The location of the assessment sites and the survey techniques employed were selected to:

- Validate state published RE and regrowth mapping
- Accurately determine the extent of each vegetation type
- Resolve heterogeneous polygons
- Determine the remnant status of vegetation
- Target threatened flora species identified during desktop assessments and their habitat, and
- Compile a species inventory for each vegetation community and the entire study area.

A total of 2 secondary and 24 quaternary assessments were conducted over the survey period, with the sites distributed over the study area to incorporate variations in community composition and structure (see ground truthed flora survey map in Figure 5).

Survey techniques

Quaternary assessment sites

Quaternary assessments were conducted to validate the vegetation community mapping and to capture any variability in the structure and composition of the community. Data collected at quaternary sites included species composition and structural information for the canopy layer. In general, focus was given to the dominant species, crown cover and median height of the ecologically dominant layer, which was used to define each community and determine the appropriate RE code and remnant status.

Secondary assessment sites

A 50 m x 10 m vegetation assessment transect was established at each of the secondary assessment sites within the study area. Within these transects a combination of quantitative and qualitative techniques was employed. The vegetation survey techniques employed and the attributes recorded during the assessments are detailed in Table 2.

Quantitative measurements such as basal area and canopy height and cover were used to describe the structural form of each community and determine the remnant status of the vegetation. Species composition and structure were used to determine the relevant RE code for each community.

Table 2: Vegetation attributes measured in vegetation survey transects

SURVEY METHOD	ATTRIBUTES MEASURED
Survey Plot 50m x 10m	Key species of each stratum Median height of each stratum Weed species and cover Complete species list Central coordinate
Transect 50m	Percentage cover of each stratum
Quadrats (x5) 1m x 1m	Groundcover species and percentage of cover
Greater area encompassing the present vegetation community	Tree basal area Incidental species observed Additional relevant notes

3.4.3 Vegetation Mapping

Mapping of vegetation communities was performed using a combination of ground traverses and aerial imagery. Using the information gained at each of the vegetation assessment sites and observations made when traversing the study area, the boundaries of vegetation communities were compared to state-mapped vegetation and amended as necessary, using a handheld GPS device. Some vegetation mapping was also refined using recent, high-resolution aerial images.

3.4.4 Random Meander Technique

Various parts of the study area were traversed using the random meander technique documented by Cropper (1993). This technique was applied to supplement other survey techniques to:

- Locate and record any flora species not identified in the vegetation assessment transects
- Target threatened flora species
- Validate vegetation community mapping, and
- Determine the presence and extent of pest species.

The meander technique is the preferred approach to identify and locate protected plants (EVNT species) according to the *Flora Survey Guidelines – Protected Plants* (EHP, 2014a). The study area is not located within a 'high-risk area' on the Flora Survey Trigger Map and, therefore, a flora survey in accordance with the Queensland guidelines is not mandatory. However, as a best-practice approach and to meet duty-of-care requirements under the EPBC Act, NRC conducted random meanders as part of the study design to develop a flora species inventory and to target locally occurring EVNT species identified during the desktop assessment. A minimum of four meanders were conducted within each habitat type in the study area, with all plant species observed either identified *in-situ* or collected and preserved for later identification. This survey effort meets the requirements prescribed in the *Flora Survey Guidelines – Protected Plants* (EHP, 2014a), which specifies that four meanders should be conducted in each area of habitat between 10 and 100 ha.

3.5 Fauna Survey Methodology

3.5.1 Survey Timing And Environmental Conditions

The fauna surveys incorporated survey timing and effort recommendations outlined in the *Terrestrial Vertebrate Fauna Survey Guidelines for Queensland* (Eyre *et al.*, 2018). One survey was conducted between 26 and 30 September 2017, which coincided with the timing for a spring to early summer survey period (September to mid-November) as recommended in Eyre *et al.* (2014) for the Brigalow Belt bioregion. The second survey was conducted between 14 and 19 May 2018, which coincided with the timing for an autumn survey period (March to mid-May) as recommended in Eyre *et al.* (2014) for the Brigalow Belt bioregion.

Weather data relevant to the fauna surveys were obtained from the Bureau of Meteorology (BoM) Emerald Airport (035264) station (Table 3). Weather conditions before and during the spring survey period were characterised by hot days and cool nights. Maximum and minimum temperatures increased during the weeks prior to the survey, with nightly temperatures increasing from 10 °C to 17 °C and daily temperatures increasing from 29°C to 39°C during September. Weather conditions before and during the autumn survey period were characterised by cooler days and cold nights. A small drop in minimum temperature was recorded during the beginning of the fauna survey and small amounts of precipitation were recorded.

Overall, weather conditions during the survey periods were considered favourable for detecting most vertebrate fauna groups, as morning temperatures allowed for an increase in bird activity whereas moderate daytime temperatures were favourable for reptiles.

Table 3: Weather conditions relevant to the survey periods

PERIOD	DATE	RAINFALL (MM)	TEMPERATURE (°C)	
			MINIMUM	MAXIMUM
2017 Pre-survey conditions	19/09/2017	0	12.7	29.4
	20/09/2017	0	12.8	33.0
	21/09/2017	0	15.4	33.8
	22/09/2017	0	14.9	34.4
	23/09/2017	0	16.5	35.5
	24/09/2017	0	15.8	36.6
	25/09/2017	0	14.2	35.9
2017 Conditions during survey	26/09/2017	0	14.6	36.9
	27/09/2017	0	16.5	38.4
	28/09/2017	0	17.8	39.9
	29/09/2017	0	17.7	38.4
	30/09/2017	0	17.2	35.9
2018 Pre-survey conditions	07/05/2018	0.2	17.4	27.2
	08/05/2018	0	14.9	29.0
	09/05/2018	0.2	15.6	30.4
	10/05/2018	0	14.9	30.7

PERIOD	DATE	RAINFALL (MM)	TEMPERATURE (°C)	
			MINIMUM	MAXIMUM
2018 Conditions during survey	11/05/2018	0	15.0	28.8
	12/05/2018	0.4	7.8	24.2
	13/05/2018	0	7.8	25.3
	14/05/2018	0	8.7	26.0
	15/05/2018	0	11.3	26.7
	16/05/2018	0	13.0	27.6
	17/05/2018	0	13.5	23.7
	18/05/2018	10	12.0	25.5
	19/05/2018	0	13.6	26.7

3.5.2 Systematic Survey Sites

During the survey periods, six systematic survey sites were established where an array of fauna trapping and survey techniques were employed as shown on Figure 1. The systematic survey sites were positioned to provide an appropriate spatial distribution within the study area while incorporating the different habitat types. A description of the habitat present at each systematic survey site is provided in Table 4.

Table 4: Fauna site numbers and corresponding habitat conditions

SITE NUMBER AND LOCATION	HABITAT DESCRIPTION	PHOTOGRAPH OF HABITAT
1. Northeast corner of the study area	RE 11.10.12 <i>Eucalyptus populnea</i> open forest with <i>Eucalyptus cambageana</i> and <i>Eucalyptus chloroclada</i> . Shrub layer of <i>Carissa lanceolata</i> and ground layer dominated by <i>Cenchrus ciliaris</i> *. Located on lower slopes of sandstone outcrops.	
2. Adjacent to Cooroora Creek, central-northeast section of the study area	RE 11.9.1/11.3.25e: Riparian community dominated by <i>Acacia harpophylla</i> , and a mid-dense shrub layer of <i>Acacia harpophylla</i> and <i>Terminalia oblongata</i> . <i>Cenchrus ciliaris</i> * dominates dense ground layer.	

SITE NUMBER AND LOCATION	HABITAT DESCRIPTION	PHOTOGRAPH OF HABITAT
3. Southwest section of the study area	RE 11.9.2: <i>Eucalyptus melanophloia</i> and <i>Acacia leiocalyx</i> open woodland on well-drained coarse sand. Sparse shrub layer dominated by <i>Dodonaea viscosa</i> and groundcover dense and diverse but desiccated and difficult to identify, dominated mainly by <i>Cenchrus ciliaris</i> *.	
4. Centre of the study area	RE 11.9.1/11.3.25e: Riparian community dominated by <i>Acacia harpophylla</i> , <i>Terminalia oblongifolia</i> , <i>Eucalyptus camaldulensis</i> and <i>Lysiphyllum hookeri</i> . A mid-dense shrub layer of <i>Acacia harpophylla</i> and <i>Terminalia oblongata</i> . A dense ground layer of native and non-native grasses with patches of dense <i>Parthenium hysterophorus</i> * cover.	
5. Central area of the study area	Non-remnant: Drainage feature flowing through <i>Cenchrus ciliaris</i> * pastures. Vegetation along the drainage feature is sparse and dominated by <i>Acacia harpophylla</i> , with scattered <i>Lysiphyllum hookeri</i> and <i>Atalaya hemiglauca</i> . Shrub layer dominated by <i>Vachellia farnesiana</i> * and regrowth <i>A. harpophylla</i> . Ground layer is dense outside the drainage feature and is dominated by <i>Cenchrus ciliaris</i> *.	

SITE NUMBER AND LOCATION	HABITAT DESCRIPTION	PHOTOGRAPH OF HABITAT
6. Southern portion of the study area along Sandy Creek	RE 11.9.1/11.3.25e: Riparian community dominated by <i>Eucalyptus camaldulensis</i>, <i>Terminalia oblongifolia</i>, <i>Acacia harpophylla</i>, <i>Lysiphyllum hookeri</i> and scattered <i>Melaleuca bracteata</i>. A lower tree layer is present with the same species but also <i>Ficus opposita</i>, <i>Cassia brewsteri</i> and <i>Santalum lanceolatum</i> are present. The sparse shrub layer is dominated by <i>Erythroxylum australe</i> with scattered <i>Carissa lanceolata</i>, <i>Lysiphyllum hookeri</i>, <i>Acacia harpophylla</i> and <i>Vachellia farnesiana</i>*. <i>Cenchrus ciliaris</i>* and <i>Urochloa mosambicensis</i>* dominate the ground layer.	

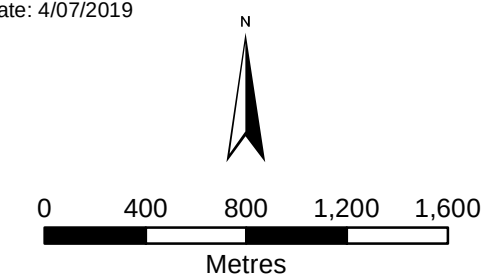
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FAIRHILL FIGURE 1 FAUNA SURVEY

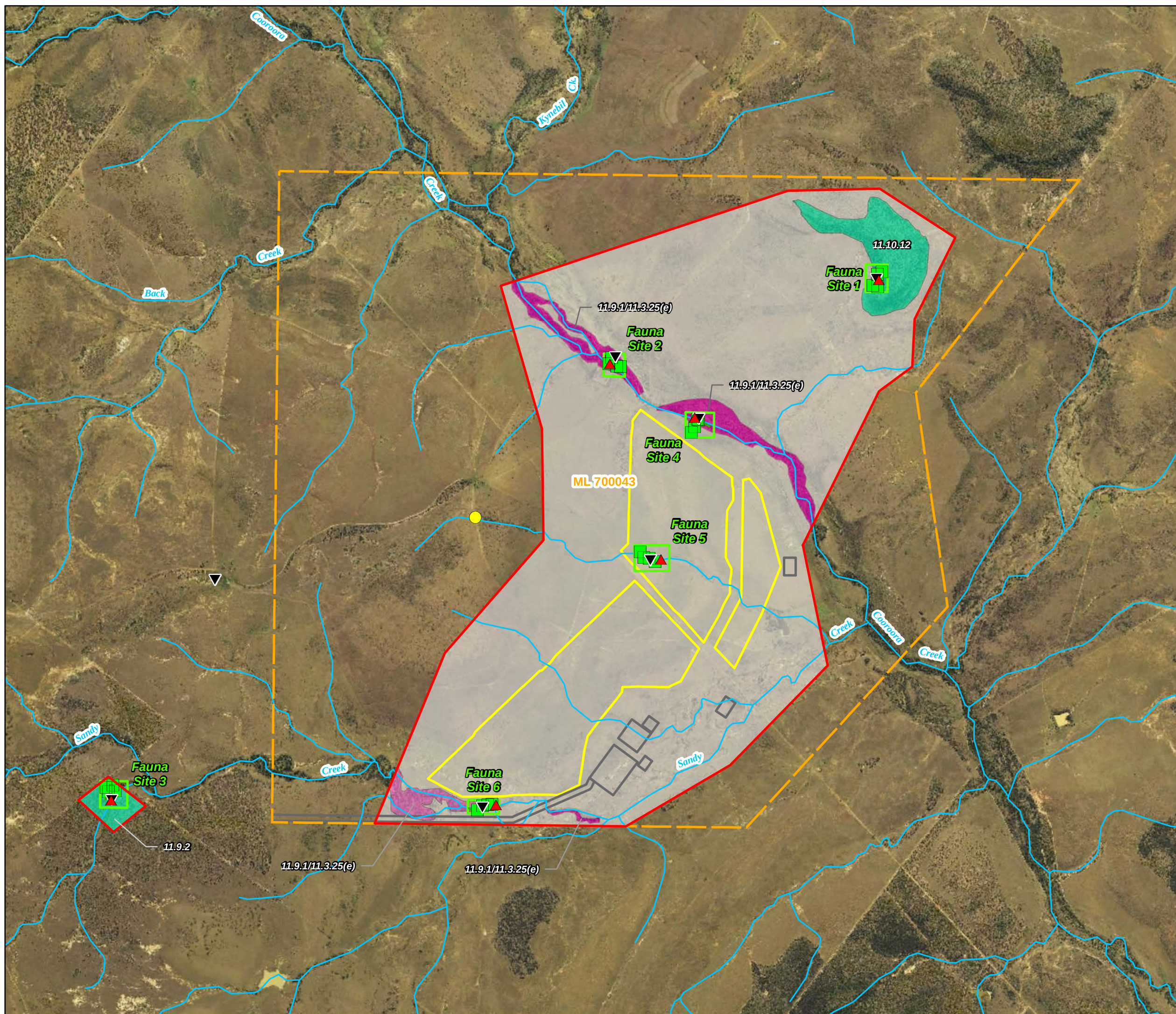
Legend

- | | |
|------------------------------|--|
| ▼ Bat Detector | Study Area |
| ■ Cage Trap | Proposed Site Infrastructure |
| ▲ IR Camera | 7 Year Pit Shell |
| ● Pigs | Ground-Truthed Remnant Vegetation |
| — Elliot trap line | Endangered Regional Ecosystem |
| — Pitfall trap line | High-Value Regrowth |
| VM | Least Concern Regional Ecosystem |
| — Watercourse (100/250K) | Non-remnant |
| □ Fauna Survey Site | |
| — Mining Lease (Application) | |

Data Sources:
Mining Lease and Vegetation Management (100/250K)
Watercourse datasets: the State of Queensland (Department of Natural Resources, Mines, and Energy) 2019; Fauna Survey, Ground-Truthed Regional Ecosystems, Proposed Site Infrastructure and 7 Year Pit Shell: SLR Consulting 2019.
Imagery Sources: 70cm Bowen Basin SISP PeriUrban 2012 Orthophoto Image Service: © State of Queensland (Department of Natural Resources, Mines, and Energy) 2019.
Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator
Datum: GDA 1994
Date: 4/07/2019



Scale: 1:30,000 at A3



3.5.3 Survey Techniques

The survey techniques employed at each systematic survey site are detailed in Table 5.

Table 5: Fauna survey methods employed at systematic survey sites

SURVEY METHOD	DESCRIPTION
Elliott traps	At each trapping site, 20 type A Elliott style traps were placed on the ground approximately 5–10m apart in a straight line for 4 nights. All traps were baited with a mixture of rolled oats, peanut butter and honey.
Pitfall and funnel traps	Drift fence lines incorporating pitfall and funnel traps were established for four nights at each of the systematic survey sites. Three pitfall traps (20L buckets) were buried flush with the ground surface with the drift fence intersecting the centre of each bucket at each site. Six funnel traps were located along the drift fencing at each site. A shade cloth covering each funnel trap was deployed to protect trapped species from exposure.
Cage traps	Four cage traps were placed at each site and baited with a mixture of rolled oats and a variety of meats.
Bat detectors	A bat call detector (Wildlife Acoustics SM4BAT FS – full-spectrum recorder) was deployed for one night at each site. Additionally, the bat call detector was placed in flyway zones within pastureland and water sources for additional nights within the study area.
Active diurnal searches	Active diurnal searches were undertaken within each of the sites. This technique involved intensive investigation of ground layer habitat features (such as under logs, rocks and leaf litter) and low vegetation (under bark and tree stumps) for cryptic fauna, particularly reptiles. Searches were focussed during the times of day when reptile activity was likely to be at its peak.
Diurnal bird surveys	Birds were surveyed within each vegetation community for a total of at least one hour at multiple periods throughout the day, but with a focus during peak activity in the morning. Incidental observations made whilst conducting other survey techniques were also recorded. Birds were identified from either direct observation or by their calls.
Nocturnal surveys	High-powered spotlights were used to survey nocturnal mammals (flying, arboreal and terrestrial), birds (active nocturnal species and roosting diurnal species), reptiles and frogs in each of the main trapping sites, and other locations throughout the study area.

3.5.4 Additional Survey Areas and Techniques

The fauna survey of the study area employed numerous survey techniques within the systematic survey sites and in additional locations. Survey techniques utilised during the baseline study included a bat detector, active diurnal searches, diurnal bird surveys and nocturnal survey techniques.

In addition to the techniques outlined previously, camera traps (motion-sensing infrared cameras) were deployed at multiple locations within the study area to target fauna that may be too large or 'shy' to be detected by other trapping techniques, or that utilised areas outside the main trapping sites. Camera traps were baited with the rolled oat mixture and a variety of meats.

Targeted nocturnal searches for arboreal mammals and nocturnal predatory birds were performed in areas considered higher quality habitat for such species.

Spotlighting surveys were also conducted while driving slowly over multiple parts of the study site and local area, where it was safe to do so.

Fauna species were continually observed throughout the survey period and records were frequently obtained outside of the systematic methodology of the survey. Any observations, tracks, scats or other signs of fauna were recorded with reference to the location and habitat type.

3.5.5 Targeted Techniques

Targeted survey techniques and searches were incorporated for some conservation significant species considered to potentially occur within the study area. Area searches for Squatter Pigeon were conducted in accordance with the relevant EPBC Act threatened bird survey guidelines. Targeted searches for other species were based on published guidelines relevant to a given species. Nocturnal spotlighting was conducted for Koala and Greater Gliders within relevant habitat areas. Spotlighting surveys were also conducted in areas of potentially suitable habitat for the Ornamental Snake to increase the likelihood of detection for this species.

3.5.6 Survey Effort

The survey effort employed for each of the fauna survey techniques is outlined in Table 6, showing the effort employed at each systematic survey site and the total survey effort over the study periods (including effort outside the systematic surveys).

Table 6: Fauna survey effort for each technique

METHOD	EFFORT PER SITE 2017	EFFORT PER SITE 2018	TOTAL SURVEY EFFORT
Pitfall trapping	12 trap nights (Array of three pits × four nights)	12 trap nights (Array of three pits × four nights)	72 trap nights
Funnel trapping	24 trap nights (Array of six funnels × four nights)	16 trap nights (Array of four funnels × four nights)	120 trap nights
Diurnal active search	Two person hours (60-minute search × two people)	Two person hours (60-minute search × two people)	Approx. 17 person hours (Six × systematic surveys sites plus five additional one-person hour survey sites)
Elliott trapping	80 trap nights (20 traps × four nights)	80 trap nights (20 traps × four nights)	480 trap nights
Cage trapping	16 trap nights (Array of four cages × four nights)	16 trap nights (Array of four cages × four nights)	96 trap nights
Diurnal bird survey	Two person hours (Six × 10-minute surveys × two people)	Two person hours (Six × 10-minute surveys × two people)	12 person hours
Camera trapping	Four trap nights (One camera × four nights)	Four trap nights (One camera × four nights)	24 trap nights
Spotlight/ nocturnal searches	Three person hours (90-minute search × two people)	Three person hours (90-minute search × two people)	18 person hours
Echolocation call detection	One detector night (One detector for one night at each site and two additional detector nights)	One detector night (One detector for one night at each site)	Eight detector nights

4. Desktop Analysis Results

4.1 Literature Review

Studies conducted on the nearby Wilton ML recorded the presence of the vulnerable Ornamental Snake and migratory Latham's Snipe (SHG, 2011). The Ornamental Snake was recorded in Brigalow dominated vegetation with numerous gilgai. It was speculated that similar gilgai habitat in non-remnant areas within the study area would likely contain this species. Latham's Snipe was recorded within the Wilton ML in an ephemeral wetland area. *Acacia spania* was also recorded in isolated patches within RE 11.7.4 throughout the study area.

Multiple surveys conducted at Curragh North Mine for the EIS identified Brigalow woodland threatened ecological communities (TEC) (RE 11.3.1), threatened species including the Ornamental Snake, Brigalow Scaly-foot, Squatter Pigeon and 41 migratory species (Environmental Protection Agency, 2004). The Brigalow Scaly-foot was delisted from the EPBC Act on 15 May 2013 and delisted from the NC Act on 12 December 2014. Although the Curragh North Mine is relatively close and is located in the same catchment as the Fairhill site, there is little similarity between the sites with regards to vegetation communities, with only RE 11.3.25 found on both sites.

4.2 Database Searches

The EPBC Act Protected Matters Report (DEE, 2018b) and WO database extract (DES, 2018d) incorporating a 30 km buffer around the study area are included in Appendix A and Appendix B, respectively. The WO database extract and Protected Matters Report identified 6 threatened flora species, 22 threatened fauna species and 11 migratory fauna species that could potentially occur within the study area. Desktop studies identified several REs, high value regrowth (HVR) and TECs.

4.2.1 Threatened Ecological Communities

Two of the REs identified (RE 11.9.1 and 11.9.5) in database searches equate to the EPBC-listed 'Brigalow' TEC within the vicinity of the EPC. Three TECs were identified in the Protected Matters Report (DEE, 2018b) as potentially occurring within the study area or within a 30 km radius. The three endangered communities are:

- Brigalow (*Acacia harpophylla* dominant and co-dominant)
- Natural grasslands of the Queensland Central Highlands and northern Fitzroy Basin, and
- Weeping Myall Woodlands.

4.2.2 Threatened Flora Species

A total of six EVNT flora species were identified in the database searches as potentially occurring within 30 km of the site. This included four species predicted by the EPBC Act Protected Matters Report (DEE, 2018b, see Appendix A) and two additional species recorded in the Queensland Government WO database extract (DES, 2018d, Appendix B). The results of these searches have been combined in Table 7 to show all EVNT flora species recorded from the database searches, their status under State and Commonwealth legislation and their likelihood of occurring within the study area.

Table D1 in Appendix C provides justification for the 'likelihood of occurrence' determination for each species. Of the six threatened or near threatened flora species identified in the desktop analyses, three were considered to have a moderate to high likelihood of occurring within the study area; the remaining three species were considered to have a low likelihood of occurring. All species that were considered to

have a moderate or high likelihood of occurring within the study area are discussed in further detail in the Impact Assessment and Management section of this report.

4.2.3 Threatened Fauna Species

A total of 22 EVNT fauna species were returned from the database searches of a 30 km radius surrounding the study area. These included 20 from the EPBC Act Protected Matters Report (DEE, 2018b, see Appendix A) and one additional species from the WO database extract (DES, 2018d, see Appendix B). The results of these searches have been combined in Table 8, which also provides an interpretation on the likelihood that each of these species would occur within the study area. Table D2 in Appendix C provides justification for how the 'likelihood of occurrence' was determined for each species.

Seven species were considered to have a moderate or high likelihood of occurring within the study area; the remaining fifteen species were considered to have a low likelihood of occurring. All species that were considered to have a moderate or high likelihood of occurring within the study area are discussed in further detail in the Impact Assessment and Management section of this report.

4.2.4 Migratory Species

The EPBC Protected Matters Search Report (DEE, 2018b) identified 11 migratory species as potentially occurring within 30 km of the study area. The results of this search are included in Table 9 along with interpretation on the likelihood that each of these species would occur within the study area. Table D3 in Appendix C provides justification for how the 'likelihood of occurrence' was determined for each species.

Only 2 of the 11 species were considered to have a high likelihood of occurring on site and are discussed in further detail in the Impact Assessment and Management section of this report.

Table 7: Near threatened and threatened flora species identified from database searches

STATUS ¹		FAMILY	SCIENTIFIC NAME	COMMON NAME	SOURCE ²	RECORDS	LIKELIHOOD OF OCCURRENCE
NC ACT	EPBC ACT						
NT	–	Mimosaceae	<i>Acacia spania</i>	–	WO	3	High
LC	V	Myrtaceae	<i>Eucalyptus raveretiana</i>	Black Ironbox	PM	0	Low
V	E	Poaceae	<i>Dichanthium queenslandicum</i>	King Bluegrass	PM/WO	4	Moderate
LC	V	Poaceae	<i>Dichanthium setosum</i>	Bluegrass	PM	0	Low
E	-	Solanaceae	<i>Solanum elaeagnifolium</i>		WO	1	Moderate
V	V	Surianaceae	<i>Cadellia pentastylis</i>	Ooline	PM/WO	1	Low

1. NC Act = *Nature Conservation Act 1992*, EPBC Act = *Environment Protection and Biodiversity Conservation Act 1999*

2. Status: LC = Least Concern, NT = Near Threatened, V = Vulnerable, E = Endangered

3. Source: WO = Wildlife Online Database, PM = EPBC Protected Matters Report

Table 8: Near threatened and threatened fauna species identified from database searches

STATUS ¹		FAMILY	SCIENTIFIC NAME	COMMON NAME	SOURCE ²	WO RECORDS	LIKELIHOOD OF OCCURRENCE
NCA	EPBC						
BIRDS							
E	V	Accipitridae	<i>Erythrotriorchis radiatus</i>	Red Goshawk	PM	0	Moderate
V	V	Columbidae	<i>Geophaps scripta scripta</i>	Squatter Pigeon	PM/WO	5	High
E	E	Estrildidae	<i>Neochmia ruficauda ruficauda</i>	Star Finch	PM	0	Low
E	E	Estrildidae	<i>Poephila cincta cincta</i>	Southern Black-throated Finch	PM	0	Low
V	V	Meliphagidae	<i>Grantiella picta</i>	Painted Honeyeater	PM	0	Low
V	E, M	Rostratulidae	<i>Rostratula australis</i>	Australian Painted Snipe	PM	0	Low
E	CE, M	Scolopacidae	<i>Calidris ferruginea</i>	Curlew Sandpiper	PM	0	Low
MAMMALS							
LC	E	Dasyuridae	<i>Dasyurus hallucatus</i>	Northern Quoll	PM	0	Low
E	E	Macropodidae	<i>Onychogalea fraenata</i>	Bridled Nailtail Wallaby	WO	1	Low
E	V	Megadermatidae	<i>Macroderma gigas</i>	Ghost Bat	PM	0	Low
V	V	Phascolarctidae	<i>Phascolarctos cinereus</i>	Koala	PM/WO	4	Moderate
V	V	Pseudocheiridae	<i>Petauroides volans</i>	Greater Glider	PM/WO	3	Moderate
V	V	Pteropodidae	<i>Pteropus poliocephalus</i>	Grey-headed Flying-fox	PM	0	Low
V	V	Vespertilionidae	<i>Nyctophilus corbeni</i>	Corben's Long-eared Bat	PM	0	Low
V	V	Vespertilionidae	<i>Chalinolobus dwyeri</i>	Large-eared Pied Bat	PM	0	Low

STATUS ¹		FAMILY	SCIENTIFIC NAME	COMMON NAME	SOURCE ²	WO RECORDS	LIKELIHOOD OF OCCURRENCE
NCA	EPBC						
REPTILES							
E	CE	Chelidae	<i>Elseya albagula</i>	Southern Snapping Turtle	PM/WO	2	Moderate
V	V	Chelidae	<i>Rheodytes leukops</i>	Fitzroy River Turtle	PM/WO	3	Moderate
V	V	Elapidae	<i>Denisonia maculata</i>	Ornamental Snake	PMWO	1	High
V	V	Elapidae	<i>Furina dunmalli</i>	Dunmall's Snake	PM	0	Low
V	V	Pygopodidae	<i>Delma torquata</i>	Collared Delma	PM	0	Low
V	V	Scincidae	<i>Egernia rugosa</i>	Yakka Skink	PM	0	Low
E	E	Scincidae	<i>Lerista allanae</i>	Retro Slider	PM	0	Low

1. NC Act = *Nature Conservation Act 1992*, EPBC Act = *Environment Protection and Biodiversity Conservation Act 1999*

2. Status: LC = Least Concern, NT = Near Threatened, V = Vulnerable, E = Endangered, CE = Critically Endangered, M = Migratory

3. Source: WO = Wildlife Online Database, PM = EPBC Protected Matters Report

Table 9: EPBC Act listed migratory species from the Protected Matters Report

STATUS ¹		FAMILY	SCIENTIFIC NAME	COMMON NAME	SOURCE ²	WO RECORDS ²	LIKELIHOOD OF OCCURRENCE
NCA	EPBC						
SLC	M	Accipitridae	<i>Pandion cristatus</i>	Eastern Osprey	PM	0	Low
SLC	M	Apodidae	<i>Apus pacificus</i>	Fork-tailed Swift	PM	0	Low
SLC	M	Cuculidae	<i>Cuculus optatus</i>	Oriental Cuckoo	PM	0	Low
SLC	M	Monarchidae	<i>Monarcha melanopsis</i>	Black-faced Monarch	PM	0	Low
SLC	M	Monarchidae	<i>Myiagra cyanoleuca</i>	Satin Flycatcher	PM/WO	1	Low
SLC	M	Motacillidae	<i>Motacilla flava</i>	Yellow Wagtail	PM	0	Low
SLC	M	Scolopacidae	<i>Actitis hypoleucos</i>	Common Sandpiper	PM	0	Low
SLC	M	Scolopacidae	<i>Calidris acuminata</i>	Sharp-tailed Sandpiper	PM/WO	6	High
E	CE, M	Scolopacidae	<i>Calidris ferruginea</i>	Curlew Sandpiper	PM	0	Low
SLC	M	Scolopacidae	<i>Calidris melanotos</i>	Pectoral Sandpiper	PM	0	Low
SLC	M	Scolopacidae	<i>Gallinago hardwickii</i>	Latham's Snipe	PM/WO	1	High

1. NC Act = *Nature Conservation Act 1992*, EPBC Act = *Environment Protection and Biodiversity Conservation Act 1999*

2. Status: SLC = Special Least Concern, LC = Least Concern, NT = Near Threatened, V = Vulnerable, E = Endangered, M = Migratory

3. WO = Wildlife Online Database, PM = EPBC Protected Matters Report

4.3 Regional Ecosystem Mapping and High Value Regrowth

The study area contains eight polygons of remnant vegetation shown on the DNRME RE mapping as shown in Figure 2. These polygons contain at least one of the following REs: RE 11.3.3, RE 11.3.25, RE 11.9.1, RE 11.9.2, RE 11.9.5, RE 11.9.7, RE 11.10.11 and RE 11.10.12. Large areas of non-remnant vegetation occur between fragments of remnant vegetation mapped within the study area. A small polygon of HVR is mapped in the southwest corner of the study area along Sandy Creek. This area is mapped as a mixed polygon of Category R and Category C regrowth vegetation.

Table 10 provides a summary of all the REs mapped throughout the study area including the short descriptions provided in the REDD (Queensland Herbarium, 2018).

Table 10: RE status and description for mapped remnant vegetation

RE CODE	VMA STATUS	BIODIVERSITY STATUS	REGIONAL ECOSYSTEM DATABASE SHORT DESCRIPTION
11.3.3	Of concern	Of concern	<i>Eucalyptus coolabah</i> woodland on alluvial plains
11.3.25	Least concern	Of concern	<i>Eucalyptus tereticornis</i> or <i>E. camaldulensis</i> woodland fringing drainage lines
11.9.1	Endangered	Endangered	<i>Acacia harpophylla</i> - <i>Eucalyptus cambageana</i> woodland to open forest on fine-grained sedimentary rocks
11.9.2	Least concern	No concern at present	<i>Eucalyptus melanophloia</i> +/- <i>E. orgadophila</i> woodland on fine-grained sedimentary rocks
11.9.5	Endangered	Endangered	<i>Acacia harpophylla</i> and/or <i>Casuarina cristata</i> open forest on fine-grained sedimentary rocks
11.9.7	Of concern	Of concern	<i>Eucalyptus populnea</i> , <i>Eremophila mitchellii</i> shrubby woodland on fine-grained sedimentary rocks
11.10.11	Least concern	No concern at present	<i>Eucalyptus populnea</i> , <i>E. melanophloia</i> +/- <i>Callitris glaucophylla</i> woodland on coarse-grained sedimentary rocks
11.10.12	Least concern	No concern at present	<i>Eucalyptus populnea</i> woodland on medium to coarse-grained sedimentary rocks

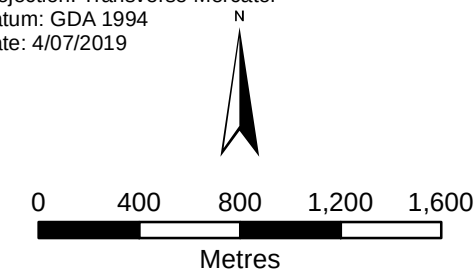
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FAIRHILL FIGURE 2 STATE-MAPPED REGIONAL ECOSYSTEMS

Legend

- Mining Lease (Application)
 - VM Watercourse (100/250K)
 - Proposed Site Infrastructure
 - 7 Year Pit Shell
- State-Mapped Regional Ecosystems**
- Category A or B area containing endangered
 - Category A or B area containing endangered and is S20AH
 - Category A or B area containing of concern
 - Category A or B area that is least concern
 - Category C area containing endangered
 - Category C area that is of least concern
 - Non-remnant

Data Sources:
Mining Lease, Vegetation Management (100/250K)
Watercourse, State-Mapped Regional Ecosystem
(v10.1) datasets: the State of Queensland (Department
of Natural Resources, Mines, and Energy) 2019;
Proposed Site Infrastructure and 7 Year Pit Shell: SLR
Consulting 2019.
Imagery Sources: 70cm Bowen Basin SISP PeriUrban
2012 Orthophoto Image Service: © State of
Queensland (Department of Natural Resources, Mines,
and Energy) 2019.
Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator
Datum: GDA 1994
Date: 4/07/2019



Scale: 1:30,000 at A3

4.4 Environmentally Sensitive Areas

ESAs are described in the Environmental Protection Regulation (2008) and DES provides an online map tool to identify mapped ESAs that are relevant to resource activities. The ESA map for the study area (DES, 2018a) shows multiple areas of Category B ESAs within the ML, in the form of REs with an endangered biodiversity status (see Figure 2). A review of the remnant RE mapping revealed that the mapped Category B ESAs equate to the mapped extent of RE 11.9.1 (see further details in the Flora Survey Results section), which has an endangered biodiversity status in the REDD (Queensland Herbarium, 2018). The extent of Category B ESAs has significant bearing on the development of resource activities and therefore these areas were subject to a ground-truthing survey effort during the field survey program.

4.5 Groundwater Dependent Ecosystems

Within the study area, a desktop assessment revealed polygons of potential groundwater dependent ecosystems (GDEs) along Cooroora Creek but none along Sandy Creek, (DNRME, 2019; BOM, 2019) (see Figure 3 and Figure 4). All of the mapped GDEs on both mapping systems identify moderate to high potential for terrestrial GDEs to occur. These are classified as “*quaternary alluvial aquifers with fluctuating, intermittent groundwater connectivity regime and unknown pH*” of low confidence (DNRME, 2019).

4.6 Geology Mapping

Geological mapping for the region was obtained from Geoscience Australia online interactive mapping. Three geology units are shown within and surrounding the study area, as shown in Table 11. The relevant landzones as defined in Wilson and Taylor (2012) are also shown.

Table 11: Geology mapping units within the study area

MAP CODE	LITHOLOGY	ROCK TYPE	LANDZONE
Ps	Quartzose to lithic sandstone, siltstone, carbonaceous shale, minor coal and sandy coquinite	Sedimentary	9
Po	Sandstone, siltstone, shale, mudstone, coal, tuff, conglomerate	Sedimentary	10
Qa	Channel and flood plain alluvium; gravel, sand, silt, clay; may be locally calcreted	Regolith	3

4.7 Essential Habitat

None of the vegetation communities mapped within the study area are mapped as essential habitat on the DNRME essential habitat map.

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FIGURE 3
STATE-MAPPED
GROUNDWATER
DEPENDENT ECOSYSTEMS

Legend

 Mining Lease (Application)

 7 Year Pit Shell

Surface GDE lines

 Derived GDE - moderate confidence

 Derived GDE - low confidence

Terrestrial GDE areas

 81-100 Derived GDE - Moderate Confidence

 81-100 Derived GDE - Low Confidence

Potential GDE aquifers

 Unconsolidated sedimentary aquifers

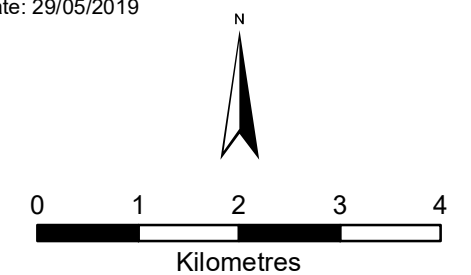
 Consolidated sedimentary aquifers

 Igneous rock aquifers

 No identified aquifers

Data Sources:
Mining Lease and Groundwater Dependent Ecosystem (GDE) datasets: the State of Queensland (Department of Natural Resources, Mines, and Energy) 2019; Fairhill Infrastructure dataset: SLR Consulting 2019.

Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator
Datum: GDA 1994
Date: 29/05/2019



Scale: 1:75,000 at A3

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FIGURE 4
NATIONALLY-MAPPED
GROUNDWATER
DEPENDENT ECOSYSTEMS

Legend

 Mining Lease (Application)

 7 Year Pit Shell

Aquatic GDE

 Moderate potential GDE - from national assessment

 Low potential GDE - from national assessment

Terrestrial GDE

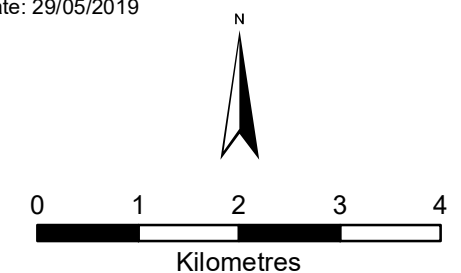
 High potential GDE - from national assessment

 Moderate potential GDE - from national assessment

 Low potential GDE - from national assessment

Data Sources:
Mining Lease dataset: the State of Queensland (Department of Natural Resources, Mines, and Energy) 2019; Groundwater Dependent Ecosystem (GDE) datasets: the Commonwealth of Australia (Bureau of Meteorology) 2019; Fairhill Infrastructure dataset: SLR Consulting 2019.

Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator
Datum: GDA 1994
Date: 29/05/2019



Scale: 1:75,000 at A3

5. Flora Survey Results

5.1 Vegetation communities

5.1.1 EPBC Act Threatened Ecological Communities

The EPBC Act Protected Matters Search Tool identified three TECs potentially occurring within 30 km of the study area. There are no areas of 'natural grasslands' or 'Weeping Myall woodlands' present within the study area; however, two REs (RE 11.9.1 and 11.9.7) are shown on the DNRME RE mapping and these REs are State equivalent units for the '*Brigalow (Acacia harpophylla dominant and co-dominant)*' TEC listed under the EPBC Act.

State-mapped remnant vegetation on Cooroora Creek shows a mixed polygon of REs 11.3.3, 11.3.25 and 11.9.1. Vegetation surveys undertaken on Cooroora Creek identified two remnant vegetation communities in this area, REs 11.9.1 and 11.3.25e. Additionally, two small mixed polygons of RE 11.9.1 and 11.3.25e were ground-truthed on a tributary of Sandy Creek, which is a tributary of Cooroora Creek, in the southern portion of the study area. Separation of these vegetation communities was not possible as RE 11.9.1 occurred adjacent to the watercourse but continued through the main channel and associated drainage features. *Eucalyptus camaldulensis* was present and dominant to co-dominant along the bed and bank of the watercourse indicating RE 11.3.25e; however, *Acacia harpophylla* was also present and occurred as sub-dominant to co-dominant. Away from the bank of the watercourse, *Acacia harpophylla* occurred as dominant to co-dominant with *Terminalia oblongata*. The mixed polygons along Cooroora Creek and Sandy Creek are situated in lower lying areas that would retain water for longer periods of time than the surrounding landscape. Possibly due to the increased water retention, eucalypts were recorded throughout remnant vegetation adjacent to the watercourse creating a broad ecotone of the two REs.

Although RE 11.9.1 is listed as a State-equivalent vegetation unit for the '*Brigalow (Acacia harpophylla dominant and co-dominant)*' TEC, the ground-truthed community does not meet key diagnostic criteria for the listed TEC. To be classified as the Brigalow TEC, the vegetation community in question must meet the following key diagnostic characteristics and condition thresholds as per the Approved Conservation Advice for the Brigalow (*Acacia harpophylla* dominant and co-dominant) ecological community (DEE, 2018a).

Key diagnostic criteria:

- The presence of *Acacia harpophylla* as one of the most abundant tree species in the patch. *A. harpophylla* is either dominant in the tree layer, or co-dominant with other species, and
- In Queensland the patch is in one of the following QLD bioregions and it meets the description of one of the 16 QLD REs determined at the time of the national listing of the Brigalow ecological community under the EPBC Act.

Condition thresholds:

- The patch is 0.5 ha or more in size, and
- Exotic perennial plants comprise less than 50% of the total vegetation cover of the patch, as assessed over a minimum sample area of 0.5 ha, that is representative of the patch.

Although the ground-truthed mixed polygon of RE 11.9.1/11.3.25e does meet the key diagnostic criteria to be classified as the listed TEC, it does not meet the condition thresholds. The ground-truthed mixed polygon of RE 11.9.1/11.3.25e do not meet the condition thresholds due to the extensive weed invasion of the ground layer that comprises greater than 50% cover. Buffel Grass (*Cenchrus ciliaris**), Parthenium (*Parthenium hysterophorus**) and Sabi Grass (*Urochloa mosambicensis**) dominated the ground layer throughout the mixed polygon. Moderate to heavy disturbance from livestock grazing was evident

throughout the ground layer. Increased disturbance towards the watercourse was recorded due to livestock using pools within the watercourse as drinking points.

Although the remnant vegetation polygons around parts of Sandy Creek and Cooroora Creek include vegetation consistent with RE 11.9.1, the purpose of listing Brigalow communities as TECs is to protect high quality remnant vegetation as defined by the key criteria and condition thresholds. The vegetation communities in question are heavily impacted by invasive species and as such do not meet the condition threshold for the listed Brigalow TEC.

5.1.2 VM Act regional ecosystems and high value regrowth

As shown in Figure 5, Vegetation community surveys largely supported the DNRME RE mapping within the main remnant areas. The two secondary and 24 quaternary surveys confirmed the presence, extent, status and condition of remnant vegetation within the study area and allowed confirmation of DNRME mapping, with some exceptions. REs identified in the study area included REs 11.3.25e, 11.9.1, 11.9.2 and 11.10.12. Both REs 11.9.2 and 11.10.12 are of 'least concern' under the VM Act and have a 'no concern at present' biodiversity status. RE 11.3.25e has a 'least concern' VM Act class and an 'of concern' biodiversity status. RE 11.9.1 has an 'endangered' VM Act class and biodiversity status.

An area in the far southwest corner of the study area is shown on the State mapping as containing numerous mixed polygons including REs 11.9.2/11.9.1/11.9.5, a mixed polygon of REs 11.9.2/11.9.1, a mixed polygon of REs 11.3.3/11.3.25/11.9.1 and a polygon of 11.10.12. The small area that was ground-truthed showed the mix of polygons as RE 11.9.2 (*Eucalyptus melanophloia* and *Acacia leiocalyx* woodland) that is listed as 'least concern' under the VM Act and has a 'no concern at present' biodiversity status (see the ground-truthed map in Figure 5).

Endangered RE 11.9.1 was confirmed in conjunction with RE 11.3.25e along Cooroora Creek and Sandy Creek. Two small polygons along Sandy Creek were State mapped as mixed polygons of high value regrowth and Category R vegetation (see Figure 5). Although confined to the edges of Sandy Creek, these polygons recorded heights and covers within thresholds defined in the VM Act (1999) when compared to the respective RE technical description provided by DES and are considered remnant vegetation. These two mixed polygons support a species composition and structure consistent with remnant REs 11.9.1 and 11.3.25e. Similar to the mixed polygon along Cooroora Creek, the small polygons of RE 11.9.1/11.3.25e along Sandy Creek occur with a broad ecotone and accurate differentiation of individual homogenous REs was not possible.

Remnant vegetation along major watercourses were State-mapped as mixed polygons. One of these (RE 11.3.3) is described as *Eucalyptus coolabah* open woodland, but this was not identified in the study area. However, scattered *Eucalyptus coolabah* were present and scattered through remnant vegetation along larger watercourses but was not a dominant component of any area assessed. The presence of *Eucalyptus coolabah* could indicate that RE 11.3.3 might have been present prior to clearing for agricultural land-use.

The small sandstone outcrop northeast section of the study area was mapped as RE 11.10.11 (*Eucalyptus populnea*, *Eucalyptus melanophloia* +/- *Callitris glaucophylla* woodland); however, ground-truthing identified it as RE 11.10.12 (*Eucalyptus populnea* woodland), as *Eucalyptus melanophloia* and *Callitris glaucophylla* were not present (Table 12).

Along the southern border of the ML the proposed haul road intersects a small polygon (0.06 ha) of high value regrowth (HVR) classified as RE 11.9.1. This small polygon adjoins a larger mixed polygon of HVR classified as 11.3.3/11.3.25/11.9.1 in proportions of 40/20/20. The proposed haul road would impact upon approximately 0.57 ha of this larger heterogeneous polygon. Together these polygons encompass a total area of 20.11 ha with proposed disturbance incorporating approximately 3.1% (0.63 ha) of the total area.

Ground-truthing assessments in this area confirmed the presence of regrowth vegetation, generally consistent with RE 11.9.1. Regrowth vegetation was dominated by *Eucalyptus cambageana* and Brigalow, with a ground layer dominated by improved pasture species (e.g. Buffel Grass and Indian Couch) and common pasture weeds (e.g. Parthenium).

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FAIRHILL FIGURE 5 GROUND-TRUTHED REGIONAL ECOSYSTEMS

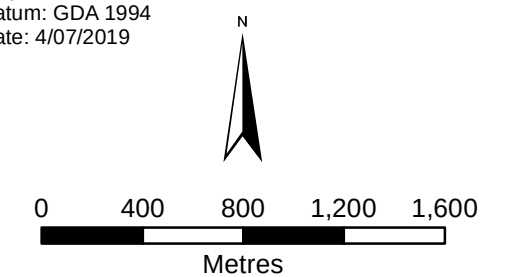
Legend

-  Quaternary Survey
-  Secondary Survey
-  VM Watercourse (100/250K)
-  Study Area
-  Mining Lease Permit (Application)
-  Proposed Site Infrastructure
-  7 Year Pit Shell

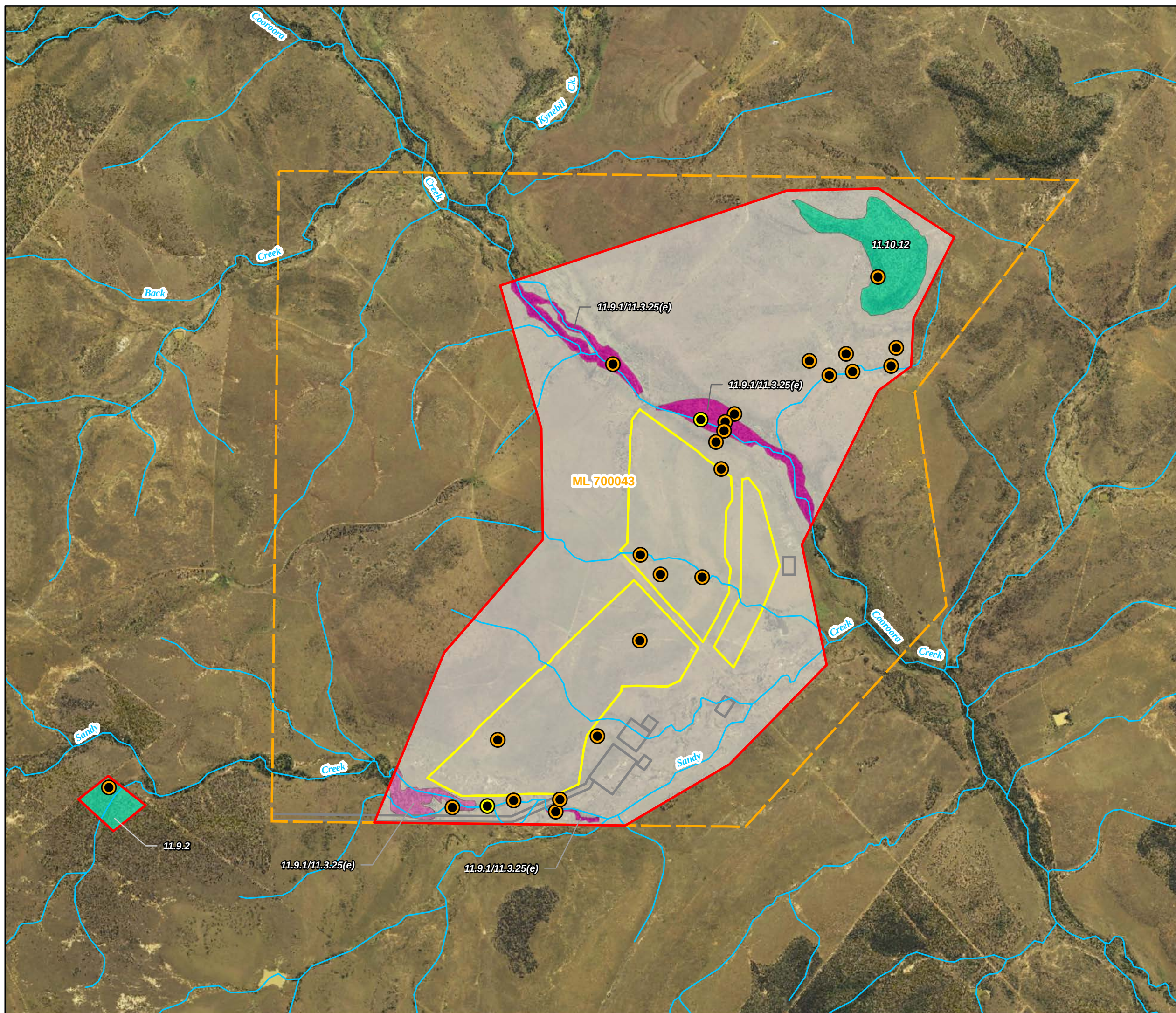
Ground-Truthed Remnant Vegetation

-  Endangered Regional Ecosystem
-  High-Value Regrowth
-  Least Concern Regional Ecosystem
-  Non-remnant

Data Sources:
Mining Lease and Vegetation Management (100/250K)
Watercourse datasets: the State of Queensland
(Department of Natural Resources, Mines, and Energy)
2019; Ground-Truthed Regional Ecosystems, Proposed
Site Infrastructure and 7 Year Pit Shell: SLR Consulting
2019.
Imagery Sources: 70cm Bowen Basin SISPP PeriUrban
2012 Orthophoto Image Service: © State of
Queensland (Department of Natural Resources, Mines,
and Energy) 2019.
Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator
Datum: GDA 1994
Date: 4/07/2019



Scale: 1:30,000 at A3



5.1.3 Non-Remnant Vegetation

Remnant vegetation is defined under the VM Act as vegetation in the dominant canopy layer having greater than 70% of the height and greater than 50% of the cover of vegetation of the same type as that in an undisturbed state. Most areas mapped as non-remnant on the DNRME RE mapping were accurate and have been extensively cleared and maintained as improved pasture areas that are now dominated by exotic pasture grasses, such as Buffel Grass*, Sabi Grass* and Indian Couch (*Bothriochloa pertusa**). Multiple quaternary surveys were conducted in State mapped non-remnant areas and the majority of these were confirmed as non-remnant status. Within non-remnant areas, scattered individual trees or stands of Brigalow persist, but due to extremely low cover and generally low height these do not meet the criteria for remnant RE status (Figure 6).

	
A: Non-remnant paddock dominated by Buffel Grass (<i>Cenchrus ciliaris</i>*) in the northeast of the study area.	B: Non-remnant regrowth <i>Acacia harpophylla</i> woodland. Watercourse and narrow riparian zone to east, open grassland to west.
	
C: Numerous trees along drainage features and watercourses showed evidence of being ringbarked.	D: Typical drainage feature within the study area. Buffel Grass understory with scattered Brigalow regrowth and Mimosa Bush*.

Figure 6: Examples of non-remnant vegetation areas

5.2 Flora Species

A total of 71 flora species from 27 families were recorded within the study area. All flora species observed throughout the study area are common and widespread throughout the region in eucalypt and *Acacia* woodland communities and improved pastures. The floristic composition is generally consistent within each of the mapped units, with some disturbance from fire, cattle grazing, ringbarking and exotic weeds being evident throughout. A full list of flora identified during the flora surveys is included in Appendix D.

5.2.1 Threatened Flora Species

No threatened or near threatened flora species (as listed under the EPBC Act or NC Act) were identified during the vegetation surveys, despite targeted surveys in suitable habitat. The potential for each threatened flora species identified in the desktop analysis to occur within the study area is discussed in Table D1 in Appendix C. Species with a moderate to high likelihood of occurrence, as determined through the desktop analyses, are discussed further in the Impact Assessment and Management section of this report.

5.2.2 Pest Species

The number of pest flora species observed within the study area was moderate, comprising around 17.1% of total flora species identified. Although a moderate diversity of pest species was recorded, some (Buffel Grass, Mimosa Bush and Parthenium) formed dense scattered communities found throughout the study area.

Significant weed species recorded include Parthenium, Common Pest Pear (*Opuntia stricta**), Prickly Pear (*Opuntia tomentosa**) and Harrisia Cactus (*Harrisia martinii**), which are restricted invasive plants under the *Biosecurity Act 2014*. Parthenium and Mimosa Bush were recorded throughout the study area on the margins of watercourses and drainage features.

Table 12: Floristic composition and structure of REs within the study area

DESCRIPTION AND STATUS	FLORISTIC COMPOSITION AND STRUCTURE	REPRESENTATIVE PHOTOGRAPH
RE 11.9.2 <i>Eucalyptus populnea</i> and <i>Eucalyptus melanophloia</i> dominate the woodland canopy. The lower tree layer was dominated by <i>Acacia leiocalyx</i> with an <i>Allocasuarina</i> sp., <i>Acacia salicina</i> and <i>Eucalyptus populnea</i> present. Groundcover was dominated by <i>Cenchrus ciliaris</i>*, with native grasses and forbs including <i>Themeda triandra</i>, <i>Heteropogon contortus</i>, <i>Carissa lanceolata</i> and <i>Pterocaulon</i> spp. Sandy surface horizon thick and comprised of yellow sand, with a blocky subsoil. Occurred near a drainage line. VM Act Status: Least concern Biodiversity Status: No concern at present Structural Category: Sparse	T1: Sparse 9.7–14.2m <i>Eucalyptus melanophloia</i> (D) and <i>Eucalyptus populnea</i> (SD) T2: Mid-dense to Dense 4.4–6.9m <i>Acacia leiocalyx</i> (D), <i>Eucalyptus populnea</i> (A), <i>Allocasuarina</i> sp. (A), <i>Acacia salicina</i> (A). S: Sparse 0.5–2.5m <i>Dodonaea viscosa</i> (D), <i>Cassia brewsteri</i> (A), <i>Acacia leiocalyx</i> (A), <i>Acacia excelsa</i> (A), <i>Opuntia tomentosa</i>* (A), <i>Denhamia cunninghamii</i> (A). G: Dense <i>Cenchrus ciliaris</i>* (D), <i>Melinis repens</i>* (A), <i>Themeda triandra</i> (A), <i>Stylosanthes scabra</i>* (A), <i>Heteropogon contortus</i> (A), <i>Carissa lanceolata</i> (A), <i>Pterocaulon redolens</i> (A), <i>Pterocaulon sphacelatum</i> (A) and <i>Sida</i> sp. (A).	

DESCRIPTION AND STATUS	FLORISTIC COMPOSITION AND STRUCTURE	REPRESENTATIVE PHOTOGRAPH
RE 11.3.25e <i>Eucalyptus camaldulensis</i> woodland fringing watercourses. Other tree species included <i>Terminalia oblongata</i>, <i>Acacia harpophylla</i> and <i>Lysiphyllum hookeri</i>. <i>Acacia harpophylla</i> dominated lower tree and shrub layers comprised of the above species along with <i>Acacia salicina</i>, <i>Lomandra</i> sp. and <i>Opuntia tomentosa</i>*. Ground layer is dominated by <i>Cenchrus ciliaris</i>*, with <i>Parthenium hysterophorus</i>*, <i>Cassia brewsteri</i> and native grasses. VM Act Status: Least concern Biodiversity Status: Of concern Structural Category: Mid-dense	E: Sparse 21.4–25.4m <i>Eucalyptus camaldulensis</i> (CD), <i>Terminalia oblongata</i> (CD) T1: Sparse 10.9–13.2m <i>Eucalyptus camaldulensis</i> (CD), <i>Terminalia oblongata</i> (CD), <i>Acacia harpophylla</i> (A), <i>Lysiphyllum hookeri</i> (A) and <i>Melaleuca bracteata</i> (A). T2: Mid-dense to Dense 4.3–7.9m <i>Acacia harpophylla</i> (D), <i>Terminalia oblongata</i> (SD), <i>Acacia salicina</i> (A), <i>Lysiphyllum hookeri</i> (A), <i>Ficus opposita</i> (A), <i>Cassia brewsteri</i> (A) and <i>Santalum lanceolatum</i> (A). S: Mid-dense to Dense 0.5–2.5m <i>Acacia harpophylla</i> (CD), <i>Terminalia oblongata</i> (CD), <i>Opuntia tomentosa</i>* (A), <i>Lomandra</i> sp. (A), <i>Lysiphyllum hookeri</i> (A), <i>Erythroxylum australe</i> (A), and <i>Carissa lanceolata</i> (A). G: Dense to Mid-dense <i>Cenchrus ciliaris</i>* (D), <i>Parthenium hysterophorus</i>* (A), <i>Cassia brewsteri</i> (A), <i>Sida</i> sp. (A), <i>Panicum</i> sp. (A) <i>Urochloa mosambicensis</i>* (A) and <i>Dactyloctenium radulans</i> (A).	

DESCRIPTION AND STATUS	FLORISTIC COMPOSITION AND STRUCTURE	REPRESENTATIVE PHOTOGRAPH
RE 11.9.1 Open forest to woodland of <i>Acacia harpophylla</i>, with scattered emergent <i>Eucalyptus camaldulensis</i>, <i>Terminalia oblongata</i> and <i>Lysiphyllum hookeri</i>. The community had a moderately dense lower tree/tall shrub layer dominated by <i>Acacia harpophylla</i> with <i>Terminalia oblongata</i>, <i>Atalaya hemiglauca</i> and <i>Acacia salicina</i>. The ground layer was densely populated by invasive <i>Cenchrus ciliaris</i>* and <i>Parthenium hysterophorus</i>*. Adjacent to and merging with riparian habitat, on cracking clay soils. VM Act Status: Endangered Biodiversity Status: Endangered Structural Category: Mid-dense	T1: Mid-dense to Dense 11.3–18.1m <i>Acacia harpophylla</i> (D), <i>Eucalyptus camaldulensis</i> (A), <i>Terminalia oblongata</i> (A), <i>Lysiphyllum hookeri</i> (A). T2: Mid-dense 4.8–7.9m <i>Acacia harpophylla</i> (D), <i>Acacia salicina</i> (A), <i>Atalaya hemiglauca</i> (A), <i>Terminalia oblongata</i> (A), <i>Lysiphyllum hookeri</i> (A). S: Very Sparse 0.5–2.5m <i>Terminalia oblongata</i> (D), <i>Vachellia bidwillii</i> (A), <i>Atalaya hemiglauca</i> (A), <i>Acacia victoriae</i> (A), <i>Lysiphyllum hookeri</i> (A), <i>Capparis lasiantha</i> (A). G: Dense <i>Cenchrus ciliaris</i>* (D), <i>Parthenium hysterophorus</i>* (A), <i>Sida</i> sp. (A).	

DESCRIPTION AND STATUS	FLORISTIC COMPOSITION AND STRUCTURE	REPRESENTATIVE PHOTOGRAPH
RE 11.10.12 <i>Eucalyptus populnea</i> and <i>Eucalyptus cambageana</i> predominated, forming a distinct but discontinuous canopy (15–20m high). A distinct and diverse low tree/ tall shrub layer (3–12m tall) contained <i>Atalaya hemiglauca</i>, <i>Acacia salicina</i>, <i>Eremophila mitchellii</i> and <i>Lysiphyllum hookeri</i>. Scattered low shrubs were present, including <i>Carissa lanceolata</i>, <i>Cassia brewsteri</i>, <i>Acacia leiocalyx</i> and <i>Acacia victoriae</i>. The ground layer was dense, dominated by <i>Cenchrus ciliaris</i>* but native grasses were present, along with forbs such as <i>Salsola australis</i>. Occurred on lower slopes of low hill, with shallow soils. VM Act Status: Least concern Biodiversity Status: No concern at present Structural Category: Sparse	T1: Sparse 15.2–20.3m <i>Eucalyptus cambageana</i> (CD), <i>Eucalyptus populnea</i> (CD), <i>Eucalyptus coolabah</i> (SD), <i>Eucalyptus crebra</i> (A). T2: Sparse to Mid-dense 5.7–12.6m <i>Atalaya hemiglauca</i> (CD), <i>Eucalyptus populnea</i> (CD), <i>Acacia salicina</i> (A), <i>Eucalyptus cambageana</i> (A), <i>Allocasuarina</i> sp. (A). T3: Sparse 2.9–4.9m <i>Eremophila mitchellii</i> (A), <i>Atalaya hemiglauca</i> (A), <i>Eucalyptus populnea</i> (A), <i>Acacia salicina</i> (A), <i>Corymbia erythrophloia</i> (A), <i>Lysiphyllum hookeri</i> (A). S: Sparse 0.5–2.5m <i>Carissa lanceolata</i> (D), <i>Cassia brewsteri</i> (A), <i>Eremophila mitchellii</i> (A), <i>Acacia leiocalyx</i> (A), <i>Acacia victoriae</i> (A), <i>Atalaya hemiglauca</i> (A), <i>Lysiphyllum hookeri</i> (A). G: Dense <i>Cenchrus ciliaris</i>* (D), <i>Carissa lanceolata</i> (A), <i>Salsola australis</i> (A), <i>Capparis lasiantha</i> (A), <i>Themeda triandra</i> (A), <i>Heteropogon contortus</i> (A), <i>Heteropogon triticeus</i> (A).	

5.3 Ground-truthed Groundwater Dependent Ecosystems

GDEs in Queensland are defined as being ecosystems which require access to groundwater on a permanent or intermittent basis to meet all or some of their water requirements so as to maintain their communities of plants and animals, ecological processes and ecosystem services' (DSITI, 2015).

At Fairhill, there is no surface expression of groundwater, and no aquatic GDEs were located during flora and fauna surveys at FHCP as outlined in Figure 5. The ephemeral nature of the watercourses and gilgai depressions doesn't allow for water to be retained for long periods of time, and the only permanent water is within artificial stock dams and impoundments. No changes in vegetation type were recorded throughout the watercourses to indicate areas with extended periods of water retention. The only exception is the northern ground-truthed vegetation community within Cooroora Creek. A man-made weir occurs on the southern boundary of this polygon, creating permanent water upstream which is used as a cattle watering point. Although surface water is retained in this area and some aquatic vegetation was noted here, it is artificial and only influenced by rainfall in the upstream catchment, not by groundwater expression.

However, there is a moderate chance that terrestrial GDE's (ecosystems dependent on the sub surface presence of groundwater) may exist along watercourses. Mapping of these types of GDEs is undertaken under the Queensland RE framework, so existing remnant RE mapping is an essential component of determining the spatial extent of GDEs on site.

Vegetation communities were ground-truthed along Sandy Creek during the flora and fauna assessments. Ground-truthing was fairly consistent with the Regulated Vegetation Management map (DNRME, 2018), identifying the majority of Sandy Creek as non-remnant vegetation as shown in Figure 5Figure 2. The only discrepancy were two small areas below the proposed disturbance area within Sandy Creek. One of these areas was shown as high value regrowth of RE 11.9.1/11.3.25/11.3.3 and the other was mapped as non-remnant vegetation on DNRME RE mapping. Ground-truthing surveys concluded that both of these areas have the height and cover to be classified as remnant vegetation. The floristic composition and diversity of both polygons is consistent with RE 11.9.1/11.3.25. The majority of the vegetation present within Sandy Creek is not classified as riparian and is a continuation of vegetation communities in the broader area. The exception is River Red Gum (*Eucalyptus camaldulensis*) and Coolibah (*Eucalyptus coolabah*) which were located immediately within the bed and bank of Sandy Creek. These species were sparsely distributed within the two ground-truthed remnant polygons along Sandy Creek. They are typically associated with watercourses and floodplains, are known to use groundwater intermittently throughout the year and were the only species located that can reach and use the saline groundwater. Although ground-truthed as meeting the requirements as remnant vegetation, these two polygons are small in size, heavily impacted from cattle and non-native species and are considered to be of low ecological function.

No areas along Sandy Creek within the study area were identified during desktop assessments as containing GDEs (see Figure 3 and Figure 4). Although scattered and of low ecological function on Sandy Creek, River Red Gums have been shown by Davies (1953) to be able to use groundwater greater than 10 m below ground level. The standing water level (SWL) associated with Sandy Creek (bore FHMB05) is approximately 11 m below ground, while the SWL recorded in groundwater bores associated with Cooroora Creek is around 8.5 m (SLR, 2019). It is likely that large River Red Gums can utilize groundwater at this level but probably only use groundwater intermittently throughout the year. Although they have deep root structures vertically, horizontal root structures have been shown to extend over 20 m from the tree horizontally (Hume, 2008). This allows for "uptake via their roots from; the adjacent stream sediments" (Hume, 2008) where they receive the majority of water needs.

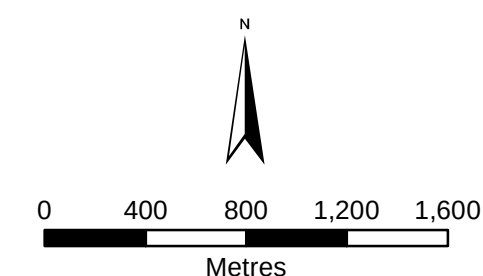
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FAIRHILL FIGURE 7 GROUND-TRUTHED GROUNDWATER DEPENDENT ECOSYSTEMS

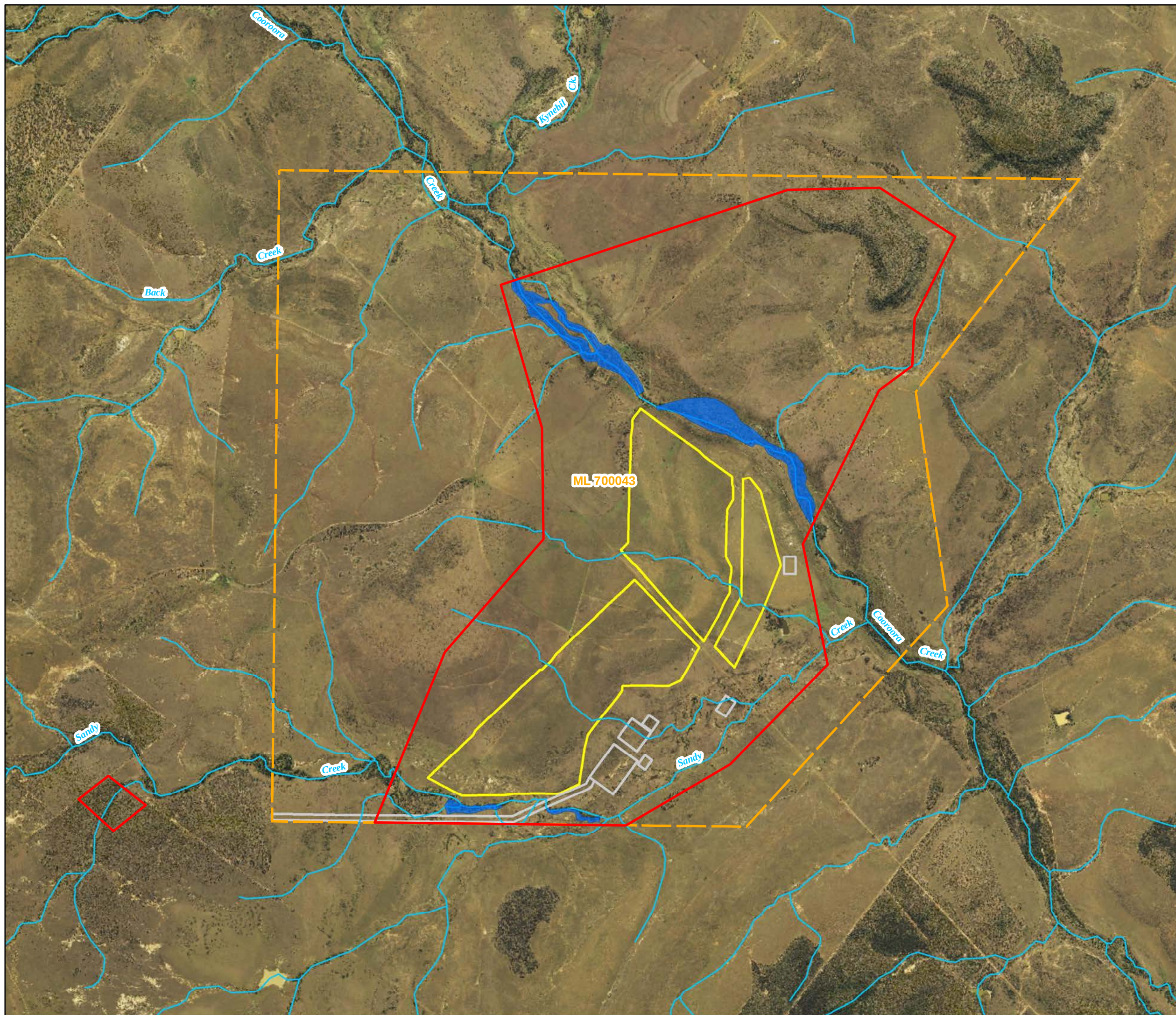
Legend

- VM Watercourse (100/250K)
- Study Area
- Mining Lease Permit (Application)
- Proposed Site Infrastructure
- 7 Year Pit Shell
- Ground-Truthed Terrestrial GDE

Data Sources:
Mining Lease and Vegetation Management (100/250K)
Watercourse datasets: the State of Queensland
(Department of Natural Resources, Mines, and Energy)
2019; Ground-Truthed Groundwater Dependent
Ecosystems (GDE), Proposed Site Infrastructure and 7
Year Pit Shell: SLR Consulting 2019.
Imagery Sources: 70cm Bowen Basin SISP PeriUrban
2012 Orthophoto Image Service: © State of
Queensland (Department of Natural Resources, Mines,
and Energy) 2019.
Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator
Datum: GDA 1994
Date: 4/07/2019



Scale: 1:30,000 at A3



Eucalyptus coolabah is more likely to be interacting with, and dependent on groundwater. Root systems of this species have the capacity to switch between shallow soil moisture stores (e.g. rainfall and streamflow infiltration) and deeper groundwater stores 6 metres deep, and probably 7-8 m (Costelloe, 2016). Similar to the River Red Gum, Coolibah has the capacity for hydraulic redistribution (Roberts & Marston, 2011). Their ability to raise moisture from groundwater to the upper soil profile where it becomes available to their lateral root systems and other plant species had led them to being described as keystone species, facilitators and bioengineers (Gillen 2017). It is likely that *Eucalyptus coolabah* dominated vegetation (RE 11.3.3) might have been present prior to clearing for agricultural land-use, however, its presence within Sandy Creek is further indication that these two vegetation polygons have high potential to be classified as terrestrial GDEs.

The remainder of Sandy Creek was ground-truthed as non-remnant vegetation with no significant interaction between groundwater and vegetation. Desktop assessments and ground-truthing surveys indicate that there is very low potential for GDEs to occur within non-remnant areas of Sandy Creek.

Ground-truthed vegetation within the study area along Cooroora Creek was similar to DNRME mapping. Two large polygons were mapped as mixed vegetation community of RE 11.9.1/11.3.25. River Red Gum was recorded as dominant immediately within the bed and bank of Cooroora Creek. It is highly likely that large River Red Gums are using groundwater at least intermittently throughout the year.

Additionally, Coolibah were present and scattered through remnant vegetation along Cooroora Creek but was not a dominant component of any area assessed.

Surface water chemistry analysed by NRC (2018/2019) for the Receiving Environment Monitoring Program (REMP) at Fairhill indicated no groundwater is expressed on the surface within Cooroora Creek or Sandy Creek. The chemistry of groundwater within the proposed disturbance area contains high Electrical Conductivity (EC) levels ranging from 15,000 to 44,000 $\mu\text{S}/\text{cm}$ (SLR, 2019), indicative of saline conditions. Coolibah has been recorded utilising groundwater with a salinity of approximately 15-20 g/L^{-1} (22,387 – 29,850 $\mu\text{S}/\text{cm}$) (Gillen, 2017), but with an estimated salinity tolerance of 30 g/L^{-1} (44,775 $\mu\text{S}/\text{cm}$) (Roberts & Marston, 2011).

EC levels recorded within surface water at Fairhill indicate a freshwater system, with low EC levels (140-250 $\mu\text{S}/\text{cm}$). The absence of that highly saline groundwater signature identified in bores shows there is no surface expression of groundwater in Cooroora or Sandy Creek.

The Fairhill site is located within the Mackenzie River sub-basin within the Fitzroy River catchment. A range of conceptual models are represented within this sub-basin, including alluvia, exclusion zones, fractured rocks, permeable rocks and sedimentary rocks (Great Artesian Basin (Queensland Government 2017a). The site is relatively flat, with no significant topography contributing to groundwater, and is outside the Great Artesian Basin. Much of the proposed development area is characterized by fine grained and lithified sediments with low permeability and low aquifer potential (SLR, 2019). However, there are areas of known groundwater within confined Permian sandstone, siltstone and mudstone units and particularly within associated coal seams (SLR, 2019). The main resource aquifers are associated with the Quaternary alluvium deposits along watercourses, including Cooroora Creek, where alluvium deposits range in width from 200-800 m and a depth of approximately 10.5 m, and extend 16.5 km upstream of the northern tenement boundary (SLR, 2019). Alluvial deposits are expected to occur along Sandy Creek, however, these have not previously been mapped on the detailed DNRME geological map and their extent is unknown (SLR, 2019).

Riparian vegetation that may be dependent on groundwater occurs within these deposits, so the most applicable groundwater dependent ecosystem conceptual model would be 'alluvia – mid-catchment'. In accordance with alluvia descriptions provided in the 'Underground Water Impact Report' (SLR, 2019), this conceptual model describes gravel, sand, silt and/or clay deposits in river channels or on floodplains, where terrestrial vegetation fringing channels may depend on the subsurface presence of groundwater typically accessed through the capillary zone above the water table (Queensland Government 2017b). A pictorial conceptual model for 'alluvia – mid-catchment' is shown in Figure 8.

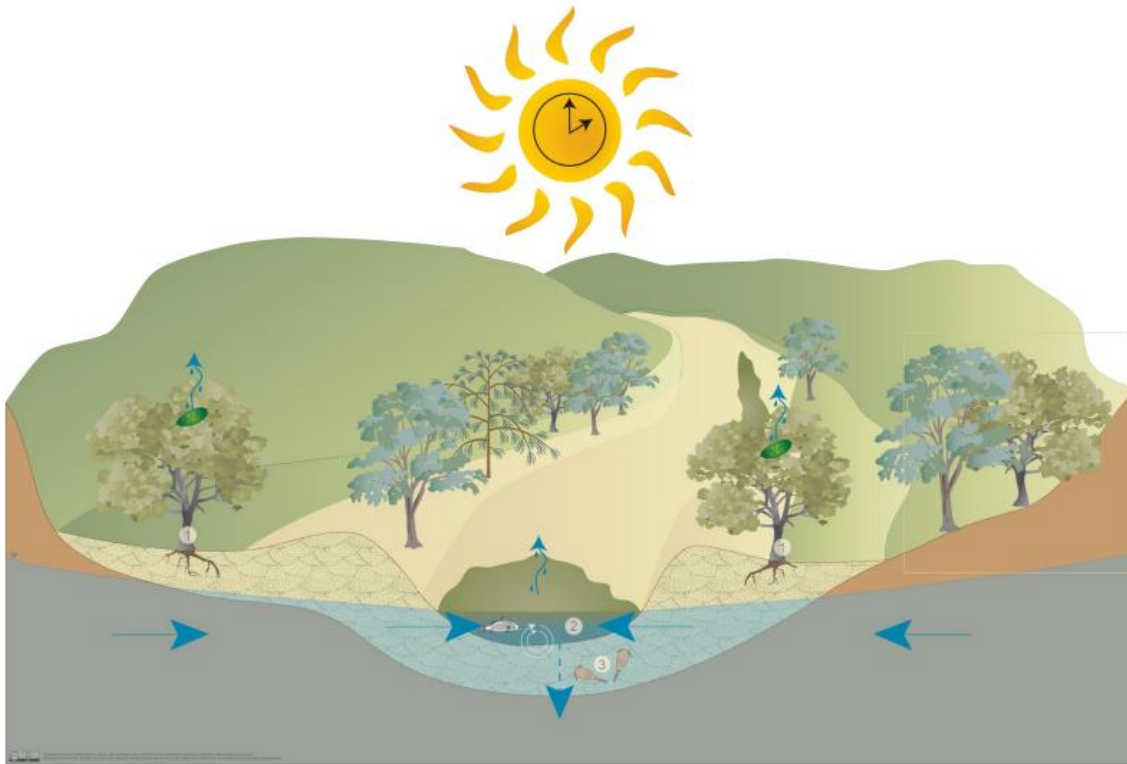


Figure 8: Groundwater dependent ecosystem pictorial conceptual model 'alluvia' with moderate alluvial development (Queensland Government 2017b)

Although the GDE Atlas (BoM, 2018) identified a moderate potential for aquatic GDEs within the tenement, no aquatic GDEs were located during flora and fauna surveys at Fairhill. A man-made weir used for cattle watering is not groundwater dependent. As Coorroora Creek is dry for most of the year with no groundwater expressed at the surface and the alluvia being dry and unsaturated to at least 6 m depth (SLR, 2019), no palustrine or lacustrine aquatic ecosystems exist and the potential for aquatic GDEs is low. Although water pools in Coorroora Creek temporarily during the wet season, the clay rich soil significantly limits the degree of groundwater recharge from surface water (SLR, 2019). A similar band of clay up to 2 m thick limits connectivity between the aquifers in the Fairhill formation and those alluvium associated aquifers along Coorroora Creek (SLR, 2019).

In addition to the pictorial concept model shown in Figure 8, a site-specific conceptual groundwater model was developed by SLR (2019) to visualise the hydrogeology around the mining lease and immediate surrounding to assess potential impact to groundwater from mining and surface activities. This model is presented in Figure 9, and shows lithology, groundwater level, groundwater flow direction, geological units, coal seams and pit and rock dump locations. An overview of the methodology, data and references used to develop the conceptual model is provided in SLR (2019).

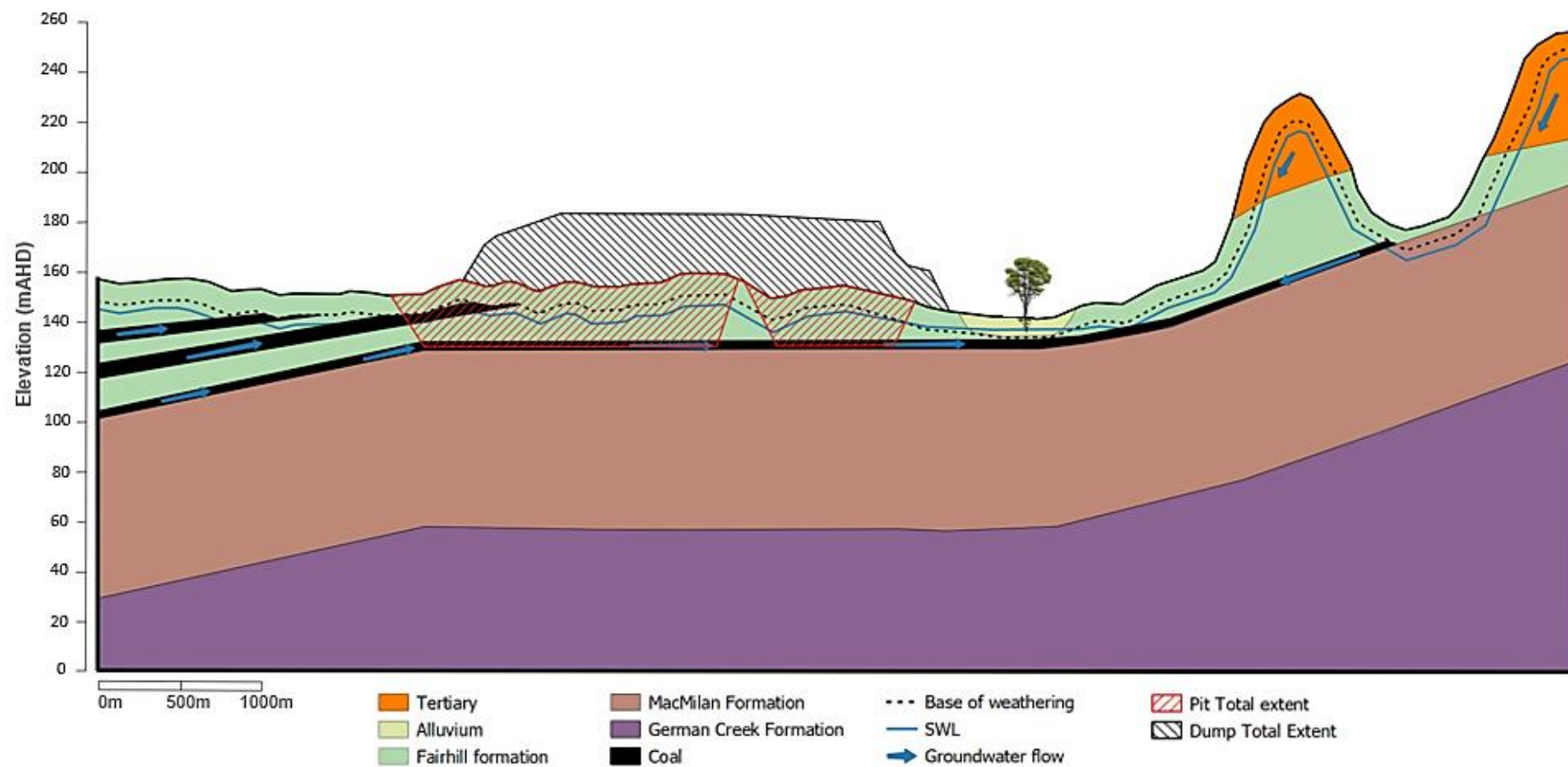


Figure 9: Groundwater conceptual model: Cross section (from SLR, 2019).

6. Fauna Survey Results

6.1 Fauna Habitat

6.1.1 Habitat Features

The site was largely flat and contained few hills and outcrops, limiting the available sheltering opportunities for small to medium-sized terrestrial fauna. Habitat features vary across the study area and are influenced by vegetation community type, landform characteristics and land use practices. Overall, habitat values for most faunal groups are low to moderate throughout the study area, with large tracts of non-remnant grassland dominated by Buffel Grass supporting very low faunal diversity. Microhabitat features across the remnant parts of the study area include coarse woody debris, leaf litter and rocky ground, with scattered hollow-bearing trees and permanent water sources also occurring within the study area in the form of stock water dams and a weir within Cooroora Creek. Some soil types provide refugia, particularly clay-dominated alluvial and fine-grained sedimentary soils in the vicinity of large watercourses that form cracks, and friable sandy soils that provide habitat for fossorial reptiles and amphibians. Across the study area there was little degradation from influences of fire; however, impacts from cattle grazing and clearing were prevalent, with many small to mature trees killed by ring-barking along drainage features.

Habitat values for faunal groups were most abundant on the rocky hill slopes, as these areas comprised the highest diversity of flora species and increased topographical complexity compared to flatter areas within the study area. Large, hollow-bearing River Red Gums (*Eucalyptus camaldulensis*) were present on the larger watercourses within the study area, resulting in increased habitat for arboreal fauna. Large woody debris was moderately distributed throughout remnant vegetation on hill slopes in the northeast, and smaller vegetative litter and debris was abundant in areas with a denser tree layer such as RE 11.10.12 to the southwest.

Non-remnant pastoral vegetation throughout the study area provided the lowest habitat values for faunal groups within the study area. Open grasslands with a very sparse regrowth tree/shrub layer and little or no large woody debris dominated these areas. Highly eroded ephemeral drainage features were evident throughout this area; however, little to no riparian vegetation was present. Adjacent to Cooroora Creek in areas of non-remnant vegetation were two large areas containing numerous gilgai. These areas contained high quality habitat features for a variety of fauna including the retention of water for longer duration into the dry season, cracking soil to provide refugia for small fauna and dense tussocks of sedges and grasses occur along the banks of the gilgai that provide shelter for wetland fauna species.

The presence of highly mobile fauna species (i.e. birds, bats and some arboreal mammals) is likely to be influenced by seasonal characteristics such as rainfall since many of these species forage when and where suitable trees are flowering or fruiting. Resultantly, habitat suitability may vary seasonally, causing species diversity to fluctuate as species follow available resources.

6.1.2 Watercourse and Wetland Habitat

There are no wetland protection areas or wetlands of high ecological significance shown on the map of referable wetlands (DES, 2018b). There are no wetlands of international significance that are relevant to the study area. There are stock water dams distributed sparsely across the study area, and the major watercourse on the northeast of the site, Cooroora Creek, holds water permanently upstream of a weir near fauna trapping site 2. These features provide minor habitat values to wetland species, such as birds and amphibians, and a reliable water source for other fauna including the Squatter Pigeon. Areas of suitable grassland on rises of stony or gravelly soils within 1 km of permanent water are potential breeding areas for Squatter Pigeons, while any remnant or regrowth open-forest to sparse, open-woodland or scrub dominated by *Eucalyptus*, *Corymbia*, *Acacia* or *Callitris* species, on sandy or gravelly soils, within 3 km of water is potential foraging habitat for Squatter Pigeons (DEE, 2019). During dry periods as ephemeral wetlands dry up, the Squatter Pigeons would retreat towards areas in proximity to permanent water.

There are a number of ephemeral drainage features throughout the study area, the largest of which is Sandy Creek that drains east and converges with Cooroora Creek downstream of the weir at the southeast corner of the study area, forming a tributary of the Mackenzie River. Most of the smaller drainage features present within the study area have similar biodiversity values to the surrounding non-riparian areas. In remnant areas, the canopy becomes denser; however, the shrub layer is generally sparse. The riparian vegetation communities on Cooroora Creek and small sections of Sandy Creek support the endangered RE 11.9.1, as defined by the canopy layer. In non-remnant areas, the vegetation associated with the drainage features is a continuation of the surrounding improved pasture species composition and structure, dominated by Buffel Grass with occasional Brigalow regrowth. Among the drainage features within the study area, only Cooroora Creek above the weir is large enough to support some aquatic habitat, all others likely only flow for very short periods immediately after rainfall events and provide lower quality habitat.

Adjacent to the southwest and northeast side of Cooroora Creek are two large areas containing scattered gilgai and cracking soils. These areas contain a range of habitat features for a variety of fauna. Dense sedges around gilgai provide seasonal habitat for secretive waders and migratory birds. During the wet season, gilgai provide potential habitat for a large diversity of amphibian species and during the dry season the cracking soil provides a refuge for small mammals and reptiles. The gilgai and surrounding habitats of RE 11.9.1/11.3.25e are the preferred habitat for the Ornamental Snake, which coincides with the preferred habitat for frogs that are its main prey. This species was recorded on the neighbouring Wilton Coal EPC in 2011 in similar gilgai habitat. These areas also provide a source of water later into the dry season compared to the majority of watercourses in the surrounding landscape. Water was observed in a few gilgai during the May 2018 survey when watercourses and drainage systems in the area were dry.

6.1.3 Connectivity

The north-eastern portion of the study area contains approximately 43 ha of disjunct remnant vegetation on a sandstone hill. Historical vegetation clearing has occurred around this hill and the surrounding area. There is one hill apparently supporting similar habitat located approximately 800 m to the northeast but there is no remnant vegetation connecting the two. This sandstone hill is isolated in the local and broader scale due to the extent of historical and current clearing in the surrounding landscape.

A fourth-order watercourse (Cooroora Creek) flows from the north to the southeast of the site, with a narrow tract of remnant vegetation along its margins, which varies between 50 m and 400 m wide. Vegetation communities associated with Cooroora Creek and smaller watercourses and drainage features, such as Sandy Creek, provide some connectivity in the local and broader contexts. Although vegetation along these watercourses does not extend beyond the top of the banks in some areas, these communities remain one of the most significant dispersal corridors in the local landscape. The study area represents a particularly disturbed area in a region where broad-scale habitat fragmentation has occurred. The non-remnant areas within the study area support very low connectivity values in the local and broad scales.

6.2 Fauna Species

Numerous fauna species were identified within the study area over the survey periods using a variety of different observational and trapping techniques. A combined list of all species identified during the survey period is included in Appendix E. The following sections provide a brief discussion of the species observed for each taxonomic group. Potential impacts to fauna are discussed in the latter sections of this report, with a focus on conservation significant species.

6.2.1 Mammals

A total of 30 species of mammals were recorded within the study area over the survey periods (Appendix E). The assemblage recorded is typical of similar habitat types in the region and the species recorded are generally common. Bats showed the greatest diversity of all mammal groups, with at least 13 and as many as 16 species identified from call data collected. The *Microbat Call Interpretation Reports* from the fauna surveys are included in Appendix F. While some calls could not be clearly distinguished between several species, most of these species are not listed as threatened or near threatened under the NC Act or EPBC Act. One of the calls is attributed to a *Nyctophilus* species. *N. corbeni* is vulnerable under the NC Act and EPBC Act but there are no records of this species near the Emerald region. It is considered a low likelihood that the call was from *N. corbeni*.

No mammals listed as near threatened or threatened were observed within the study area; however, evidence of the Short-beaked Echidna (*Tachyglossus aculeatus aculeatus*, listed as special least concern under the NC Act) was observed in the form of termite mound excavation at fauna trapping site 3 in the southwest of the study site. Figure 2 shows a termite mound extensively dug out by foraging Echidnas.



Figure 10: Short-beaked Echidna (*Tachyglossus aculeatus aculeatus*) excavations in a termite mound, observed in the *Eucalyptus populnea* and *Eucalyptus melanophloia* woodland in the southwest portion of the study area

6.2.2 Reptiles

Nineteen species of reptiles from eight families were observed within the study area (see Appendix E). All these species are common and widespread throughout similar habitats within the broader region.

No evidence of any reptiles listed as near threatened or threatened was observed within the study area.

6.2.3 Amphibians

Eleven amphibian species from three families were recorded within the study area, all of which are common and widespread in the local area. Most native amphibian observations were restricted to areas adjacent to permanent water or within larger watercourses.

The majority of recorded frog species were actively calling during the 2017 survey period and the majority of species were active after a small amount of rainfall during the 2018 survey.

The introduced Cane Toad (*Rhinella marina**) was encountered near drainage lines and other water sources throughout the study area. No amphibians listed as near threatened or threatened were identified during the survey periods.

6.2.4 Birds

A total of 77 species of bird were observed within the study area during the survey period. This species assemblage includes a number of both sedentary and nomadic species. The majority of species observed are common in similar habitats throughout the region. No threatened or near threatened bird species were observed during the survey program. However, some locally occurring threatened bird species have the potential to occur within the study area. The likelihood of impacts to listed threatened species is discussed in the Impact Assessment and Management section of this report.

6.2.5 Pest Species

Eight invasive fauna species were identified during the fauna surveys, all of which commonly occur in disturbed habitats throughout Queensland. The following species were observed within the study area:

- Common Myna (*Acridotheres tristis**)
- European Rabbit (*Oryctolagus cuniculus**)
- Wild Boar (*Sus scrofa**)
- House Mouse (*Mus musculus**)
- Cane Toad (*Rhinella marinus**), and
- Feral Cat (*Felis catus**).

Domestic Cattle (*Bos Taurus**) and Horses (*Equus caballus**) were also recorded within the study area and likely impact native fauna through competition and destruction or modification of habitat.

7. Impact Assessment and Management

7.1 Matters of State Environmental Significance

The following sections detail the presence of MSES, as identified in the Environmental Offsets Regulation 2014 (Qld). The potential for impacts to these matters is discussed with reference to the *Queensland Environmental Offsets Policy – Significant Residual Impact Guideline* (EHP, 2014b). Habitat for endangered or vulnerable species ('Protected wildlife habitat') is discussed in Section 1.4; however, further details regarding the potential occurrence of conservation significant species is provided in Sections 3 and 4.

7.1.1 Potential Impacts to GDE

Under section 334ZP of the *Mineral Resources Act 1989*, the proponent has a statutory right to take underground water ('associated water'), however, this must comply with conditions and obligations relating to underground water as specified in Chapter 3 of the *Water Act 2000*. This includes the prior preparation of Underground Water Impact Reports (UWIR) and Baseline Assessment Plans (BAP) and requires the proponent to identify sensitive receptors and environmental values that are impacted by the proposed 'take' of underground water, such as GDEs.

The GDE Atlas (BoM, 2018) identified a high potential for a terrestrial GDE in a large portion of Cooroora creek within and downstream of the tenement, and a low to moderate confidence GDE along Sandy Creek upstream from tenement.

Terrestrial vegetation likely to be utilising groundwater (i.e. River Red Gum and Coolibah trees) were identified within small pockets of remnant vegetation on Sandy Creek and Cooroora Creek, and these areas would constitute potential GDEs and likely sensitive receptors. These GDEs would likely be utilising aquifers in unconsolidated alluvial sediments.

The ecological water requirements of the GDE was assessed through available literature, and no measures of sap flow or transpiration have been undertaken on the Fairhill site. It should be noted that estimates of water usage are likely to differ between subspecies, populations and sites (Casanova, 2015).

Pre-clearing vegetation includes areas mapped as RE 11.3.3 (*Eucalyptus coolabah* open woodland). The small extent of vegetation remaining from what was likely a more widespread community would result in a significantly lower drawdown of the aquifer from root uptake and transpiration compared to pre-clearing rates. River Red Gums and Coolibah trees have been recorded having a mean annual transpiration rate of 10-560mm and 70-140mm respectively, depending on flooding frequency, groundwater salinity and tree health (Costelloe 2016). Transpiration rates are higher when surface water is present. The Fairhill area has a mean annual rainfall of 557.9 mm (Blackwater, located 44.5 km SE of Fairhill). Although some very large Coolibah trees do occur in the remnant pockets on Sandy Creek, they are spatially rare along the creek and are likely to have a negligible impact on groundwater levels.

Flood events are important for these riparian communities, with an optimal frequency of two to four years for River Red Gum and seven to twenty years for Coolibah (Casanova, 2015). Coolibah is flood dispersed (Costelloe 2016), with additional soil moisture from rainfall in the first summer considered likely to improve establishment (Casanova, 2015). In the post-establishment phase of their life cycle, they are considered to be less reliant on floods than the other floodplain *Eucalyptus* species, with groundwater becoming increasingly important for growth and maintaining vigour in mature trees (Casanova, 2015). River Red Gum utilise rain, river water or groundwater at different

times in its life history, with rainfall or flooding critical for establishment, but both surface water or groundwater can sustain adult trees (Casanova, 2015). A decline in flooding frequency will result in a decline in tree health (Casanova, 2015).

Other plant species in these remnant riparian areas are less likely to be reliant on groundwater and are more likely to be reliant on annual flow events in the watercourses on site. River Red Gum and Coolibah do have the capacity to raise moisture from groundwater to the upper soil profile where it becomes available to their lateral root systems and other plant species (Gillen 2017), however, their spatial rarity at Fairhill is unlikely to make them keystone species facilitating other plant growth in these water courses. Consequently, any anticipated draw down of aquifers in the area is unlikely to have any impact on shallow-rooted species such as shrubs, grasses and herbaceous plants.

Significant water drawdown can potentially impact identified GDE areas. It has been shown that groundwater associated with Cooroora Creek to be around 8.5 m below the surface in the local area (SLR, 2019) and River Red Gums can grow roots greater than 10 m. Root depth of the groundwater-dependent Coolibah is unknown but thought to extend to at least 6 m (Costelloe, 2016), but probably much deeper. Large groundwater drawdown below 10 m has a potential to impact Coolibah and River Red Gums along Cooroora Creek and two small areas of Sandy Creek. The ability of Coolibah to survive in arid areas with infrequent surface flooding has been attributed to their ability to access saline groundwater (Roberts & Marston 2011, Casanova, 2015).

Although there is a potential to impact River Red Gums from groundwater drawdown, this species receives its water by overland flooding, access to riverine water directly or via seepage, access to groundwater of suitable quality, and rainwater (Casanova, 2011). Due to the lower reliance on groundwater, there is a lower likelihood of significant impacts to River Red Gum communities due to groundwater drawdown.

Further to this, groundwater modelling (SLR, 2019) has determined that there will be a 2.1 m groundwater drawdown associated with Cooroora Creek, while drawdown in Sandy Creek is expected to be within the downstream area. Alluvium within Sandy Creek will not be intercepted by the proposed mine, and the extent to drawdown will depend on the extent of hydraulic connectivity to the Fairhill formation that will be subject to dewatering (SLR, 2019). The high clay content with associated low permeability is likely to limit this connectivity, and models predict only limited drawdown in Sandy Creek (SLR, 2019).

Impacts within Cooroora Creek as a consequence of the anticipated 2.1 m drawdown are difficult to predict, as the critical groundwater depth threshold is unknown at this site. Ecological responses may be linear, with tree condition decline with a change in groundwater depth, or a threshold response, where tree condition remains relatively stable until the groundwater depth declines below the critical depth threshold (Kath *et al.* 2014). Studies undertaken in the Condamine region showed *E.camaldulensis* showed a threshold type response to declines in groundwater, however, these thresholds varied from between 12.1 m and 22.6 m (Kath *et al.* 2014). Previous thresholds of 12-15 m for *E.camaldulensis* on the Murray River floodplain had been proposed by Horner *et al.* (2009), similar to the 13-16 m threshold for *E.camaldulensis* on the Upper Condamine floodplain (Reardon-Smith, 2011). Declines in tree condition as a result of critical levels being exceeded were manifested by a decline in 'crown vigour', as measured using the Foliage Index (FI) method (Kath *et al.* 2014).

With a current groundwater of approximately 8.5 m at Cooroora Creek and an estimated drawn-down of 2.1 m (SLR, 2019), the final anticipated depth of 10.6 m does not exceed any of the previously predicted thresholds. It should be noted, however, that response to drawdown is likely to vary depending on tree size, with younger trees with shallow roots likely to have different thresholds and responses than larger trees (Kath *et al.* 2014).

Monitoring of Coolibah tree health will be an ongoing requirement to ensure that groundwater drawdown is not having a significant deleterious impact on GDEs. Changes in groundwater level as a result of potential seepage into the pit will be monitored by water level measurements and water quality sampling in impacted and reference monitoring bores. Impacts on potentially GDEs in Cooroora and Sandy Creek will be undertaken by assessing the health of indicator species, particularly Coolibah and River Red Gum within those mapped GDE areas. These tree species will be monitored for mortality and crown vigour (Foliage Index (FI) method), however, interpretation of these results will need to be addressed with regards to other potentially confounding factors such as defoliating insects and disease. Measurements of diameter at breast height (dbh) will be used to assess impacts to trees within different size classes, however, it is unlikely to be a useful indicator of tree health considering that growth rates of Coolibah are very slow, limited to an average 1 mm dbh /yr (Gillen, 2017).

Assessments of tree health of Coolibah and River Red Gum within Cooroora and Sandy Creek will be made over a temporal and spatial scale, by comparing tree health parameters over time, with baseline measurements to be undertaken prior to mining, and by comparison to trees at reference sites outside the influence of the mine area that have similar environmental conditions including groundwater conditions.

Assessments of tree health within likely GDEs will be undertaken biannually to monitor the potential environmental impact of groundwater drawn down. The results of these assessments will be combined with groundwater data to produce a vegetation assessment report. This report will include all data sheets recorded in the field, photographs of individually numbered indicator trees, and a summary and interpretation of the results from that monitoring event.

7.1.2 Watercourses and Wetlands

The study area does not contain any wetland protection areas or wetlands of high ecological significance as shown on the map of referable wetlands (DES, 2018b). The watercourses and drainage features present within the study are not 'high ecological value waters' as identified under the Environmental Protection (Water) Policy 2009. Disturbance to watercourse features (Cooroora and Sandy Creek) within the study area have been avoided by design to minimise impacts to local environmental values.

The smaller, ephemeral watercourses in the study area do not represent significant biodiversity or habitat values; however, the larger watercourses on site (i.e. Cooroora Creek and Sandy Creek) are both receiving environments of the smaller watercourses on site. These creeks also represent higher biodiversity values, supporting a Brigalow-dominated riparian community and connectivity values at the local scale. The current disturbance footprint has been designed to avoid Cooroora Creek and remnant vegetation along Sandy Creek. Two State mapped tributaries of Sandy Creek are within the disturbance footprint but are within State mapped non-remnant areas.

Adjacent to Cooroora Creek are two large areas with numerous gilgai. This wetland area is situated in the northern extent of the proposed disturbance area. This habitat is outside of the proposed disturbance area with a minimum 50 m buffer zone included. Although this area is not shown on the map of referable wetlands (DES, 2018b) this habitat type is a seasonal wetland and is considered potential habitat for Ornamental Snakes.

7.1.3 Regulated Vegetation

Regional ecosystems

Cooroora Creek intersects the study area in the north, running in a south-easterly direction through the ML. Multiple surveys corroborated with DNRME mapping as a mixed polygon of REs 11.3.25e/11.9.1 – *Acacia harpophylla* was dominant to sub-dominant in the canopy and sub-canopy layers, with *Eucalyptus camaldulensis* lining creek margins with other riparian species present. A few other remnant vegetation communities were observed within the study area, predominantly recorded in association with hill slopes and watercourses, with large areas of vegetation cleared for cattle grazing. Current mining and infrastructure plans avoid disturbance to all remnant and HVR vegetation by design. The exception is approximately 0.63 ha of HVR along the southern border of the ML within the proposed haul road. This area could not be avoided due to constraints from the ML boundary, infrastructure layout and proximity to remnant vegetation. Although a small area of HVR will be impacted, resource activities are exempt from clearing restriction in association with HVR under the *Vegetation Management Act 1999*.

Category B Environmentally Sensitive Areas

The small mixed polygons containing RE 11.9.1 along Cooroora and Sandy Creek equate to category B ESAs. These areas are small in size and are heavily disturbed by cattle and invasive flora. They represent low environmental values in the local landscape but are unlikely to be impacted by the proposed action as they are avoided by design. Although there is no clearing of remnant vegetation associated with the proposed action, impacts will occur within protection zones for these ESAs. All works within these protection zones are located in non-remnant areas of significant existing disturbance with very limited native vegetation and other biodiversity values.

Remnant vegetation associated with a watercourse

Remnant vegetation associated with a watercourse or drainage feature shown on the *Vegetation Management Watercourse and Drainage Feature Map* (as certified under the VM Act) is classified as a MSES under the Queensland environmental offsets framework. There are several watercourse and drainage features within the study area that are represented on the *Vegetation Management Watercourse and Drainage Feature Map*. The extent to which remnant vegetation associated with a watercourse is considered a protected matter is determined by the bioregional context and stream order of the watercourse or drainage feature.

Mapped watercourses and drainage features within the proposed disturbance areas are all within non-remnant vegetation. Cooroora Creek and Sandy Creek contain some remnant vegetation. These areas are avoided by design. Buffer zones from the defined distance of the banks of the state-mapped features are noted in Table 13.

Table 13: Defined distance for REs associated with a watercourse (non-coastal bioregions) as shown in the Queensland Environmental Offsets Policy V1.2

WATERCOURSE STREAM ORDER	DISTANCE FROM DEFINING BANK (M)
1 or 2	25
3 or 4	50

7.1.4 Connectivity Areas

The proposed disturbance area is located within a large patch of non-remnant vegetation in the form of cleared grazing pasture dominated by Buffel Grass, which contains small, highly fragmented patches of remnant vegetation. A hill in the northeast of the study area is surrounded entirely by non-remnant grazing land and is considered isolated from any significant tracts of remnant vegetation. In any case, this area of remnant vegetation has been avoided in the current design.

Connectivity values at the local scale are higher in watercourse and drainage features that are scattered throughout the study area. Cooroora Creek and Sandy Creek provide higher connectivity values at the local scale. These creeks are fringed with Brigalow-dominated vegetation and support a higher faunal diversity than elsewhere on site. This vegetation provides some corridor values to facilitate fauna movement and dispersal within the study area and to larger patches of remnant vegetation outside the study area. The current project design avoids these areas.

7.1.5 Protected Wildlife Habitat

None of the vegetation communities mapped within the study area are mapped as essential habitat on the DNRME essential habitat map. The proposed disturbance area does not include any areas shown on the flora survey trigger map as being 'high risk'.

No threatened flora or fauna species were detected within the study area during the survey periods. Two threatened fauna species, the Squatter Pigeon (southern) and the Ornamental Snake, have been recorded in the local area (SHG, 2011) and therefore have a high likelihood of occurrence within the study area. These species are both listed as vulnerable under the EPBC Act and NC Act. Habitat suitable for the Ornamental Snake was mapped in the northern extent of the proposed disturbance area, adjacent to Cooroora Creek. Two areas contain cracking soils with gilgai microrelief that retains water into the dry season for a longer duration than the surrounding landscape. These gilgai areas may equate to protected wildlife habitat due to the potential suitability for Ornamental Snake. Further details are provided in Section 4.7 below. Potential protected wildlife habitat for the Squatter Pigeon is found along permanent water in Cooroora Creek in association with the weir. Additional sources of permanent water also occur in various stock dams in the area, none of which are within the proposed mine footprint. As this species is reliant on and typically nests and forages within 1 km and 3 km of water respectively, these permanent water sources are highly likely to be utilised by Squatter Pigeon, so suitable vegetation within those buffers is potentially protected wildlife habitat. Further details are provided in the Section 4.4 below.

Evidence of one 'special least concern' species, the Short-beaked Echidna (*Tachyglossus a. aculeatus*), was recorded within the study area during the 2017 baseline survey. The potential for impacts to this species, and other threatened species with potential to occur within the study area, is discussed in Section 4 below.

7.1.6 Protected Areas

There are no protected areas relevant to the study area.

7.2 Matters of National Environmental Significance

The following sections detail the presence of MNES and potential impacts to these matters as assessed with reference to the Matters of National Environmental Significance - *Significant Impact Guidelines 1.1* (Department of the Environment, 2013). Listed threatened species and ecological communities are discussed in Section 2.1; however, further details regarding the potential occurrence of conservation significant species are provided in Sections 3 and 4.

7.2.1 Threatened Ecological Communities

Desktop surveys identified three listed TECs as potentially occurring within the local area:

- Brigalow (*Acacia harpophylla* dominant and co-dominant)
- Natural grasslands of the Queensland Central Highlands and northern Fitzroy Basin, and
- Weeping Myall Woodlands.

There were no state equivalent units shown on State-mapping and ground-truthed surveys did not record Natural grasslands and Weeping Myall Woodland TECs within the study area. Some areas of remnant vegetation adjacent to portions of Cooroora Creek and Sandy Creek were ground-truthed as containing RE 11.9.1. This is an 'endangered' RE that contains Brigalow in the dominant layer. Although these areas contain Brigalow as one of the dominant tree species, groundcover was dominated by non-native species. Buffel Grass incursion from the surrounding non-remnant pastureland was evident throughout the area. Dense patches of Parthenium and Sabi Grass were also noted throughout this RE, thus reducing the cover of native species. Due to groundcover containing greater than 50% non-native species, these areas of Brigalow-dominated vegetation do not meet the condition thresholds to be classified as Brigalow TEC. Although it does not meet the threshold for protection under the EPBC Act, this vegetation community has been avoided by the current design.

7.2.2 Threatened Species

No flora or fauna species listed as threatened under the EPBC Act were detected within the study area during the current surveys. Details regarding the potential occurrence of relevant threatened species listed under the EPBC Act that were not observed during the survey are provided in Sections 3 and 4.

7.2.3 Listed Migratory Species

Eleven migratory species were listed as potentially occurring within 30 km of the study area during desktop studies, none of which were recorded during the current study. All the listed migratory species are widespread throughout areas of Queensland and habitat utilised by each species was mostly poorly represented or absent within the study area.

Remnant vegetation, stock water dams and gilgai areas throughout the study area may afford some suitable habitat for a few of these species. In particular, stock water dams within Cooroora Creek and the gilgai area adjacent to it may provide potential habitat for Latham's Snipe (*Gallinago hardwickii*) and Sharp-tailed Sandpiper (*Calidris acuminata*) and other wetland species. The current design avoids Cooroora Creek, Sandy Creek and the two gilgai areas associated with Cooroora Creek. Habitat features within the study area are common within the broader region and the study area itself does not support any unique or important habitat values for any of these migratory species.

The majority of migratory species are highly mobile in nature, contain large distributions and have broad habitat requirements resulting in a low likelihood that individuals or populations will be affected by mining activities. Table D3 in Appendix C includes a list of all migratory species that have the potential to occur within the study area and their likelihood of occurrence. Species with a high likelihood to occur onsite are discussed below.

7.2.4 Wetlands of International Importance

No wetlands of international importance (Ramsar wetlands) are located within the study area or the region in general.

7.3 Conservation Significant Flora Species

No threatened or near threatened flora species were found within the study area, despite conducting targeted threatened flora surveys. Three conservation significant flora species were identified in the desktop analyses as having a moderate to high likelihood of occurrence within the study area and are discussed below. Likelihood of occurrence was determined using criteria based on local records and habitat suitability/quality. The remaining species identified from the desktop assessment (see Table 7) were considered to have a low likelihood of occurring within the study area and will not be discussed further here. However, Table D1 in Appendix C details the 'likelihood of occurrence' assessment for the conservation significant species identified in the desktop assessment.

7.3.1 *Acacia Spania*

This species is listed as near threatened under the NC Act. The WO database identified three records of this species within 30 km of the study area.

This species grows mostly on rocky sandstone ridges and hills on sandy to loamy soils in eucalypt or *Acacia* dominated woodland communities and has also been recorded in vine thickets along scarp edges. This species sometimes forms relatively pure stands within these communities. There are few documented threats for this species; however, potential threatening processes include destruction of habitat, disturbance of habitat by timber harvesting, general development, inappropriate grazing regimes and inappropriate fire regimes (DES, 2018e). Records of this species exist less than 1 km west of the study area and due to the presence of suitable habitat within the study area, this species was given a high likelihood of occurring.

This species was not detected during targeted surveys within the study area. The habitat present within the proposed disturbance footprint is marginal for this species, as it typically occurs on sandstone ridges at 400–600 m elevation. The disturbance footprint is restricted to flatter areas within non-remnant areas. As vegetation disturbance is proposed in non-remnant grasslands, it is unlikely the proposed action will significantly impact this species.

7.3.2 King Bluegrass

This species is listed as endangered under the EPBC Act and as vulnerable under the NC Act. The WO database identified four records of this species within 30 km of the study area.

This species is endemic to central and southern Queensland where it occurs in three disjunct populations: 1) Hughenden district; 2) from Nebo to Monto and west to Clermont and Rolleston; and 3) Dalby district, Darling Downs. Its area of occupancy is unknown but based on the extent of occurrence it is likely to be restricted. The main identified threats to this species are habitat loss

through agricultural and mining activities, road construction and other infrastructure developments, and weed invasion resulting in competition and potential displacement (Threatened Species Scientific Committee (TSSC), 2013 and references therein).

King Bluegrass is found on black cracking clay soils mainly in association with other *Dichanthium* species and in natural grassland communities. The relevant soil types and landforms within the study area consist of highly disturbed non-remnant areas dominated by Buffel Grass. Remnant areas occur on rocky slopes with groundcover highly disturbed by cattle grazing. Some cracking soil was observed near Cooroora Creek. This area is avoided by design. This species was not detected during the targeted surveys within the study area. Suitable habitat areas for this species are highly degraded, with disturbance from cattle grazing and pasture improvement with introduced grasses. Overall, it is unlikely the proposed action will cause a significant impact to this species.

7.3.3 *Solanum Elachophyllum*

This species occurs from Nebo south to around Theodore in Queensland. It grows on fertile cracking-clay soils in open forest of eucalypts and *Acacia* species (DES, 2018f; DEE 2018c). This species is similar in appearance to other spiny *Solanum* species but can be distinguished by the smaller size of the leaves that are glabrescent on the upper surface and densely hairy on the lower surface. One record of this species exists from the local area but the majority of records occur further south. Some habitat for this species occurs within the study area on cracking soils adjacent to Cooroora Creek. Despite the distinguishable characteristics of this *Solanum* species, none were recorded within the study area during either survey. The project design avoids preferred habitat for this species and it is unlikely that the proposed action will cause a significant impact to this species.

7.4 Conservation Significant Fauna Species

No threatened or near threatened fauna species were found within the study area during the current survey, despite conducting targeted threatened fauna surveys. Twenty-two conservation-significant fauna species with relevance to the study area were identified in the desktop analyses, and the likelihood of their occurrence within the study area was assessed using key criteria such as local records and habitat suitability/quality. Seven species were determined to have a moderate to high likelihood of occurring within the study area and are discussed below. The remaining 15 species were considered to have a low likelihood of occurring within the study area and will not be discussed further. Table D2 in Appendix C provides further details of the likelihood of occurrence assessment for the conservation significant species identified in the desktop assessment.

7.4.1 Latham's Snipe

Latham's Snipe (*Gallinago hardwickii*) is listed as a migratory wetland species under the EPBC Act. This species migrates to Australia and can be found mostly on the east coast from Cape York Peninsula south to South Australia. Preferred habitat for this species is a variety of permanent and ephemeral wetlands including swamps, lagoons, flooded pastures, bogs, waterholes, billabongs, lagoons, lakes, creek or river margins, river pools and floodplains. Latham's Snipe can be found in preferred habitats that are in close proximity to human activity (DEE 2018c).

There is one record of this species occurring within 30 km of the study area. Some low-quality habitat for this species was recorded within and adjacent to Cooroora Creek. Areas within the creek, especially above the weir, contain pools of water that are retained further into the dry season with clumps of grasses and sedges surrounding portions of the bank. Bordering Cooroora Creek to the

south and north are large areas containing numerous gilgai. The majority of the gilgai contain dense tussocks of grass and sedges that are considered potential habitat for this species. This species was not recorded on site, however, both fauna surveys were conducted just outside of the recommended survey timeframe for this species (October to February; DEE, 2018c). The project design avoids disturbance to potential habitat within Cooroora Creek and adjacent gilgai habitats. Higher quality habitat is found in the broader area including the Fitzroy River and Lake Maraboon. It is unlikely that the proposed disturbance would significantly impact this species.

7.4.2 Sharp-tailed Sandpiper

The Sharp-tailed Sandpiper (*Calidris acuminata*) is listed as a migratory wetland species under the EPBC Act. This species can be found inland and along the coast of eastern Australia (DEE, 2018c and references within) with migrants arriving in September and departing around April. The Sharp-tailed Sandpiper can be found along the edges of shallow, fresh or brackish wetlands. Preferred habitat for this species includes shallow freshwater or saltwater areas with inundated or emergent sedges, grasses or other vegetation, swamps, lagoons, salt pans, flooded paddocks, sedgelands, ephemeral wetlands, lakes and dams (DEE, 2018c). When inland ephemeral wetlands dry up, this species will travel to similar habitat along the coast.

There are six records of this species in the local area. Habitat for this species is similar to that of Latham's Snipe and is primarily found within Cooroora Creek above the weir and within the gilgai areas adjacent to Cooroora Creek. The project design avoids disturbance to these areas, therefore it is unlikely that the proposed disturbance would significantly impact this species.

7.4.3 Red Goshawk

The Red Goshawk (*Erythrotriorchis radiatus*) is listed as vulnerable under the EPBC Act and endangered under the NC Act. This species is very sparsely distributed from the western Kimberly area in Western Australia to north-eastern New South Wales (Marchant & Higgins, 1993). It typically occurs in coastal and sub coastal areas in wooded and forested lands of tropical and warm-temperate Australia (Marchant & Higgins, 1993). It nests in large trees, typically less than 1 km from a permanent water source (Aumann & Baker-Gabb, 1991). The home range for this species is very large, between 50 and 220 km² (Debus & Czechura, 1988) and the study area is within its known distribution.

There are no records of the Red Goshawk in the local area as identified in the WO database, nor any recent records in the region. No evidence of this species was detected during the fauna surveys. Given its low population density and large home range, it is possible that this species may fly over the study area or use the area as part of a much larger home range. However, the study area does not contain any unique habitat features for the Red Goshawk. Rather, the vegetated parts of the study area are characteristic of habitats widespread throughout the surrounding landscape. It is unlikely that the relatively minor loss of vegetation associated with the proposed development would significantly affect this species.

7.4.4 Squatter Pigeon (Southern)

The southern subspecies of the Squatter Pigeon (*Geophaps scripta scripta*) is listed as vulnerable under both the NC Act and EPBC Act. The WO database identified five records of this species within 30 km of the study area, so is considered to have a high likelihood of occurrence on the basis of those records.

The study area is within the known distribution of this species. It is predominantly found near permanent water such as rivers, creeks and waterholes, as Squatter Pigeons need to drink daily, and consequently prefer to nest within 1 km of water. Foraging areas extend out to 3 km from a suitable, permanent or seasonal waterbody, where they feed primarily on seeds of grasses, herbs and shrubs that have fallen to the ground (DEE, 2018c and references therein). Foraging areas may include any areas of remnant or regrowth open-forest to sparse, open-woodland or scrub dominated by *Eucalyptus*, *Corymbia*, *Acacia* or *Callitris* species, preferably on sandy or gravelly soils with open and short grass cover that allows easier movement (DEE, 2018c and references therein). Squatter Pigeons are known to be less common on heavier soils with dense grass, particularly where Buffel Grass (*Cenchrus ciliaris*) is the dominant pasture species (Curtis *et al.* 2012). Typically, the ground cover in nesting and foraging habitat rarely exceeds 33%, however, cover tends to be variable over a given area (DEE 2018c). The species often occurs in burnt areas and is sometimes found on tracks and roadsides (TSSC, 2015a). Some degree of tree cover is generally required, with densities ranging from woodland and savannas to grassland with sparse or scattered remnant trees, as they often roost in trees at night (Higgins & Davies 1996). No thresholds of tree cover are available for determining habitat suitability.

This species was not recorded within the study area during the survey periods, and although no permanent water source exists within the proposed development area footprint, permanent water does occur within close proximity. The entire proposed footprint is within 3 km of permanent water, and much of the northern development area is within 1 km of permanent water. Areas of permanent water were targeted through regular opportunistic and targeted surveys, however, Squatter pigeons were not located.

Aerial imagery of the site shows a high level of heterogeneity within the landscape and soils. These were surveyed along a transect parallel to Cooroora Creek across the northern boundary of the proposed 7-year pit extent to identify whether any of the identifiable polygons within 1 km of water represented suitable Squatter Pigeon nesting habitat. Results of these surveys are provided in Table 14 .

Table 14: Habitat suitability for Squatter Pigeons within different representative landscape features

FEATURE	1	2	3	4	5	6	7
Location	-23.2325 148.6457	-23.2294 148.6448	-23.2263 148.6435	-23.2236 148.6408	-23.2214 148.6375	-23.2198 148.6350	-23.2182 148.6265
Distance to water	0.24 km	0.4 km	0.79 km	1.09 km	1.21 km	0.93 km	0.44 km
Soil	Black cracking clay	Reddish fine sand	Grey-brown clay loam with pale crust		Black cracking clay	Black cracking clay	Black cracking clay
Ground Cover density	Grass: 40% Buffel Grass: 10% Total cover: 75% Bare ground: 25%	Grass: 75% Buffel Grass: 40% Total cover: 80% Bare ground: 20%	Grass: 75% Buffel Grass: 15% Total cover: 80% Bare ground: 20%	Grass: 82% Buffel Grass: 20% Total cover: 85% Bare ground: 15%	Grass: 70% Buffel Grass: 40% Total cover: 80% Bare ground: 20%	Grass: 35% Buffel Grass: 25% Total cover: 70% Bare ground: 30%	Grass: 80% Buffel Grass: 50% Total cover: 85% Bare ground: 15%
Tree Cover	0%	0%	0%	<1%	0%	0%	0% (tree regrowth <1m)
Dominant Ground cover genera	<i>Bothriochloa</i> , <i>Cenchrus</i> , <i>Salsola</i> , <i>Sclerolaena</i> , <i>Sporobolus</i> ,	<i>Bothriochloa</i> , <i>Cenchrus</i> , <i>Paspalum</i>	<i>Aristida</i> , <i>Cenchrus</i> , <i>Chloris</i> , <i>Eleusine</i>	<i>Bothriochloa</i> , <i>Cenchrus</i> , <i>Chloris</i> are codominant	<i>Cenchrus</i> , <i>Dichanthium</i> , <i>Parthenium</i> , <i>Stylosanthes</i>	<i>Cenchrus</i> , <i>Dichanthium</i> , <i>Melinus</i> , <i>Parthenium</i> , <i>Sclerolaena</i> <i>Sporobolus</i>	<i>Aristida</i> , <i>Cenchrus</i> , <i>Dichanthium</i>
Habitat Suitability	Low: Wrong soil type, very high ground cover with a high proportion of Buffel Grass, no tree cover	Low/ Moderate: Suitable sandy soils but very high ground cover with a high proportion of Buffel Grass, no tree cover	Low: Wrong soil type, very high ground cover, no tree cover	Low: very high ground cover with no tree cover, site has been mechanically cleared	Low: Wrong soil type, very high ground cover with a high proportion of Buffel Grass, no tree cover, site has been mechanically cleared	Low: Wrong soil type, very high ground cover with a high proportion of Buffel Grass, no tree cover, site has been mechanically cleared	Low: Wrong soil type, very high ground cover with a high proportion of Buffel Grass, site has been mechanically cleared

The sites described in Table 14 are reflective of habitat types within the proposed mine development footprint. Low ridges of reddish fine sand within 1 km of permanent water occur in the northern part of the proposed development area and would probably have provided good Squatter Pigeon habitat. However, the high abundance of Buffel grass, low abundance of likely food plants and the absence of tree cover significantly reduced the value of these areas for Squatter Pigeons. These sandy ridge features are widespread through the broader region. While the habitat suitability of those areas outside the survey area haven't been assessed, those areas within the proposed development area have been significantly altered by introduced grasses. While this is beneficial for the grazing industry, it is deleterious for Squatter Pigeons. These sandy ridges are dissected by vast areas of unsuitable habitat and are better represented within the broader region outside the ML; therefore, these habitat features are neither unique nor critical to this species.

Areas of permanent water are an essential resource requirement for Squatter Pigeons, but are widespread across the broader region. Surveys on site targeting Squatter Pigeons did not find any evidence of a Squatter Pigeon population utilising any of these potential watering points. Nevertheless, potential water points are all avoided by design and will not be impacted by the proposed development. Overall, it is unlikely that the proposed disturbance will have a significant impact on this species within the local or broader area. Recommendations for minimising potential impacts to this species are included below.

7.4.5 Greater Glider

The Greater Glider (*Petauroides volans*) is listed as vulnerable under both the EPBC Act and the NC Act. The WO database has one record of this species within 30 km of the study area.

The Greater Glider is the largest gliding possum in Australia and is physically distinct from similar species. This species is restricted to eastern Australia, occurring from the Windsor Tableland in north Queensland through to central Victoria. The historical area of occupancy of this species has decreased substantially, mostly due to land clearing since European settlement. This species is largely restricted to eucalypt forests and woodlands, and is found in highest abundance in taller, montane, moist eucalypt forests with relatively old trees and abundant hollows. However, this distribution may be patchy even in suitable habitat. Home ranges of this species are typically relatively small, although ranges are larger in low-productivity forests and more open woodlands (TSSC, 2016).

This species was not detected during the fauna surveys. Hollow-bearing trees were present on Cooroora Creek, providing potential roosting habitat; however, the number of large eucalypts on the creek was minimal due to the extent and proximity of previous clearing to the creek. While the study area potentially contains habitat that is suitable for the Greater Glider, it represents a small area that is outside the disturbance footprint. There are no habitat features unique to the study area on which this species would be relying and the area does not represent a link between other habitat areas. Additionally, the proposed development will take place in non-remnant habitats previously disturbed by agriculture. If buffer zones around Cooroora Creek are adhered to, the risk of affecting habitat vital to this species can be negated. It is unlikely that any disturbance within the study area would result in:

- A long-term decrease in the size of the local population
- A reduced extent of occurrence of the species
- Fragmentation of the existing population
- The formation of genetically distinct populations as a result of habitat isolation, or
- Disruption to ecologically significant locations for the species.

It is therefore unlikely there would be any significant impacts to the Greater Glider as a result of the proposed development.

7.4.6 Koala

The combined Queensland, New South Wales and Australian Capital Territory populations of the Koala (*Phascolarctos cinereus*) are listed as vulnerable under both the EPBC Act and NC Act.

Koala habitat can be broadly defined as any forest of woodland containing species that are known food trees. The diet of the Koala is mainly restricted to foliage of selected *Eucalyptus* spp.; however, it may also consume foliage of some species within related genera, including *Corymbia* spp., *Angophora* spp. and *Lophostemon* spp. (DEE, 2018c). The study area is within the modelled distribution for Koala and the WO database extract returned four records within a 30 km radius of the study area. The study area contains some habitat that supports Koala food trees, namely *Eucalyptus camaldulensis* woodland along drainage lines (RE 11.3.25e). This RE occurs as thin riparian habitat in a matrix of non-remnant Buffel Grass paddocks.

A habitat assessment was conducted in accordance with the *EPBC Act Referral Guidelines for the vulnerable Koala* (2014). The outcome of this assessment was that, while there are no records of the Koala that are of significant relevance to the study area, the site contains habitat that may be important to the Koala (Table 14). Key outcomes from the habitat assessment tool were:

- There is no evidence of any Koalas within 2 km of the edge of the impact area within the last 10 years
- Emergent trees of at least two species that are known as Koala food trees are present
- The Koala-relevant habitat within the study area is part of a contiguous landscape
- The study area has some degree of vehicle threat present, and
- Habitat within the study area is potentially important for achieving the interim recovery objective.

Table 14: Koala habitat assessment

ATTRIBUTE	SCORE	HABITAT ASSESSMENT	
Koala occurrence	0	Desktop studies	The EPBC Act Protected Matters Report states that Koalas or Koala habitat is likely to occur within a 30 km radius from the centre point of the proposed disturbance area (see Appendix A) A search of the Queensland Government WO database shows four records of Koalas within 30 km from the centre point of the proposed disturbance area. All records were over 30 years old, with no new records in the local area. There are no records within 2 km of the study area within the last 10 years.
		Field studies	Targeted searches throughout the study area revealed no evidence of Koalas inhabiting the area Field studies included spotlighting, examining trees for signs of Koala activity and scat searches.
Vegetation structure and composition	2	Desktop studies	The Queensland RE and Essential Habitat mapping reveals there is no mapped Koala essential habitat within 10 km of the study area. The RE mapping within the impact area for the proposed action shows vegetation communities that contain one known preferred Koala food tree in the canopy (<i>Eucalyptus camaldulensis</i>).
		Field studies	The vegetation surveys identified one community present within the proposed impact area that contains a preferred food tree that forms >50% of the vegetation in the canopy stratum (<i>Eucalyptus camaldulensis</i>).
Habitat connectivity	0	Both desktop and field studies reveal that the study area and a considerable area surrounding it contains non-contiguous habitat (area is not part of a contiguous landscape above 500ha in size) The study area itself does not create a notable link between surrounding remnant units, and it does not represent an important link or stepping stone in the landscape. Movement of fauna and other factors affecting biodiversity (such as genetic flow) in the area will not be restricted as there will be no loss in habitat associated with the proposed development.	
Key existing threats	1	No Koala sightings have occurred in the study area or the surrounding landscape in the recent past, therefore no records of Koala mortality from vehicle strike or dog attack exist. There is potential for a moderate level of traffic associated with the operation of local mines and the transport of material to rail sidings. Wild dogs were not recorded within the study area during the field survey program. Key existing threats has been scored as 1 (medium), as there is some threat from vehicle strike present.	
Recovery value	1	The habitat within the study area is part of a thin remnant unit in the form of riparian habitat, surrounded by cleared open grazing landscape. At the broader scale, the remnant unit has poor connectivity values. The study area supports remnant habitats that form a distinct riparian unit that may provide refugia for the Koala. Due to the lack of recent records, there is no information available on disease prevalence for the local area.	
Total Score	4	Decision: Not habitat critical to the survival of the Koala – assessment of significance not required.	

There are four records of the Koala within 30 km of the study area in the WO database extract; however, none of these records occurred in the last 30 years. Remnant vegetation within the proposed disturbance area that supports potentially suitable habitat for the Koala is limited to REs 11.3.25e/11.9.1 community on Cooroora Creek. Targeted surveys were conducted in areas supporting food trees, including searches for scats and claw marks. No evidence of the Koala was observed anywhere within the study area.

The study area supports potentially suitable habitat; however, the specific disturbance footprint for the proposed action does not include the remnant riparian vegetation in question. Given the absence of any evidence this species occurs within the study area, it is important to consider the following characteristics for assessment of significance:

- A habitat score of 4 represents a low habitat value and in this case the score is based entirely on habitat suitability, with no relevant records of the Koala in the local area
- The amount of habitat to be cleared for the proposed action is low to nil, particularly compared to the size of the overall remnant vegetation unit
- Due to the isolation of the remnant vegetation unit at the landscape scale, it is unlikely it supports a functional population of Koala and, if this species is present, the density of the population is likely to be very low, and
- The proposed action is located within cleared pasture and partially overlaps with a vegetation community supporting suitable feed trees. Habitat clearing associated with the proposed action would not occur along the creek itself and would not result in fragmentation or isolation of any habitats. There will be no impacts to connectivity values at any scale.

On this basis, it is unlikely that the proposed action will result in significant impacts to any local population of the Koala that may occur in the area.

Due to the lack of any evidence for this species during the field survey, the lack of any relevant local records and the relatively minor loss of habitat, it is unlikely the construction and operation of the proposed action will:

- Lead to a long-term decrease in the size of the population of the species (if present)
- Reduce the area of occupancy of the population
- Fragment any population into multiple populations
- Adversely affect habitat critical to the survival of the species
- Disrupt the breeding cycle of an important population
- Modify, destroy, remove or isolate; or decrease the availability or quality of habitat to the extent that the species is likely to decline
- Result in invasive species that are harmful to Koalas becoming established in Koala habitat
- Introduce disease that may cause the species to decline, or
- Interfere substantially with the recovery of the species.

Overall, it is considered unlikely there will be any significant impacts to the listed population of the Koala because of this proposed project.

7.4.7 Ornamental Snake

The Ornamental Snake is listed as vulnerable under both the NC Act and EPBC Act. The WO database has identified one record of this species within 30 km of the study area.

The species is known only from the Brigalow Belt North and parts of the Brigalow Belt South biogeographical regions. The core of the species' distribution occurs within the drainage system of the Fitzroy and Dawson Rivers. This species preys almost exclusively on amphibians and favours gilgai formations (which form on cracking clay soils) in open woodland (DEE, 2018c and references therein).

The majority of habitat within the proposed disturbance footprint is marginal for this species, being typically characterised by rocky slopes or cleared open pasture. The only habitat of high suitability occurs within areas adjacent to Cooroora Creek that contain numerous gilgai on cracking clay soil. Although surveys did not record this species, they were not conducted after significant rainfall events. Guidelines specify looking for this species between January to mid-March in and around suitable gilgai habitat. Searches should be conducting during the evenings, 1–3 days after rainfall events when frog activity is at its peak (DEE, 2018c). There are records of this species in the local area and potential protected wildlife habitat was recorded on site. The project design avoids the gilgai areas but if any disturbance occurs in these areas, targeted surveys to assess the habitat as a MSES/MNES and any potential impacts to them will be required.

Recommendations to determine the presence of this species and management of this species are detailed below.

7.4.8 Southern Snapping Turtle

The Southern Snapping Turtle (*Elseya albagula*) is listed as endangered under the EPBC Act and critically endangered under the NC Act. Australia's largest Chelid turtle, its scientific name is derived from the pale-yellow to white face and throat displayed by adult females. Males are less distinctive, with a dark brown to black head and neck. Found primarily in the Fitzroy, Mary, Burnett and southern Burdekin catchments, it is threatened by a range of processes including water quality impacts of agricultural run-off; egg predation by native and non-native animals; various effects of the construction of dams and weirs including fragmentation, mortality and changing of flow rates; and loss of riparian vegetation causing depletion of food sources. There is evidence of extreme ageing in populations within each catchment, to the extent that populations contain between 0.5% and 1.1% juvenile turtles. This low recruitment into populations is caused by egg loss, likely as a result of increased egg predation by feral animals, and anthropogenic flooding events (TSSC, 2014).

While this species prefers clear flowing water, it does also occur in non-flowing, moderately anoxic environments. Such habitat occurs in the study area, upstream of the weir on Cooroora Creek; however, given that the creek immediately downstream of the weir does not hold permanent water it is unlikely that this section of the creek has, in recent history, presented suitable habitat for the Southern Snapping Turtle. While there are two records within a 30 km radius of the site, the actual distance of the nearest record downstream when following the watercourse is approximately 45 km from the disturbance area (Atlas of Living Australia, 2018) and this species was not identified on-site. Only Krefft's River Turtle (*Emydura macquarii krefftii*) was observed, readily identified by its pale post-ocular spot (Wilson, 2015).

Due to the likely absence of this species within the study area it is unlikely that the proposed development will affect this species at a local or regional level.

7.4.9 Fitzroy River Turtle

The Fitzroy River Turtle (*Rheodytes leukops*) is a Chelid turtle confined to the Fitzroy River drainage system on the central Queensland coast. It is a physically distinct and ecologically unique turtle, with a white ring in its iris and long, conical tubercles on its long neck. Many Australian freshwater turtles are capable of obtaining oxygen while underwater through the skin, the buccal cavity (throat) and highly vascularised sacs in the cloaca (excretory/reproductive orifice); however, the Fitzroy River Turtle is exceptional in that it regularly attains the majority of its oxygen in this way, rarely surfacing to breathe (TSSC, 2008).

Similar to the Southern Snapping Turtle, the Fitzroy River Turtle is threatened by egg predation, with no recruitment into populations—particularly as this species nests communally (TSSC, 2008 and references therein). It is also vulnerable to changes in water quality and flow regime as a result of mining, damming and agriculture.

Suitable habitat occurs in the study area, upstream of the weir on Cooroora Creek; however, given that the creek immediately downstream of the weir does not hold permanent water it is unlikely that this section of the creek has, in recent history, presented suitable habitat for the Fitzroy River Turtle. While there are three records within a 30 km radius of the site, the actual distance downstream when following the watercourse is approximately 50 km from the disturbance area (Atlas of Living Australia, 2018) and this species was not identified on-site (only Krefft's River Turtle (*Emydura macquarii krefftii*) was observed, readily identified by its pale post-ocular spot) (Wilson, 2015).

Due to the likely absence of this species within the study area it is unlikely that the proposed development will affect this species at a local or regional level.

7.4.10 Short-beaked Echidna

The Short-beaked Echidna (*Tachyglossus aculeatus*) is listed as 'special least concern' wildlife under the NC Act. Special least concern wildlife habitat is a MSES under the Queensland environmental offsets framework. Any action involving significant impacts to special least concern wildlife habitat may require the provision of an environmental offset under this framework.

This well-known species occurs throughout Australia in almost all terrestrial habitats except intensively managed farmland (Menkhorst & Knight, 2011). Mostly solitary, Short-beaked Echidnas occupy large home ranges, feeding on soil invertebrates. Evidence of this species in the form of excavated termite mounds was recorded in the southwest portion of the study area, outside the proposed disturbance footprint, in mapped remnant vegetation. This area is likely used as foraging habitat.

The study area supports limited potentially suitable habitat for the Short-beaked Echidna and represents a small area within a vast expanse of similar habitat outside the ML boundaries. There are no habitat features unique to the study area on which this species would be relying, and the area does not represent a link between other habitat areas. It is unlikely that any disturbance within the study area would result in:

- A long-term decrease in the size of the local population
- A reduced extent of occurrence of the species
- Fragmentation of the existing population
- The formation of genetically distinct populations because of habitat isolation, or
- Disruption to ecologically significant locations for the species.

It is therefore unlikely there would be any significant impacts to the Short-beaked Echidna because of the proposed development.

7.5 Pest Species

The number of pest flora and fauna species observed within the study area was low to moderate, although introduced pasture grasses (particularly Buffel Grass) have invaded most native habitat areas and often form a dense groundcover. Parthenium was also widespread on site, often in dense stands near watercourse and drainage features.

Significant weed species recorded include Parthenium, Prickly Pears (*Opuntia tomentosa** and *O. stricta**) and Harrisia Cactus, which are restricted invasive plants under the *Biosecurity Act 2014*. These species have the potential to impact local biodiversity values and grazing pastures. Weed management strategies should be implemented to avoid increases in the occurrence of pest flora species and the threat they represent to local biodiversity values

Pest fauna species including the Cane Toad and the European Rabbit were frequently observed at numerous locations within the study area. These species are widespread in the surrounding region, so development within the study area is unlikely to modify the landscape in a way that would substantially increase the occurrence of these species or the threats they represent to local biodiversity values. Small flocks of the invasive Common Myna were regularly observed in close proximity to cattle water troughs on site. This species is typically restricted to cleared or urban areas that have undergone recent change (particularly decreases in tree cover); however, it may also cause decreases in native bird species richness by competitive exclusion (Grarock *et al.* 2014).

Feral Cats were observed on site by cage trap and by spotlighting. Feral cats are considered among the greatest threats to Australia's small terrestrial species, particularly small mammals and reptiles; however, as they do not readily take baits, control of feral cats is extremely difficult (Department of Sustainability, Environment, Water, Population and Communities 2011).

Recommendations to minimise threats from pest species are provided in the following section of this report.

8. Recommendations

8.1 Impact Management for Significant Values

8.1.1 Significant Vegetation Communities

Remnant patches containing endangered RE 11.9.1 along Cooroora Creek and Sandy Creek are avoided in the current design and the application of appropriate buffer zones to each polygon should be included to avoid any potential impacts. Although mapped as non-remnant vegetation, the gilgai area to the south of Cooroora Creek is considered high-quality habitat for the Ornamental Snake and disturbance to this ephemeral wetland is also avoided in the current design. This gilgai wetland may also provide some habitat and foraging area for migratory wetland birds such as Latham's Snipe and the Sharp-tailed Sandpiper. Avoiding disturbance to this area will also ensure a larger buffer zone to the endangered RE 11.9.1 along portions of Cooroora Creek.

The absence of records of terrestrial flora and fauna MNES within the currently proposed disturbance footprint (both historical and from current baseline studies) indicates a low likelihood of significant impacts to any terrestrial flora and fauna matters protected under the EPBC Act. Consequently, there are no known controlling provisions for terrestrial flora and fauna matters requiring the project to be referred to the Commonwealth Minister for the Environment and Energy for formal assessment. However, given the close proximity to various MNES, if the project footprint is modified in any way, the likelihood of significant impacts may change and referral under the EPBC Act may be required. Other matters, outside the scope of terrestrial flora and fauna matters, may need to be considered when identifying potential impacts to MNES. For example, the EPBC Act was amended in June 2013 to provide that water resources are a MNES in relation to coal seam gas and large coal mining development. The 'water trigger' allows the impacts of proposed coal seam gas and large coal mining developments on water resources to be comprehensively assessed at a national level. Furthermore, if the project is part of a staged development or component of a larger project, then a referral may be required to ensure potential cumulative impacts are assessed.

8.1.2 Groundwater Dependent Ecosystems

Proposed infrastructure has been designed to avoid remnant vegetation and areas that potential contain terrestrial GDEs. Groundwater modelling (SLR, 2019) has determined that there will be minimal groundwater drawdown associated with Cooroora Creek (maximum 2.1m) and varying levels associated with Sandy Creek.

To determine if significant drawdown of groundwater is occurring which may have the potential to impact terrestrial GDEs, additional groundwater bores will be installed along Sandy Creek. These coupled with the existing bores along Cooroora Creek will allow the mapping of groundwater levels over time. Additionally, vegetation monitoring locations will be established along Cooroora and Sandy Creek within suspected terrestrial GDEs. Within these locations indicator trees will be marked and monitored over time. Measurements of canopy cover, the diameter of the trunk at breast height (DBH) and recruitment counts will be compared over time in association with SWL of adjacent bores and local rainfall records to determine if any impacts are occurring to River Red Gums. Any tree mortality in the vegetation monitoring areas will be recorded and investigated to determine the cause. These monitoring locations in association with groundwater bore data will help to determine if any effects are occurring on River Red Gum communities due to groundwater draw down. If a change in vegetation condition is recorded that is determined to occur from groundwater drawdown, a review of management plans will be initiated.

8.1.3 Significant Fauna Species

The Squatter Pigeon has been recorded in close proximity to the study area and is considered occasionally likely to occur within the proposed disturbance footprint. Potential protected wildlife habitat for this species has been avoided by design with proposed disturbance incorporating a buffer of approximately 400 m. Vehicle strike represents a general threat to native fauna species, but is particularly relevant to the Squatter Pigeon, a ground-dwelling species that inhabits bare ground and low grassland such as on roadsides. The following controls are recommended to minimise the likelihood of vehicle strike in general, with a focus on reducing the likelihood of death or injury to Squatter Pigeons if present:

- Site inductions or toolbox meetings should include information about sensitive aspects of the environment in which personnel are working, including the risk of injury or death to Squatter Pigeons from vehicles
- Due to the ground dwelling nature of the species, all vehicles should remain on existing access tracks and roads wherever possible
- Clearing works should be carried out in a sequential manner that allows fauna to escape to natural areas away from construction works
- Speed limits should be implemented as appropriate for the condition of the roads and access tracks on site. Locations of Squatter Pigeon sightings should be recorded and a limit of 20 km/h is recommended within 200 m of locations where Squatter Pigeons have been regularly observed
- Retain existing dams on Cooroora Creek that allow water to be retained throughout the dry season, and
- The introduction of new permanent water sources as part of mine infrastructure will influence the activities of Squatter Pigeons during the dry season. These and other birds are likely to congregate near water bodies—efforts should be made where possible to distance traffic from water sources to avoid potential mortality.

Potential protected wildlife habitat for the Ornamental Snake was recorded adjacent to Cooroora Creek. Potential habitat includes preferred gilgai areas where frogs are present. The current disturbance footprint does not impact habitat for this species and a 50 m buffer has been placed between it and proposed infrastructure.

8.2 General Clearing and Vegetation Management

During construction activities, the following measures should be implemented to minimise disturbance impacts and the potential harm to habitat values, and flora and fauna present within the area:

- The boundary of areas to be cleared should be clearly marked to ensure the disturbance footprint is minimised, and
- Clearing should occur in a sequential manner to allow any fauna present in the area to escape to areas away from construction activities.

Vegetation stockpiles will provide habitat for small ground-dwelling mammals and reptiles during the construction phase. It is important to locate these stockpiles away from high traffic areas and ensure they are not isolated from contiguous vegetation at the edge of the site. This will reduce the likelihood of fauna travelling across the construction site.

Cleared vegetation should be managed according to the following best practice principles:

- Where possible, logs and large branches with hollows should be reserved and stockpiled separately (at the edge of the site) for rehabilitation purposes, and
- Any mulching should occur as near as possible to the time of clearing to prevent the establishment of stockpiles as fauna habitat.

8.3 Soil Management

During construction, soil stockpiles should be managed to maximise suitability for future use in rehabilitation processes. Topsoil should be stockpiled separately from sub-soils and to a maximum height of 0.8 m. This will improve the likelihood of retention of a seed bank within the topsoil, which will increase the effectiveness of its use for rehabilitation in the future. Stockpiles should also be managed to allow passage for fauna by leaving a sufficient gap between stockpiles.

8.4 Pest Management

Several pest plant and animal species were identified during surveys, including species listed as restricted invasive species under the *Biosecurity Act 2014*. Soil disturbance is a major contributor to weed establishment and invasion.

The following recommendations are relevant to the construction phase as well as ongoing monitoring and management post-construction:

- Wherever possible, construction activities should work from areas with fewer weed species and smaller infestations towards areas where there is a greater abundance of weeds
- Vehicles and machinery brought on site should be clean and free of weeds, dirt and other material that may contain weed seeds and cause exotic species to become established within the works areas
- Weed spread should attempt to be minimised by implementing some control measures within the proposed works areas prior to construction
- Regular observation and surveys of disturbance sites and stockpiles for incidence of weed species (particularly restricted species) should be undertaken
- Where any weed establishment is identified, appropriate control measures should be implemented to minimise the impacts of weeds on native habitat, and
- Control measures to reduce and eliminate pest fauna species, particularly Feral Cats and Common Mynas should be implemented throughout construction and operational phases.

8.5 Dust Management

Excavation and vehicle movements produce increased levels of dust, which can have a cumulative impact on plant function. However, due to the size of the disturbance area it is unlikely that dust produced over a short period of time will significantly impact plant function. However, advisable dust suppression techniques include:

- Application of water on trafficable surfaces
- Limiting activities in high wind conditions, and
- Application of water/binding agent to disturbed sites during construction.

8.6 Fauna Management

Excavated areas can pose a risk to native fauna through entrapment and exposure. Excavated areas should be checked regularly for trapped fauna, with inspection occurring at least twice daily. These areas should be checked early in the morning for fauna that has become trapped overnight, and again in the late afternoon for fauna that has become trapped over the course of the day.

Safe egress points should be included to allow fauna to escape of their own accord. Any fauna that cannot escape of its own accord should be removed in a manner that is safe for both the animal and the

person handling the animal. Dangerous fauna species such as snakes should only be handled by suitably qualified and experienced persons, and it is advisable to have qualified snake handlers on site. The use of a fauna spotter-catcher during the vegetation-clearing and construction period is recommended to minimise the chances of injury to native fauna. The fauna spotter-catcher should have a current rehabilitation permit and should be present during clearing activities. The role of the spotter-catcher would be to advise on appropriate clearing methods to ensure animal escape paths are maintained and relocate fauna located within the disturbance area accordingly.

9. References

- Atlas of Living Australia. (2018). Retrieved from <http://www.ala.org.au>.
- Aumann, T., & Baker-Gabb, D. (1991). *RAOU Report 75. A management plan for the Red Goshawk*. Melbourne: Royal Australasian Ornithologists Union.
- Bostock, P.D., & Holland, A.E. (eds) (2017). *Census of the Queensland flora 2016*. Brisbane: Queensland Department of Science, Information Technology, Innovation and the Arts.
- Bureau of Meteorology (BOM). (2019). Groundwater Dependent Ecosystems Atlas. Available at: <http://www.bom.gov.au/water/groundwater/gde/map.shtml>
- Casanova M.T. (2015) Review of Water Requirements for Key Floodplain Vegetation for the Northern Basin: Literature review and expert knowledge assessment. Report to the Murray–Darling Basin Authority, Charophyte Services, Lake Bolac
- Costelloe J.F. (2016) Water use strategies of a dominant riparian tree species (*Eucalyptus coolabah*) in dryland rivers. *Proceedings of the 11th International Symposium on Ecohydraulics*, Melbourne, Australia
- Cropper, S.C. (1993). *Management of endangered plants*. East Melbourne, Victoria: CSIRO Publications.
- Davies, N., 1953. Investigations on the soil and water relations of the river red gum forests by Murray Management Survey/final report. Sydney: Forestry Commission of NSW, October 6th 1953.
- Debus, S., & Czechura, G. (1988). The Red Goshawk *Erythrorchis radiatus*: A review. *Australian Bird Watcher*, 12, 175–199.
- Department of Environment and Heritage Protection (EHP). (2014a). *Flora survey guidelines – Protected plants*. State of Queensland.
- Department of Environment and Heritage Protection (EHP). (2014b). Queensland Environmental Offsets Policy. *Significant Residual Impact Guideline*. State of Queensland, December 2014.
- Department of Environment and Science (DES). (2018a). *Environmentally sensitive areas map*. Brisbane: Department of Environment and Heritage Protection. Retrieved from http://www.ehp.qld.gov.au/licences-permits/maps_of_environmentally_sensitive_areas.php.
- Department of Environment and Science (DES). (2018b). *Map of referable wetlands*. Extracted 13/07/17.
- Department of Environment and Science (DES). (2018c). *Protected plants flora survey trigger map*. Extracted 20/03/17.
- Department of Environment and Science (DES). (2018d). *Queensland Government wildlife online*. Extracted 20/03/17.
- Department of Environment and Science (DES). (2018e). WetlandInfo: *Acacia spania*. Retrieved from <<https://wetlandinfo.ehp.qld.gov.au/wetlands/ecology/components/species/?acacia-spania>>.
- Department of Environment and Science. (DES) (2018f). WetlandInfo: *Solanum elaeagnifolium*, viewed 3 July 2018, <<https://wetlandinfo.des.qld.gov.au/wetlands/ecology/components/species/?solanum-elaeagnifolium>>.
- Department of Natural Resources, Mines and Energy (DNRME). (2018). *Regulated vegetation management map and vegetation management supporting map*. The State of Queensland. Requested on 29/06/18.
- Department of Natural Resources, Mines and Energy. (DNRME). (2019). Groundwater Dependent Ecosystems modelling; GDE information portal. Available at: <https://qldglobe.information.qld.gov.au/>

Department of Science, Information Technology and Innovation (DSITI) (2015) Queensland Groundwater Dependent Ecosystem Mapping Method: A method for providing baseline mapping of groundwater dependent ecosystems in Queensland, Department of Science, Information Technology and Innovation, Brisbane

Department of Sustainability, Environment, Water, Population and Communities (2011). The Feral Cat (*Felis catus*). Retrieved from <http://www.environment.gov.au/system/files/resources/34ae02f7-9571-4223-beb0-13547688b07b/files/cat.pdf>

Department of the Environment and Energy (DEE) (2018a). Species profile and threats database: Brigalow (*Acacia harpophylla* dominant and co-dominant). Retrieved from <http://www.environment.gov.au/cgi-bin/sprat/public/publicshowcommunity.pl?id=28>

Department of the Environment and Energy (DEE) (2018c). Species profile and threats database, Department of the Environment, Canberra. Retrieved from <http://www.environment.gov.au/sprat>.

Department of the Environment and Energy (DEE). (2018b). *EPBC Act protected matters report*. Requested on 29/06/18.

Department of the Environment and Energy (2019). *Species Profile and Threats Database – Geophaps scripta scripta— Squatter Pigeon (southern)*. Accessed online: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=64440

Department of the Environment. (2013). *Matter of national environmental significance. Significant impact guidelines 1.1*. Commonwealth of Australia.

Environmental Protection Agency (2004). EIS assessment report – Curragh North Coal Project. Retrieved from <https://www.ehp.qld.gov.au/management/impact-assessment/eis-processes/documents/eis-assessment-report-curragh-north-web.pdf>

Eyre, T. J., Ferguson, D. J., Hourigan, C. L., Smith, G. C., Mathieson, M. T., Kelly, A. L., Venz, M. F., & Hogan, L. D. (2018). *Terrestrial vertebrate fauna survey assessment guidelines for Queensland*. Queensland Government, Brisbane: Department of Science, Information Technology, Innovation and the Arts.

Garnett, S.T., Clarkson, J.R., Felton, A., Harrington, G.N., & Freeman, A.N. D. (2005). Habitat and diet of the Star Finch (*Neochmia ruficauda clarescens*) in the early wet season at Princess Charlotte Bay, Cape York Peninsula, Australia. *Emu*, 105, 81–86.

Geoscience Australia (GA). (2018). Geoscience Australia interactive maps: Australian and region surface geology. Commonwealth of Australia. Retrieved from <http://www.ga.gov.au/interactive-maps/#/theme/minerals/map/geology>

Gillen J.S. (2017) *Coolibah (Eucalyptus coolabah Blakely & Jacobs) of the Diamantina and Warburton River systems in north-eastern South Australia*. Report to the South Australian Arid Lands Natural Resources Management Board, Fenner School of Environment and Society, Australian National University

Garrock, K. Tidemann, C. R., Wood, J. T., & Lindenmayer, D. B. (2014). Are invasive species drivers of native species decline or passengers of habitat modification? A case study of the impact of the Common Myna (*Acridotheres tristis*) on Australian bird species. *Austral Ecology*, 39, 106–114.

Grosenbaugh, L.R. (1952). 'Plotless timber estimates – new, fast, easy'. *Journal of Forestry* 50: 32-37.

Higgins, P.J., & Davies, S.J.J.F. (eds). (1996). *Handbook of Australian, New Zealand and Antarctic birds. Volume Three - Snipe to Pigeons*. Melbourne, Victoria: Oxford University Press.

Horner, G.J., Baker, P.J., Mac Nally, R., Cunningham, S.C., Thomson, J.R., Hamilton, F. (2009). Mortality of developing floodplain forests subjected to a drying climate and water extraction. *Global Change Biol.* 15, 2176–2186.

- Hume, A. Karen., (2008). *Eucalyptus camaldulensis* (river red gum) Biogeochemistry: An Innovative Tool for Mineral Exploration in the Curnamona Province and Adjacent Regions. School of Earth and Environmental Sciences. University of Adelaide, April 2008
- Kath J., Reardon-Smith K., Le Brocque A.F., Dyer F.J., Dafny E., Fritz L., Batterham M. (2014) Groundwater decline and tree change in floodplain landscapes: Identifying non-linear threshold responses in canopy condition. *Global Ecology and Conservation* 2: 148-160
- Marchant, S., & P.J. Higgins (eds) (1993). *Handbook of Australian, New Zealand and Antarctic birds. Volume 2: Raptors to Lapwings*. Melbourne: Oxford University Press.
- Menkhorst, P., & Knight, F. (2011). *A field guide to the mammals of Australia. Third edition*. Oxford University Press.
- Morcombe, M. (2003). *Field guide to Australian birds*. Steve Parish Publishing Pty Ltd.
- Neldner, V. J., Wilson, B.A., Dillewaard, H.A., Ryan T. S., & Butler, D. W. (2017). *Methodology for survey and mapping of regional ecosystems and vegetation communities in Queensland*. Version 4.0. Brisbane: Queensland Herbarium, Queensland Department of Science, Information Technology and Innovation.
- Northern Resource Consultants (NRC) (2018) Receiving Environment Monitoring Report (REMP) for Fairhill. Prepared for Futura Resources, March 2018.
- Northern Resource Consultants (NRC) (2018) Receiving Environment Monitoring Report (REMP) for Fairhill. Prepared for Futura Resources, May 2019.
- Northern Resource Consultants (NRC). (2017). Wilton Coal Project terrestrial flora and fauna technical report
- Pizzey, G., & Knight, F. (2012). *Field guide to the birds of Australia. Ninth edition*. Sydney: Harper Collins.
- Queensland Government (2017a) Groundwater dependent ecosystem pictorial conceptual model overview: version 1.5, Queensland Government, Brisbane. Retrieved from: <https://wetlandinfo.des.qld.gov.au/resources/static/pdf/ecology/gde/170303-gde-pcm-overview.pdf>
- Queensland Government (2017) Groundwater dependent ecosystem pictorial conceptual model 'alluvia': version 1.5, Queensland Government, Brisbane. Retrieved from: <https://wetlandinfo.des.qld.gov.au/resources/static/pdf/ecology/gde/170303-gde-pcm-alluvia.pdf>
- Queensland Herbarium (2018). Regional Ecosystem Description Database (REDD). Version 10.1 (March 2018) (DSITI: Brisbane).
- Reardon, T.B., Armstrong, K.N., & Jackson, S.M. (2015). A current taxonomic list of Australian Chiroptera. Australasian Bat Society. Retrieved from <http://ausbats.org.au/taxonomic-list/4589345107>.
- Reardon-Smith, K.M. (2011). *Disturbance and resilience in riparian woodlands on the highly-modified Upper Condamine floodplain*. PhD thesis, University of Southern Queensland, Toowoomba QLD Australia
- Roberts, J. and Marston, F. (2011) Water regime for wetland and floodplain plants: A source book for the Murray-Darling Basin. National Water Commission, Canberra.
- Saunders Havill Group (SHG). (2011). Wilton Coal Flora and Fauna Technical Report. 24 November 2011.
- SLR Consulting Australia (SLR). (2019). Fairhill Coal Project – Underground water impact report. Prepared for Fairhill Coking Coal Pty Ltd. May 2019.
- Threatened Species Scientific Committee (TSSC). (2008). Approved conservation advice for *Rheodytes leukops* (Fitzroy tortoise).

Threatened Species Scientific Committee (TSSC). (2013). Commonwealth listing advice on the *Dichanthium queenslandicum* (King Blue-grass). Retrieved from <http://www.environment.gov.au/biodiversity/threatened/species/pubs/5481-listing-advice.pdf>

Threatened Species Scientific Committee (TSSC). (2014). Commonwealth listing advice on the *Elseya albagula* (White-throated Snapping Turtle).

Threatened Species Scientific Committee (TSSC). (2015a). Commonwealth listing advice on the *Geophaps scripta scripta* (Squatter Pigeon, southern).

Threatened Species Scientific Committee (TSSC). (2015b). Commonwealth listing advice on the *Nyctophilus corbeni* (South-eastern Long-eared Bat).

Van Dyck, S., Gynther, I., & Baker, A. (2013). *Field companion to the mammals of Australia*. Sydney, Australia: New Holland Publishers.

Vanderduys, E. (2012). *Field guide to the frogs of Queensland*. Collingwood, Victoria: CSIRO Publishing.

Wilson, P.R., & Taylor, P.M. (2012). *Land zones of Queensland*. Brisbane: Queensland Herbarium, Queensland Department of Science, Information Technology, Innovation and the Arts.

Wilson, S. (2015). *Field guide to the reptiles of Queensland*. Sydney, Australia: New Holland Publishers.

Appendix summary

Appendix A	EPBC Act Protected Matters Report
Appendix B	Wildlife Online Database Extract
Appendix C	Potential Occurrence of EVNT Species
Appendix D	Flora Species List for 2017 and 2018 Baseline Surveys
Appendix E	Fauna Species List for 2017 and 2018 Baseline Surveys
Appendix F	Microbat Call Interpretation Reports

Appendix A

EPBC Act Protected Matters Report



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.

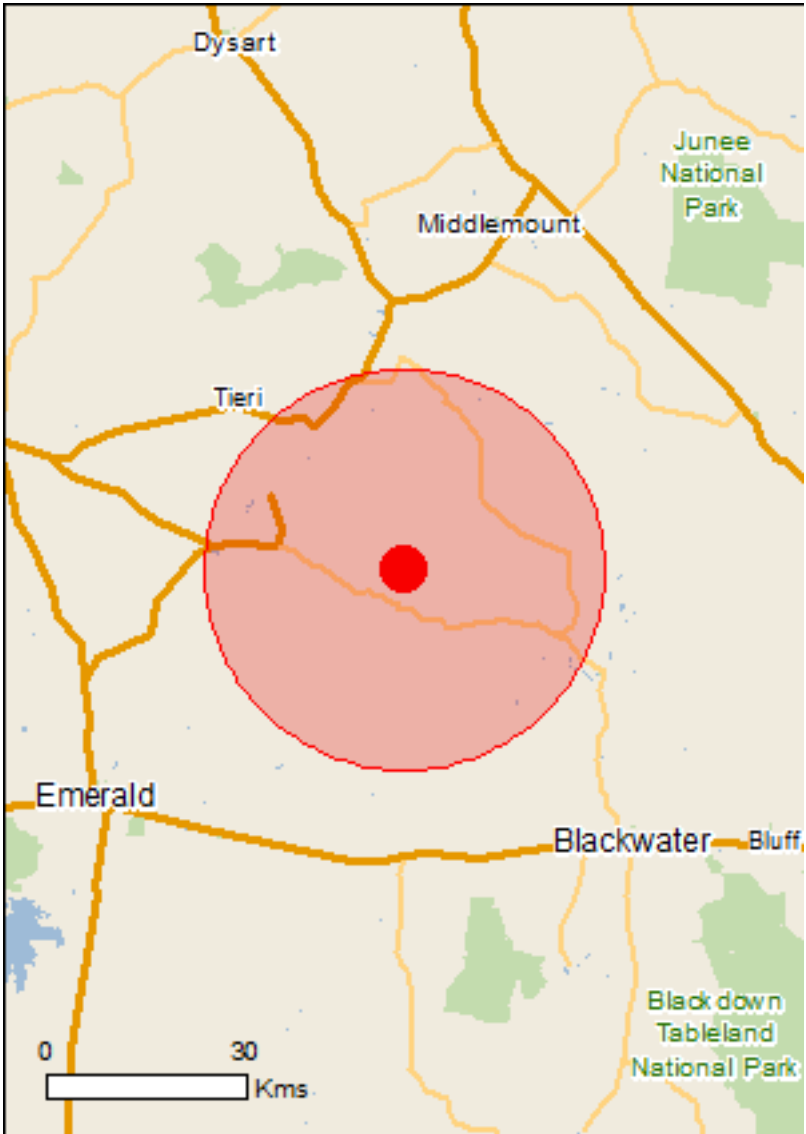
Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about [Environment Assessments](#) and the EPBC Act including significance guidelines, forms and application process details.

Report created: 29/06/18 08:18:31

- [Summary](#)
- [Details](#)

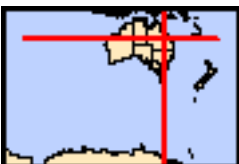
[Matters of NES](#)[Other Matters Protected by the EPBC Act](#)[Extra Information](#)
- [Caveat](#)
- [Acknowledgements](#)



This map may contain data which are
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[Coordinates](#)

Buffer: 30.0Km



Summary

Matters of National Environmental 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:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	3
Listed Threatened Species:	25
Listed Migratory Species:	11

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 <http://www.environment.gov.au/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 Land:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	17
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Commonwealth Reserves Marine:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	1
Regional Forest Agreements:	None
Invasive Species:	25
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	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.

Name	Status	Type of Presence
Brigalow (Acacia harpophylla dominant and co-dominant)	Endangered	Community known to occur within area
Natural Grasslands of the Queensland Central Highlands and northern Fitzroy Basin	Endangered	Community likely to occur within area
Weeping Myall Woodlands	Endangered	Community likely to occur within area

Listed Threatened Species

[Resource Information]

Name	Status	Type of Presence
Birds		

Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Erythrotriorchis radiatus Red Goshawk [942]	Vulnerable	Species or species habitat known to occur within area
Geophaps scripta scripta Squatter Pigeon (southern) [64440]	Vulnerable	Species or species habitat known to occur within area
Grantiella picta Painted Honeyeater [470]	Vulnerable	Species or species habitat may occur within area
Neochmia ruficauda ruficauda Star Finch (eastern), Star Finch (southern) [26027]	Endangered	Species or species habitat likely to occur within area
Poephila cincta cincta Southern Black-throated Finch [64447]	Endangered	Species or species habitat may occur within area
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat may occur within area

Mammals

Chalinolobus dwyeri Large-eared Pied Bat, Large Pied Bat [183]	Vulnerable	Species or species habitat may occur within area
Dasyurus hallucatus Northern Quoll, Digul [Gogo-Yimidir], Wijingadda [Dambimangari], Wiminji [Martu] [331]	Endangered	Species or species habitat likely to occur within area
Macroderma gigas Ghost Bat [174]	Vulnerable	Species or species

Name	Status	Type of Presence
Nyctophilus corbeni Corben's Long-eared Bat, South-eastern Long-eared Bat [83395]	Vulnerable	habitat likely to occur within area Species or species habitat may occur within area
Petauroides volans Greater Glider [254]	Vulnerable	Species or species habitat likely to occur within area
Phascolarctos cinereus (combined populations of Qld, NSW and the ACT) Koala (combined populations of Queensland, New South Wales and the Australian Capital Territory) [85104]	Vulnerable	Species or species habitat known to occur within area
Pteropus poliocephalus Grey-headed Flying-fox [186]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Plants		
Cadellia pentastylis Ooline [9828]	Vulnerable	Species or species habitat likely to occur within area
Dichanthium queenslandicum King Blue-grass [5481]	Endangered	Species or species habitat known to occur within area
Dichanthium setosum bluegrass [14159]	Vulnerable	Species or species habitat known to occur within area
Eucalyptus raveretiana Black Ironbox [16344]	Vulnerable	Species or species habitat known to occur within area
Reptiles		
Delma torquata Adorned Delma, Collared Delma [1656]	Vulnerable	Species or species habitat may occur within area
Denisonia maculata Ornamental Snake [1193]	Vulnerable	Species or species habitat known to occur within area
Egernia rugosa Yakka Skink [1420]	Vulnerable	Species or species habitat known to occur within area
Elseya albagula Southern Snapping Turtle, White-throated Snapping Turtle [81648]	Critically Endangered	Species or species habitat known to occur within area
Furina dunmalli Dunmall's Snake [59254]	Vulnerable	Species or species habitat may occur within area
Lerista allanae Allan's Lerista, Retro Slider [1378]	Endangered	Species or species habitat may occur within area
Rheodytes leukops Fitzroy River Turtle, Fitzroy Tortoise, Fitzroy Turtle, White-eyed River Diver [1761]	Vulnerable	Species or species habitat known to occur within area

Listed Migratory Species	[Resource Information]	
* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.		
Name	Threatened	Type of Presence
Migratory Marine Birds		
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat likely to occur within area

Name	Threatened	Type of Presence
Migratory Terrestrial Species		
Cuculus optatus Oriental Cuckoo, Horsfield's Cuckoo [86651]		Species or species habitat may occur within area
Monarcha melanopsis Black-faced Monarch [609]		Species or species habitat known to occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat may occur within area
Myiagra cyanoleuca Satin Flycatcher [612]		Species or species habitat may occur within area
Migratory Wetlands Species		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat likely to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area
Pandion haliaetus Osprey [952]		Species or species habitat likely to occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species		[Resource Information]
* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.		
Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area
Anseranas semipalmata Magpie Goose [978]		Species or species habitat may occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba Great Egret, White Egret [59541]		Species or species habitat likely to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within

Name	Threatened	Type of Presence area
Calidris acuminata Sharp-tailed Sandpiper [874]	Critically Endangered	Species or species habitat likely to occur within area
Calidris ferruginea Curlew Sandpiper [856]		Species or species habitat may occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Cuculus saturatus Oriental Cuckoo, Himalayan Cuckoo [710]		Species or species habitat may occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]	Endangered*	Species or species habitat likely to occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Monarcha melanopsis Black-faced Monarch [609]		Species or species habitat known to occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat may occur within area
Myiagra cyanoleuca Satin Flycatcher [612]		Species or species habitat may occur within area
Pandion haliaetus Osprey [952]	Endangered*	Species or species habitat likely to occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]		Species or species habitat may occur within area

Extra Information

State and Territory Reserves	[Resource Information]
Name	State
German Creek	QLD

Invasive Species

[Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Birds		
Anas platyrhynchos Mallard [974]		Species or species habitat likely to occur within area
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Passer domesticus House Sparrow [405]		Species or species habitat likely to occur within area
Streptopelia chinensis Spotted Turtle-Dove [780]		Species or species habitat likely to occur within area
Sturnus vulgaris Common Starling [389]		Species or species habitat likely to occur within area
Frogs		
Rhinella marina Cane Toad [83218]		Species or species habitat known to occur within area
Mammals		
Bos taurus Domestic Cattle [16]		Species or species habitat likely to occur within area
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Lepus capensis Brown Hare [127]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Rattus rattus Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Sus scrofa Pig [6]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Acacia nilotica subsp. indica Prickly Acacia [6196]		Species or species

Name	Status	Type of Presence
Cryptostegia grandiflora		habitat may occur within area
Rubber Vine, Rubbervine, India Rubber Vine, India Rubbervine, Palay Rubbervine, Purple Allamanda [18913]		Species or species habitat likely to occur within area
Hymenachne amplexicaulis		
Hymenachne, Olive Hymenachne, Water Stargrass, West Indian Grass, West Indian Marsh Grass [31754]		Species or species habitat likely to occur within area
Jatropha gossypifolia		
Cotton-leaved Physic-Nut, Bellyache Bush, Cotton-leaf Physic Nut, Cotton-leaf Jatropha, Black Physic Nut [7507]		Species or species habitat likely to occur within area
Lantana camara		
Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]		Species or species habitat likely to occur within area
Opuntia spp.		
Prickly Pears [82753]		Species or species habitat likely to occur within area
Parkinsonia aculeata		
Parkinsonia, Jerusalem Thorn, Jelly Bean Tree, Horse Bean [12301]		Species or species habitat likely to occur within area
Parthenium hysterophorus		
Parthenium Weed, Bitter Weed, Carrot Grass, False Ragweed [19566]		Species or species habitat likely to occur within area
Vachellia nilotica		
Prickly Acacia, Blackthorn, Prickly Mimosa, Black Piquant, Babul [84351]		Species or species habitat likely to occur within area
Reptiles		
Hemidactylus frenatus		
Asian House Gecko [1708]		Species or species habitat likely to occur within area

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

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.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for 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 reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-23.2442 148.5733

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.

Appendix B

Wildlife Online Database Extract



Queensland Government

Wildlife Online Extract

Search Criteria: Species List for a Specified Point
Species: All
Type: Native
Status: Rare and threatened species
Records: All
Date: All
Latitude: -23.2442
Longitude: 148.5733
Distance: 30
Email: scott@northres.com.au
Date submitted: Friday 29 Jun 2018 08:16:06
Date extracted: Friday 29 Jun 2018 08:20:08

The number of records retrieved = 11

Disclaimer

As the DSITIA is still in a process of collating and vetting data, it is possible the information given is not complete. The information provided should only be used for the project for which it was requested and it should be appropriately acknowledged as being derived from Wildlife Online when it is used.

The State of Queensland does not invite reliance upon, nor accept responsibility for this information. Persons should satisfy themselves through independent means as to the accuracy and completeness of this information.

No statements, representations or warranties are made about the accuracy or completeness of this information. The State of Queensland disclaims all responsibility for this information and all liability (including without limitation, liability in negligence) for all expenses, losses, damages and costs you may incur as a result of the information being inaccurate or incomplete in any way for any reason.

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	birds	Columbidae	<i>Geophaps scripta scripta</i>	squatter pigeon (southern subspecies)		V	V	5
animals	mammals	Macropodidae	<i>Onychogalea fraenata</i>	bridled nailtail wallaby		E	E	1
animals	mammals	Phascolarctidae	<i>Phascolarctos cinereus</i>	koala		V	V	4
animals	mammals	Pseudocheiridae	<i>Petauroides volans</i>	greater glider		V	V	3
animals	reptiles	Chelidae	<i>Elseya albagula</i>	southern snapping turtle		E	CE	2
animals	reptiles	Chelidae	<i>Rheodytes leukops</i>	Fitzroy River turtle		V	V	3
animals	reptiles	Elapidae	<i>Denisonia maculata</i>	ornamental snake		V	V	1
plants	higher dicots	Mimosaceae	<i>Acacia spania</i>			NT		3/3
plants	higher dicots	Surianaceae	<i>Cadellia pentastylis</i>	ooline		V	V	1
plants	lower dicots	Solanaceae	<i>Solanum elachophyllum</i>			E		1/1
plants	monocots	Poaceae	<i>Dichanthium queenslandicum</i>			V	E	4/4

CODES

I - Y indicates that the taxon is introduced to Queensland and has naturalised.

Q - Indicates the Queensland conservation status of each taxon under the *Nature Conservation Act 1992*. The codes are Extinct in the Wild (PE), Endangered (E), Vulnerable (V), Near Threatened (NT), Least Concern (C) or Not Protected ().

A - Indicates the Australian conservation status of each taxon under the *Environment Protection and Biodiversity Conservation Act 1999*. The values of EPBC are Conservation Dependent (CD), Critically Endangered (CE), Endangered (E), Extinct (EX), Extinct in the Wild (XW) and Vulnerable (V).

Records – The first number indicates the total number of records of the taxon for the record option selected (i.e. All, Confirmed or Specimens).

This number is output as 99999 if it equals or exceeds this value. The second number located after the / indicates the number of specimen records for the taxon.

This number is output as 999 if it equals or exceeds this value.

Appendix C

Potential Occurrence of EVNT Species

Table D1: Potential of near threatened and threatened flora identified in the Protected Matters Search Tool and Queensland Government WO searches to occur within the study area

STATUS ¹		FAMILY	SCIENTIFIC NAME	COMMON NAME	SOURCE ²	WO RECORDS	POTENTIAL TO OCCUR IN THE STUDY AREA
NCA	EPBC						
NT	–	Mimosaceae	<i>Acacia spania</i>		WO	3	High – This species was recorded approximately 800m west of the southwest edge of the study site and within the northern portion of the Wilton ML during the 2011 baseline study by Saunders Havill. This species grows mostly on rocky sandstone ridges and hills in sandy to loamy soils in eucalypt or <i>Acacia</i> dominated woodland communities. Given the presence of local records within 30 km of the study area and records of this species occurring within an adjacent ML, there is a high likelihood for this species to occur within the study area.
LC	V	Myrtaceae	<i>Eucalyptus raveretiana</i>	Black Ironbox	PM	0	Low – This species has a wide distribution in coastal and sub-coastal areas of Queensland, from south of Townsville to Nebo, around Rockhampton and areas 100 km west of the city. It has been recorded from about 23 sites throughout its range, in two main areas: Nebo to Ayr and Aps Creek to Rockhampton. The majority of sites are on roadsides, freehold land and leasehold land. However, it is also present in both state forests and national parks. This species usually grows along watercourses and sometimes on river flats or open woodland. Soil varies from sand through to heavy clay. Black Ironbox does not occur in pure stands, but is co-dominant with other species (DEE, 2018c and references therein). The nearest records of the species occur in an area approximately 100 km east of the study area. Due to the lack of local records it is considered of low likelihood that this species occurs within the study area.
V	E	Poaceae	<i>Dichanthium queenslandicum</i>	King Blue-grass	PM/WO	4	Moderate – There are numerous records of this species to the west of the study area, including four records 30 km from the southwest corner. This species is endemic to central and southern Queensland where it occurs in three disjunct populations: 1) Hughenden district; 2) from Nebo to Monto and west to Clermont and Rolleston; and 3) Dalby district, Darling Downs. It has been recorded to occur within the Brigalow Belt; however, its extent of occurrence has reduced significantly. Its area of occupancy is unknown but based on the extent of occurrence is likely to be restricted. The main identified threats to this species are habitat loss through agricultural and mining activities, road construction and other infrastructure developments, and weed invasion resulting in competition and potential displacement (TSSC, 2013, and references therein). Given the presence of local records within 30 km of the study area, but the highly degraded condition of suitable habitat, there is a moderate likelihood for this species to occur within the study area.
LC	V	Poaceae	<i>Dichanthium setosum</i>	Bluegrass	PM	0	Low – The nearest records of this species occur approximately 100 km to the south of the study area. This species is a warm season perennial, and commences growing in spring, flowers in summer and becomes dormant in late autumn. It is associated with heavy basaltic black soils and red-brown loams with clay subsoil. It is often found in moderately disturbed areas such as cleared woodland, grassy roadside remnants and highly disturbed pasture. It is often collected from disturbed open grassy woodlands on the northern tablelands, where the habitat has been variously grazed, nutrient-enriched and water-enriched. This species may tolerate or benefit from disturbance; otherwise, disturbance is indicative of threatening processes in its habitat (DEE, 2018c and references therein). Due to the lack of local records and patchy distribution of this species, it is considered a low likelihood for this species to occur within the study area.
E	-	Solanaceae	<i>Solanum elachophyllum</i>		WO	1	Moderate – There is one record of this species in the local area. This species is a perennial shrub to 0.4m in height and grows on fertile cracking clay soils in open forests dominated by <i>Eucalyptus</i> and <i>Acacia</i> species (DES, 2018f). It is known from the Leichardt district of Queensland from Nebo south to near Theodore. As there is one record of this species in the local area and cracking clay soils are found within the study area along the edges of Cooroora Creek, there is a moderate likelihood that this species occurs on site.
V	V	Surianaceae	<i>Cadellia pentastylis</i>	Ooline	PM/WO	1	Low – This species occurs on the northwest slopes of New South Wales and in central and southern Queensland. In Queensland, Ooline occurs from Balcomba south to the New South Wales border and west to near Blackall. This species grows in semi-evergreen vine thickets and sclerophyll vegetation on undulating terrain of varying geology; including sandstone, conglomerate and claystone (DEE, 2018c and references therein). There is one record of this species within the local area, but this occurs at the northern extent with the majority of records occurring further south. Given the low numbers recorded near the study area and preferred habitat not recorded on site, there is a low likelihood for this species to occur within the study area.

1. Status: LC = Least Concern, NT = Near Threatened, V = Vulnerable, E = Endangered.
2. WO = Queensland Government Wildlife Online Database Extract, PM = EPBC Act Protected Matters Report.
3. NCA = *Nature Conservation Act* 1992, EPBC = *Environment Protection and Biodiversity Conservation Act* 1999.

Table D2: Potential of near threatened and threatened fauna identified in the Protected Matters Search Tool and Queensland Government WO searches to occur within the study area

STATUS ¹		FAMILY	SCIENTIFIC NAME	COMMON NAME	SOURCE ²	WO RECORDS	POTENTIAL TO OCCUR IN THE STUDY AREA
NCA	EPBC						
		BIRDS					
E	V	Accipitridae	<i>Erythroriorchis radiatus</i>	Red Goshawk	PM	0	Moderate – This species prefers forest and woodland with a mosaic of vegetation types, particularly near riverine systems and permanent water, where there is an abundance of prey species (DEE, 2018c and references therein). The home range in northern Australia has been reported as up to 200 km ² ; with indications it may be even larger (Aumann & Baker-Gabb, 1991). Given the large home range of this species and the spatial uncertainty of the local record (54,000m), this species has a moderate likelihood of occurring within the site.
V	V	Columbidae	<i>Geophaps scripta scripta</i>	Squatter Pigeon	PM/WO	5	High – There are five local records of this species within 30 km of the study area, which falls within the distribution of this species. Habitats that this species occur in are generally defined as open-forests to sparse, open-woodlands and scrub that is mostly dominated in the overstorey by <i>Eucalyptus</i> , <i>Corymbia</i> , <i>Acacia</i> or <i>Callitris</i> species (DEE, 2018c and references therein). The presence of local records and suitable habitat within the study area results in a high likelihood of this species to occur within the study area.
E	E	Estrildidae	<i>Neochmia ruficauda ruficauda</i>	Star Finch	PM	0	Low – This species occurs only in central Queensland and the overall distribution of this species is very poorly known. The project area is not within the suspected range of the species described in the conservation advice, and some authors consider it to be locally extinct (Garnett <i>et al.</i> , 2005). This species occurs mainly in grasslands and grassy woodlands that are located close to bodies of fresh water. It also occurs in cleared or suburban areas such as along roadsides and in towns (DEE, 2018c and references therein). Due to the lack of local records and the nearest record occurring approximately 120 km to the northeast, it is unlikely that this species occurs within the study area.
E	E	Estrildidae	<i>Poephila cincta cincta</i>	Southern Black-throated Finch	PM	0	Low – This species occurs mainly in grassy, open woodlands and forests, typically dominated by <i>Eucalyptus</i> , <i>Corymbia</i> and <i>Melaleuca</i> , and occasionally in tussock grasslands or other habitats, often along or near watercourses, or in the vicinity of water (DEE, 2018c and references therein). While potentially suitable habitat exists, due to the limited distribution and the lack of records of this species within the study area it has a low likelihood of occurring.
V	V	Meliphagidae	<i>Grantiella picta</i>	Painted Honeyeater	PM	0	Low – This species is sparsely distributed from south-eastern Australia to north-western Queensland and eastern Northern Territory. The greatest concentrations and almost all records of breeding come from inland slopes of the Great Dividing Range between the Grampians, Victoria and Roma, Queensland. This species exhibits seasonal north-south movements governed principally by the fruiting of mistletoe. Many birds move after breeding to semi-arid regions such as north-eastern South Australia, central and western Queensland, and central Northern Territory (DEE, 2018c). The nearest record of this species is approximately 50 km to the southeast of the study area. Due to the absence of local records and the study area fringing the edge of this species distribution it is unlikely that this species occurs within the study area.
V	E, M	Rostratulidae	<i>Rostratula australis</i>	Australian Painted Snipe	PM	0	Low – This species has been recorded at wetland sites throughout much of Australia but is most common in the eastern States. The Australian Painted Snipe is a distinct species, but its cryptic and crepuscular behaviour can make it difficult to detect. This species typically occurs in shallow freshwater wetlands and other permanently or temporarily inundated areas, particularly where rank tussocks of grasses, sedges, rushes or reeds are present (DEE, 2018c; Morcombe, 2003). The study area is located within the known distribution for this species; however, limited suitable foraging habitat and lack of nearby records of this species results in a low likelihood of this species occurring within the study area.
E	CE, M	Scolopacidae	<i>Calidris ferruginea</i>	Curlew Sandpiper	PM	0	Low – This species typically inhabits intertidal mudflats in sheltered coastal areas; however, have also been recorded inland around ephemeral and permanent lakes, dams, waterholes and bore drains as well as around floodplains (Higgins & Davies, 1996). There are no records of this species within 30 km of the study area and the nearest being at Lake Maraboon, south of Emerald. It is considered that this species is unlikely to occur within the study area as there is no suitable habitat for this species within the study area.

STATUS ¹		FAMILY	SCIENTIFIC NAME	COMMON NAME	SOURCE ²	WO RECORDS	POTENTIAL TO OCCUR IN THE STUDY AREA
NCA	EPBC						
		MAMMALS					
LC	E	Dasyuridae	<i>Dasyurus hallucatus</i>	Northern Quoll	PM	0	Low – The distribution of this species is highly fragmented in the state and surveys indicate severe reductions from the species former distribution. This species occupies a diversity of habitats across its range, including rocky areas, forests, woodlands, rainforests, sandy lowlands and beaches, shrubland, grasslands and desert (DEE, 2018c and references therein). The nearest record of this species is approximately 90 km west of the study area. While the study area falls within the species known distribution and there are scattered records in the region, the lack of records within 30 km and very small, disjointed and degraded pockets of potential habitat result in a low likelihood of occurrence.
E	E	Macropodidae	<i>Onychogalea fraenata</i>	Bridled Nailtail Wallaby	WO	1	Low – This species is confined to Idalia National Park west of Tambo, Taunton National Park near Dingo and a pocket of remnant vegetation 40 km south of Emerald. This species occurs in woodland, particularly in Brigalow scrub, preferring areas with the most fertile soil (DEE, 2018c and references therein). The one local record of this species was recorded in 1845 and is not considered part of the current distribution (Atlas of Living Australia, 2018). As the study area is situated outside of the currently known distribution for this species, and as no recent local records are available, it is unlikely this species occurs within this study area.
E	V	Megadermatidae	<i>Macroderma gigas</i>	Ghost Bat	PM	0	Low – This species has a patchy distribution in rainforest, semi-deciduous vine thicket, open woodland, spinifex, black soil and grasslands. It has been recorded to roost in caves, boulder piles, shallow escarpments and mines (Van Dyck <i>et al.</i> , 2013). Due to unsuitable roosting habitat within the study area and the nearest recording being approximately 170 km east of the study area, it is considered unlikely that this species occurs within the study area.
V	V	Phascolarctidae	<i>Phascolarctos cinereus</i>	Koala	PM/WO	4	Moderate – This species range includes the eastern half of Queensland in sclerophyll forest and woodland (Menkhorst & Knight, 2011). Although widespread, suitable feed species and leaf moisture are the primary determinants of habitat suitability (DEE, 2018c). Numerous records of this species occur within 30 km of the study area; however, these records are over 30 years old, and habitat for this species is fragmented and greatly disturbed. There is a moderate likelihood that this species occurs in the study area.
V	V	Pseudocheiridae	<i>Petauroides volans</i>	Greater Glider	PM/WO	3	Moderate – This species occurs in eastern Australian states from Cairns to Victoria, inhabiting eucalypt-dominated low open forests on the coast to tall forests in the ranges and low woodlands west of the Great Dividing Range (Van Dyck <i>et al.</i> , 2013). There are three records of this species within 30 km of the study site and a thin strip of highly disturbed habitat. Due to the presence of local records and low-quality habitat it is of moderate likelihood that this species occurs within the study area.
V	V	Pteropodidae	<i>Pteropus poliocephalus</i>	Grey-headed Flying-fox	PM	0	Low – This species occurs in the coastal belt from Rockhampton in central Queensland to Melbourne in Victoria; however, only a small proportion of this range is used at any one time, as the species selectively forages where food is available. As a result, patterns of occurrence and relative abundance within its distribution vary widely between seasons and between years. This species requires foraging resources and roosting sites. It is a canopy-feeding frugivore and nectarivore, which utilises vegetation communities including rainforests, open forests, closed and open woodlands, <i>Melaleuca</i> swamps and <i>Banksia</i> woodlands (DEE, 2018c and references therein). Due to there being no local records of this species and the nearest record being approximately 200 km to the east of the study area, and this species' varied distribution, it is unlikely this species occurs within the study area.
V	V	Vespertilionidae	<i>Nyctophilus corbeni</i>	Corben's Long-eared Bat	PM	0	Low – This species is found in southern central Queensland, central western New South Wales, north-western Victoria and eastern South Australia, where it is patchily distributed, with most of its range in the Murray Darling Basin. This species is uncommon within this distribution and is rarely recorded, except in some areas including the Nandewar and Brigalow Belt South bioregions in New South Wales and Queensland. It is found in a wide range of inland woodland vegetation types, but in Queensland is distinctly more common in box/ironbark/cypress pine vegetation that occurs in a north-south belt along the western slopes and plains of New South Wales and southern Queensland. This species is more abundant in extensive stands of vegetation than in smaller woodland patches, suggesting its home range is probably large (TSSC, 2015b and references therein). The study area is situated on the northern edge of this species distribution, with the nearest record being over 200 km away. Because of the lack of local records, it is unlikely this species occurs within the study area.
V	V	Vespertilionidae	<i>Chalinolobus dwyeri</i>	Large-eared Pied Bat	PM	0	Low – This species distribution is poorly known, but records indicate that this species can be found from near Rockhampton, QLD south to Ulladulla, NSW (DEE, 2018c). The majority of records are located within large sandstone escarpments particularly in the Sydney basin but have been known to occupy disused mines and adits. There are no records of this species within the local area and suitable habitat of large sandstone escarpments is not located within the study area. This species has a low likelihood of occurring within the study area.

STATUS ¹		FAMILY	SCIENTIFIC NAME	COMMON NAME	SOURCE ²	WO RECORDS	POTENTIAL TO OCCUR IN THE STUDY AREA
NCA	EPBC						
		REPTILES					
E	CE	Chelidae	<i>Elseya albagula</i>	Southern Snapping Turtle	PM/WO	2	Moderate – This species is found in Queensland in the Fitzroy, Mary and Burnett Rivers, and associated smaller drainages in southeastern Queensland (TSSC, 2014). This species has been recorded in permanent waterways to the south and east, within 30 km of the study area. There is one permanent body of water in the study area upstream of a weir; however, the creek upon which the weir is built is naturally dry during the wet season. This species requires permanent water to persist. Permanent water is present in the study area; however, the weir downstream represents fragmentation of habitat. As such, this species has a moderate likelihood of occurring in the study area.
V	V	Chelidae	<i>Rheodytes leukops</i>	Fitzroy River Turtle	PM/WO	3	Moderate – This species is only found in the drainage system of the Fitzroy River, Queensland. Known sites include Coolburra, Gainsford, Glenroy Crossing, Theodore, Baralba, the Mackenzie River, the Connors River, Duaringa, Marlborough Creek and Gogango. This species is found in rivers with large deep pools with rocks, gravelly or sandy substrates, connected by shallow riffles. Preferred areas have high water clarity, and are often associated with Ribbonweed beds (DEE, 2018c and references therein). Numerous records of this species occur within 30 km of the study area; however, the spatial uncertainty of these records is very high, with most being approximately 10 km. This species requires permanent water to persist. Permanent water is present in the study area; however, the weir downstream represents fragmentation of habitat. As such, this species has a moderate likelihood of occurring in the study area.
V	V	Elapidae	<i>Denisonia maculata</i>	Ornamental Snake	PM/WO	1	High – The species is known only from the Brigalow Belt North and parts of the Brigalow Belt South biogeographical regions. The core of the species distribution occurs within the drainage system of the Fitzroy and Dawson Rivers. The preferred habitat of this species is within, or close to, habitat that is favoured by its prey – frogs. The species is known to prefer woodlands and open forests associated with moist areas, particularly gilgai mounds and depressions, but also lake margins and wetlands (DEE, 2018c and references therein). This species was recorded at a trap site in the northwest of the Wilton North ML during the baseline surveys by Saunders Havill in 2011. It was found to be associated with gilgai in an isolated patch of remnant <i>Acacia harpophylla</i> open forest (RE 11.5.16). One record in the Atlas of Living Australia (2018) is located approximately 20 km to the southeast of the study area. Due to these local records and high-quality habitat occurring within the study area, there is a high likelihood of this species occurring within the study area.
V	V	Elapidae	<i>Furina dunmalli</i>	Dunmall’s Snake	PM	0	Low –This species occurs primarily in the Brigalow Belt region in the south-eastern interior of Queensland. Records indicate this species occupies sites at elevations between 200 and 500m ASL. This species is very rare or secretive with limited records existing. This species has been found in a broad range of habitats, including; Forests and woodlands on black alluvial cracking clay and clay loams dominated by Brigalow, other wattles, Native Cypress or Bull-oak, and various Blue Spotted Gum, Ironbark, White Cypress Pine and Bull-oak open forest and woodland association on sandstone derived soils. Due to there being no local records of this species and the nearest record being over 100 km away, there is a low likelihood this species occurs within the study area.
V	V	Pygopodidae	<i>Delma torquata</i>	Collared Delma	PM	0	Low – This species has been recorded within the Bunya Mountains, Blackdown Tablelands, Expedition National Park, Western Creek near Millmerran, and in the Toowoomba Range. This species normally inhabits eucalypt-dominated woodlands and open-forests in Queensland (DEE, 2018c and references therein). The closest record on Atlas of Living Australia (2018) occurs within the Blackdown Tableland, situated approximately 75 km from the study area. Due to the lack of local records and patchy distribution of this species it is unlikely to occur within the study area.
V	V	Scincidae	<i>Egernia rugosa</i>	Yakka Skink	PM	0	Low – The known distribution of this species extends from the coast to the hinterland of sub-humid to semi-arid eastern Queensland. This vast area covers portions of the Brigalow Belt, Mulga Lands, South-east Queensland, Einasleigh Uplands, Wet Tropics and Cape York Peninsula biogeographical regions. This species is known to occur in open dry sclerophyll forest, woodland and scrub. The core habitat of this species is within the mulga lands and Brigalow Belt South bioregions. It is more commonly found in cavities under and between partly buried rocks, logs or tree stumps, root cavities and abandoned animal burrows. This species often takes refuge in large hollow logs and has been known to excavate deep burrow systems, sometimes under dense ground vegetation. In cleared habitat, this species can persist where there are shelter sites such as raked log piles, deep gullies, tunnel erosion/sinkholes and rabbit warrens (DEE, 2018c and references therein). The only local record of this species is more than 30 km to the east of the study area, so while small fragments of suitable remnant habitat occurring throughout the area it has a low likelihood of occurring.
E	E	Scincidae	<i>Lerista allanae</i>	Retro Slider	PM	0	Low – The range of this species is believed to occur within the Clermont area in eastern Central Queensland. It is known only from black soil downs of the Oxford land system in the Brigalow Belt North Biogeographic Region (DEE, 2018c). Due to the lack of local records and restricted distribution of this species it is unlikely to occur within the study area.

1. Status: LC = Least Concern, NT = Near Threatened, V = Vulnerable, E = Endangered, CE = Critically Endangered, M = Migratory.

2. WO = Queensland Government Wildlife Online Database Extract, PM = EPBC Act Protected Matters Report.
3. NCA = *Nature Conservation Act 1992*, EPBC = *Environment Protection and Biodiversity Conservation Act 1999*.

Table D3: Potential for terrestrial migratory fauna identified in the Protected Matters Search Tool and Queensland Government WO searches to occur within the study area

STATUS ¹		FAMILY	SCIENTIFIC NAME	COMMON NAME	SOURCE ²	WO RECORDS	POTENTIAL TO OCCUR IN THE STUDY AREA
NCA	EPBC						
		BIRDS					
SLC	M	Accipitridae	<i>Pandion cristatus</i>	Eastern Osprey	PM	0	Low – Found on the coasts, interior, and many offshore islands of Australia. This species occurs in coastal habitats and terrestrial wetlands of tropical and temperate Australia. This species may travel inland along major rivers in its northern distribution (DEE, 2018c). There are records from Lake Maraboon and Emerald; however, due to the lack of suitable habitat and records within 30 km it is unlikely that this species occurs within the study area.
SLC	M	Apodidae	<i>Apus pacificus</i>	Fork-tailed Swift	PM	0	Low – This species is a non-breeding visitor to all states and territories of Australia. There are scattered records of this species in the Gulf Country and a few records on Cape York Peninsula. In the north-east region, there are many records east of the Great Divide from near Cooktown and south to Townsville. They are also widespread but scattered in coastal areas in the south-eastern region of Queensland. They are more widespread west of the Great Divide and are commonly found west of the line joining Chinchilla and Hughenden. In Australia, they mostly occur over inland plains but sometimes over foothills or in coastal areas. They often occur over cliffs and beaches and occur over islands and sometimes well out to sea. There are no local records within 30 km of the study area with only scattered records throughout the surrounding landscape. Due to the aerial nature of this species it is unlikely to occur within the study area, or utilise the area for an extended period.
SLC	M	Cuculidae	<i>Cuculus optatus</i>	Oriental Cuckoo	PM	0	Low – This species is widespread in the northern and eastern parts of Australia, inhabiting rainforest margins, monsoon forest, vine scrubs, riverine thickets, wetter, densely canopied eucalypt forests, paperbark swamps and mangroves (Morcombe, 2003). Due to the habitat requirements of this species not being met within the study area, and the nearest local record being over 100 km away, it is unlikely this species occurs within the study area.
SLC	M	Monarchidae	<i>Monarcha melanopsis</i>	Black-faced Monarch	PM	0	Low – This species is widespread in eastern Australia in a variety of rainforest ecosystems (DEE, 2018c), but can also occur in drier habitats, especially during winter or during passage. There is one record of this species 26 km from the study area; however, it has a spatial uncertainty of 5 km and the study area is on the periphery of the known distribution for this species. As a result, there is a low likelihood of this species occurring within the study area.
SLC	M	Monarchidae	<i>Myiagra cyanoleuca</i>	Satin Flycatcher	PM	1	Low – This species occurs across Australia and inhabits temperate forests and subtropical and tropical moist lowland forests (Morcombe, 2003). There is one record of this species within 30 km of the study site; however, the habitat within the study area is unsuitable for this species. It is considered of low likelihood that this species could occur in the study area.
SLC	M	Motacillidae	<i>Motacilla flava</i>	Yellow Wagtail	PM	0	Low – This species is a rare but regular migrant to coastal areas within Australia. It typically inhabits open habitats, often near water, and occasionally drier inland plains (Morcombe, 2003). Due to sporadic and scattered occurrences of this species and unsuitable habitat within the study site, it is unlikely to occur.
SLC	M	Scolopacidae	<i>Actitis hypoleucos</i>	Common Sandpiper	PM	0	Low – Widespread but patchy distribution along all coastlines of Australia. Found in coastal wetlands and inland wetlands with varying levels of salinity (DEE, 2018c). Most commonly found in muddy or rocky shores of estuaries, deltas of streams, banks upstream, lakes, pools, billabongs, reservoirs, and dams. The study area does not support suitable habitat for this species and its likelihood of occurrence is low.
SLC	M	Scolopacidae	<i>Calidris acuminata</i>	Sharp-tailed Sandpiper	PM	6	High – This species occurs around the entire coast of Australia outside its breeding season, where it occurs around a broad range of permanent or ephemeral water bodies, primarily brackish. In Queensland, it is sparsely distributed across the state during this period, with many records being fly-overs (DEE, 2018c and references therein). It has been recorded northeast of Emerald, less than 30 km from the study site, around watercourses and dams similar to those, which occur on the study site. It is likely that any occurrence in this area would be a pass-over; however, due to the presence of habitat similar to that with local records, there is a high likelihood of this species occurrence on the study site.
E	CE, M	Scolopacidae	<i>Calidris ferruginea</i>	Curlew Sandpiper	PM	0	Low – This species typically inhabits intertidal mudflats in sheltered coastal areas; however, it has also been recorded inland around ephemeral and permanent lakes, dams, waterholes and bore drains as well as around floodplains (Higgins & Davies, 1996). There are no records of this species within 30 km of the study area and the nearest being at Lake Maraboon, south of Emerald. It is considered that this species is unlikely to occur within the study area, as there is limited suitable habitat for this species within the study area.

STATUS ¹		FAMILY	SCIENTIFIC NAME	COMMON NAME	SOURCE ²	WO RECORDS	POTENTIAL TO OCCUR IN THE STUDY AREA
NCA	EPBC						
SLC	M	Scolopacidae	<i>Calidris melanotos</i>	Pectoral Sandpiper	PM	0	Low – While this species has been recorded inland in Queensland around Roma and Longreach, the majority of records occur east of the Great Dividing Range between Cairns and Yeppoon. It is more particular about habitats than many of its relatives, preferring shallow wetlands (fresh to marine) and doesn't tend to utilise small or ephemeral water bodies (Pizzey & Knight, 2012). Due to the lack of nearby records and suitable habitat the likelihood of this species occurring on the study sites is low.
SLC	M	Scolopacidae	<i>Gallinago hardwickii</i>	Latham's Snipe	PM	1	High – This species is distributed along the east coast of Australia from Cape York Peninsula south to south eastern Australia. This species occurs in permanent and ephemeral wetlands with low to dense vegetation up to 2000 m above sea-level (DEE, 2018c). This species is also known to occur close to humans and human activity. This species has been recorded within 30 km of the study area on one occasion and ephemeral wetlands have been recorded within the study area. As a result, there is a high likelihood of this species occurring within the study area.

1. Status: LC = Least Concern, NT = Near Threatened, V = Vulnerable, E = Endangered, CE = Critically Endangered, M = Migratory.

2. WO = Queensland Government Wildlife Online Database Extract, PM = EPBC Act Protected Matters Report.

3. NCA = *Nature Conservation Act 1992*, EPBC = *Environment Protection and Biodiversity Conservation Act 1999*.

Appendix D

Flora Species List for 2017 and 2018 Baseline Surveys

Table E1: Flora species recorded within the study area during the September 2017 and May 2018 baseline surveys

STATUS ¹		FAMILY	SCIENTIFIC NAME	COMMON NAME	HABITAT			
NCA	EPBC				RE 11.3.25e/11.9.1	RE 11.9.2	RE 11.10.12	NON-REMNANT
LC	-	Amaranthaceae	<i>Achyranthes aspera</i>	Chaff Weed	X			
LC	-	Apocynaceae	<i>Carissa lanceolata</i>	Currant Bush	X	X	X	X
LC	-	Asparagaceae	<i>Eustrephus latifolius</i>	Wombat Berry				
*	-	Asteraceae	<i>Xanthium sp.</i>	Noogoora Burr	X			
*	-	Asteraceae	<i>Parthenium hysterophorus</i>	Parthenium	X			X
LC	-	Asteraceae	<i>Pterocaulon redolens</i>	Ragweed		X	X	
LC	-	Asteraceae	<i>Pterocaulon sphacelatum</i>	Applebush		X	X	
LC	-	Bignoniaceae	<i>Pandorea pandorana</i>	Wonga Vine				X
LC	-	Boraginaceae	<i>Ehretia membranifolia</i>	Weeping Koda				X
*	-	Cactaceae	<i>Harrisia martinii</i>	Harrisia Cactus	X			X
*	-	Cactaceae	<i>Opuntia stricta</i>	Prickly Pear			X	
*	-	Cactaceae	<i>Opuntia tomentosa</i>	Velvety Tree Pear	X	X	X	X
LC	-	Caesalpiniaceae	<i>Cassia brewsteri</i> var. <i>brewsteri</i>	Leichhardt Bean		X	X	X
LC	-	Caesalpiniaceae	<i>Lysiphyllum hookeri</i>	Hookers Bauhinia	X		X	X
LC	-	Capparaceae	<i>Capparis lasiantha</i>	Wait-a-while	X			X
LC	-	Casuarinaceae	<i>Casuarina cristata</i>	Belah				X
LC	-	Celastraceae	<i>Denhamia cunninghamii</i>	Yellowberry Bush		X	X	

STATUS ¹		FAMILY	SCIENTIFIC NAME	COMMON NAME	HABITAT			
NCA	EPBC				RE 11.3.25e/11.9.1	RE 11.9.2	RE 11.10.12	NON-REMNANT
LC	-	Chenopodiaceae	<i>Einadia nutans</i>	Climbing Saltbush	X			
LC	-	Chenopodiaceae	<i>Salsola australis</i>	Soft Roly-poly	X			X
LC	-	Chenopodiaceae	<i>Scleroleaena birchii</i>		X			
LC	-	Chenopodiaceae	<i>Scleroleaena calcarata</i>		X			
LC	-	Combretaceae	<i>Terminalia oblongata</i>	Yellow Wood	X			X
LC	-	Erythroxylaceae	<i>Erythroxylum australe</i>	Cocaine Bush				X
LC	-	Euphorbiaceae	<i>Acalypha eremorum</i>	Smooth Acalypha	X			X
LC	-	Euphorbiaceae	<i>Breynia oblongifolia</i>	Coffee Bush				X
LC	-	Fabaceae	<i>Hovea longipes</i>	Brush Hovea				X
LC	-	Fabaceae	<i>Indigofera linifolia</i>	Narrow-leaved Indigo				X
*	-	Fabaceae	<i>Stylosanthes scabra</i>	Shrubby Stylo		X	X	X
LC	-	Malvaceae	<i>Grewia retusifolia</i>	Dogs Balls				X
*	-	Malvaceae	<i>Malvastrum americanum</i>	Spiked Malvastrum	X			
LC	-	Meliaceae	<i>Owenia acidula</i>	Emu Bush				X
LC	-	Mimosaceae	<i>Acacia excelsa</i>	Ironwood		X	X	X
LC	-	Mimosaceae	<i>Acacia harpophylla</i>	Brigalow	X			X
LC	-	Mimosaceae	<i>Acacia leiocalyx</i>	Black Wattle	X	X	X	X
LC	-	Mimosaceae	<i>Acacia salicina</i>	Sally Wattle	X	X	X	
LC	-	Mimosaceae	<i>Acacia victoriae</i>	Lancewood	X			

STATUS ¹		FAMILY	SCIENTIFIC NAME	COMMON NAME	HABITAT			
NCA	EPBC				RE 11.3.25e/11.9.1	RE 11.9.2	RE 11.10.12	NON-REMNANT
LC	-	Mimosaceae	<i>Archidendropsis basaltica</i>	Dead Finish				X
LC	-	Mimosaceae	<i>Vachellia bidwillii</i>	Corkwood Wattle	X			
*	-	Mimosaceae	<i>Vachellia farnesiana</i>	Mimosa Bush	X			X
LC	-	Moraceae	<i>Ficus opposita</i>	Sandpaper Fig	X			
LC	-	Myrtaceae	<i>Corymbia dallachiana</i>	Ghost Gum				X
LC	-	Myrtaceae	<i>Corymbia erythrophloia</i>	Red Bloodwood	X			
LC	-	Myrtaceae	<i>Corymbia tessellaris</i>	Moreton Bay Ash	X			X
LC	-	Myrtaceae	<i>Eucalyptus camaldulensis</i>	River Red Gum	X			X
LC	-	Myrtaceae	<i>Eucalyptus cambageana</i>	Dawson River Blackbutt	X			
LC	-	Myrtaceae	<i>Eucalyptus chloroclada</i>	Bradine Red Gum			X	
LC	-	Myrtaceae	<i>Eucalyptus coolabah</i>	Coolibah	X			
LC	-	Myrtaceae	<i>Eucalyptus crebra</i>	Narrow-leaved Ironbark	X			
LC	-	Myrtaceae	<i>Eucalyptus melanophloia</i>	Silver-leaved Ironbark		X	X	X
LC	-	Myrtaceae	<i>Eucalyptus orgadophila</i>	Mountain Coolibah				X
LC	-	Myrtaceae	<i>Eucalyptus populnea</i>	Poplar Box	X	X	X	X
LC	-	Myrtaceae	<i>Melaleuca bracteata</i>	Black Teatree	X		X	
LC	-	Orchidaceae	<i>Cymbidium canaliculatum</i>	Black Orchid				X
LC	-	Poaceae	<i>Aristida queenslandica</i>	Aristida	X			X
LC	-	Poaceae	<i>Astrelba lappacea</i>	Curly Mitchell Grass				X

STATUS ¹		FAMILY	SCIENTIFIC NAME	COMMON NAME	HABITAT			
NCA	EPBC				RE 11.3.25e/11.9.1	RE 11.9.2	RE 11.10.12	NON-REMNANT
*	-	Poaceae	<i>Bothriochloa pertusa</i>	Indian Bluegrass				X
*	-	Poaceae	<i>Cenchrus ciliaris</i>	Buffel Grass	X	X	X	X
LC	-	Poaceae	<i>Dactyloctenium radulans</i>	Button Grass	X			
LC	-	Poaceae	<i>Heteropogon contortus</i>	Black Speargrass	X	X	X	
*	-	Poaceae	<i>Melinis repens</i>	Red Natal Grass		X	X	X
LC	-	Poaceae	<i>Themeda triandra</i>	Kangaroo Grass	X	X	X	X
*	-	Poaceae	<i>Urochloa mosambicensis</i>	Sabi Grass	X			X
LC	-	Proteaceae	<i>Grevillea striata</i>	Beef Wood	X			X
LC	-	Proteaceae	<i>Hakea lorea</i>	Bootlace Oak				X
LC	-	Rubiaceae	<i>Coelospermum reticulatum</i>	Medicine Bush				X
LC	-	Santalaceae	<i>Santalum lanceolatum</i>	Sandalwood				X
LC	-	Sapindaceae	<i>Atalaya hemiglauca</i>	Whitewood	X			X
LC	-	Sapindaceae	<i>Dodonaea viscosa</i>	Hopbush		X	X	
LC	-	Scrophulariaceae	<i>Eremophila mitchellii</i>	False Sandalwood	X			X
LC	-	Scrophulariaceae	<i>Myoporum acuminatum</i>	Boobialla				X

1. Status: LC = Least Concern, NT = Near Threatened, V = Vulnerable, E = Endangered, * = Species not native to Australia.
2. NCA = *Nature Conservation Act 1992*, EPBC = *Environment Protection and Biodiversity Conservation Act 1999*.

Appendix E

Fauna Species List for 2017 and 2018 Baseline Surveys

Table F1: Fauna species recorded within the study area during the September 2017 and May 2018 baseline surveys

STATUS		FAMILY	SCIENTIFIC NAME	COMMON NAME	S1	S2	S3	S4	S5	S6	INCIDENTAL	
NCA	EPBC											
BIRDS												
LC	-	Dromaiidae	<i>Dromaius novaehollandiae</i>	Emu							X	
LC	-	Phasianidae	<i>Coturnix ypsilophora</i>	Brown Quail				X			X	
LC	-	Anatidae	<i>Anas superciliosa</i>	Pacific Black Duck		X					X	
LC	-	Anatidae	<i>Anas gracilis</i>	Grey Teal							X	
LC	-	Anatidae	<i>Chenonetta jubata</i>	Australian Wood Duck							X	
LC	-	Anatidae	<i>Cygnus atratus</i>	Black Swan							X	
LC	-	Columbidae	<i>Ocyphaps lophotes</i>	Crested Pigeon		X					X	
LC	-	Columbidae	<i>Phaps chalcoptera</i>	Common Bronzewing							X	
LC	-	Columbidae	<i>Geopelia striata</i>	Peaceful Dove			X				X	
LC	-	Columbidae	<i>Geopelia humeralis</i>	Bar-shouldered Dove							X	
LC	-	Anhingidae	<i>Anhinga novaehollandiae</i>	Australasian Darter		X					X	
LC	-	Podargidae	<i>Podargus strigoides</i>	Tawny Frogmouth						X	X	
LC	-	Aegothelidae	<i>Aegotheles cristatus</i>	Owlet Nightjar							X	
LC	-	Phalacrocoracidae	<i>Microcarbo melanoleucos</i>	Little Pied Cormorant		X						
LC	-	Ardeidae	<i>Ardea intermedia</i>	Intermediate Egret		X					X	
LC	-	Ardeidae	<i>Egretta novaehollandiae</i>	White-faced Heron		X					X	

STATUS		FAMILY	SCIENTIFIC NAME	COMMON NAME	S1	S2	S3	S4	S5	S6	INCIDENTAL
NCA	EPBC										
LC	-	Ardeidae	<i>Nycticorax caledonicus</i>	Nankeen Night Heron		X					
LC	-	Threskiornithidae	<i>Threskiornis spinicollis</i>	Straw-necked Ibis							X
LC	-	Threskiornithidae	<i>Platalea regia</i>	Royal Spoonbill							X
LC	-	Threskiornithidae	<i>Platalea flavipes</i>	Yellow-billed Spoonbill							X
LC	-	Accipitridae	<i>Elanus axillaris</i>	Black-shouldered Kite				X			
LC	-	Accipitridae	<i>Haliastur sphenurus</i>	Whistling Kite		X	X			X	
LC	-	Accipitridae	<i>Aviceda subcristata</i>	Pacific Baza		X					
LC	-	Accipitridae	<i>Aquila audax</i>	Wedge-tailed Eagle	X						X
LC	-	Falconidae	<i>Falco berigora</i>	Brown Falcon							X
LC	-	Falconidae	<i>Falco cenchroides</i>	Nankeen Kestrel							X
LC	-	Gruidae	<i>Grus rubicunda</i>	Brolga				X			X
LC	-	Rallidae	<i>Fulica atra</i>	Eurasian Coot							X
LC	-	Otididae	<i>Ardeotis australis</i>	Australian Bustard							X
LC	-	Charadriidae	<i>Vanellus miles</i>	Masked Lapwing							X
LC	-	Turnicidae	<i>Turnix pyrrhothorax</i>	Red-chested Buttonquail					X		
LC	-	Psittaculidae	<i>Cacatua galerita</i>	Sulphur-crested Cockatoo	X	X					X
LC	-	Psittaculidae	<i>Eolophus roseicapilla</i>	Galah		X					X
LC	-	Psittaculidae	<i>Aprosmictus erythropterus</i>	Red-winged Parrot	X	X		X			X
LC	-	Psittaculidae	<i>Trichoglossus haematodus</i>	Rainbow lorikeet		X		X			

STATUS		FAMILY	SCIENTIFIC NAME	COMMON NAME	S1	S2	S3	S4	S5	S6	INCIDENTAL
NCA	EPBC										
LC	-	Psittaculidae	<i>Nymphicus hollandicus</i>	Cockatiel							X
LC	-	Psittaculidae	<i>Platycercus adscitus</i>	Pale-headed Rosella				X		X	X
LC	-	Psittaculidae	<i>Melopsittacus undulatus</i>	Budgerigar					X		X
LC	-	Tytonidae	<i>Tyto delicatula</i>	Eastern Barn Owl		X					X
LC	-	Cuculidae	<i>Scythrops novaehollandiae</i>	Channel-billed Cuckoo	X						
LC	-	Cuculidae	<i>Cacomantis pallidus</i>	Pallid Cuckoo							X
LC	-	Alcedinidae	<i>Dacelo novaeguineae</i>	Laughing Kookaburra	X	X				X	X
LC	Ma	Meropidae	<i>Merops ornatus</i>	Rainbow Bee-eater		X	X	X			
LC	-	Pomatostomidae	<i>Pomatostomus temporalis</i>	Grey-crowned Babbler			X		X		X
LC	-	Maluridae	<i>Malurus melanocephalus</i>	Red-backed Fairywren							X
LC	-	Acanthizidae	<i>Gerygone olivacea</i>	White-throated Gerygone						X	
LC	-	Acanthizidae	<i>Smicrornis brevirostris</i>	Weebill	X		X				
LC	-	Pardalotidae	<i>Pardalotus striatus</i>	Striated Pardalote	X		X	X		X	X
LC	-	Meliphagidae	<i>Manorina melanocephala</i>	Noisy Miner	X	X				X	
LC	-	Meliphagidae	<i>Manorina flavigula</i>	Yellow-throated Miner							X
LC	-	Meliphagidae	<i>Entomyzon cyanotis</i>	Blue-faced Honeyeater		X					
LC	-	Meliphagidae	<i>Gavicalis virescens</i>	Singing Honeyeater				X			X
LC	-	Meliphagidae	<i>Philemon corniculatus</i>	Noisy Friarbird		X					
LC	-	Campephagidae	<i>Coracina novaehollandiae</i>	Black-faced Cuckoo Shrike				X			

STATUS		FAMILY	SCIENTIFIC NAME	COMMON NAME	S1	S2	S3	S4	S5	S6	INCIDENTAL
NCA	EPBC										
LC	-	Campephagidae	<i>Lalage sueurli</i>	White-winged Triller							X
LC	-	Pachycephalidae	<i>Pachycephala rufiventris</i>	Rufous Whistler			X			X	
LC	-	Pachycephalidae	<i>Colluricincla harmonica</i>	Grey Shrikethrush		X	X				
LC	-	Artamidae	<i>Artamus cinereus</i>	Black-faced Woodswallow							X
LC	-	Artamidae	<i>Artamus personatus</i>	Masked Woodswallow							X
LC	-	Artamidae	<i>Gymnorhina tibicen</i>	Australian Magpie			X				X
LC	-	Artamidae	<i>Cracticus nigrogularis</i>	Pied Butcherbird		X	X			X	X
LC	-	Artamidae	<i>Cracticus torquatus</i>	Grey Butcherbird	X	X		X			
LC	-	Rhipiduridae	<i>Rhipidura leucophrys</i>	Willie Wagtail		X			X		X
LC	-	Rhipiduridae	<i>Rhipidura albiscapa</i>	Grey Fantail				X		X	
LC	-	Corvidae	<i>Corvus orru</i>	Torresian Crow	X	X	X	X	X	X	X
LC	-	Monarchidae	<i>Muyiagra rubecula</i>	Leaden Flycatcher			X				
LC	-	Monarchidae	<i>Grallina cyanoleuca</i>	Magpie-lark		X					X
LC	-	Corcoracidae	<i>Struthidea cinerea</i>	Apostlebird		X	X			X	X
LC	-	Alaudidae	<i>Mirafra javanica</i>	Horsfield's Bushlark							X
LC	-	Cisticolidae	<i>Cisticola exilis</i>	Golden-headed Cisticola				X			
LC	-	Megaluridae	<i>Megalurus curalis</i>	Brown Songlark							X
LC	-	Hirundinidae	<i>Petrochelidon nigricans</i>	Tree Martin							X
*	-	Sturnidae	<i>Acridotheres tristis</i>	Common Myna				X			X

STATUS		FAMILY	SCIENTIFIC NAME	COMMON NAME	S1	S2	S3	S4	S5	S6	INCIDENTAL
NCA	EPBC										
LC	-	Motacillidae	<i>Anthus novaeseelandiae</i>	Australasian Pipit							X
LC	-	Estrildidae	<i>Taeniopygia guttata</i>	Zebra Finch					X	X	X
LC	-	Estrildidae	<i>Taeniopygia bichenovii</i>	Double-barred Finch						X	X
LC	-	Estrildidae	<i>Aidemosyne modesta</i>	Plum-headed Finch						X	X
MAMMALS											
*	-	Bovidae	<i>Bos tauros*</i>	Domestic Cattle					X	X	X
LC	-	Dasyuridae	<i>Planigale ingrami</i>	Long-tailed Planigale				X	X		
LC	-	Emballonuridae	<i>Saccolaimus flaviventris</i>	Sac-winged Bat	X	X	X				X
LC	-	Emballonuridae	<i>Taphozous troughtoni</i>	Troughton's Sheathtail-bat	X						
*	-	Equidae	<i>Equus caballus*</i>	Domestic horse							X
*	-	Felidae	<i>Felis catus*</i>	Feral Cat				X		X	X
*	-	Leporidae	<i>Oryctolagus cuniculus*</i>	European Rabbit							X
LC	-	Macropodidae	<i>Lagorchestes conspicillatus</i>	Spectacled Hare-wallaby							X
LC	-	Macropodidae	<i>Macropus giganteus</i>	Eastern Grey Kangaroo		X	X				X
LC	-	Macropodidae	<i>Macropus robustus</i>	Common Wallaroo	X						
LC	-	Molossidae	<i>Chaerephon jobensis</i>	Northern Free-tailed Bat	X	X	X	X	X	X	X
LC	-	Molossidae	<i>Mormopterus (Ozimops) lumsdenae</i>	Northern Free-tailed Bat	X	X	X	X			X
LC	-	Molossidae	<i>Mormopterus (Ozimops) petersi</i>	Inland Free-tailed Bat		X	X				X
LC	-	Molossidae	<i>Mormopterus (Ozimops) ridei</i>	Eastern Free-tailed Bat	X	X	X	X			P

STATUS		FAMILY	SCIENTIFIC NAME	COMMON NAME	S1	S2	S3	S4	S5	S6	INCIDENTAL
NCA	EPBC										
LC	-	Molossidae	<i>Setirostris eleryi</i>	Hairy-nosed Freetail-bat	P		P				
*	-	Muridae	<i>Mus musculus*</i>	House Mouse	X						
LC	-	Muridae	<i>Pseudomys delicatulus</i>	Delicate Mouse			X			X	
LC	-	Muridae	<i>Pseudomys gracilicaudatus</i>	Eastern Chestnut Mouse						X	
LC	-	Petauridae	<i>Petaurus breviceps</i>	Sugar Glider				X			
LC	-	Phalangeridae	<i>Trichosurus vulpecula</i>	Brush-tailed Possum	X	X	X	X	X	X	X
LC	-	Potoroidae	<i>Aepyprymnus rufescens</i>	Rufous Bettong							X
*	-	Suidae	<i>Sus scrofa*</i>	Wild Pig							X
LC	-	Vespertilionidae	<i>Chalinolobus gouldii</i>	Gould’s Wattled Bat	X	X	X	X	X	X	X
LC	-	Vespertilionidae	<i>Chalinolobus morio</i>	Chocolate Wattled Bat	X	X	X				X
LC	-	Vespertilionidae	<i>Chalinolobus picatus</i>	Little Pied Bat	X	X	X	X	X	X	X
LC	-	Vespertilionidae	<i>Miniopterus orianae oceanensis</i>	Eastern Bent-wing Bat	X	X		X			
LC	-	Vespertilionidae	<i>Nyctophilus sp.</i>	Long-eared Bat		X					
LC	-	Vespertilionidae	<i>Scotorepens balstoni</i>	Western Broad-nosed Bat							P
LC	-	Vespertilionidae	<i>Scotorepens greyii</i>	Little Broad-nosed Bat	X	X	X	X			X
LC	-	Vespertilionidae	<i>Vespadelus baverstocki</i>	Inland Forest Bat		X	X				X
REPTILES											
LC	-	Agamidae	<i>Pogona barbata</i>	Eastern Bearded Dragon							X
LC	-	Cheluidae	<i>Emydura macquarii</i>	Murray River Turtle		X					X

STATUS		FAMILY	SCIENTIFIC NAME	COMMON NAME	S1	S2	S3	S4	S5	S6	INCIDENTAL
NCA	EPBC										
LC	-	Colubridae	<i>Dendrelaphis punctulatus</i>	Common Tree Snake		X					
LC	-	Diplodactylidae	<i>Oedura monilis</i>	Oscillated Velvet Gecko		X					
LC	-	Diplodactylidae	<i>Strophurus williamsi</i>	Eastern Spiny-tailed Gecko			X				
LC	-	Elapidae	<i>Brachyurophis australis</i>	Australian Coral Snake	X						
LC	-	Elapidae	<i>Cryptophis boshmai</i>	Carpentaria Snake		X					
LC	-	Gekkonidae	<i>Gehyra catenata</i>	Chain-backed Dtella		X					
LC	-	Gekkonidae	<i>Gehyra dubia</i>	Dubious Dtella		X	X	X	X	X	
LC	-	Gekkonidae	<i>Heteronotia binoei</i>	Bynoe’s Gecko		X	X				
LC	-	Gekkonidae	<i>Nephrurus asper</i>	Prickly Knob-tailed Gecko	X						
LC	-	Scincidae	<i>Carlia munda</i>	Striped Rainbow Skink		X	X	X	X	X	
LC	-	Scincidae	<i>Carlia rubigo</i>	Orange-flanked Rainbow Skink							X
LC	-	Scincidae	<i>Cryptoblepharus sp.</i>	Snake-eyed Skink	X	X		X			
LC	-	Scincidae	<i>Lygisaurus foliorum</i>	Iridescent Litter-skink		X					
LC	-	Scincidae	<i>Morethia taeniopleura</i>	Fire Tailed Skink	X						X
LC	-	Scincidae	<i>Tiliqua scincoides</i>	Eastern Blue-tongued Lizard							X
LC	-	Scincidae	<i>Ctenotus spaldingi</i>	Straight-browed Ctenotus	X						
LC	-	Typhlopidae	<i>Anilius affinis</i>	Small-headed Blind Snake			X				

STATUS		FAMILY	SCIENTIFIC NAME	COMMON NAME	S1	S2	S3	S4	S5	S6	INCIDENTAL
NCA	EPBC										
AMPHIBIANS											
*	-	Bufonidae	<i>Rhinella marina</i> *	Cane toad		X		X	X	X	X
LC	-	Hylidae	<i>Cyclorana alboguttata</i>	Striped Burrowing Frog						X	
LC	-	Hylidae	<i>Cyclorana novaehollandiae</i>	New Holland Frog						X	
LC	-	Hylidae	<i>Litoria caerulea</i>	Green Tree Frog		X		X		X	X
LC	-	Hylidae	<i>Litoria inermis</i>	Bumpy Rocket Frog		X				X	
LC	-	Hylidae	<i>Litoria latopalmata</i>	Broad Palmed Frog		X		X		X	
LC	-	Hylidae	<i>Litoria rubella</i>	Desert Tree Frog		X				X	
LC	-	Limnodynastidae	<i>Limnodynastes fletcheri</i>	Marsh Frog		X					
LC	-	Limnodynastidae	<i>Limnodynastes salmini</i>	Salmon-striped Frog						X	
LC	-	Limnodynastidae	<i>Limnodynastes tasmaniensis</i>	Spotted Marsh Frog				X	X	X	
LC	-	Limnodynastidae	<i>Platyplectrum ornatum</i>	Ornate Burrowing Frog				X	X	X	

1. Status: LC = Least Concern, SLC = Special Least Concern, NT = Near Threatened, V = Vulnerable, E = Endangered, M - Migratory, Ma = Marine, * = Species not native to Australia.
2. NCA = *Nature Conservation Act 1992*, EPBC = *Environment Protection and Biodiversity Conservation Act 1999*.

Appendix F

Microbat Call Interpretation Reports



Microbat Call Identification Report

Prepared for ("Client"):	Northern Resource Consultants
Survey location/project name:	Emerald area
Survey dates:	26-30 September 2017
Client project reference:	
Job no.:	NRC-1703
Report date:	17 October 2017

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Methods

Data received

Bat calls were recorded over four consecutive nights using a Song Meter SM4BAT detector (Wildlife Acoustics, USA). Call data were saved as full-spectrum audio files (WAV format), 2976 of which were received by *Balance! Environmental* for analysis.

Post processing

All WAV files were processed with Wildlife Acoustics' *Kaleidoscope* (Version 4.0.3) software to generate zero-crossing analysis format bat call sequence files (ZC files). The 'advanced signal enhancement' feature was enabled for the ZC conversion process.

Call identification

All ZC files were analysed using *AnaLookW* (Corben 2015), with a subset of files selected to represent all call types recorded on each night. Species identification was achieved manually by comparing the call spectrograms of the selected calls with those of reference calls from northern and central Queensland and with reference to published call descriptions (e.g. Reinhold *et al.* 2001). In most cases, only the ZC data were required for species identification; however, the original WAV file spectrograms were analysed in *Kaleidoscope Viewer* to obtain a more reliable determination of species identity for some calls.

Species' identification was also guided by considering the probability of a species' occurrence based on published distributions (Churchill 2008; van Dyck *et al.* 2013) and/or on-line database records (<http://www.ala.org.au>).

Reporting standard

The format and content of this report follows Australasian Bat Society standards for the interpretation and reporting of bat call data (Reardon 2003).

Species nomenclature follows Jackson & Groves (2015). Note that this treatment of Australian mammal taxonomy elevates the sub-genus names proposed by Reardon *et al.* (2014) for the *Mormopterus* spp. free-tailed bats to genus level, hence *Ozimops* (*O. lumsdenae*, *O. petersi*, *O. ridei*) and *Setirostris* (*S. eleryi*) are used herein.

Results & Discussion

The WAV-ZC conversion process produced 2426 ZC sequence files that contained potentially-identifiable bat calls, from which a sub-set of 561 ZC files was selected for species identification.

At least 13 and up to 16 species were recorded during this survey (see Table 1). Twelve species were positively identified from at least one characteristic call sequence; however, some calls could not be reliably identified due to similarities in call features between a number of species that may occur in the study area. These unresolved calls were allocated to one of the species groups described below.

Where unresolved calls were allocated to one of these groups, both group members are shown as “possible” in Table 1 unless other calls were positively identified for one or both group members.

Species groups used for unresolved calls:

- *Chalinolobus gouldii* / *Ozimops petersi* / *O. ridei*
 - o Characteristic frequency (Fc) overlaps in the range 28-34 kHz
 - o *C. gouldii* reliably identified where calls had steep, curvilinear pulses and distinctive alternating Fc
 - o Calls with broader, flatter curvilinear pulses and no obvious alternation were allocated to *Ozimops* spp., with *O. petersi* attributed where pulses were steeper and Fc<28 kHz and *O. ridei* attributed to calls with Fc>28 and flatter pulses
 - o Many sequence files had calls from multiple individuals with highly variable pulse shapes that could have represented any of these species
- *Chalinolobus gouldii* / *Scotorepens balstoni*
 - o Steep, curvilinear pulses with Fc in the range 30-34 kHz
 - o *C. gouldii* identified primarily on alternating frequency and responsible for majority of steep, curvilinear calls in this frequency range
 - o Two calls recorded on 29th September lacked evidence of alternating Fc and may have been from *S. balstoni*
- *Nyctophilus* species
 - o Steep, linear pulses with broad frequency sweep down to about 40 kHz
 - o Distinctive from other bats, but species in the genus cannot be differentiated
 - o Two species are potentially present in the study area – *N. geoffroyi* and *N. gouldi*
- *Scotorepens greyii* / *Setirostris eleryi*
 - o Steep curvilinear calls with Fc=37-40 kHz
 - o Most calls had uniform, short duration pulses with distinctive hooked bodies and up-swept tails and were allocated to *S. greyii*
 - o A few calls had longer-duration pulses with variable pulse shapes, somewhat more typical of calls from the family Molossidae, and may have been from *S. eleryi*
 - o The calls of the latter species are poorly-known, but several brief reference calls collected in New South Wales and the Northern Territory indicate they are similar to those of *S. greyii*

Technical terms used in the above call descriptions are explained in the Glossary.

Table 1 summarises the species recorded at each site; and sample spectrograms of each recorded call type are shown at Appendix 1.

Table 1. Microbat species recorded at Emerald, 26-30 September 2017.

- ◆ = at least one call from the site was attributed unequivocally to the species
□ = calls similar to those of the species were recorded, but could not be reliably identified

Date:	26-Sep	27-Sep	28-Sep	29-Sep
Total ZC sequence files:	609	225	929	663
Number of calls identified:	183	87	149	142
<i>Chalinolobus gouldii</i>	◆	◆	◆	◆
<i>Chalinolobus morio</i>	◆	◆	◆	◆
<i>Chalinolobus picatus</i>	◆	◆	◆	◆
<i>Nyctophilus</i> species			◆	
<i>Scotorepens balstoni</i>				□
<i>Scotorepens greyii</i>	◆	◆	◆	◆
<i>Vespadelus baverstocki</i>		◆	◆	◆
<i>Miniopterus orianae oceanensis</i>	◆		◆	
<i>Chaerephon jobensis</i>	◆	◆	◆	◆
<i>Ozimops lumsdenae</i>	◆	◆	◆	◆
<i>Ozimops petersi</i>		◆	◆	◆
<i>Ozimops ridei</i>	◆	◆	◆	□
<i>Setirostris eleryi</i>	□	□		
<i>Saccolaimus flaviventris</i>	◆	◆	◆	◆
<i>Taphozous troughoni</i>	◆			

References

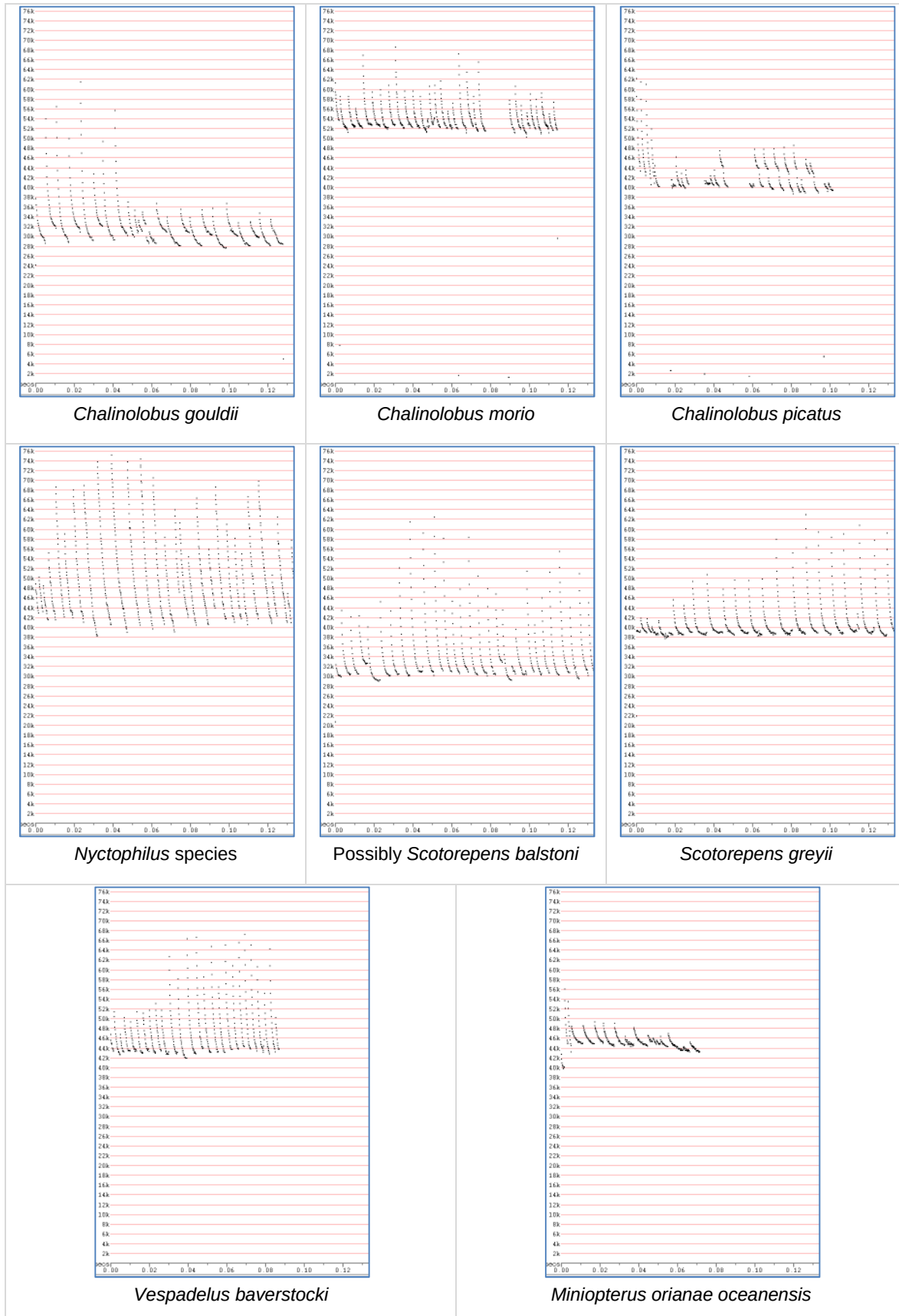
- Churchill, S. (2008). *Australian Bats*. Jacana Books, Allen & Unwin; Sydney.
- Corben, C. (2015). *AnalookW for bat call analysis using ZCA*. Version 4.1z, 20 September 2015.
- Jackson, S. and Groves, C. (2015). *Taxonomy of Australian Mammals*. CSIRO Publishing, Melbourne.
- Reardon, T. (2003). Standards in bat detector based surveys. *Australasian Bat Society Newsletter* **20**, 41-43.
- Reardon, T. B., McKenzie, N. L., Cooper, S. J. B., Appleton, B., Carthew, S. and Adams, M. (2014). A molecular and morphological investigation of species boundaries and phylogenetic relationships in Australian free-tailed bats *Mormopterus* (Chiroptera: Molossidae). *Aust. J. Zool.* **62**, 109–136.
- Reinhold, L., Law, B., Ford, G. and Pennay, M. (2001). *Key to the bat calls of south-east Queensland and north-east New South Wales*. Department of Natural Resources and Mines, Brisbane.
- van Dyck, S., Gynther, I. and Baker, A. (ed.) (2013). *Field Companion to the Mammals of Australia*. New Holland; Sydney.

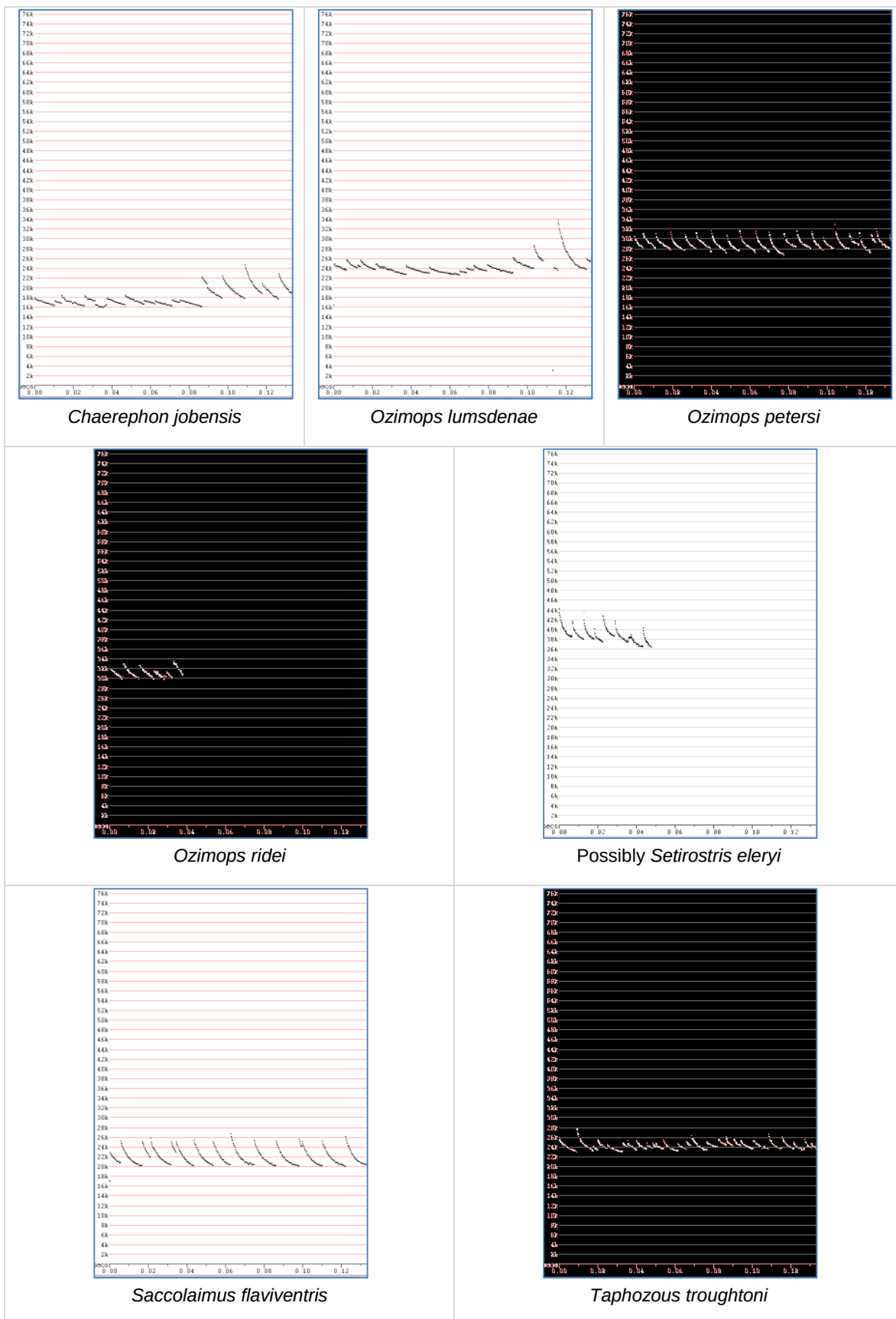
Glossary

Technical terms used in this report are described in the following table.

Approach phase	The part of a bat <i>call</i> emitted as the bat starts to home in on a detected prey item; a transitional series of <i>pulses</i> between the <i>search phase</i> and <i>feeding buzz</i> , that become progressively steeper and shorter in duration.
Call	Refers to a single bat call, made up of a series of individual sound <i>pulses</i> in one or more <i>phases</i> (<i>search, approach, feeding buzz</i>).
CF (=Constant Frequency)	A type of <i>pulse</i> in which the dominant component consists of a more-or-less 'pure tone' of sound at a Constant Frequency; with <i>shape</i> appearing flat on the sonogram. Often also contains a brief <i>FM</i> component at the beginning and/or end of the CF component (<i>viz.</i> FM-CF-FM).
Characteristic frequency (Fc)	The frequency of the flattest part of a <i>pulse</i> ; usually the lowest frequency reached in the <i>qCF</i> component of a pulse. This is often the primary diagnostic feature for species identification.
Duration	The time period from the beginning of a <i>pulse</i> to the end of the pulse.
Feeding buzz	The terminal part of a <i>call</i> , following the <i>approach phase</i> , emitted as the bat catches a prey item; a distinctive, rapid series of very steep, very short-duration pulses.
FM (=Frequency Modulated)	A type of <i>pulse</i> in which there is substantial change in frequency from beginning to end; <i>shape</i> ranges from almost vertical and linear through varying degrees of curvature.
FC range	Refers to the range of frequencies occupied by the <i>characteristic frequency</i> section of <i>pulses</i> within a call or set of calls.
Frequency sweep or "band-width"	The range of frequencies through which a <i>pulse</i> sweeps from beginning to end; Maximum frequency (Fmax) – minimum frequency (Fmin).
Knee	The transitional part of a <i>pulse</i> between the initial (usually steeper) frequency sweep and the <i>characteristic frequency</i> section (usually flatter); time to knee (Tk) and frequency of knee (Fk) can be diagnostic for some species.
Pulse	An individual pulse of sound within a bat <i>call</i> ; the <i>shape, duration</i> and <i>characteristic frequency</i> of a pulse are the key diagnostic features used to differentiate species.
Pulse body	The part of the <i>pulse</i> between the <i>knee</i> and <i>tail</i> and containing the <i>characteristic frequency</i> section.
Pulse shape	The general appearance of a <i>pulse</i> on the sonogram, described using relative terms related to features such as slope and degree of curvature. See also <i>CF, qCF</i> and <i>FM</i> .
qCF (=quasi Constant Frequency)	A type of <i>pulse</i> in which there is very little change in frequency from beginning to end; <i>shape</i> appears to be almost flat. Some pulses also contain an <i>FM</i> component at the beginning and/or end of the qCF component (<i>viz.</i> FM-qCF).
Search phase	The part of a bat <i>call</i> generally required for reliable species diagnosis. A consistent series of <i>pulses</i> emitted by a bat that is searching for prey or and/or navigating through its habitat. Search phase pulses generally have longer duration, flatter slope and more consistent shape than <i>approach phase</i> and <i>feeding buzz</i> pulses.
Sequence	Literally, a sequence of <i>pulses</i> that may be from one or more bats; but generally refers to a <i>call</i> or part (e.g. <i>phase</i>) of a call.
Tail	The final component of a <i>pulse</i> , following the <i>characteristic frequency</i> section; may consist of a short or long sweep of frequencies either upward or downward from the Fc; or may be absent.

Appendix 1 Representative call sequences from the Emerald survey, 26-30 September 2017.
(Scale: 10msec per tick; time between pulses removed)







Microbat Call Interpretation Report

Prepared for ("Client"):	Northern Resource Consultants
Survey location/project name:	Emerald
Survey dates:	15-18 May 2018
Client project reference:	
Job no.:	NRC-1805
Report date:	29 June 2018

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Methods

Survey summary

Balance! Environmental received 673 full-spectrum (WAV format) audio files, recorded using a Song Meter SM4BAT-FS detector (Wildlife Acoustics, USA). The data were recorded over three consecutive nights (15th, 16th, 17th May 2018), in the Emerald area, central Queensland.

Post-processing and call analysis

Bat call data were extracted from the WAV files by converting to zero-crossing analysis format (ZC files) using Wildlife Acoustics' *Kaleidoscope Pro* (Version 4.5.4). The ZC files were then analysed in *AnaLookW* (Corben 2017), with species identification achieved manually by comparing the recorded call spectrograms and derived metrics with those of reference calls from central and northern Queensland and/or with published call descriptions (e.g. Reinhold et al. 2001; Milne 2002). Consideration was also given to the probability of species' occurrence based on published distribution information (e.g. Churchill 2008; van Dyck et al. 2013) and on-line database records (e.g. <http://www.ala.org.au>).

In some cases, the original full-spectrum files were also analysed in *Kaleidoscope Viewer* to confirm species identities, e.g. where foraging sequences (*i.e.* calls with contiguous search-phase, attack-phase and feeding-buzz components) were evident in the WAV file but fragmented or lost in the ZC conversion. The feeding buzzes of *Miniopterus* species (bent-winged bats) and some Molossids (free-tailed bats) are quite distinctive, compared with those of Vespertilionids (vesper bats) with which they often share search-phase characteristics (Corben 2010).

Reporting standard

The format and content of this report follows Australasian Bat Society standards for the interpretation and reporting of bat call data (Reardon 2003), available on-line at <http://www.ausbats.org.au/>.

Species nomenclature follows Jackson & Groves (2015), with several name changes reflected in this report, including:

Ozimops lumsdenae (Northern Free-tailed Bat) – formerly *Mormopterus beccarii*;

Ozimops ridei (Ride's Free-tailed Bat) – formerly *Mormopterus ridei* and *M.* 'species 2';

Ozimops petersi (Inland Free-tailed Bat) – formerly *M. petersi* and *M.* 'species 3'; and

Miniopterus orianae (Large Bent-winged Bat) – formerly *M. schreibersii*.

Results & Discussion

The WAV-ZC conversion yielded 577 ZC files. *Kaleidoscope* allocated 149 of those files to “noise” based on the brevity of calls (<3 pulses) within each file; however, a rapid scan of those files revealed six contained two call-types that were not observed in the other 428 identifiable files. The identification data-set therefore included 434 ZC files, which yielded a total of 452 identified bat-calls.

Species detected

At least nine species were recorded during the Emerald survey (see Table 1). Six call-types were reliably attributed to individual species:

- *Chalinolobus gouldii*;
- *Chalinolobus picatus*;
- *Scotorepens greyii*;
- *Miniopterus orianae*;
- *Chaerephon jobensis*; and
- *Ozimops lumsdenae*.

A further three call-types allocated to groups of species that share similar call-characteristics, including:

- *Ozimops ridei*/*O. petersi*;
- *Chalinolobus morio*/*Vespadelus troughtoni*; and
- *Nyctophilus* species.

Several other calls were also unresolved but belonged to species that were otherwise positively identified. These were allocated to the following groups:

- *C. gouldii* / *Ozimops* spp.; and
- *C. picatus* / *S. greyii*

Sample spectrograms of each recorded call type are shown at Appendix 1.

Table 1 Microbat species recorded during the Emerald survey, 15-18 May 2018.

Number of calls allocated to each species or unresolved group per night

Night of:	15/05/2018	16/05/2018	17/05/2018	Species Total
Positively identified				
<i>Chalinolobus gouldii</i>	54	35	5	94
<i>Chalinolobus picatus</i>	19	15	7	41
<i>Scotorepens greyii</i>	15			15
<i>Miniopterus orianae</i>	23			23
<i>Chaerephon jobensis</i>	149	69	4	222
<i>Ozimops lumsdenae</i>	1			1
<i>Ozimops ridei</i> / <i>O. petersi</i>	10	3		13
Unresolved calls				
<i>C. gouldii</i> / <i>Ozimops</i> species	12	1	8	21
<i>Chalinolobus morio</i> / <i>Vespadelus troughtoni</i>	1	3		4
<i>C. picatus</i> / <i>S. greyii</i>	11	2	1	14
<i>Nyctophilus</i> species	4			4
Nightly Total	299	128	25	452

References

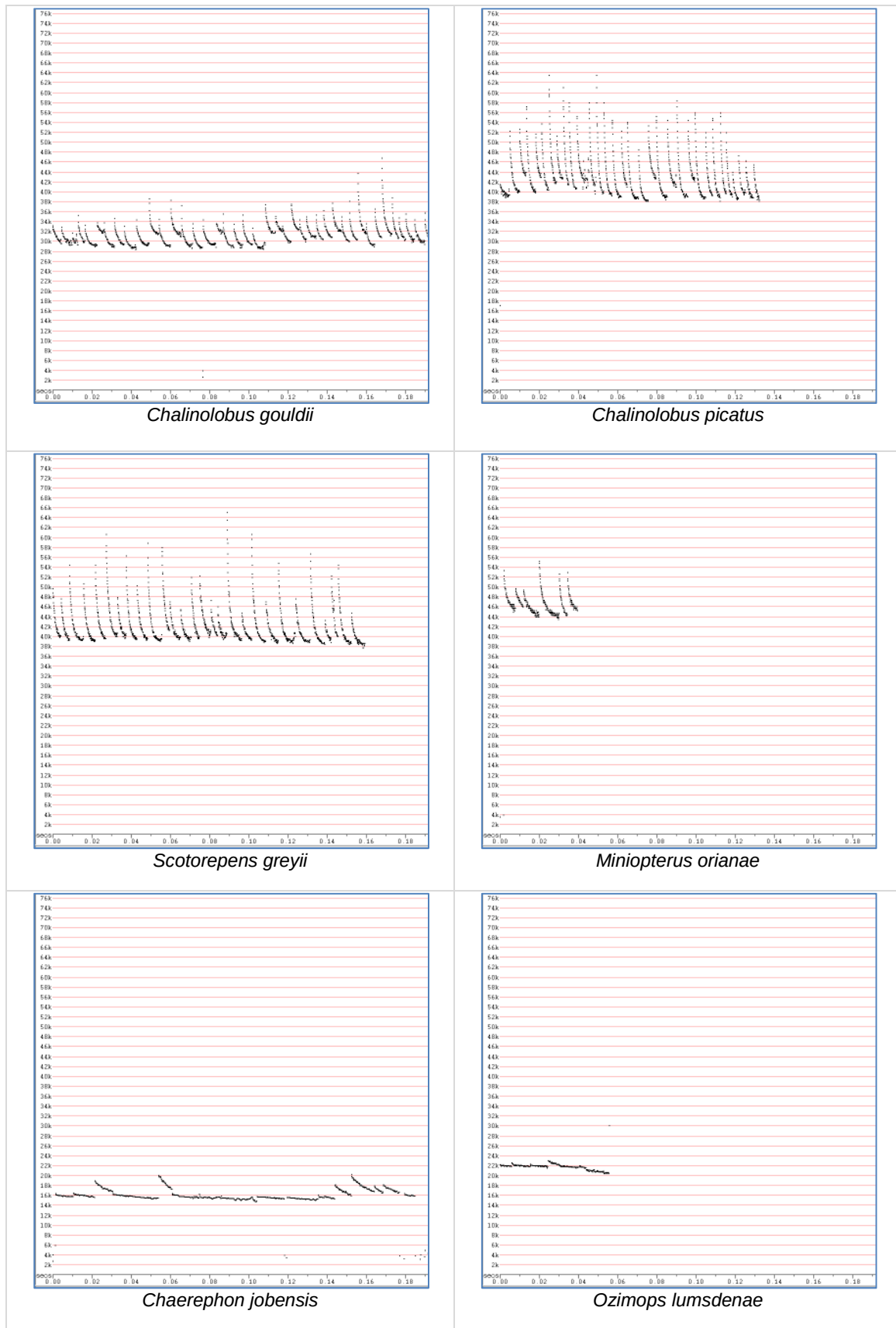
- Churchill, S. (2008). *Australian Bats*. Jacana Books, Allen & Unwin; Sydney.
- Corben, C. (2010). Feeding Buzzes. *Australasian Bat Society Newsletter* **35**, 40-44.
- Corben, C. (2017). *AnalookW for bat call analysis using ZCA*. Version 4.2.n, 16 March 2017.
- Jackson, S. and Groves, C. (2015). *Taxonomy of Australian Mammals*. CSIRO Publishing, Melbourne.
- Milne, D.J. (2002). *Key to the bat calls of the Top End of the Northern Territory*. Technical Report No. 71; Parks and Wildlife Commission of the Northern Territory, Darwin.
- Pennay, M., Law, B. and Reinhold, L. (2004). *Bat Calls of New South Wales*. Department of Environment and Conservation, Hurstville.
- Reardon, T. (2003). Standards in bat detector based surveys. *Australasian Bat Society Newsletter* **20**, 41-43.
- Reardon, T. B., McKenzie, N. L., Cooper, S. J. B., Appleton, B., Carthew, S. and Adams, M. (2014). A molecular and morphological investigation of species boundaries and phylogenetic relationships in Australian free-tailed bats *Mormopterus* (Chiroptera : Molossidae). *Australian Journal of Zoology* **62**, 109–136.
- Reinhold, L., Law, B., Ford, G. and Pennay, M. (2001). *Key to the bat calls of south-east Queensland and north-east New South Wales*. Department of Natural Resources and Mines, Brisbane.
- van Dyck, S., Gynther, I. and Baker, A. (ed.) (2013). *Field Companion to the Mammals of Australia*. New Holland; Sydney.

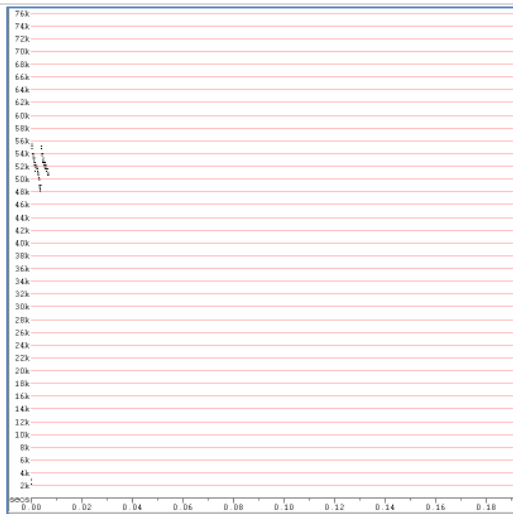
Glossary

Technical terms used in this report are described in the following table.

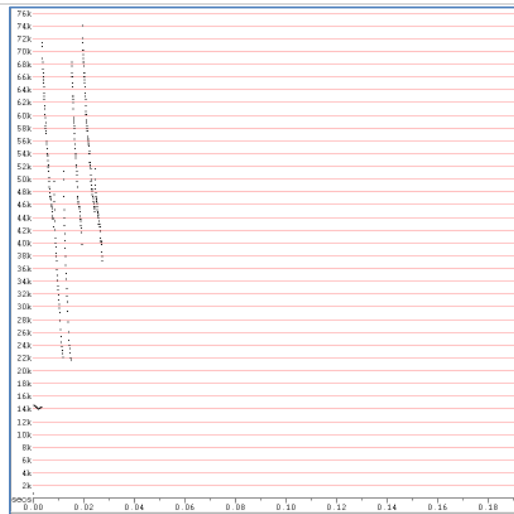
Approach phase	The part of a bat <i>call</i> emitted as the bat starts to home in on a detected prey item; a transitional series of <i>pulses</i> between the <i>search phase</i> and <i>feeding buzz</i> , that become progressively steeper and shorter in duration.
Call	Refers to a single bat call, made up of a series of individual sound <i>pulses</i> in one or more <i>phases</i> (<i>search, approach, feeding buzz</i>).
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Duration	The time period from the beginning of a <i>pulse</i> to the end of the pulse.
Feeding buzz	The terminal part of a <i>call</i> , following the <i>approach phase</i> , emitted as the bat catches a prey item; a distinctive, rapid series of very steep, very short-duration pulses.
FM (=Frequency Modulated)	A type of <i>pulse</i> in which there is substantial change in frequency from beginning to end; <i>shape</i> ranges from almost vertical and linear through varying degrees of curvature.
FC range	Refers to the range of frequencies occupied by the <i>characteristic frequency</i> section of <i>pulses</i> within a call or set of calls.
Frequency sweep or "band-width"	The range of frequencies through which a <i>pulse</i> sweeps from beginning to end; Maximum frequency (Fmax) – minimum frequency (Fmin).
Knee	The transitional part of a <i>pulse</i> between the initial (usually steeper) frequency sweep and the <i>characteristic frequency</i> section (usually flatter); time to knee (Tk) and frequency of knee (Fk) can be diagnostic for some species.
Pulse	An individual pulse of sound within a bat <i>call</i> ; the <i>shape, duration</i> and <i>characteristic frequency</i> of a pulse are the key diagnostic features used to differentiate species.
Pulse body	The part of the <i>pulse</i> between the <i>knee</i> and <i>tail</i> and containing the <i>characteristic frequency</i> section.
Pulse shape	The general appearance of a <i>pulse</i> on the sonogram, described using relative terms related to features such as slope and degree of curvature. See also <i>CF, qCF</i> and <i>FM</i> .
qCF (=quasi Constant Frequency)	A type of <i>pulse</i> in which there is very little change in frequency from beginning to end; <i>shape</i> appears to be almost flat. Some pulses also contain an <i>FM</i> component at the beginning and/or end of the qCF component (<i>viz.</i> FM-qCF).
Search phase	The part of a bat <i>call</i> generally required for reliable species diagnosis. A consistent series of <i>pulses</i> emitted by a bat that is searching for prey or and/or navigating through its habitat. Search phase pulses generally have longer duration, flatter slope and more consistent shape than <i>approach phase</i> and <i>feeding buzz</i> pulses.
Sequence	Literally, a sequence of <i>pulses</i> that may be from one or more bats; but generally refers to a <i>call</i> or part (e.g. <i>phase</i>) of a call.
Tail	The final component of a <i>pulse</i> , following the <i>characteristic frequency</i> section; may consist of a short or long sweep of frequencies either upward or downward from the Fc; or may be absent.

Appendix 1 Representative call sequences from the Emerald survey, 15-18 May 2018.
AnalogW spectrograms with time between pulses removed

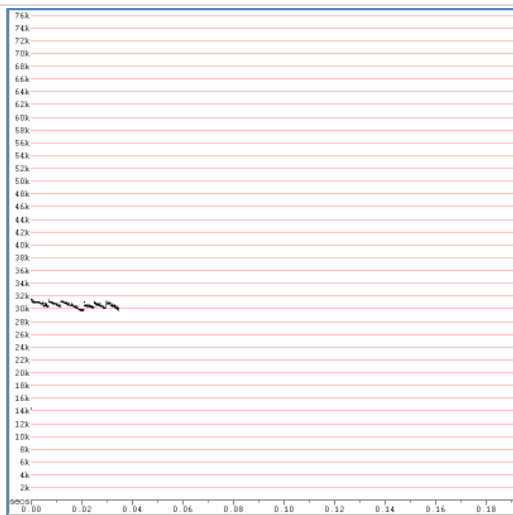




C. morio / V. troughstoni



Nyctophilus species



Ozimops ridei / O. petersi



REPORT

FAIRHILL COKING COAL PTY LTD

FAIRHILL COAL PROJECT

Water Management Assessment

Date: July 2019

Report Number: 112108-04R001-rev0

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ATC Williams Pty Ltd
ABN 64 005 931 288
Melbourne T: +61 3 8587 0900 Perth T: +61 8 9213 1600 Brisbane T: +61 7 3352 7222
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ABN 64 005 931 288
Melbourne T: +61 3 8587 0900 Perth T: +61 8 9213 1600 Brisbane T: +61 7 3352 7222
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EXECUTIVE SUMMARY

ATC Williams Pty Ltd have been engaged to undertake a water management assessment for the Fairhill project's Environmental Authority application being prepared by SLR Consulting Australia Pty Ltd on behalf of Fairhill Coking Coal Pty Ltd.

This report presents assessment of the surface water environment at the project site, including the proposed mine site water management aspects and potential impacts on surface water resources in the vicinity of the project. A flood assessment of the project area was also undertaken to understand the natural flooding extents and assess the impacts of flooding on the proposed site infrastructure, as well as impacts of the project on flood levels and discharge rates. No residential dwellings or other third-part infrastructure were identified downstream for some 20km. Impact on flooding to downstream occupancy is therefore assessed as negligible.

A conceptual site water management system based on upstream diversion of clean water around the project area, and the capture and controlled release of site impacted water to minimise impacts to the receiving environment was developed. In general terms, mine affected water within the pits is to be managed through collection within pit water sumps, with pumped transfer to a series of site water dams located downslope of the pits and overburden dumps. Discharge from the site water dams would be allowed under controlled release conditions when sufficient flow in downstream drainage features is available. Similarly, sediment laden runoff from cleared areas will be captured within sediment traps, with controlled release to the environment in accordance with acceptable water quality conditions.

Water balance modelling of the conceptual site water management system was conducted using Goldsim Pro coupled with an Australian Water Balance Model (AWBM) to model runoff from upstream and site water catchments. Model results indicate that on average, mine affected water accumulation over the life of the project would occur. As such, additional use of site water in the form of enhanced evaporation or irrigation will be required in order to maintain acceptable spill risk of the site water dams as well as ensure that water volumes within the pits remain within operational constraints. Model results also indicate the water volumes within the sediment ponds will also be able to be managed through selection of appropriate pump capacities, with clean water transferred to the environment.

Hydrogeological investigations at the site location undertaken by others indicate that in general terms, groundwater is primarily associated with the coal seams, at depths of between 10m and 40m below ground level. The encountered aquifers were generally low yielding, with high salinity levels. It is therefore anticipated that interaction with groundwater would occur during mining activities; however, groundwater inflows to the pits are expected to be minimal, with any groundwater inflows that do occur able to be managed by the proposed surface water management system (i.e. groundwater inflows will be pumped to the site water dams).

The design of the final landform was not available for this assessment; however, the expected extent of the final landform (after seven years) is shown on Figure 007, representing the extent of rehabilitation works on completion of mining activity. As such, the total extent of the final landform would exist as clean water catchment, generally draining either to the final voids or the watercourses to the east of the site. It is expected that the final voids would naturally fill with surface water runoff over time, with final void water quality expected to improve overtime as the rehabilitated surfaces of the overburden dumps revegetate.

Flood modelling for a number of rainfall sequences undertaken for both the pre-mining and post-closure conditions suggest that the final landform will have limited impact on downstream flooding. The presence of the final voids would act as a storage mechanism, effectively removing or delaying the contribution of runoff from the upstream catchment. Notwithstanding, modelled flood depths and velocities indicate that key development areas within the project site are at risk from flooding associated with Cooroora Creek and Sandy Creek, for the AEP 1% and above events. To mitigate the safety and operational risks associated with potential flood impacts, detailed design of the project will require consideration of flood protection bunds/drains, armouring of embankments and batter slopes, to improve Sandy Creek flows.

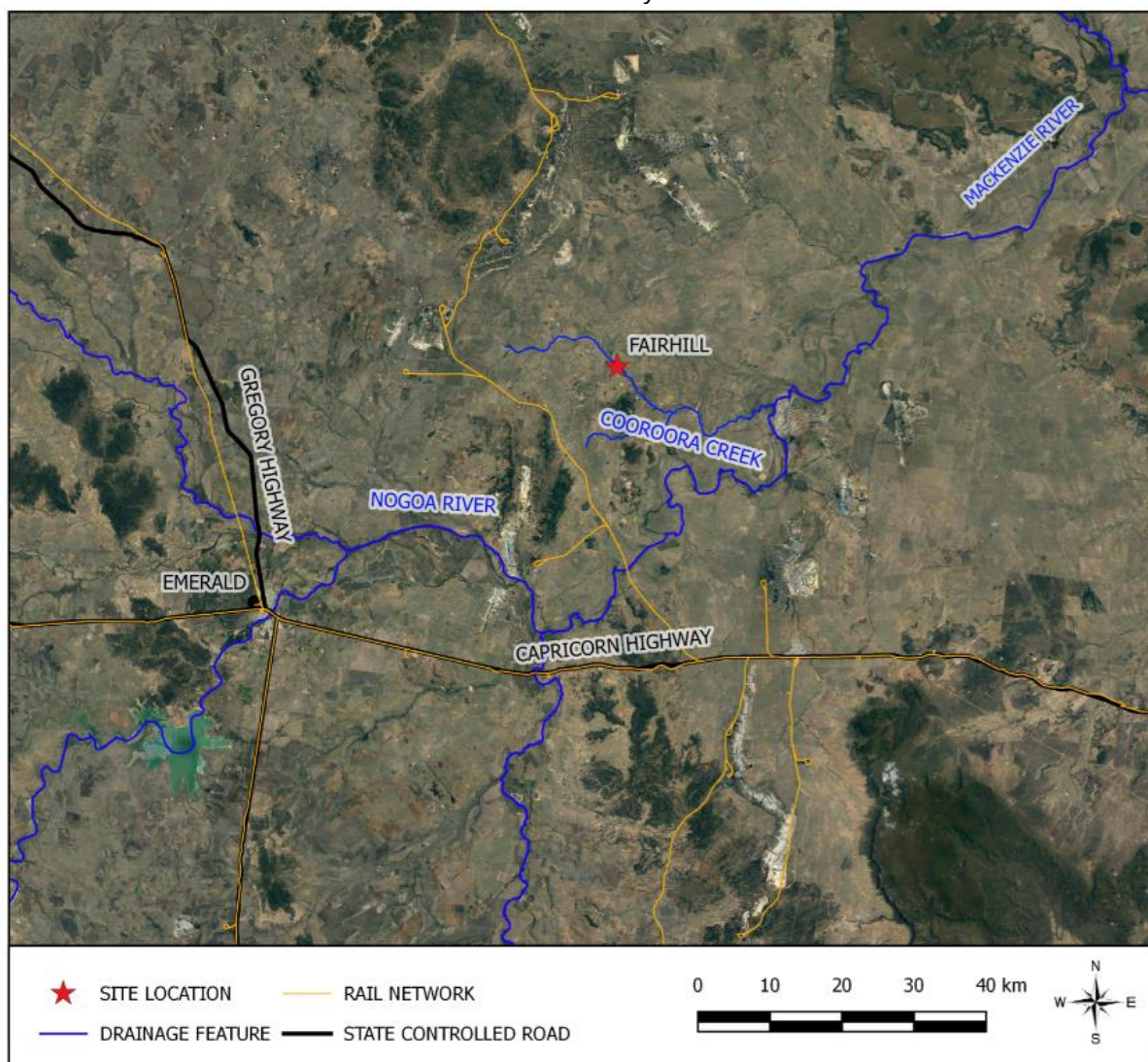
1 INTRODUCTION

1.1 Background

Fairhill Coking Coal Pty Ltd (FCCPL) is proposing to develop the Fairhill Coal Project, which is located approximately 60km north-east of Emerald, and 280km west of Gladstone, in central Queensland. The Fairhill project is located 16km to the south-east of the Oaky Creek Coal Mine within the Bowen Basin. Queensland Coal Corporation's Wilton Project adjoins Fairhill to the south. The Blackwater rail system passes some 10km to the south-west of the project site.

The project is situated on sloping agricultural (grazing) land near to the top of the local water catchment and is bounded by Cooroora Creek to the north and Sandy Creek to the south. Ephemeral water courses run through the project site, with all watercourses generally draining to the east. A site locality plan is provided in Plate 1.

Plate 1
Site Locality



FCCPL has engaged SLR Consulting Australia Pty Ltd (SLR) as project managers for compilation and submission of the project's Environmental Authority (EA) application with the Department of Environment and Science (DES). ATC Williams Pty Ltd (ATCW) developed a first draft of the water management assessment to support the EA application based on a 5-year development of the site.

Subsequent development plans have been modified to a 7-year time frame along with corresponding changes to the proposed layout. ATCW have been engaged to provide an updated water management assessment reflecting the updated proposed development for the site.

This report presents the assessment of the surface water environment at the project site, including the proposed mine site water management aspects and potential impacts on surface water resources in the vicinity of the project.

1.2 Scope of Works

The scope of work comprising this water management assessment is as follows:

- Provide contextual information of project setting with respect to surface water flows, define design criteria and confirmation site layout options for water management structures;
- Undertake hydrological assessment through development of catchment areas, flood hydrology, flood modelling, identification of local/regional water quality and groundwater;
- Develop mine site water management system including modelling of the proposed system, including water management layout, diversions, storage systems and contaminant sources;
- Undertake preliminary consequence category assessment based on available project data, to be completed as outlined in the Manual¹;
- Describe the expected impacts on existing hydrology and flooding;
- Describe post mining water management aspects relating to final landform drainage systems and final voids; and,
- Describe surface water monitoring requirements and programs for site drainage systems and storages.

1.3 Report Structure

The structure of this report, to address the above scope, is as follows;

- | | |
|-------------|--|
| Section 2.0 | - Provides a description of the operation and site setting covering climatic and hydrological conditions. |
| Section 3.0 | - Presents the flood modelling component of the assessment. |
| Section 4.0 | - Presents the key components of the proposed site water management system and presents details of the site water balance modelling carried out to review overall hydrological performance based on the adopted water management layout. |
| Section 5.0 | - Presents the consequence category assessment undertaken for the primary water storage types. |
| Section 6.0 | - Presents the post mining water management aspects relevant to the project. |
| Section 7.0 | - Presents the surface water and groundwater monitoring requirements. |

¹ *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures* (DEHP, 2016)

2 SITE & PROJECT DESCRIPTION

2.1 Regulatory Context

It is proposed that the site will operate in accordance with conditions outlined in the following relevant legislation:

- Environmental Protection Act 1994 (EP Act)
- Environmental Protection (Water) Policy 2009
- Water Act 2000
- Environmental Authority Mining Lease.

The objective of the EP Act is to protect Queensland's environment while allowing for development that improves the total quality of life, both now and in the future in a way that maintains the ecological processes on which life depends. The EP Act outlines the general duty to take all reasonable and practical steps to avoid harm to the environment.

The purpose of the Environmental Protection (Water) Policy 2009 is to:

- Identify environmental values and management goals for Queensland waters
- State water quality guidelines and water quality objectives to enhance or protect the environmental values
- Provide a framework for making consistent, equitable and informed decisions about Queensland waters
- Outline monitoring and reporting on the condition of Queensland waters.

The Water Act (2000) provides guidelines for failure impact assessment in addition to providing sustainable and integrated management procedures for the utilisation of water sources in QLD for the benefit of both present and future generations.

Whereas, the Environmental Authority for a Mining Lease issued by the DES, is a license to cause environmental harm with limitations.

2.2 Fairhill Project Description

The project concerns the development of a mine for the extraction, processing and export of coking and thermal coal. The project timeline is based on a 7-year Life of Mine (LOM) operation and involves mining of some 10.6 million tonnes of Run of Mine (ROM) coal, at a maximum rate of 1.7 million tonnes per annum (Mtpa). The mine will primarily operate via cast-doze-excavate mining methods with ROM coal to be transported via truck for offsite processing at the Gregory Mine Coal Handling and Preparation Plant (CHPP), located approximately 25km to the north-west. Product coal will be transported via the Blackwater rail system to the Port of Gladstone for export, with total production estimated to be 10.6 million tonnes.

Mining shall commence via an initial box-cut to the south-east of the proposed Waste Rock Dump, with formed strips running north-east to south-west progressively moving in an upslope north-westerly direction. Mine development is planned based on formation of two defined pits (northern and southern), initially offset by some 50m. The shallow overburden will be removed using truck and excavator/shovel supported by dozers, with cast blasting used as required on specific portions of the waste material. The majority of waste material will remain in-pit, with cast and doze material directed into the void of the previous strip, and truck and shovel excavator being placed on top of earlier cast and doze waste placement.

The schedule of production and material movements for the project is summarised in Table 1.

Table 1
Mining Schedule

	2019	2020	2021	2022	2023	2024	2025
Mining & Production							
ROM Coal (t)	460,385	1,700,000	1,700,000	1,700,000	1,700,000	1,700,000	1,700,000
Waste (bcm)	3,772,591	5,144,412	7,451,186	7,046,494	7,063,794	8,848,594	10,912,076

Site access will be via a constructed haul road from the west, which will enter the mine area from the south-west corner. Infrastructure associated with the project will comprise the GO-line, workshop and administration areas, plus a ROM overflow pad, all located in the south-eastern corner of the site.

2.3 Climate

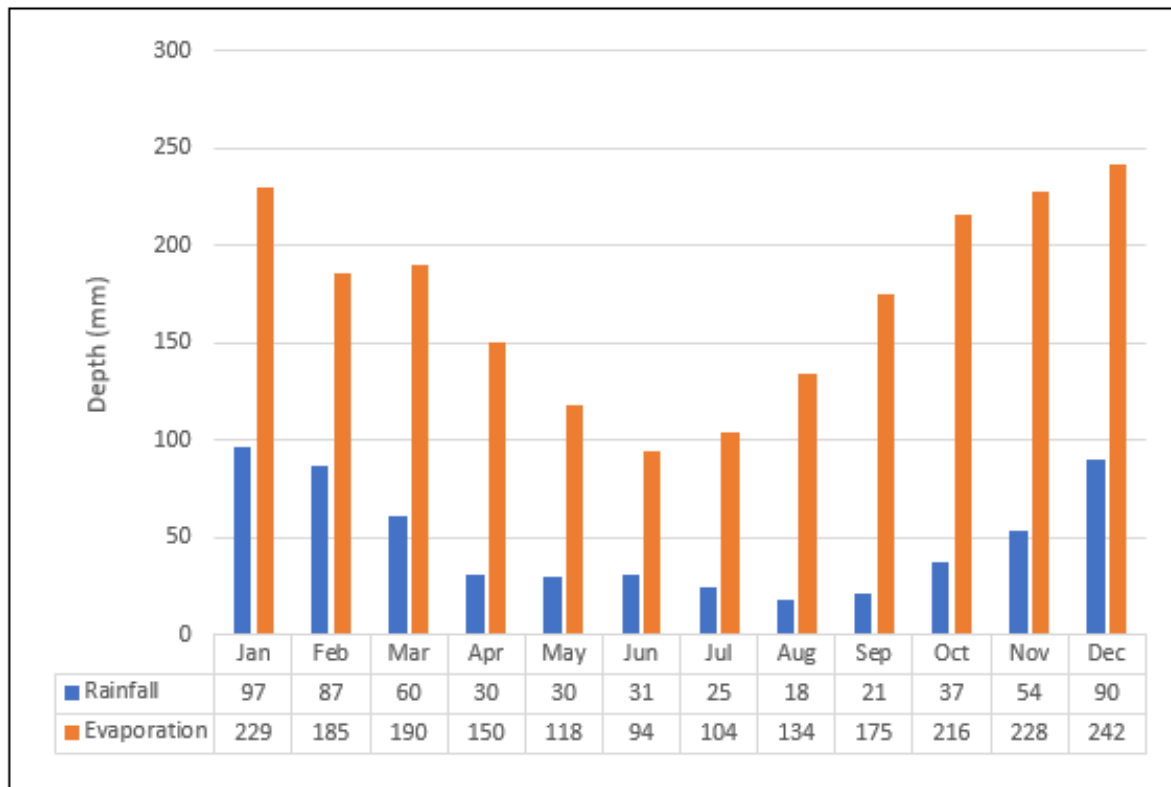
The project site, located in central Queensland, is subject to a humid subtropical environment. This climate is associated with variable rainfall conditions; however, average values indicate a distinct seasonal pattern with lower rainfall conditions associated with the winter months, and higher rainfall conditions during the summer months. The wet season occurs from November to March, with 66% of mean annual rainfall occurring during these months.

The nearest meteorological station to the site is Emerald Airport Station (No. 035264). Rainfall data from this station shows an annual average rainfall of 561mm. This station does not have long term evaporation data - a significant parameter in the assessment of surface water management. Therefore, long-term rainfall and evaporation data used in this assessment has been based on SILO data for the site location². Average monthly rainfall and evaporation SILO data is shown in Plate 2, with the long-term average annual rainfall for the site location (580mm) being significantly less than the average annual evaporation (2,060mm).

On an average monthly basis, the greatest average evaporation of approximately 220mm per month occurs during November to March. During winter months, average monthly evaporation is lower, with the lowest during August at 97mm per month.

² SILO Data Drill: Latitude -23.35; Longitude - 148.65

Plate 2
Average Rainfall and Evaporation Data



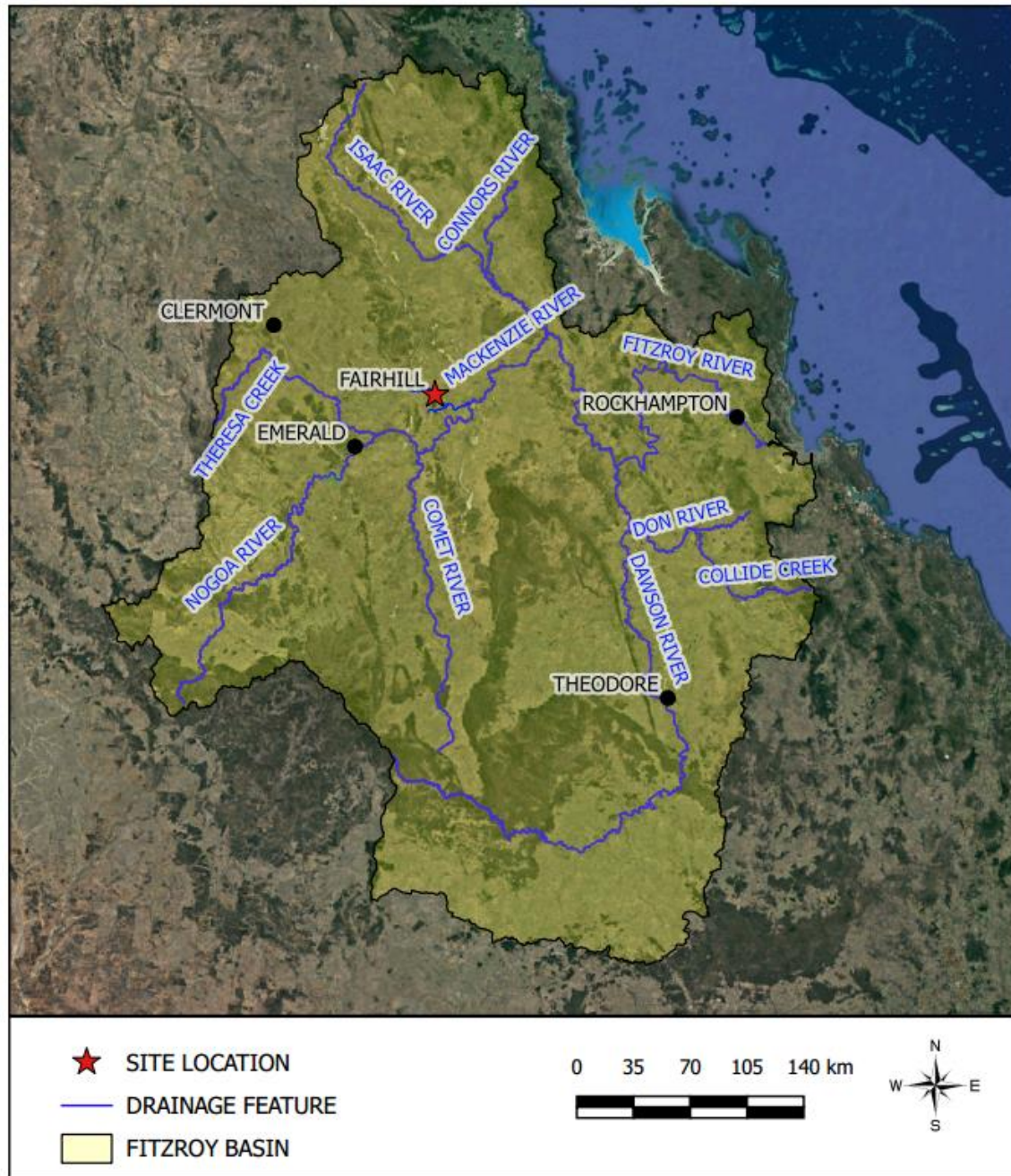
Source: Silo Data Drill, accessed 23/05/2019

2.4 Catchment Characteristics

2.4.1 Regional Hydrology

Regionally, the Fairhill site is located within the Fitzroy River Basin (refer Plate 3). The Fitzroy River catchment covers an area of 142,665 square kilometres, making it the largest river catchment flowing to the eastern coast of Australia. The catchment stretches from the Carnarvon Ranges in the west to the river mouth in Keppel Bay, near Rockhampton. It is bounded to the north by the Burdekin River catchment area and to the south by the Burnett River catchment area.

Plate 3
Regional Drainage



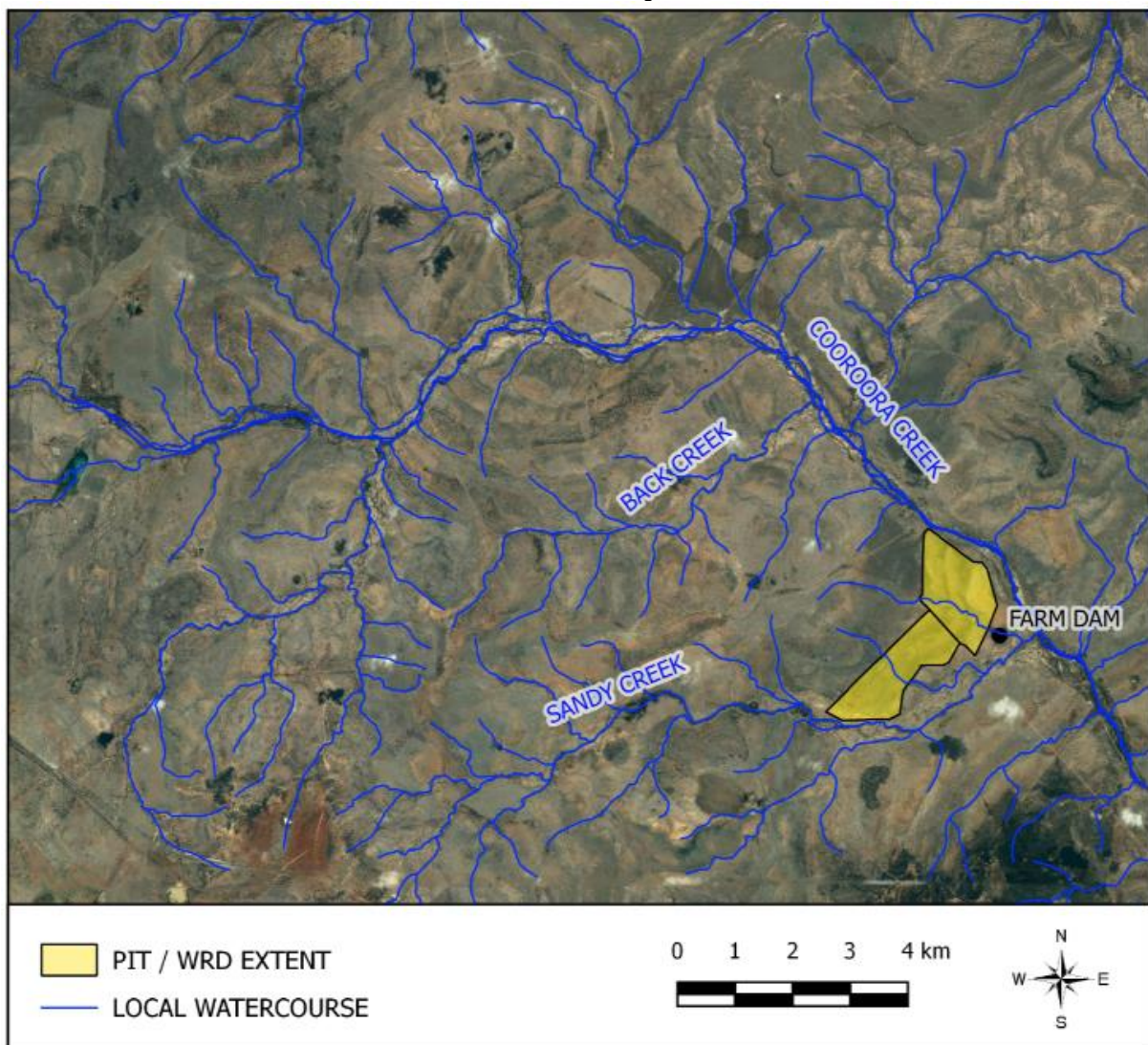
In terms of the nearest major watercourse to the project site, the Nogoa River rises on the Carnarvon Range in the Carnarvon National Park in Central Queensland and flows in a north easterly direction. The Nogoa River originates at an elevation of RL 501m AHD and drops around 361m in elevation over its 569km length. The river ends where it meets the Comet River, north of Comet, where it becomes the Mackenzie River. The Mackenzie River continues for a length of 275km before forming the Fitzroy River at a confluence with the Dawson River at Duaringa. The start of the Fitzroy River is at an elevation of RL 58.4m and travels 335km before it reaches Keppel Bay.

2.4.2 Local Hydrology

The Fairhill project site is elevated between RL140m and RL170m with an upstream catchment of some 400ha. Cooroora Creek flows to the south-east past the northern extents of the project site. At RL220m, this creek is formed some 15km to the west of the site, from a number of unnamed drainage lines. Cooroora Creek flows approximately 51km before joining the Mackenzie River, dropping some 100m elevation over its length.

Sandy Creek, formed at approximately RL190m from a number of unnamed drainage lines, flows along the southern boundary of the project site. This creek flows in an easterly direction to join Cooroora Creek some 2km downstream of the project site, at approximately RL150m. The drainage lines flowing through the project site itself are ephemeral with flow occurring only in response to rainfall events and expected to be of short duration. Drainage paths within the proposed project site are shown in Plate 4.

Plate 4
Local Drainage



There are no known gauging stations within the project site. The closest gauging station downstream of the site is located on the Mackenzie River at Bingegang (Latitude: -23.0762; Longitude: 149.0331), located 70km downstream. The Bingegang gauging station collects both time series flow and water quality data.

2.5 Environmental Values and Beneficial Uses

The project site is situated in a rural landscape where agriculture (in the form of low-intensity cattle grazing) is the predominant land use (in terms of land disturbance area). Water for agricultural use (stock water) is primarily sourced from local surface water impoundments visible on aerial photography.

Several existing open cut and underground coal mines exist in the region, with the closest being Oaky Creek Coal Mine located approximately 16km to the north-west. The project area and surrounds have been largely cleared of native vegetation, except for the bounds of Cooroora Creek and along watercourses where some remnant riparian vegetation exists.

As described in Section 2.4.2, the project site is located close to the top of the local catchment (approximately 2km to the northwest). Surface water flows through the project site (refer Plate 4), via both overland flow and two ephemeral drainage lines. A small surface water storage (farm dam) is observed downstream of the site.

Schedule 1 of the Environmental Protection (Water) Policy 2009 (EPP Water), subordinate legislation to the Environmental Protection Act 1994 (EP Act), documents the waters for which the legislation applies that are to be enhanced or protected and specifies relevant environmental values (EV's) and water quality objectives (WQO's). Review of Schedule 1 indicates that the Project lies within the Environmental Protection (Water) Policy 2009 Mackenzie River Sub-basin³, and as such EV's and WQO's have been pre-determined and listed in Section 1.2 of Schedule 1. The WQO's to protect aquatic ecosystem EV's have been developed for moderately disturbed waters, consistent with the nature of the project site which can be defined as a slightly to moderately disturbed ecosystem. These WQO's are displayed in Table 2.

Table 2
Mackenzie River Sub-basin Surface Water Quality Objectives

Parameter	Water Quality Objectives to Protect Aquatic Ecosystem EV
Ammonia (N)	<20 µg/L ^a
Oxidised (N)	<60 µg/L ^a
Organic (N)	<420 µg/L ^a
Total Nitrogen (TN)	<775 µg/L ^a
Filterable Reactive Phosphorus (FRP)	<20 µg/L ^a
Total Phosphorus (TP)	<160 µg/L ^a
Chlorophyll a	<5.0 µg/L ^a
Dissolved Oxygen	85%-110% saturation
Turbidity	<50 NTU ^a
Suspended Solids	<110 mg/L ^b
pH	6.5-8.5 ^b
Conductivity (EC) baseflow	<310 µS/cm
Conductivity (EC) high flow	<210 µS/cm ^b
Sulfate	<10 mg/L ^b

^a and ^b: As per Table 2 in the EP(W)P 2009 for the Mackenzie River Sub-basin WQO's

³ South-eastern tributaries including Cooroora creek

Groundwater WQO's for the Mackenzie River Sub-basin are also specified in Schedule 1. The groundwater chemistry zone relevant to the project site is described as the saline (Na, Cl) sodic sequence which implies generally saline groundwater conditions, dominated by sodium and chloride. The corresponding WQO's for this zone are summarised in Table 3, for the 50th percentile for both deep (>30m) and shallow (<30m) aquifers.

Table 3
Selected Mackenzie River Sub-Basin Groundwater Quality Objectives

Parameter	Groundwater Water Quality Objectives to Protect Aquatic Ecosystems	
Zone 34	Shallow	Deep
EC (μScm^{-1})	2,150	6,100
Hardness (mgL^{-1})	674	919
pH	7.75	7.80
Alkalinity (mgL^{-1})	435	275
Ca (mgL^{-1})	84	145
Mg (mgL^{-1})	108	115
Na (mgL^{-1})	747	1100
Cl (mgL^{-1})	1,309	1900
SO ₄ (mgL^{-1})	140	138
HCO ₃ (mgL^{-1})	536	330
NO ₃ (mgL^{-1})	0.95	2.15
SiO ₂ (mgL^{-1})	36	25
F (mgL^{-1})	0.280	0.155
Fe (mgL^{-1})	0.030	0.050
Mn (mgL^{-1})	0.010	0.050
Zn (mgL^{-1})	0.015	0.025
Cu (mgL^{-1})	0.010	0.030

Notes: As per Table 14 in the EP(W)P 2009 for the Mackenzie River Sub-basin WQO's

2.6 Groundwater Interaction

Hydrogeological investigations at the site location are understood to have been undertaken by others, but for the purpose of these works the following understanding has been provided by NRC.

In general terms, based on available information from investigations, groundwater is understood to be primarily associated with the coal seams, at depths of between 10m and 40m below ground level. The encountered aquifers were generally low yielding, with high salinity levels. It is therefore anticipated that interaction with groundwater will occur during mining activities; however, groundwater inflows to the pit are expected to be minimal, with any groundwater inflows that do occur during mining able to be managed by the proposed surface water management system i.e. direct rainfall and runoff (plus groundwater inflows) entering the pit would be captured within constructed sumps in the pit floor, and subsequently pumped to mine water dams for treatment/release in accordance with EA conditions.

The design of the final landform was not available at the time of this report and therefore prior to mine closure, simulation of the final void to assess the level of filling and the groundwater interaction would be required. Notwithstanding, based on the anticipated limited groundwater flows, the expected quality of water within the final voids primarily originating from the surface runoff of natural and rehabilitated catchments would be such that no impacts on groundwater would be expected, particularly give the saline characterisation of regional groundwater resources described in Section 2.5, and those encountered during hydrogeological investigations.

3 FLOOD ASSESSMENT

3.1 General

A flood assessment of the project area was undertaken to understand the natural flooding extents and assess the impacts of flooding on the proposed site infrastructure and the potential flood risk issues associated with site access and operations, as well as the impacts of the project on flood levels and discharge rates. In terms of downstream impacts, the ideal post development condition is to ensure that peak flows occurring within drainage systems around the site are not increased as a result of the development, compared to pre-development conditions. In this regard, it would be expected that the project development may potentially increase local flow velocities by restricting the hydraulic capacity of Cooroora Creek and Sandy Creek and associated floodplains.

No residential dwellings or other third-party infrastructure were identified downstream for some 20km. Impact on flooding to downstream occupancy is therefore assessed as negligible. Potential exists for localised scouring due to increased flow velocities however these impacts would be mitigated by erosion and sediment controls. Based on the expected post development impacts to flooding, the assessment focussed on the magnitude of flooding within the development area.

The flood assessment was undertaken through hydraulic analysis using the two-dimensional finite difference program TUFLOW, which is an industry accepted, Australian owned and commercially available software package highly suited to the investigation of flood behaviour in complex flow scenarios. The model can simulate unsteady hydrodynamic flow in two directions on a rectilinear grid as well as one dimensional unsteady hydrodynamic flow through waterway structures such as culverts. The model is based on a robust finite difference solution scheme able to compute both sub critical and supercritical flow regimes.

3.2 Survey Data Assessment

The suitability of the following survey data sources was assessed for use within the flood assessment:

- 1 Second Shuttle Radar Topography Mission (SRTM) Hydrologically Enforced survey data, available from Geoscience Australia; and
- Drone survey data provided by NRC.

The SRTM survey is supplied in a 30m grid and has had drainage lines imposed and smoothed using the ANUDEM interpolation software. The accuracy of SRTM survey, as reported by Geoscience Australia (2011), is described as follows:

- Comparison of SRTM with reference data (Rodriguez *et al*, 2006) showed that 90% of tested heights were within 6m of the reference heights. In much of the clear flat areas of Australia the height errors are less than 3m, although there are some areas where the errors are much larger. Trees and buildings produce offsets in the elevation much larger than these height errors, since the radar frequency used by SRTM is reflected by them.
- A total of 1198 Permanent Survey Marks (PSM) made available through State land survey agencies were used to assess the overall vertical accuracy of the data at the national level. The PSM data uses AHD71 for the vertical datum and GDA94 for the horizontal datum. The following results were observed relative to the AHD71 vertical datum:
 - o Mean: 1.278m
 - o Min: -9.882m

- o Max: 31.285m

Based on the level of accuracy available in the SRTM survey, the following is noted:

- Flooding results are not suitable to identify exact flooding extents or for design of flood protection infrastructure.
- For the detailed design phase of the project, further flood modelling would be required using LiDAR survey or other similar survey that can accurately survey the ground surface.

To compare the two survey datasets, surface elevations for the long- and cross-section locations shown in Plate 5, are compared in Plate 6 and Plate 7.

Plate 5
Survey Data Assessment - Location of Sections

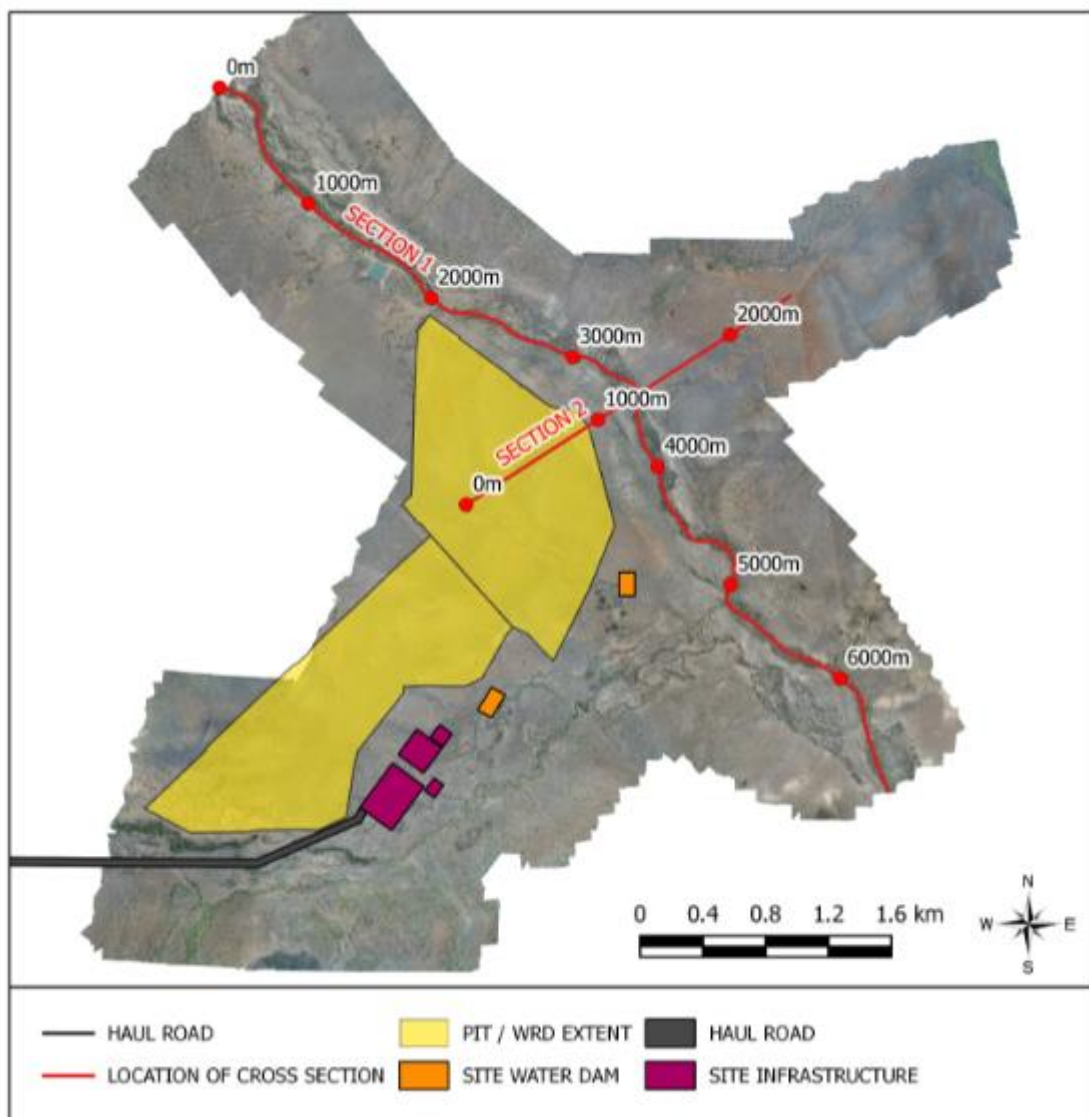


Plate 6 below shows the longitudinal section through Cooroora Creek, mapped as the inferred invert of the primary drainage channel using the aerial imagery supplied. Also, the section indicates vertical rises and depressions of up to 25m over short distances. It is assumed that these locations contain vegetation and therefore do not represent the ground surface. In addition, the average grade over this long-section (approximately 6.5km in length) shows little change in grade over its length.

The SRTM survey shows a gradual drop in elevation from RL155.5m to around RL147m for the 6.5km section, indicating an average grade of 0.1%. Vertical rises and depressions are present in the order of 2m which is attributed to both errors in the SRTM survey and the alignment of the section, moving within and out of the primary drainage channel, noting that the drainage channel within the aerial imagery supplied is not consistently aligned with the SRTM survey. This also highlights that the primary drainage channel does not align completely between the surveys.

Plate 6
Survey Assessment - Section 1

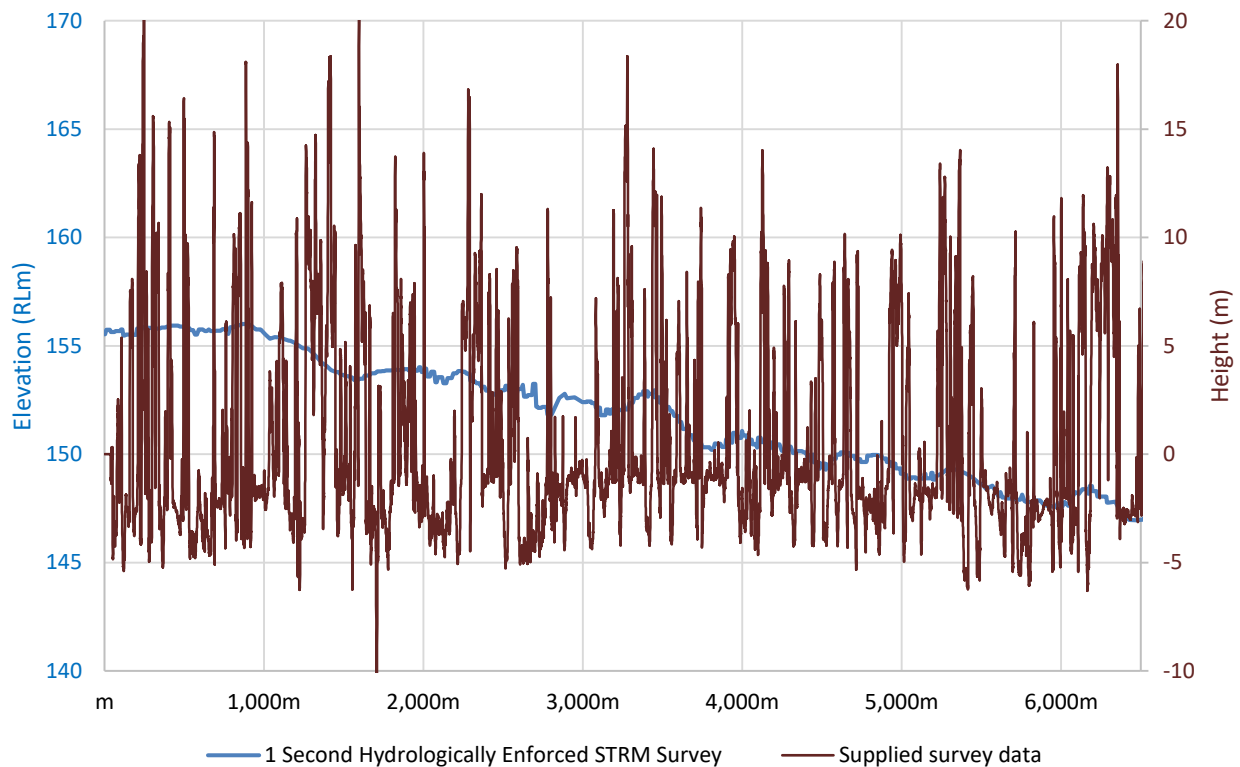
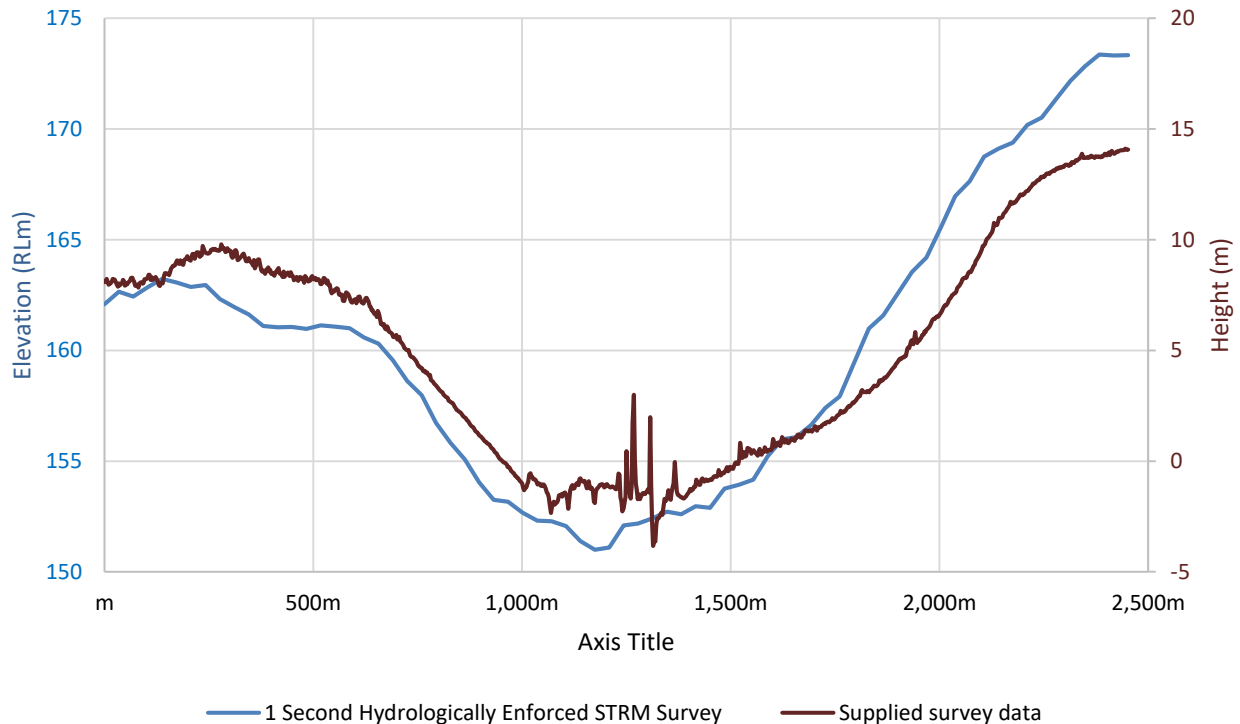


Plate 7 indicates some correlation in the surveys with the cross section through Cooroora Creek. The sections show similarities in grades and widths of the primary channel. Consistent with Section 1, discrepancies in the primary drainage channel are present in the supplied survey data. The coarseness of the SRTM data is apparent in Plate 7, where changes in vertical elevation appear to be serrated, indicative of infrequent sampling points used to generate the survey and large grid size.

Plate 7
Survey Assessment - Section 2



In summary, assessment of available drone survey data for the project site area highlighted the following limitations in relation to use of the data for flood assessment:

- Recorded surface levels incorporated vegetation and tree surfaces, which could not be removed. Use of such levels would result in unrealistic attenuation and reduced flow velocities within the model.
- No fall in elevation was apparent for a 6.5km section of Cooroora Creek, which would potentially result in unrealistic flood model outcomes.

Based on the available data, the SRTM survey appears to be the most suitable survey for use in the flood model, and has therefore been adopted for this purpose.

3.3 Model Domain and Boundary Conditions

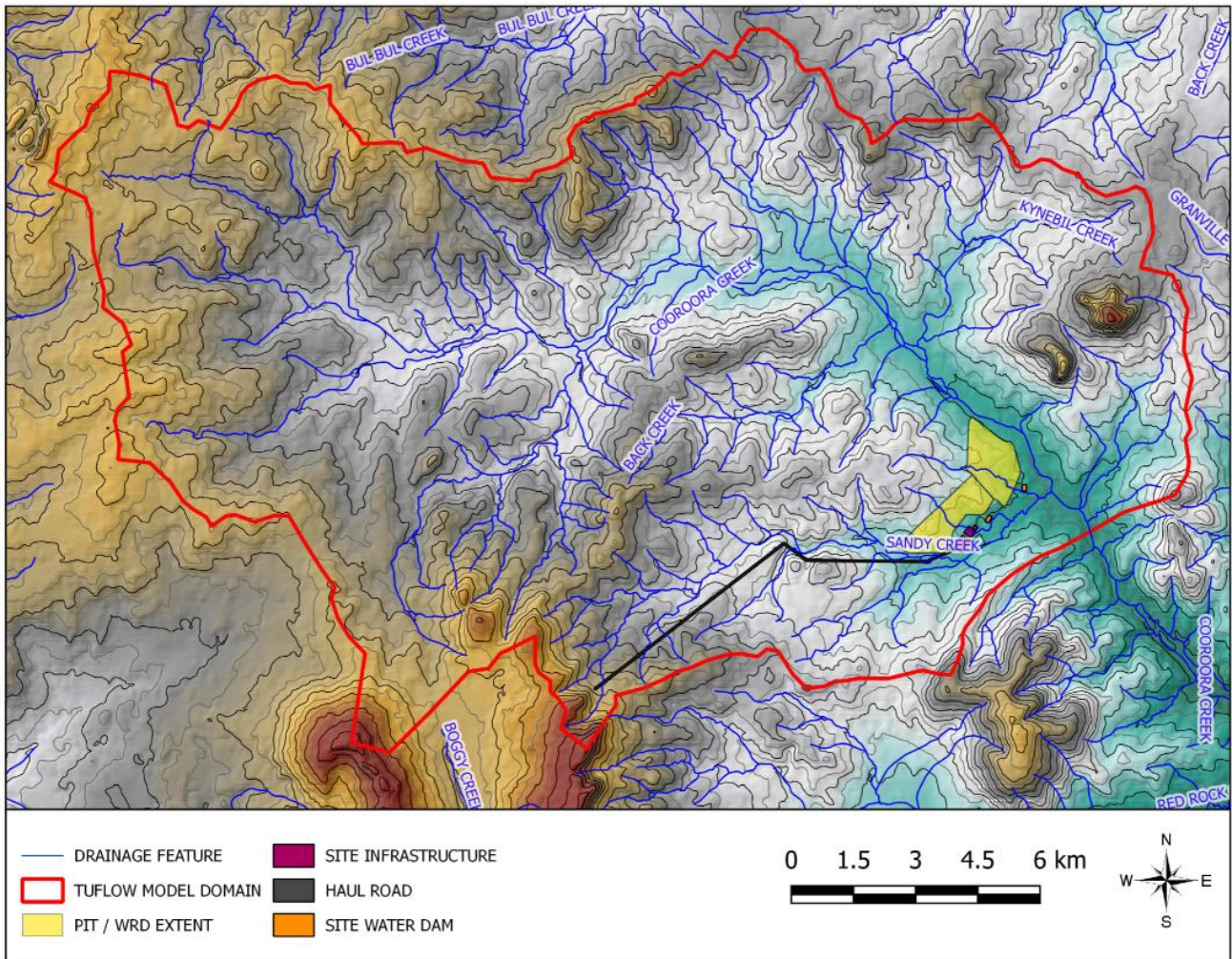
The model domain adopted comprised the upstream catchment to the project site and a further 3km downstream. Delineation of the upstream catchment was completed using SRTM survey data and included an area of some 310km². The model domain is depicted in Plate 8.

The exit boundary condition was modelled as follows:

- Downstream Boundary Conditions (Calculated as a normal flow boundary)
 - 3km downstream of the site location

As previously outlined, the design of the final landform was not made available at the time of this report. Consequently, the 'Post-Mining' condition model domain was modified to exclude the extents of the final landform. Furthermore, the 'Post-Mining' model was adapted to include an assumption of "vertical walls" surrounding the final landform (i.e. increasing the elevation to disrupt natural flow through the landform extent). Notwithstanding, it is noted that in large rainfall events the pits may act as a storage and receive inflows from Cooroora Creek and Sandy Creek, potentially reducing modelling downstream depths and velocities.

Plate 8
Model Domain



3.4 Design Rainfall Events

The adopted design rainfall conditions used for the flood assessment comprised 1% and 0.1% Annual Exceedance Probability (AEP) events and the Probable Maximum Precipitation (PMP) event.

The AEP of a rainfall event defines the statistical likelihood of an event occurring in a given year. AEPs are reported in the form of a recurrence period, equivalent to the annual probability that a given rainfall total accumulated over a given duration will be equalled or exceeded in any one year.

The PMP event comprises the greatest depth of precipitation for a given duration meteorologically possible for a given size storm area at a particular location at a particular time of the year, with no allowance made for long-term climatic trends. The notional AEP of the PMP event is set at one in ten million. The flood conditions arising from a PMP rainfall event is referred to as the Probable Maximum Flood (PMF).

The critical storm event (the storm duration producing the greatest magnitude of flooding) was determined using RORB. RORB is a general runoff and streamflow routing program used to calculate flood hydrographs from rainfall and other channel inputs. It subtracts losses from rainfall to produce rainfall-excess and routes this through catchment storage to produce the hydrograph. Results from the RORB model indicated a critical storm duration of 24 hours using 1% AEP rainfall data.

The data sources, temporal patterns used and determined rainfall depths for the design rainfall events are presented in Table 4.

Table 4
Flood Assessment Design Rainfall Events

Parameter	1% AEP	0.1% AEP	PMP
Source	BOM 2016 IFD Table	BOM 2016 IFD Table	GSDM (BOM, 2013)
Rainfall Duration	24hrs	24hrs	24hrs
Temporal Pattern	AR&R - East Coast (North) temporal pattern No. 1095	AR&R - East Coast (North) temporal pattern (No. 1095)	GSDM
Rainfall Depth	226mm	342mm	1,050mm

3.5 Inputs & Losses

A rain-on-grid approach for surface runoff was adopted within the model domain. Rainfall losses for the region were assessed using data from the AR&R Datahub for the project location. This indicated an Initial Loss (IL) of 47mm and Continuing Loss (CL) of 0.7mm/hr were applicable.

3.6 Surface Roughness

Desktop selection of the Manning's 'n' roughness coefficient was made considering the apparent roughness of surfaces over the extent of the model domain based on examination of aerial photography. Two types of areas and assigned Manning's n values were identified as follows:

- Pasture with some trees and shrubs: 0.035
- Primary drainage channel (winding with regular trees and obstructions): 0.04

3.7 Flooding Assessment Results

The flood modelling results for the pre-mining and post-closure scenarios within the project site have been extracted for the following:

- Maximum Modelled Flood Depth
- Maximum Modelled Flood Velocity

For each 30m×30m grid, the greatest modelled flood depth and velocity is recorded throughout the 40-hour modelling period (selected to allow for accumulation following the 24-hour design rainfall events). The maximum modelled flood depth is an indication of the worst-case flood depth, subject to the assumptions outlined listed above.

It is noted that the timing of when the maximum water level occurs at the cells may vary from grid to grid. Consequently, the depicted results do not represent one specific time within the modelling duration, but rather the worst-case outcome across a 24-hour duration period. Additionally, to assist with the clarity of depicted results, water depth results less than 100mm are not shown.

Flood outcomes (inundation depth and flow velocity) for the 1% AEP, 0.1% AEP and PMP events are presented for the proposed areas of work (refer Plate 9) in Table 5. Plates 10 to 15 show a graphical representation of the modelling results for the 1%, 0.1% AEP and PMP events.

Table 5
Flood Modelling Results

Scenario	Parameter	1% AEP	0.1% AEP	PMP
Pre-mining Plates 10 - 12	Maximum Modelled Depth (m)	4.51	5.35	7.48
	Maximum Modelled Velocity (m/s)	1.32	1.29	1.54
Post-closure Plates 13 - 15	Maximum Modelled Depth (m)	3.78	4.67	6.78
	Maximum Modelled Velocity (m/s)	1.15	1.22	1.46

Plate 9
Flood Modelling: Location of Table 5 Results

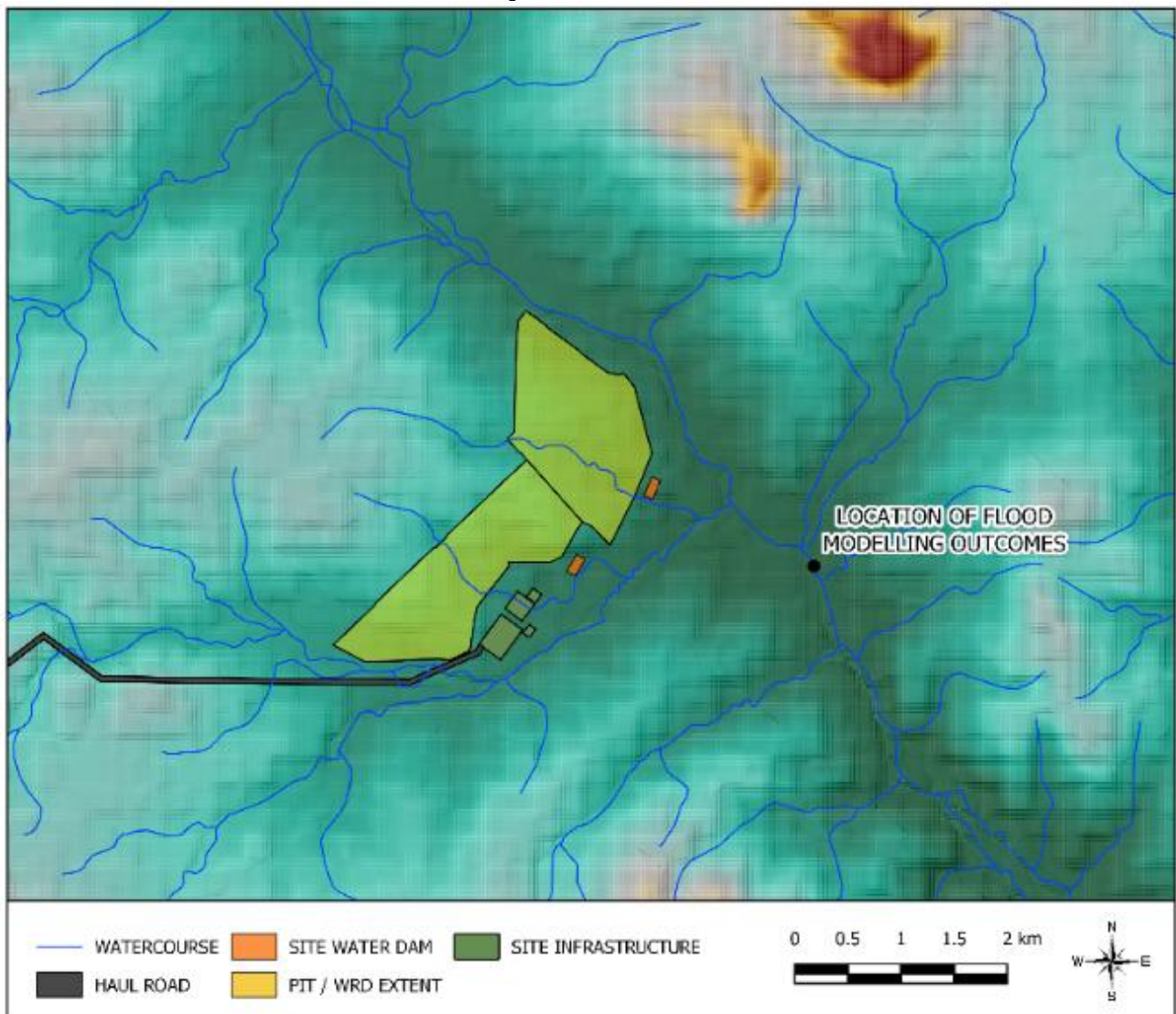


Plate 10
Flood Modelling: Pre-mining condition, 1% AEP

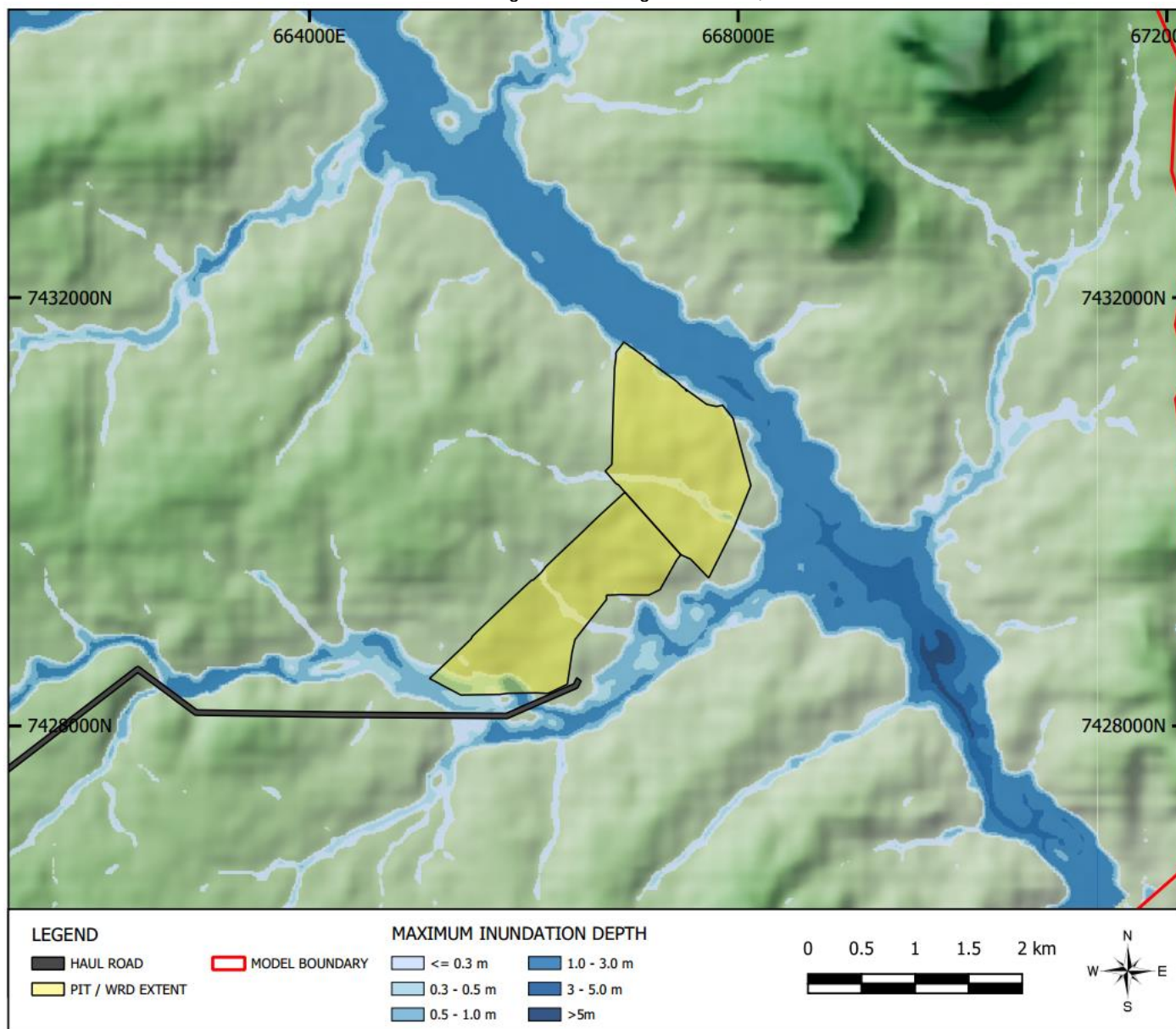


Plate 11
Flood Modelling: Pre-mining condition, 0.01% AEP

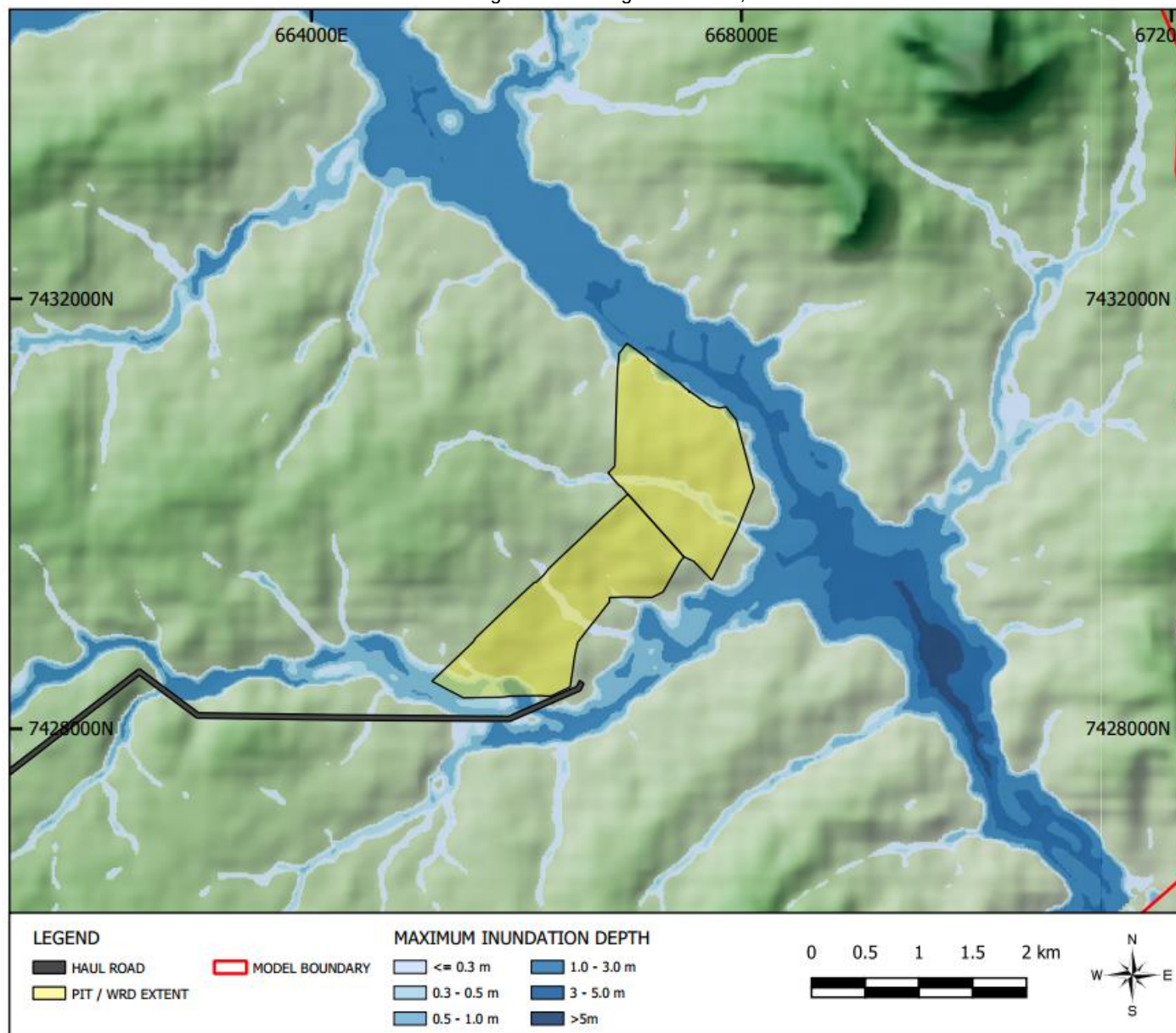


Plate 12
Flood Modelling: Pre-mining condition, PMP

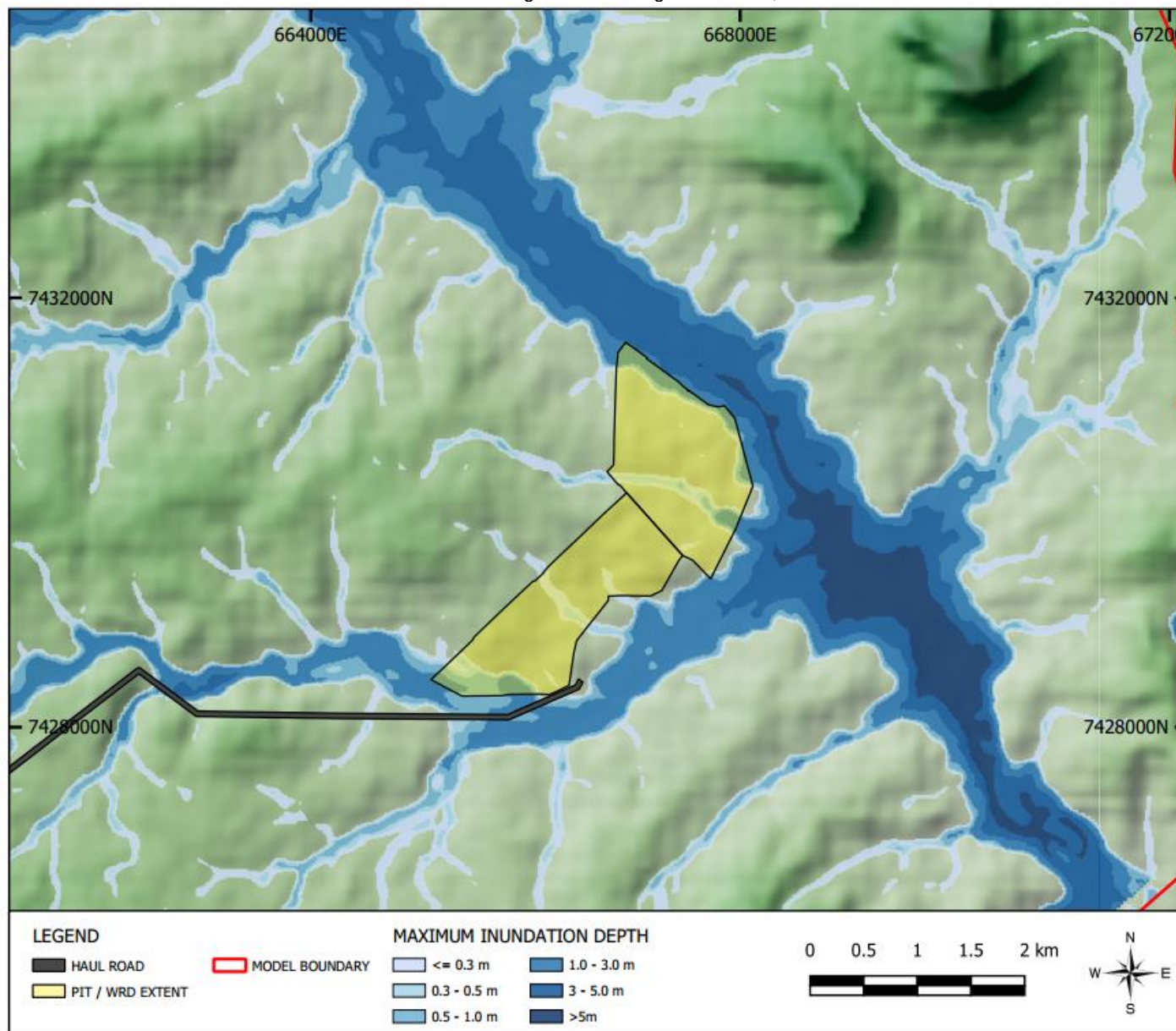


Plate 13
Flood Modelling: Post-closure condition, 1% AEP

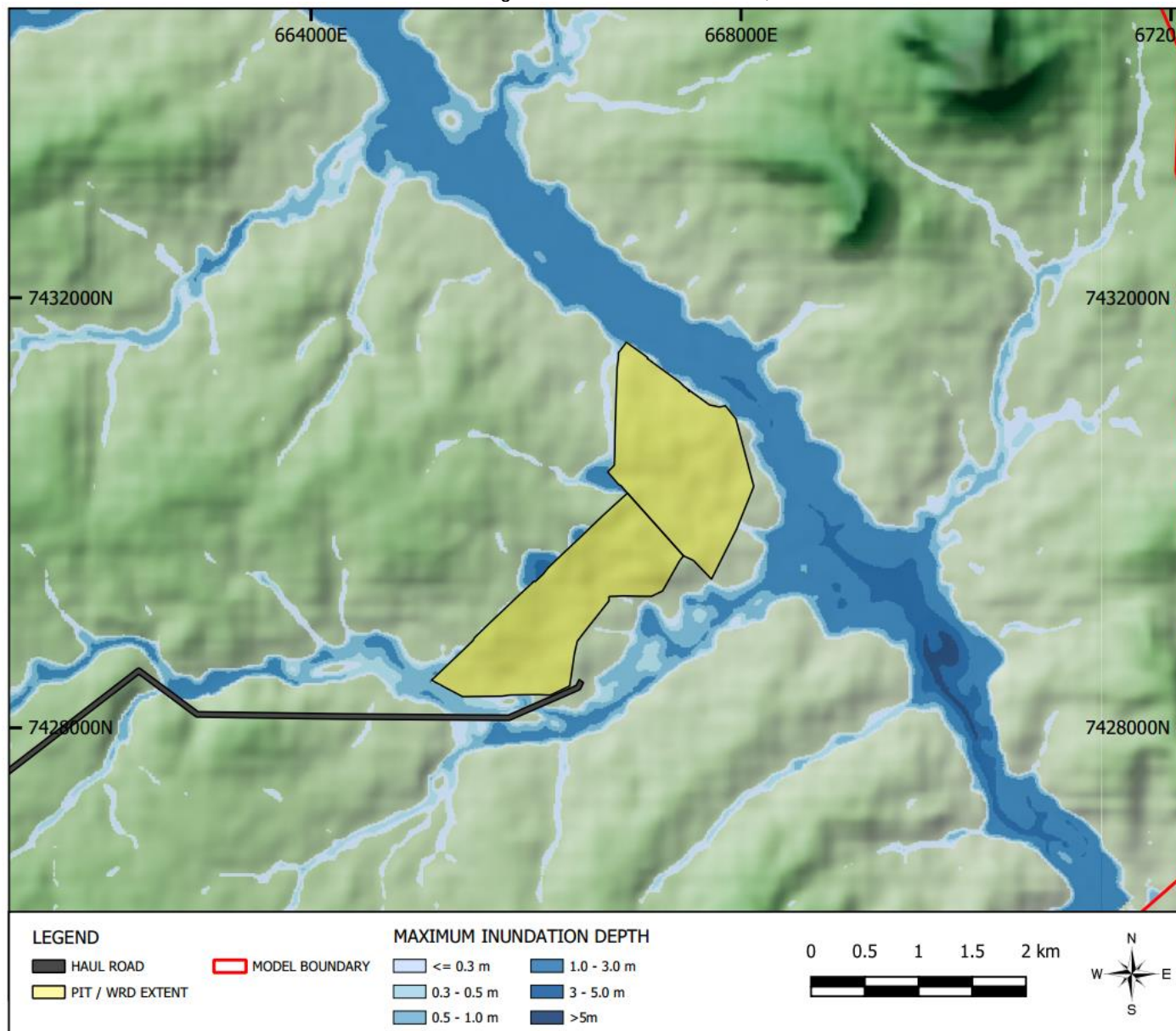


Plate 14
Flood Modelling: Post-closure condition, 0.1% AEP

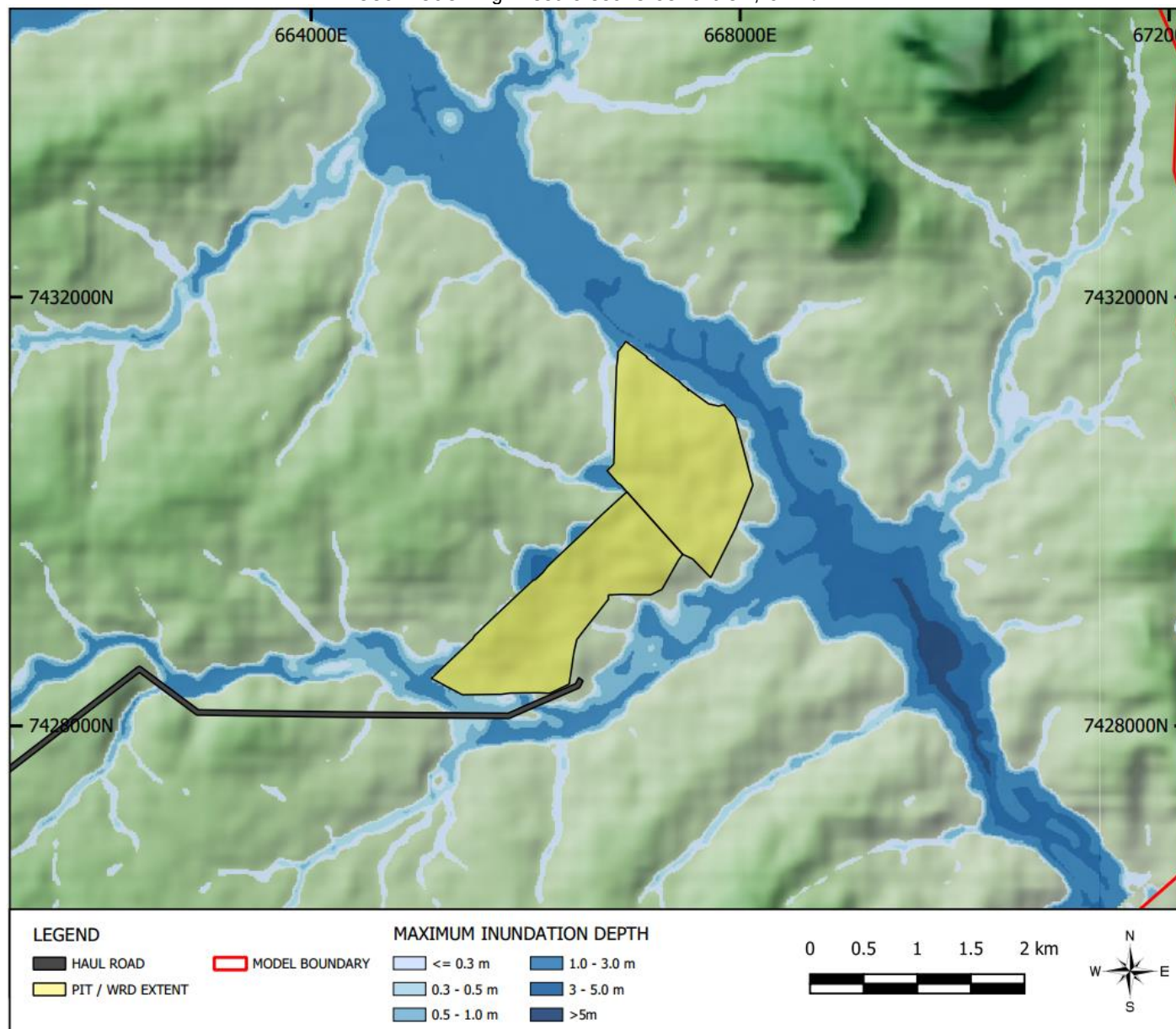
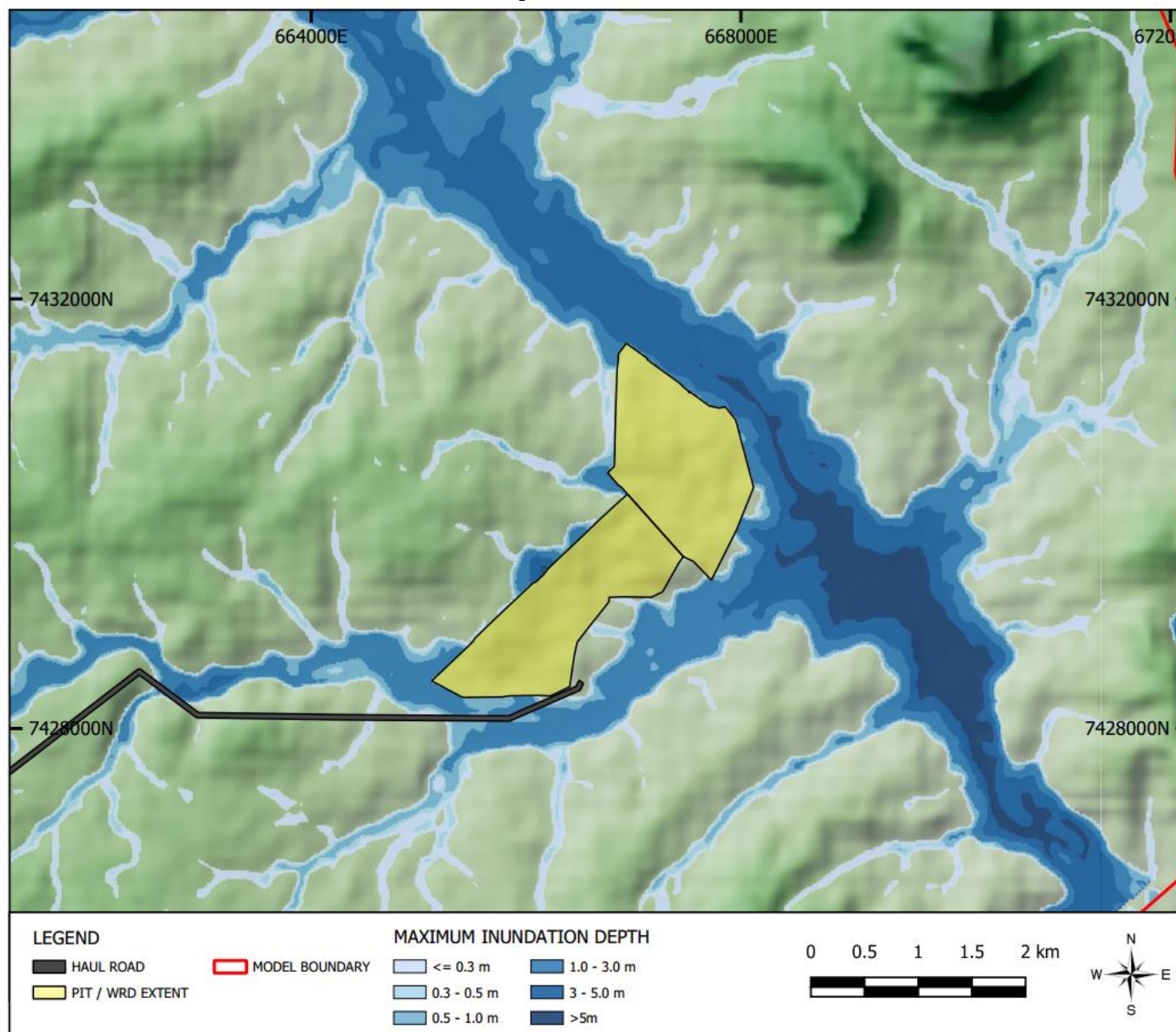


Plate 15
Flood Modelling: Post-closure condition, PMP



The following can be derived from the modelling results:

- Modelled flood depths and velocities for the pre-mining condition indicate that key development areas within the project site area are at risk from flooding associated with Cooroora Creek and Sandy Creek, for the 1% AEP and above events. These modelled inundation areas encroach on:
 - o the southern extent of the south pit;
 - o the northern extent of the north pit;
 - o up to 1.5km of the haul road alignment adjacent to and crossing Sandy Creek in the southern portion of the site;
 - o the haul road crossing alignment over Cooroora Creek area at the northern extent of the site;
 - o the southern and eastern batter slopes of the south waste rock dump;
- To mitigate the safety and operational risks associated with potential flood impacts, detailed design of the project will require consideration of the following flood mitigation/protection measures:
 - o pit flood protection bunds with armoured embankments around the northern and southern pit extents;
 - o the haul road creek crossings should be constructed as armoured causeway crossings with culverts (noting that construction of the crossings would potentially increase upstream flood levels);
 - o armouring of the waste rock dump batter slopes within inundation areas;
 - o potential creek bank armouring of Sandy Creek and Cooroora Creek adjacent to the project site;
- Comparison of the results between the pre-mining and post-closure condition suggests that the final landform will have a limited impact on downstream flooding. The presence of the final voids would act as a storage mechanism, effectively removing or delaying the contribution of runoff from the upstream catchment. As a result of the upstream catchment of the Cooroora Creek, limited reductions in modelled peak discharge rates were observed. Notwithstanding, an associated reduction of 0.2m and 0.1m in the maximum inundation depths for the 1% AEP and 0.1% AEP events respectively was observed from the model outputs. Minimal difference in maximum modelled velocities between the two conditions was also observed.

The above outcomes highlight that the project site location represents a number of safety and operational risks in relation to potential flood impacts - these will need to be addressed during detailed design.

Given the inherent limitations associated with the survey data used as the basis for this flood assessment (refer Section 3.1), and the fact that detailed design of flood mitigation or creek protection measures will necessarily be informed by flood modelling outcomes (i.e. pit bund design crest levels/Site Water Dam locations) - it is recommended that the flood model be updated with accurate survey data (e.g. LiDAR survey) once available. Further assessment of impacts on flood depths and velocities from proposed mitigation measures will also be required.

4 SITE WATER MANAGEMENT

4.1 Water Management Strategy

The key objectives with respect to site water management are to:

- Minimise mine affected (disturbed) areas and divert clean water around the development area for ultimate discharge to receiving waters; and
- Control the release of impacted water from the site to the extent that the environmental values of the receiving environment are not detrimentally impacted.

For the purpose of site water management system design, three specific types of water will exist in relation to the development: clean, sediment laden and mine affected. These are described in Table 6 along with their overall management approach.

Table 6
Water Types & Management Approach

Water Type	Description	Management Approach
Clean water	Runoff derived from areas: • upstream of the mine development footprint or • stabilised/rehabilitated surfaces within the footprint. This water is considered to be unaffected by mine operations and therefore clean.	Direct off-site release via diversion drains, bunds and / or clean water sump and pump systems to defined discharge locations without causing excessive erosion of the receiving environment and sediment discharge.
Sediment laden water	Runoff coming into contact with disturbed earth surfaces associated with cleared areas ahead of active strip mining. Contact with these surfaces is considered likely to mobilise sediments and therefore requires capturing of the sediments prior to release to the clean water system.	Minimise extent of disturbed surfaces. Divert runoff from these surfaces to sediment basins for capture and settlement/treatment (flocculation if required) of sediments prior to release by transfer or release to the clean water system and the receiving environment.
Mine affected water	Runoff coming into contact with • disturbed/unstabilised earth surfaces located within the open cut pits or • unstabilised surfaces of the overburden dumps. Contact with these surfaces is considered to increase the potential for mobilisation of sediments and other diffuse source contaminants and as such is considered to be 'mine affected'. This would include any groundwater that reports to the mine pits.	Minimise extent of areas of disturbance. Capture and contain runoff from these areas, for release to the environment subject to sufficient flow events and accordance with predetermined volumetric flow ratio. Further settlement/treatment (including flocculation) of sediments or other contaminants (including salinity) might be required prior to release to the clean water system and the receiving environment. Enhanced evaporation may also be required to remove water.

There is no requirement for process water for the Fairhill project as ROM coal is to be transported offsite for processing. Demand for site water is therefore limited to that required for dust suppression or irrigation (for vegetation establishment during rehabilitation) purposes. Subject to acceptable water quality, it is envisaged that 'mine affected water' could be used for dust suppression and irrigation which would preferentially be taken from the Site Water Dams described in Section 4.2.

As described in Section 2.4.2, the project site is located near to the top of the local catchment within the headwaters of a number of local unnamed drainage features. As such, the total upstream clean water catchment of the site is relatively small, estimated at 700 hectares when mining commences. Notwithstanding the small upstream catchment size, and consistent with the management objectives described above, it is preferential to maximise the separation of clean water runoff from active mine areas in order to minimise requirements for onsite water storage and/or treatment. This is to be achieved via construction of diversion drains and bunds upstream of the pit. Where local topography precludes appropriate drainage of clean water, sumps will be constructed in order to collect and enable offsite discharge via pump systems.

4.2 Water Management Infrastructure Description

Consistent with the water management strategy outlined in Section 4.1, a number of surface water management facilities will be constructed and used to manage water needs for the mine site. These are described in Table 7 along with the design basis relevant to each.

Table 7
Surface Water Management Facilities

Facilities	Description
Clean Water Sumps (CWS)	Clean water sumps are proposed to capture runoff from the upstream undisturbed catchment where diversion around the development is not possible due to local topography. Runoff will be directed to the sumps via formed drains and bunds. Channels or pumps will be installed to transfer collected water to nearby discharge points. The CWSs will be constructed as required, in advance of clearing associated with development of subsequent strips. As such, these will be temporary in nature, with reporting catchment areas reducing over time as the mine develops.
Pre-Strip Sediment Traps	As described in Section 2.2, development of the open cut pits is planned in a north-westerly direction, and accordingly the pits will advance upslope. During operations, the areas immediately upslope of both pits will therefore be subject to pre-stripping activities prior to the next stage of pit development, with the land disturbance associated with clearing and topsoil removal activities resulting in exposed bare earth surfaces. Control measures will be implemented in order to reduce the extent of erosion and subsequent downstream mobilisation of sediments, including pre-strip sediment traps that shall be constructed upstream of the pits in order to collect the potentially sediment laden water. The objective of the sediment traps is to both minimise the volumes of water entering the pits (requiring subsequent management as mine affected water) and to allow appropriate retention time for sediments to settle and/or be treated via addition of flocculants. Subject to acceptable water quality, water would then be suitable for transfer for either direct offsite release, or to the clean water system. Provision can also be made to enable transfer to the site water dams (refer below) should the water quality within the sediment traps be unsuitable for release as clean water, when storage capacity is required ahead of forecast rainfall events. The sediment traps will either be constructed in advance of pre-stripping activities, or will make use of the existing CWSs as these become redundant (clean water inflows replaced with sediment laden runoff) and are replaced by newly constructed CWs upslope.

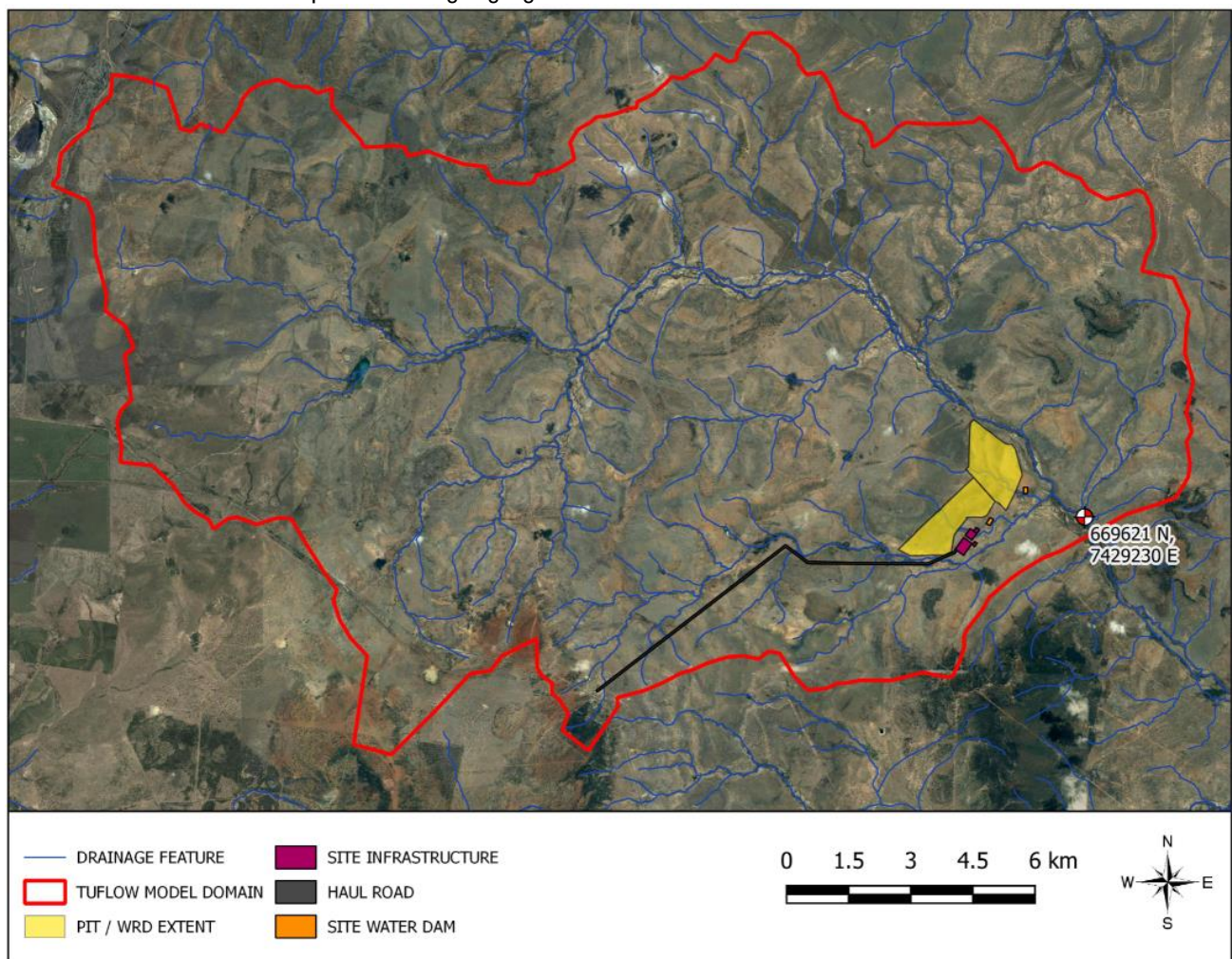
Table 7 (Cont.)
Surface Water Management Facilities

Facilities	Description
Pit Sumps	Water within the pit shall be managed via construction of pit water sumps and temporary bunding as required to direct water within the pit to the sumps. Water levels within the sumps shall be maintained at appropriate levels by transfer of collected mine affected water to the Site Water Dams (SWDs, refer below) as required, for treatment and offsite release or use in dust suppression and irrigation. The location of excavated pit sumps will be determined based on natural low points on the pit floor as the mine develops, and operational consideration shall be given to allowance for accumulation of water within the pit around the sump should insufficient capacity be available in the SWDs to enable transfer. Specific sediment management within the pits is not necessary, however, it is expected that some settlement of mobilised sediment would occur within the sumps. This settlement of mobilised sediment could be further enhanced by delaying pumping to the SWDs with 24 hours following rainfall events. This would be an operational decision balanced with discharge from the SWDs during flow events within the natural drainage features.
Site Water Dams (SWD)	The SWDs will contain water pumped from the pit and mine impacted surface runoff from un-stabilised overburden dump surfaces. It is envisaged that up to three SWDs will be constructed along to the immediate east of the proposed overburden dump and will receive pumped transfers from the pit sumps. The SWDs shall be constructed on a cut to fill basis as excavations with perimeter embankment elevation higher than a nominated design flood level and designed to accommodate the modelled transfer volumes limiting spill events to less than 5% AEP. Discharge from the SWDs would be allowed under controlled release conditions when flow in downstream drainage features (measured at a flow gauging station to be installed, refer below) is available. Controlled discharge would not make up more than 1:20 of the downstream drainage features flow.
Clean water diversion drains and bunds	The clean water diversion drains and bunds capture runoff from the undisturbed land and divert the flow either around the mining operations or to clean water sumps, thereby reducing the total amount of runoff requiring containment within the site water management system. Temporary clean water diversion drains and bunds would be designed to accommodate a 1% AEP event of critical duration. Permanent clean water diversion drains and bunds would be designed to accommodate a 0.05% AEP event of critical duration. Closure drainage systems will be designed to safely convey, collect and discharge clean runoff without causing geotechnical instability or excessive erosion of the receiving environment and sediment discharge.
Pumps	The CWS and sediment trap arrangements are proposed as temporary measures to capture and divert water that would otherwise enter the pit. For this assessment, a nominal pump capacity has been selected as 130 L/s, to transfer water to the proposed clean water drains and subsequently discharge into existing natural watercourses. Using the assumed pump capacity, the sump capacity and number of pumps required can be optimised to achieve the appropriate spill/containment risk. A similar approach would apply to sizing pumps required for the pit sumps.

Table 7 (Cont.)
Surface Water Management Facilities

Facilities	Description
Flow gauging station	It is proposed to install a flow gauging station approximately 2km downstream of the project site as shown in Plate 16. Determination of the actual location of the flow gauging station will be subject to ground-truthing to confirm suitability and accessibility of the proposed location, as well as obtaining landholder consent for the installation and subsequent access as required. The purpose of the flow gauging station is to provide information on background flows prior to commencement of operations; monitor creek flows on an ongoing basis in order to provide information on environmental flows; and, inform the conditions under which operational releases from the site water dams will be permissible in terms of both timing and volumes (based on a maximum overall dilution factor of 1:20). The type of flow gauging station to be installed will be confirmed during detailed design of the site water management system however it is envisaged that an ultrasonic Doppler area/velocity flow meter sensor installed on a concrete block embedded within the creek channel bed would be appropriate. Data from the sensor would be logged via a remote (solar-powered) datalogger installed adjacent to the creekline, with data retrieved on request from the station via the GSM network.

Plate 16
Proposed flow gauging station location and catchment area



4.3 Water Management System Development

The proposed strip mine development is scheduled to occur in a north-westerly direction i.e. progressively advancing up-catchment. Accordingly, the clean water diversion system (and sediment traps) is necessarily temporary in nature and will need to be moved in stages upslope in advance of mine development. A conceptual water management system layout based on the infrastructure described in Section 4.2 has therefore been developed for each year of the mining operation. Where possible, infrastructure has been designed to function over multiple years and cater for changes in operation as the mine advances. This is described below and shown in Figures 001 to 007.

Year 1 (see Figure 001)

- The downstream site water management system infrastructure constructed prior to commencement of operations would remain for the life of the operation, and comprise up to two SWDs located at intervals adjacent to the extent of the overburden dump. It is noted that the SWD's are shown for illustrative purposes only and have not been sited. Consideration of flood extents will be required for positioning of storages as part of the detailed design stage. Construction of multiple SWDs enables operational flexibility and greater capacity in terms of managing mine affected water collected within the pit. Following construction of the SWDs the pump arrangement would be formalised, with construction of a dedicated pipeline and standpipe infrastructure for ongoing dust suppression and irrigation purposes as required.
- Pit sumps would be constructed within each pit, located to balance pit operational requirements, drainage directions and potential water volume accumulation, with volumes pumped to the SWDs for controlled release during flow events.
- Diversion drains and pre-strip sediment traps would be constructed for the areas west of the WRD to be cleared in preparation for the Year 2 strip. Settled water in the northern and southern sediment traps would be discharged to the respective drainage features to the north and south for release offsite.
- Clean water diversions located upstream would be constructed to divert clean water around the development. A second clean water diversion and two CWSs would be constructed to drain clean water runoff that cannot be diverted around the development due to the site topography. Water collected within these sumps would be pumped to the diversion drains constructed further upstream, for release offsite.

Year 2 (Figure 002)

- The SWDs, and pit sumps would be managed as per Year 1.
- New clean water diversions would be constructed upslope to divert clean water around the development.
- The CWSs constructed for Year 1 would be used as the central sediment traps for the pre-strip area.
- The remaining pre-strip water for Year 2 would be managed in a similar arrangement to Year 1, with one sediment trap and diversion drains constructed for each of the northern and southern areas, with both of these ponds discharging to the respective adjacent drainage features.
- CWSs would be constructed for the areas west of the pre-strip areas that cannot be diverted around the project site.
- Clean water runoff from rehabilitated surfaces of the backfilled pit dump would be allowed to shed offsite to the natural water courses. It is noted the final design or operational management of the initial overburden dump will need to facilitate clean water drainage around or through the dump, which could be achieved through material removals and placement as part of pit backfilling.

Year 3 (Figure 003)

- The SWDs, CWSs, and pit sumps would continue to be managed as per Year 2.
- Diversion drains and pre-strip sediment traps would be constructed for the areas west of the pits to be cleared in preparation for the Year 3 strip.
- Clean water runoff from rehabilitated surfaces of the backfilled pit dump would continue to be allowed to shed offsite to the natural water courses.

Year 4 (Figure 004)

- The SWDs, CWSs, pit sumps, and rehabilitated surfaces runoff would continue to be managed as per previous years.
- Diversion drains and pre-strip sediment traps would be constructed for the areas west of the pits to be cleared in preparation for the Year 4 strip.

Year 5 (Figure 005)

- The SWDs, pit sumps and rehabilitated surfaces runoff would continue to be managed as per previous years.
- New clean water diversions would be constructed on the upslope to divert clean water around the development.
- The CWSs constructed for Year 3 would be used as the central sediment traps for the pre-strip area, with one sediment trap and diversion drains constructed for each of the northern and southern areas, with both these ponds discharging to the respective adjacent drainage features.

Year 6 (Figure 006)

- The SWDs, CWSs, pit sumps and rehabilitated surfaces runoff would continue to be managed as per previous years.
- Diversion drains and pre-strip sediment traps would be constructed for the areas west of the pits to be cleared in preparation for the Year 6 strip.

Year 7 (Figure 007)

- The SWDs, CWSs, pit sumps and rehabilitated surfaces runoff would continue to be managed as per previous years.
- As Year 7 is the final year of mine operations, there is no pre-strip water to manage.

Closure

- Following mine closure, and shaping and rehabilitation of the final landform profile, surface water is expected to interact with the final voids formed to the west of the rehabilitated pit dump. Void inflows would originate from the natural upstream catchment and western slopes of the rehabilitated dump. The eastern slopes of the rehabilitated dump would shed to the natural water courses draining to the east. Further assessment of the final voids is required to determine the expected long-term behaviour, however should the voids fill to capacity, they would naturally discharge to the watercourses draining to the east.

4.4 Water Balance Modelling

4.4.1 Modelling Results and Interpretation

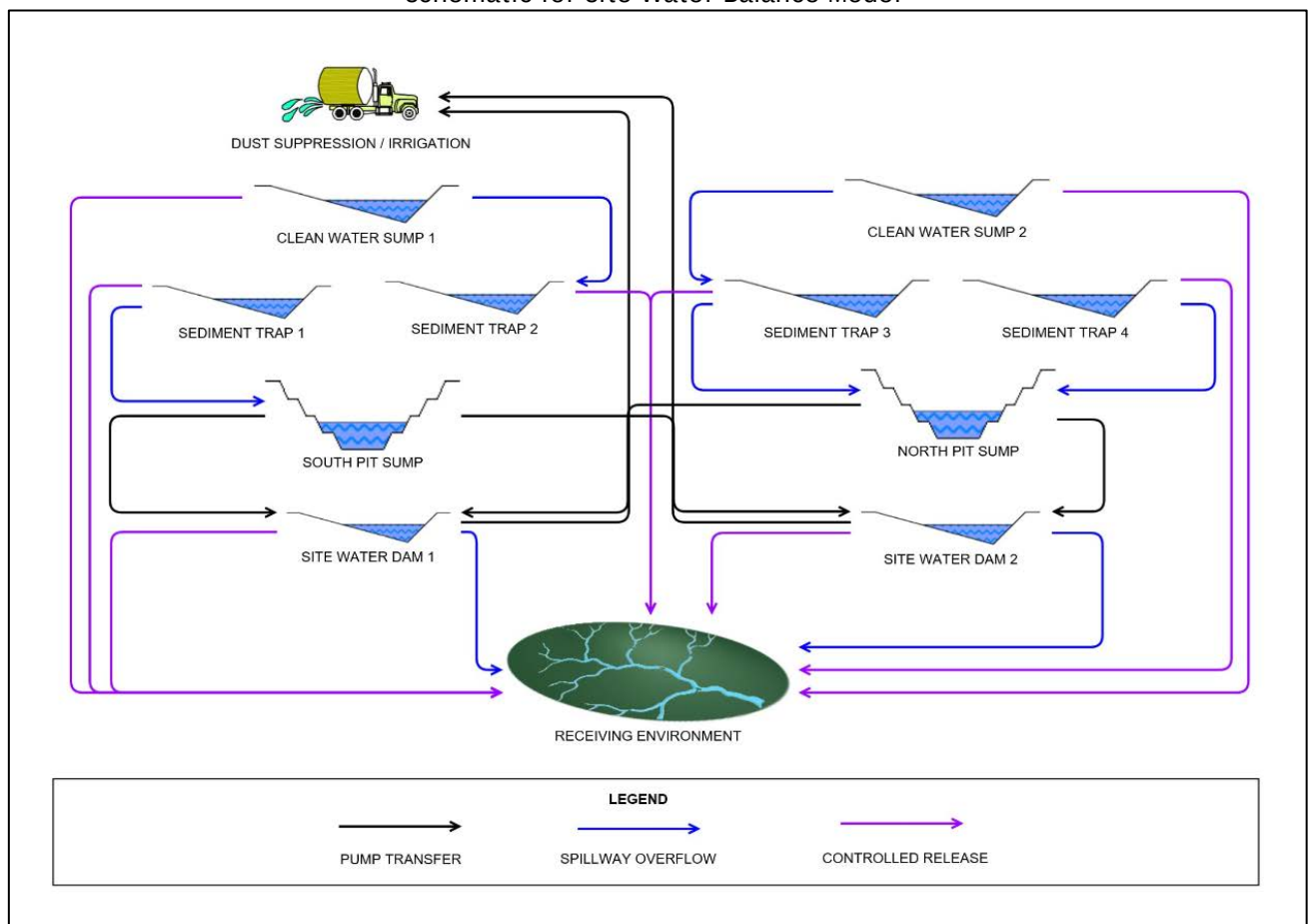
The specific objective of this water balance modelling is to assess required containment capacity and minimise release of potentially mine-impacted site water to comply with the criteria as outlined in Section 4.0, by the appropriate sizing of site water management elements, as well as to manage the quantity of water captured on the mine site. Additionally, water balance modelling has been conducted to estimate the extent to which the capture of overland flow from clean water catchments can meet construction and operational water demands for the Project site. The water balance model was also used to evaluate the quantities of mine-affected water that would require management, and volumes of diverted clean water.

4.4.2 Model Structure

A dynamic probabilistic simulation modelling approach, utilising the program Goldsim Pro v12.1, was adopted for the water balance model based on a daily climatic record for the site. An integrated catchment yield analysis for the site water catchments was also coupled with the water balance model.

The key elements of the site water balance model are described in Section 4.2, with a schematic diagram representing the model shown in Plate 17.

Plate 17
Schematic for Site Water Balance Model



The water balance model was applied to the conceptual mine site layout and conditions for the full seven-year life-of-mine (refer Figures 001 - 007). Rainfall sequences adopted for modelling therefore comprised a seven-year window extracted from the 129 years of available data to generate 122 realisations.

4.4.3 Model Data Input

Data inputs for the project water balance model are summarised below.

4.4.3.1 Climate Data Inputs

Input data adopted for the water balance model are summarised in Table 8.

Table 8
Site Water Balance - Base Data

Model Parameter	Available Data	Data Source
<u>CLIMATE DATA</u>		
• Rainfall	SILO Data Drill Program for the Site Location (1889 - 2019)	SILO Data drill for project site location.
• Evaporation	Evaporation data obtained from the SILO Data Drill Program for the Site Location (1889 - 2019)	SILO Data drill for project site location. Evapotranspiration data based on Class A Pan. Evaporation data, taken as representative of open-water evaporation.
• Evapotranspiration	SILO Data Drill Program for the Site Location (1889 - 2019)	SILO Data drill for project site location.
<u>PIT GROUNDWATER INFLOWS</u>	Assumed minimal (zero) inflow	Summary hydrogeological assessment information provided by NRC (refer Section 2.6).

4.4.3.2 Site Water Requirements

As described in Section 4.1, water requirements on the mine site will mainly comprise dust suppression and irrigation of rehabilitation areas. These operational water needs will be preferentially sourced from the SWDs constructed to the east of the waste rock dump, with water excess to requirements being released to the environment subject to acceptable water quality and sufficient environmental flows. The pit inflow water is the accumulation of both rainfall and runoff from upstream catchment areas unable to be diverted due to the natural topography. This water will be managed as mine impacted water and will be pumped to the SWDs.

4.4.3.3 Catchment Elements Input

Modelling conditions applying to key elements are detailed in Table 9, based on the conditions described in Section 4 as applied over the seven-year life-of-mine.

Table 9
Summary of Modelling Conditions

Proposed Site Water Management Elements	Component	Adopted Modelling Condition
Site Water Dams (2 in total)	Storage Capacity	100 ML (per dam)
	Contributing Catchment	Full supply areas
	Water release criteria	1:20 dilution based on modelled clean water flows
Pit Sumps (2 in total)	Full Supply Level Storage	Undefined
	Contributing Catchment	Refer Table 10
Pre-strip Sediment Traps (4 in total)	Full Supply Level Storage	2.0 ML
	Contributing Catchment	Refer Table 10
Clean Water Sumps (2 in total)	Full Supply Level Storage	2.0 ML
	Contributing Catchment	Refer Table 10
Transfer Systems		
Pit Sumps to SWDs	Transfer Capacity	80 L/s
CWS to diversion drain	Transfer Capacity	130 L/s*
SPs to CWS/diversion drain	Transfer Capacity	130 L/s*
Dust suppression	Water Demand	0.2 ML/day*
Irrigation/Enhanced Evaporation	Water Demand	1.0 ML/day**

* Applied when daily rainfall < 5mm/day.

** Preliminary modelling results indicated water surplus for the site, necessitating use of enhanced evaporation.

* 200L/s transfer capacity also modelled (refer Section 4.4.4.1).

Water storage characteristics were based on a linear height-volume relationship, with the capacity optimised for storage, to contain transfers from the pits and generated catchment runoff.

The catchment areas applied in the water balance model are presented in Table 10.

Table 10
Modelled Catchment Areas

Storage	Catchment Areas (hectares) ⁴						
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
South Pit Sump	45.4	68.8	42.0	45.2	41.2	64.2	73.1
North Pit Sump	36.5	70.1	92.2	58.5	29.1	37.1	37.9
Clean Water Sump 1 (South)	27.6	44.6	44.6	44.8	23.0	23.0	23.0
Clean Water Sump 2 (North)	41.2	36.9	41.1	36.5	34.1	34.1	34.1
Sediment Trap 1 (South)	11.8	20.3	13.6	8.4	16.3	9.6	0
Sediment Trap 2	10.5	29.4	22.0	8.5	25.3	13.4	0
Sediment Trap 3	25.8	35.3	10.2	4.6	16.8	10.9	0
Sediment Trap 4 (North)	10.4	18.8	8.4	8.8	15.5	10.3	0
Flow Gauging Station Catchment	30,670	30,555	30,605	30,664	30,678	30,676	30,711

⁴ Catchment areas related to active mining area and diversions in place during each year.

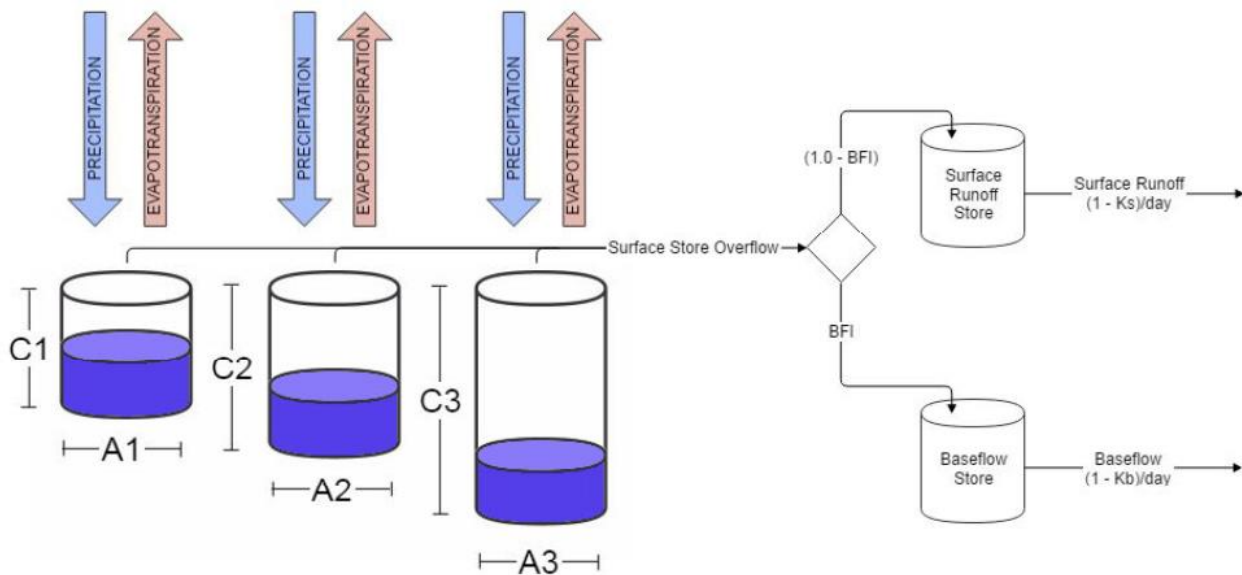
4.4.3.4 Operating Priorities

The water balance model process is based on “priorities” assigned to each water supply source, with these priorities identifying the sequence by which site water is recovered from specific storages and used for either dust suppression or irrigation. In this case, sole priority is assigned to the Site Water Dams.

4.4.3.5 Catchment Runoff Estimation

The Australian Water Balance Model (AWBM) was utilised to simulate daily runoff from rainfall generated within the various sub-catchment types that are present on the project site, as well as the broader catchment area that would report to the proposed flow gauging station (refer Table 10). Plate 18 represents a schematic of the AWBM model, reproduced from Boughton (2009).

Plate 18
Schematic of AWBM Rainfall-Runoff Model



Where:

- C1 - C3 = Surface Storage Capacities
- A1 - A3 = Partial Areas Represented by Surface Storages
- BFI = Baseflow Index
- K_b = Daily Baseflow Recession Constant
- BS = Current Volume in Baseflow Store
- K_s = Daily Surface Flow Recession Constant
- S = Current Volume in Surface Store Routing

The catchment types and AWBM model parameters used to simulate these different catchment types and the average yields from these catchment areas (refer Table 10) are summarised in Table 11. Model parameters have been selected based on experience with similar water balance model studies, and are considered to be conservative in the context of this uncalibrated model.

Table 11
AWBM Model Parameters

AWBM Parameters	Split Areas (sum=1.0)			Storage Capacities (mm)			Ks (day-1)	BFI	Kb (day-1)
	A1	A2	A3	C1	C2	C3			
Natural	0.134	0.433	0.433	12	120	250	0.2	0.1	1
Open Cut	0.1	0.9	0	5	20	20	0.2	0.1	1

4.4.4 Modelling Results and Interpretation

4.4.4.1 Model Output

Outputs from the water balance model are summarised in Plates 19 to 22 for the pit sumps and site water dams in the form of storage volume percentiles, over the respective modelling period, with mean and median conditions also shown.

Plate 19
South Pit Sump Water Balance Model Output
(Storage Volume)

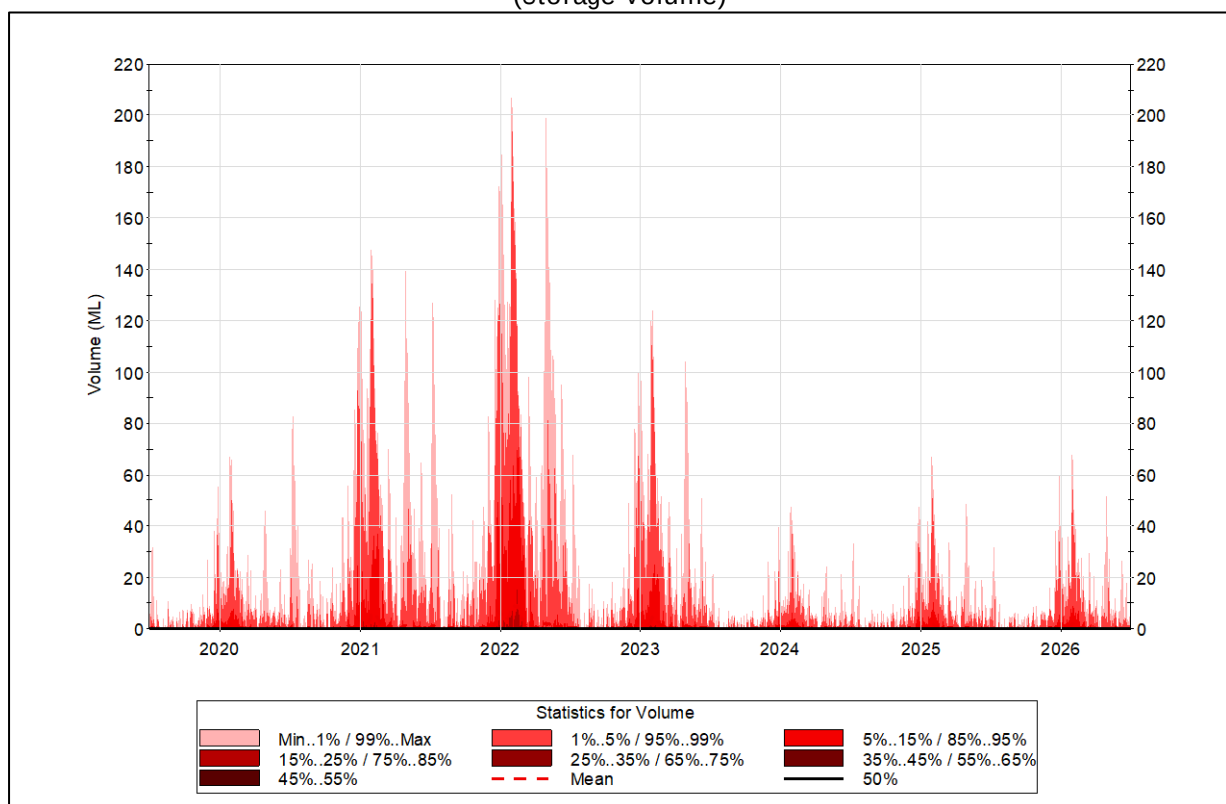


Plate 20
North Pit Sump Water Balance Model Output
(Storage Volume)

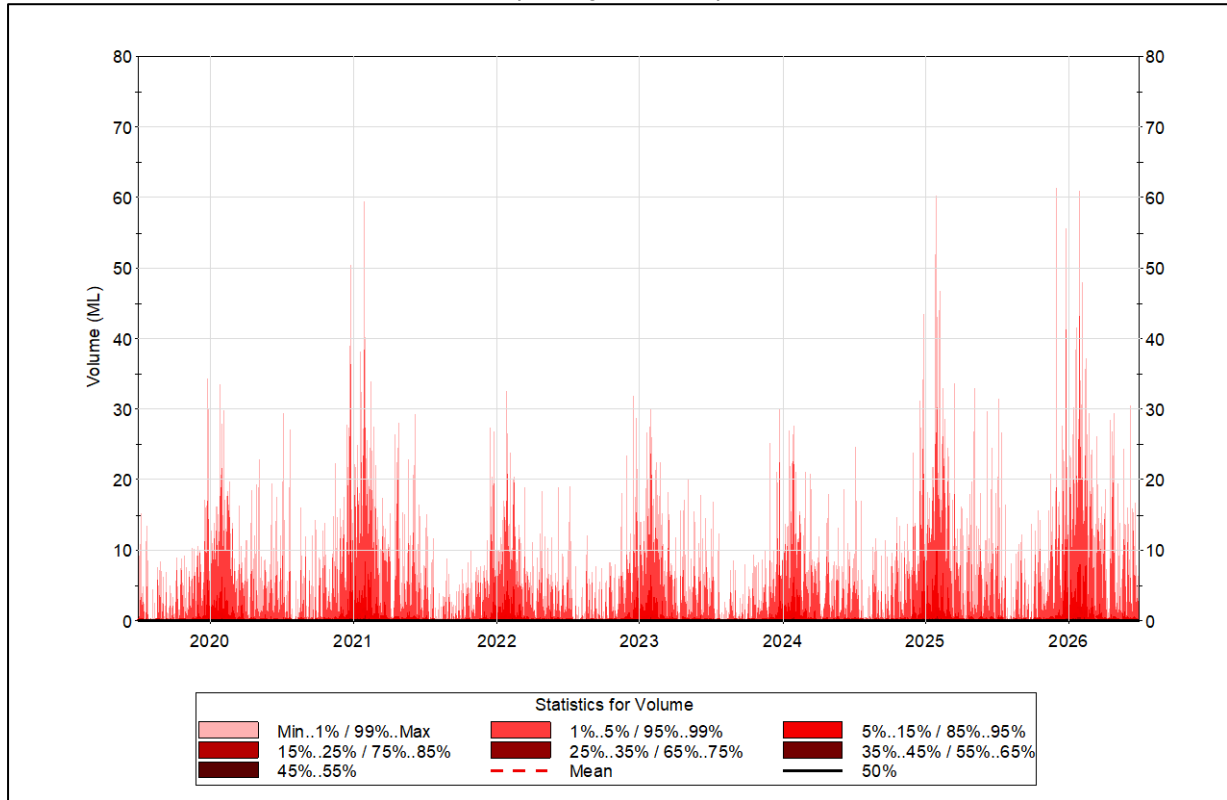


Plate 21
Site Water Dam 1 Water Balance Model Output
(Storage Volume)

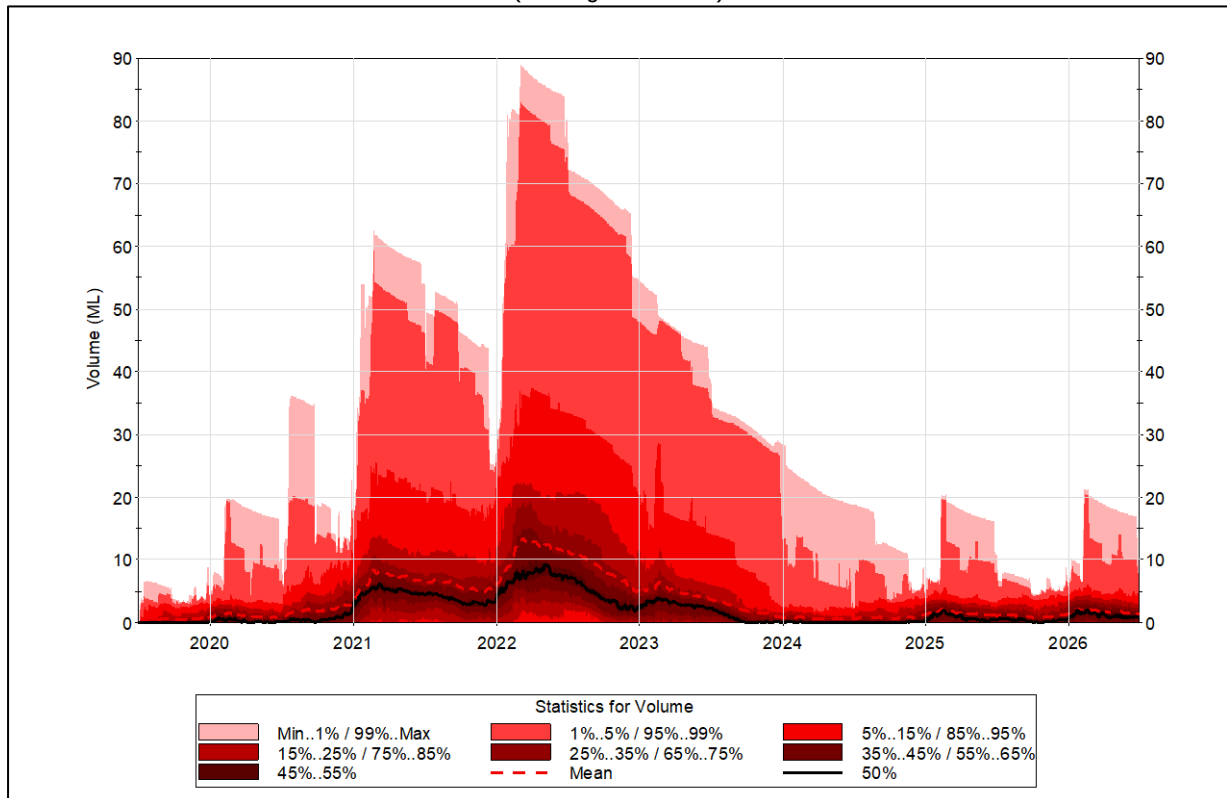
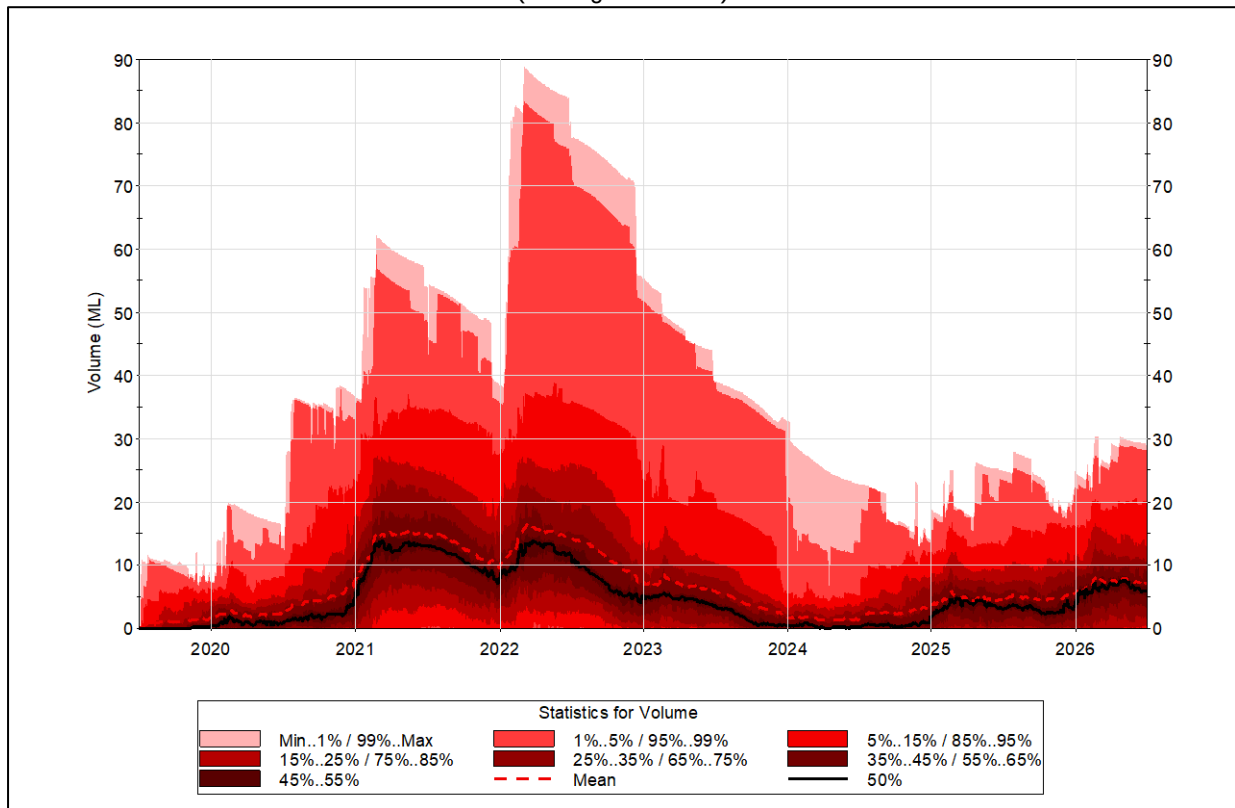
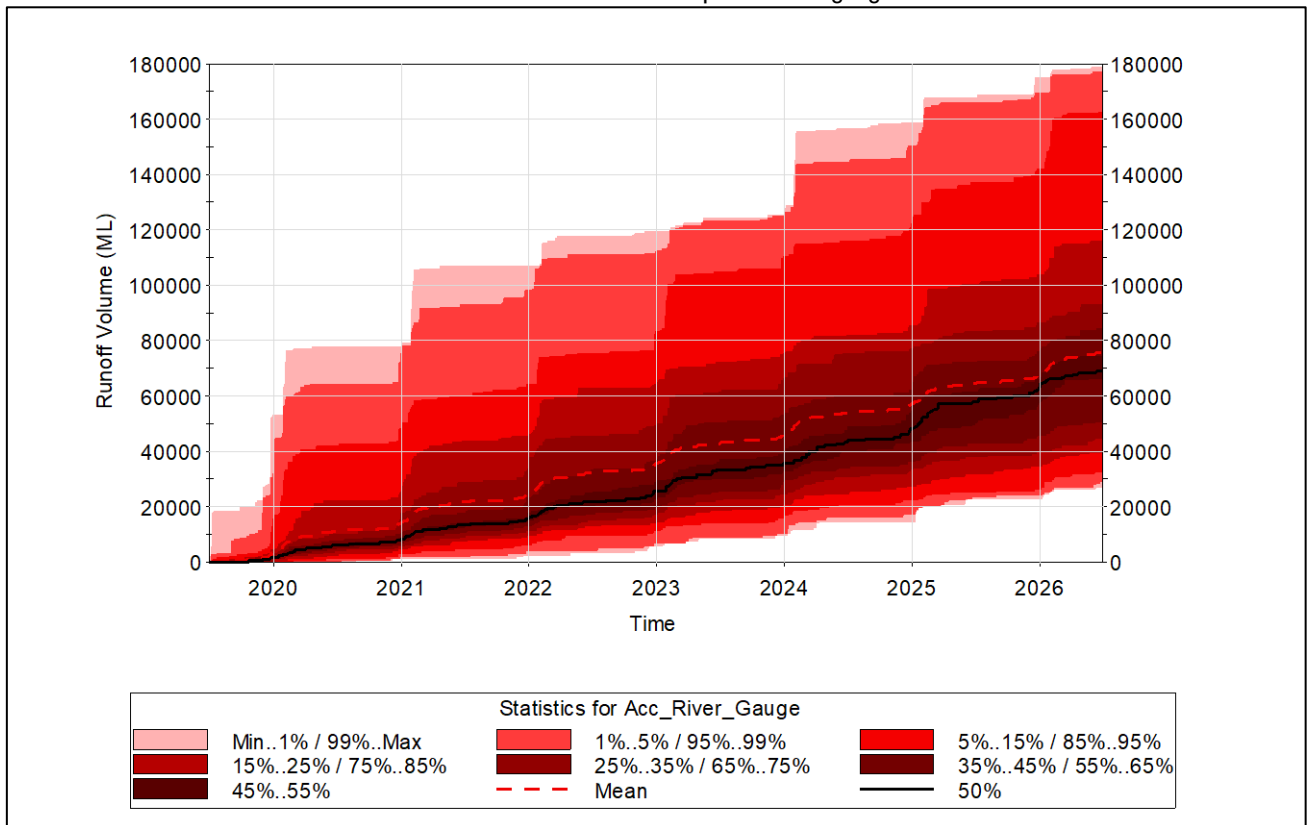


Plate 22
Site Water Dam 2 Water Balance Model Output
(Storage Volume)



The modelled flow rates at the proposed flow gauging station (refer Table 10) represented by the accumulated flow volume is presented in Plate 23 where it can be seen that over the seven-year modelling period, mean total flow volumes of some 75,000 ML were observed. While this represents some 330L/s as an average, the variable nature of the rainfall depths in the region, particularly over the summer months mean that local creek flows will be highly responsive to rainfall events, and potentially exhibit near zero flow at times (consistent with the ephemeral nature of local water courses).

Plate 23
Modelled Flow Volumes at Proposed Gauging Station



As described in Table 9, controlled releases from the Site Water Dams are based on a maximum dilution factor of 1:20, relative to the flow rates occurring at the flow gauging station location. Accordingly, Plate 24 shows these controlled discharge volumes (as combined accumulated totals) from both Site Water Dams.

Plate 24
Site Water Dams (Controlled Release Flows)

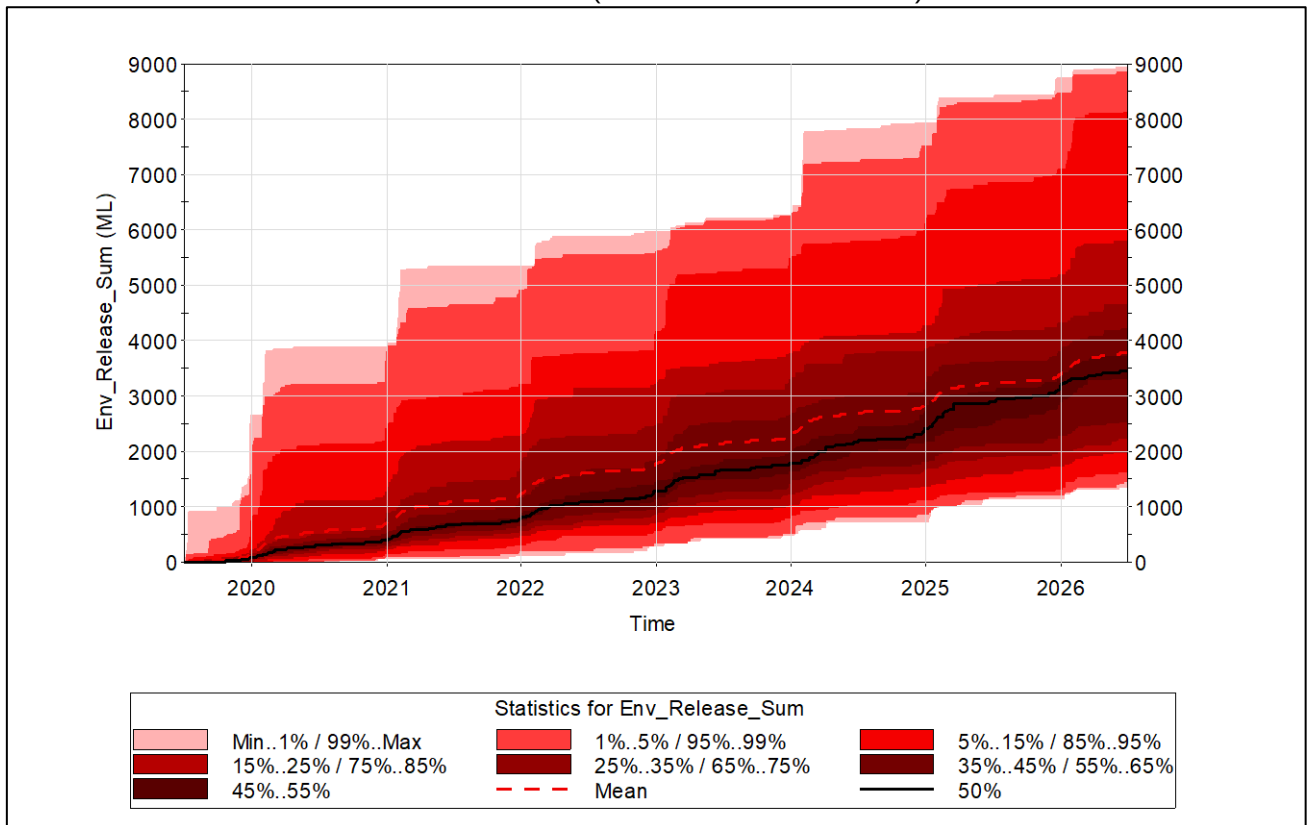


Table 12 presents the mean annual spill risk for the storages. In order to test the sensitivity of the Pre-strip Sediment Trap performance (in terms of spill risk, representing the probability of overflows from the sediment traps into the pits), the model was also run with an increased pump transfer rate of 180L/s for the Clean Water Sumps and Pre-strip Sediment Traps. These spill risk results are also displayed in Table 12.

Table 12
Modelled Spill Risks

Storage	Mean Annual Spill Risk	
	130L/s	180L/s
South Pit Sump	<1.0%	<1.0%
North Pit Sump	<1.0%	<1.0%
Site Water Dam 1 (South)	<1.0%	<1.0%
Site Water Dam 2 (North)	<1.0%	<1.0%
Clean Water Sump 1 (South)	4.9%	<1.0%
Clean Water Sump 2 (North)	4.1%	<1.0%
Sediment Pond 1 (South)	<1.0%	<1.0%
Sediment Pond 2	<1.0%	<1.0%
Sediment Pond 3	<1.0%	<1.0%
Sediment Pond 4 (North)	<1.0%	<1.0%

The spill risk results indicate no modelled scenarios resulted in overflow from the pits or site water dams. A modelled spill risk of a maximum of 4.9% (inferring a 4.9% probability of overflow) was modelled for Pre-strip Sediment Traps and CWSs (overflowing into the pits / pre-strip areas). Sensitivity modelling indicated that this spill risk can be reduced to less than 1% by increasing the pump transfer capacity to 180 L/sec during extreme events. This result implies that water volumes within the sediment ponds and clean water sumps can be adequately managed through selection of appropriate pump capacities in order to minimise overflow volumes into the pits. Model results indicate that the maximum daily spill volume for the sediment traps (with spills entering the pits) are in the order of 3.1ML, compared with maximum overall volumes in the pits of 200ML at this corresponding time, noting that these overflows are associated with extreme rainfall events.

4.4.5 Summary of Model Results

The preliminary results of water balance modelling indicated that on average, mine affected water accumulation over the life of the project would occur. This was expected given that demand for stored water was limited given that no onsite coal processing operations that require water use are planned, and that the open cut pits would receive inflow from direct rainfall and upstream catchments unable to be diverted due to the natural topography. As such, additional use of water to reduce this accumulation of water volumes is required to ensure that water within the pit remains below operational constraints.

In addition to use of site water for dust suppression, this reduction of water accumulation was achieved through the incorporation of two site water use requirements (totalling 1ML/day) that work in conjunction to reduce overall volumes:

- Irrigation of vegetation on rehabilitated surfaces (assumes acceptable water quality for vegetation); and
- Enhanced evaporation of water contained with the site water dams.

The overall site water demand (including water used for dust suppression) reduces the water accumulating in the pit sumps, of which the modelled water volumes for the 95th percentile result is generally between 50ML and 120ML during the wet season, with a maximum volume result of some 220ML.

Modelled storage volumes within the site water dams are limited to below full supply capacity resulting in a <1% spill risk. These results also indicate that storage capacities described in Section 4.4.3.3 would be adequate to achieve the site water objective of ensuring that no uncontrolled releases of mine affected water occur from the site. This reflects operational management of the dams to ensure that pit water is not pumped to the site water dams when full.

The modelled spill risk of the clean water sumps and sediment ponds over the seven-year modelled period is up to 4.9% depending on the pump transfer capacities used. The layout and configuration of these structures means that spills would ultimately enter the pits, and therefore no uncontrolled releases off site will occur. Furthermore, these spill volumes are minor and would subsequently be managed in the pit sumps as mine affected water.

5 CONSEQUENCE CATEGORY ASSESSMENT

5.1 Basis of the Consequence Category Assessment

The site water storages described in Section 4.2 are subject to the assessment of a Consequence Category, as per the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures* (DEHP, 2016). The consequence category assessment has been undertaken for each *storage type* based on the currently available information, and it is envisaged that the assessment will be revisited for each individual storage as part of the detailed design phase. The assessment involved a review of potential harm, associated with failure-to-contain or dam break scenarios. Section 5.4 presents a summary of the consequence category assessment outcome.

5.2 Consequence Category Assessment Requirements

The Manual (Version 5.00, March 2016) sets out the requirements of the administering authority for a consequence category assessment and certification of the design of regulated structures, constructed as part of environmentally relevant activities under the Environmental Protection Act (1994). The purpose of the Manual is to:

- Guide the assessment of the Consequence Category of all structures constructed as part of activities that require an EA or development approval.
- Guide the determination of the structure that requires formal documentation.
- Provide approved methods for specifying the design performance and monitoring requirements for those structures.

Assessment criteria for consequence category assessments are based on the following failure event scenarios:

- | | |
|--------------------------------------|---|
| (a) Failure to contain - seepage | - spills or release to ground and/or groundwater via seepage from the floor and/or sides of the structure. |
| (b) Failure to contain - overtopping | - spills or releases from the structure that result from loss of containment due to overtopping of the structure. |
| (c) Dam Break | - collapse of the structure due to any possible cause. |

Under the above scenarios, several modes of failure are possible as described below:

- A failure to contain scenario means a release from the structure that results from loss of containment due to excessive seepage, overtopping of the structure and/or other deficiencies in water management aspects of the storage. Although such a failure mechanism is typically non-flood producing, failure to contain events may involve the release of contaminants, which could endanger environmental values or human life/wellbeing.

- A dam break scenario involves the collapse of a dam due to any possible cause. A dam break is typically flood producing, also with the potential for rapid release of contaminants, either of which could endanger environmental values or human life. An embankment dam break could take place via the following failure modes:
 - o spillway failure,
 - o erosion-induced stability failure from flooding,
 - o piping failure, and,
 - o static or seismic stability failure.

The consequence category to be applied for a structure is the highest category determined under the three failure event assessments and the contaminant concentration/dam volume assessment, as outlined in the Manual.

The basis for assessment of consequence category from the Manual is reproduced in Table 13.

Table 13
Consequence Category Assessment

Environmental Harm	Consequence Category		
	High	Significant	Low
Harm to Humans	Location such that people are routinely present in the failure path and if present loss of life to greater than 10 people is expected ⁷ . Note: The requirement to consider the location of people in the failure path is only relevant to the ‘dam break’ scenario.	Location such that people are routinely present in the failure path and if present loss of life to 1 person or greater but less than 10 people is expected ⁷ . Note: The requirement to consider the location of people in the failure path is only relevant to the ‘dam break’ scenario.	Location such that people are not routinely present in the failure path and loss of life is not expected ⁷ . Note: The requirement to consider the location of people in the failure path is only relevant to the ‘dam break’ scenario.
	Location such that contamination of waters (surface and/or groundwater ⁸) used for human consumption could result in the health of 20 or more people being affected ⁹ .	Location such that contamination of waters (surface and/or groundwater ⁸) used for human consumption could result in the health of 10 or more people but less than 20 people being affected ⁹ .	Location such that contamination of waters (surface and/or groundwater ⁸) used for human consumption could result in the health of less than 10 people being affected ⁹ .
General environmental harm	Location such that: a) Contaminants may be released to areas of MNES, MSES or HEV waters that are not already authorised to be disturbed to at least the same extent under other conditions of this authority subject to any applicable offset commitment (Significant Values); and b) Adverse effects ¹⁰ on Significant Values are likely; and c) The adverse effects ¹⁰ are likely to cause at least one of the following: i) loss or damage or remedial costs greater than \$50,000,000; or ii) remediation of damage is likely to take 3 years or more; or iii) permanent alteration to existing ecosystems; or iv) the area of damage (including downstream effects) is likely to be at least 5km ² .	Location such that contaminants may be released so that adverse effects ¹⁰ (that are not already authorised to be disturbed to at least the same extent under other conditions of the authority subject to any applicable offset commitment) either: a) Would be likely to be caused to Significant Values but those adverse effects ¹⁰ would not be likely to meet the thresholds for the High consequence category and instead would be likely to cause at least one of the following: i) loss or damage or remedial costs greater than \$10,000,000 but less than \$50,000,000; or ii) remediation of damage is likely to take more than 6 months but less than 3 years; or iii) significant alteration to existing ecosystems; or iv) the area of damage (including downstream effects) is likely to be at least 1km ² but less than 5km ² . or b) Would be likely to be caused to environmental values classed as slightly or moderately disturbed waters ¹¹ , wetland of general ecological significance ¹² , riverine areas, springs or lakes and associated flora and fauna (Moderate Values), and the adverse effects ¹⁰ are likely to cause at least one of the following: i) loss or damage or remedial costs greater than \$20,000,000; or ii) remediation of damage is likely to take more than 1 year; or iii) significant alteration to existing ecosystems; or iv) the area of damage (including downstream effects) is likely to be at least 2 km ² .	Location such that either: a) Contaminants are unlikely to be released to areas of Significant Values or Moderate Values; or b) Contaminants are likely to be released to those areas, but would be unlikely to meet any of the minimum thresholds specified for the Significant Consequence Category for adverse effects ¹⁰
General economic loss or property damage	Location such that harm (other than a different category of harm as specified above) to third party assets in the failure path would be expected to require \$10 million or greater in rehabilitation, compensation, repair or rectification costs ¹³ .	Location such that harm (other than a different category of harm as specified above) to third party assets in the failure path would be expected to require \$1 million and greater but less than \$10 million in rehabilitation, compensation, repair or rectification costs ¹³ .	Location such that harm (other than a different category of harm as specified above) to third party assets in the failure path would be expected to require less than \$1 million in rehabilitation, compensation, repair or rectification costs ¹³ .

6 To be used for all failure event scenarios

7. ‘People routinely present in the failure path’ could be considered to be people who occupy buildings or other places of occupation that lie within the failure impact zone. For the purposes of this Manual, this should refer to people other than site personnel engaged by the resource operation and located on the tenements and tenure associated with the resource operation; for other ERAs, it would be the ‘premises referred to in the authority’. It should be noted that while this is appropriate for the assessment of consequence categories in accordance with this Manual, adherence to the requirements of this Manual does not limit, amend or change in any way, any other requirements to be complied with under relevant health and safety acts or legislation that requires the safety of site personnel to be considered.

8 When considering potential impacts on groundwater, it is not envisaged that a full hydrogeological assessment will be required in all cases. Any consideration of potential impacts on groundwater systems should consider the water quality of the potential receiving aquifer as well as the quality of fluid stored in the regulated dam. Existing groundwater drawdown in areas surrounding resource operations (e.g. drawdown as a result of mine pit or underground mine dewatering) can also be considered when assessing the consequence of dam seepage on groundwater systems.

9 ‘An adverse effect on human health means a physiological effect on human health and does not include an impact on the quality of downstream water that merely negatively affects taste and which is unlikely to cause persons to become physically ill.

10 Adverse effects include chronic and acute effects where an acute effect is on living organism/s which results in severe symptoms that develop rapidly, and a chronic effect is an adverse effect on a living organism/s which develops slowly. In some instances, it may be necessary to carry out or reference existing ecological/toxicological studies to assess the impacts of contaminants on living organisms.

11 See Water EPP for definitions

12 Wetland of general ecological significance’ means a wetland shown on a map of referable wetland as a ‘general ecologically significant wetland’ or ‘wetland of other environmental value’.

13 This does not include the holder’s own mine or gas production, on-site industrial or commercial assets, the holder’s workers’ accommodation, agricultural facilities on the holder’s land such as a farm shed or farm dam or infrastructure solely for servicing the holder.

5.3 Consequence Category Assessment

5.3.1 Site Water Dams (SWDs)

5.3.1.1 *Storage Description and Water Quality*

The SWDs are excavated voids with constructed embankments (cut/fill balance) used to contain pumped water captured within the pit sumps. It is envisaged that there will be up to two SWDs, located to the east of the overburden dump, downstream of the pit. Refer to Figure 001 for nominal locations.

The SWDs will be pumped out to adjacent watercourses during rainfall events that result in sufficient flow. Each dam will also contain an emergency spillway.

Given the source of the water contained within the SWDs (primarily water that has entered the pit and come into contact with disturbed surfaces), the water quality within the SWDs is expected to be potentially elevated in salts and also contain suspended solids.

5.3.1.2 *Failure to Contain - Seepage*

The SWDs have been assessed for a failure to contain - seepage scenario. This scenario assumes that water would seep through the dam wall into the subsurface profile.

The SWDs will be lined with low permeability material, meaning that seepage and release of contaminants through the dam liner is anticipated to be minimal, with seepage not likely to have a significant impact on downstream environmental values. It is also noted that regional groundwater quality is classed as saline (refer Section 2.5) with no known users of local groundwater resources.

Long term potential adverse effects on the environment due to release of contaminants to groundwater systems and soils profiles would be unlikely. Based on the consequence criteria outline in the Manual (reproduced in Table 13), the consequence category for 'failure to contain - seepage' is considered to be 'Low'.

5.3.1.3 *Failure to Contain - Overtopping*

The SWDs have been assessed for a failure to contain - overtopping scenario. The overtopping scenario therefore assumes that the 'mine affected water' contained within the storages would be released to the receiving environment. A summary of the outcomes is presented in Table 14.

Table 14
SWDs Failure to Contain - Overtopping Scenario

Categories of Harm	Assessment	Consequence Category
Harm to Humans	Based on expecting water quality it is considered that runoff from the SWDs would potentially be hazardous to human health if consumed. The following has been considered for the assessment: - It is considered that large populations do not exist directly downstream of the SWDs; - Given the relatively small volume of the SWDs it is assumed that volume of water which would be released as a result of an overtopping event would not significantly impact any individuals downstream. - Based on the above, an overtopping scenario is expected to affect less than 10 people The consequence category based on harm to humans is considered to be 'Low'.	LOW
General Environmental Harm	Based on expected water quality it is considered that runoff from the SWDs would not be likely to cause significant adverse effects on livestock and the environment. The following has been considered for the assessment: - The storages would discharge water from the spillways to the receiving environment. The concentrations of these contaminants would be unlikely to cause the following: - Significant alteration to existing ecosystems; - Affect an area of at least 1km²; - Cause loss or damage equal to greater than \$10,000,000; - Cause loss or damage that would require more than 6 months to remedy. - Adverse effects on significant values in this area would be unlikely. The consequence category for the SWDs, based on Harm to the Environment is therefore selected as 'Low'.	LOW
General Economic Loss or Property Damage	The location of the SWDs is such that relatively low economic loss is expected from any overtopping event. No major third-party assets have been identified downstream (using Google Earth imagery). Any overtopping event would flow in a north-easterly direction towards Cooroora Creek, and it is considered that the impact from an overtopping scenario would not be significant to third party assets (predominantly farm land downstream). Rehabilitation costs associated with an overtopping failure would be expected to be less than \$1 million.	LOW

5.3.1.4 Dam Break Scenario

The SWDs have been conceptually assessed for a failure to contain - dam break scenario.

The SWDs embankments are to be formed on the basis of an excavated cut/fill balance. If a dam break were to occur, water stored within the SWDs would flow into the local drainages immediately adjacent to the storages.

The failure impact of the SWDs has not been quantitatively assessed for the purpose of this conceptual assessment; however, it is noted that based on the cut/fill balance method of construction, a portion of the storage below natural ground level would likely be maintained in the event of any embankment breach.

The release of water from the SWDs under this scenario is considered unlikely to cause the following:

- Significant alteration to existing ecosystems;
- Cause loss or damage equal to greater than \$10,000,000; or,
- Cause loss or damage that would require more than 6 months to remedy.

Given that discharge from a dam break is likely to be generally contained within the local watercourses and that no major third-party assets located downstream, it is considered that the impact from a dam break scenario would not be significant to third party assets, with rehabilitation costs expected to be less than \$1 million. It is also considered that loss of life is not expected due to the nature of downstream land use and the fact that people would not routinely be expected to be present within the failure path.

It is therefore considered that overall consequence category for a dam break scenario is 'Low'.

5.3.1.5 Consequence Category Outcome

Based on the above failure scenarios, the consequence category of the SWDs is considered to be 'Low' and as such, are not classified as "Regulated Structures".

5.3.2 Pit Sumps

5.3.2.1 Storage Description and Water Quality

The Pit Sumps will be constructed within the active pit area in order to provide a collection point for pit water (originating from direct rainfall or runoff from upstream catchments where unable to be diverted). It is intended that the sumps be constructed at low points within the pit, with localised drainage and bunds used to direct inflows to the sumps, in order to pump contained water to the SWDs on the surface, for treatment and/or release to environment as appropriate. A nominal capacity of the sumps shall exist for the purpose of maintaining low water levels; however available capacity within the surface SWDs shall dictate the pump out rates and subsequent accumulated volumes within the pit. These volumes would exceed the 'capacity' of the sumps at times; however, the significant capacity within the pit itself would serve to buffer storage demand on the SWDs if not available.

5.3.2.2 Failure to Contain - Seepage

The Pit Sumps have been assessed for a failure to contain - seepage scenario. This scenario assumes that that water would seep through the pit walls and base of the sump into the subsurface profile.

The Pit Sumps will be formed as excavated storages within the pit, with no clay or geomembrane liners. Seepage through the pit wall has the potential to adversely affect groundwater quality, with possible significant alteration to existing ecosystems. However, it is likely that water quality within the pit sumps will be consistent with the assumed regional quality topography and as such, release of contaminants to the receiving environment via seepage is considered to have limited potential to cause impact to the downstream environment. Based on the consequence criteria outline in the Manual (reproduced in Table 13), the consequence category for ‘failure to contain - seepage’ is considered to be ‘Low’.

5.3.2.3 Failure to Contain - Overtopping

The Pit Sumps have been assessed for a failure to contain - overtopping scenario, with a summary of the outcomes presented in Table 15.

Table 15
Pit Failure to Contain - Overtopping Scenario

Categories of Harm	Assessment	Consequence Category
Harm to Humans	The Pit Sumps store mine affected water collected from direct rainfall and surface runoff from upstream catchments entering the pits. The following has been considered for the assessment: - The storage capacity within the pit itself is considered to be in excess of the PMP event for the site, and as such, overtopping of the pit is considered extremely unlikely; - It is considered that large populations do not exist directly downstream of the Pit; - No known residences were identified immediately downstream of the Pit. It is therefore considered that loss of life is unlikely; - Based on the above, an overtopping scenario is expected to affect less than 10 people. The consequence category based on harm to humans is considered to be ‘Low’.	LOW
General Environmental Harm	It is considered that overtopping of the Pits would result in mine affected water being discharged into the receiving environment. The following has been considered for the assessment: The storage capacity within the pit itself is considered to be in excess of the PMP event for the site, and as such, overtopping of the pit is considered extremely unlikely. The consequence category for the Pits, based on Harm to the Environment is therefore selected as ‘Low’.	LOW
General Economic Loss or Property Damage	The location of the Pits is such that relatively low economic loss is expected from any overtopping event. No major third-party assets have been identified downstream (using Google Earth imagery). As above, the storage capacity within the pit itself is considered to be in excess of the PMP event for the site, and as such, overtopping of the pit is considered extremely unlikely	LOW

5.3.2.4 *Dam Break Scenario*

The Pit Sumps have been assessed for a failure to contain - dam break scenario.

Given that the Pit Sumps are formed as excavated storages within the Pits and do not comprise any formal embankment above ground, a dam break scenario cannot occur. It is therefore considered that overall consequence category for a dam break scenario is 'Low'.

5.3.2.5 *Consequence Category Outcome*

Based on the above failure scenarios, the consequence category of the Pit Sumps is considered to be 'Low' and as such, are not classified as "Regulated Structures".

5.3.3 Summary

Consequence category assessment has been undertaken for the following surface water storage types for the project:

- Site water dams; and,
- Pit sumps.

The consequence category of all storage types was assessed as 'Low' and as such, are not classified as "Regulated Structures".

It is however recommended that the hydraulic capacity and inspection and maintenance regimes for any surface storage structures with a 'Low' assessment still be designed and planned in accordance with the requirements of a dam assessed as having a 'Significant' consequence category.

6 POST MINING WATER MANAGEMENT

The design of the final landform was not available at the time of this report. However, the expected extent of the final landform (after seven years) is shown on Figure 007 and represents the extent of rehabilitation works on completion of mining activity. As such, the total extent of the final landform would exist as clean water catchment, which would generally drain either to the west (to the final voids) or to the watercourses to the east. The final landforms will be subject to investigation works and detailed design and would typically include assessment of the water chemistry, surrounding environment and consideration of infrastructure to remain post closure (subject to relevant agreements).

The typical objectives to be adopted for rehabilitation of the overburden dumps would be to create landforms that are:

- Stable and sustainable;
- Safe to humans and wildlife;
- Of minimum long-term environmental impact (i.e. non-polluting); and
- Able to sustain an appropriate land use after rehabilitation.

Consideration of specific water management aspects that are relevant to the post-closure condition are as follows:

Final Voids: As described in Section 4.3 it is expected (although unconfirmed) that the final voids would naturally fill with surface water runoff over time. The water quality in the final voids would be expected to improve over time as the revegetated surfaces of the rehabilitated overburden dump establish and mature, thus reducing the mobilisation of sediments and remnant salinity associated with the operational phase of the mine. Final water levels in the voids have not been assessed, however these voids could overflow during rainfall events discharging to the natural environment on the eastern and northern extents of the project site.

Drainage Systems: The final landform design will need to consider shaping of effective drainage lines in order to shed surface runoff without causing erosion of the final land surface. In the establishment phase, this will comprise cleaning of all drains, landscaping and placement of a soil layer that is followed with revegetation. Permanent drainage will be designed and constructed for long term durability, which could include increasing capacity, reducing gradients or providing erosion protection as required.

7 WATER QUALITY MONITORING

7.1 Surface Water Quality Monitoring Approach

Water quality monitoring of site water storages and downstream of the release locations would be undertaken to examine surface water quality at the site. Monitoring of storages would be undertaken on a monthly basis at a minimum, and daily during release events. Surface water samples in water courses should be collected during flow events.

7.1.1 Monitoring Locations

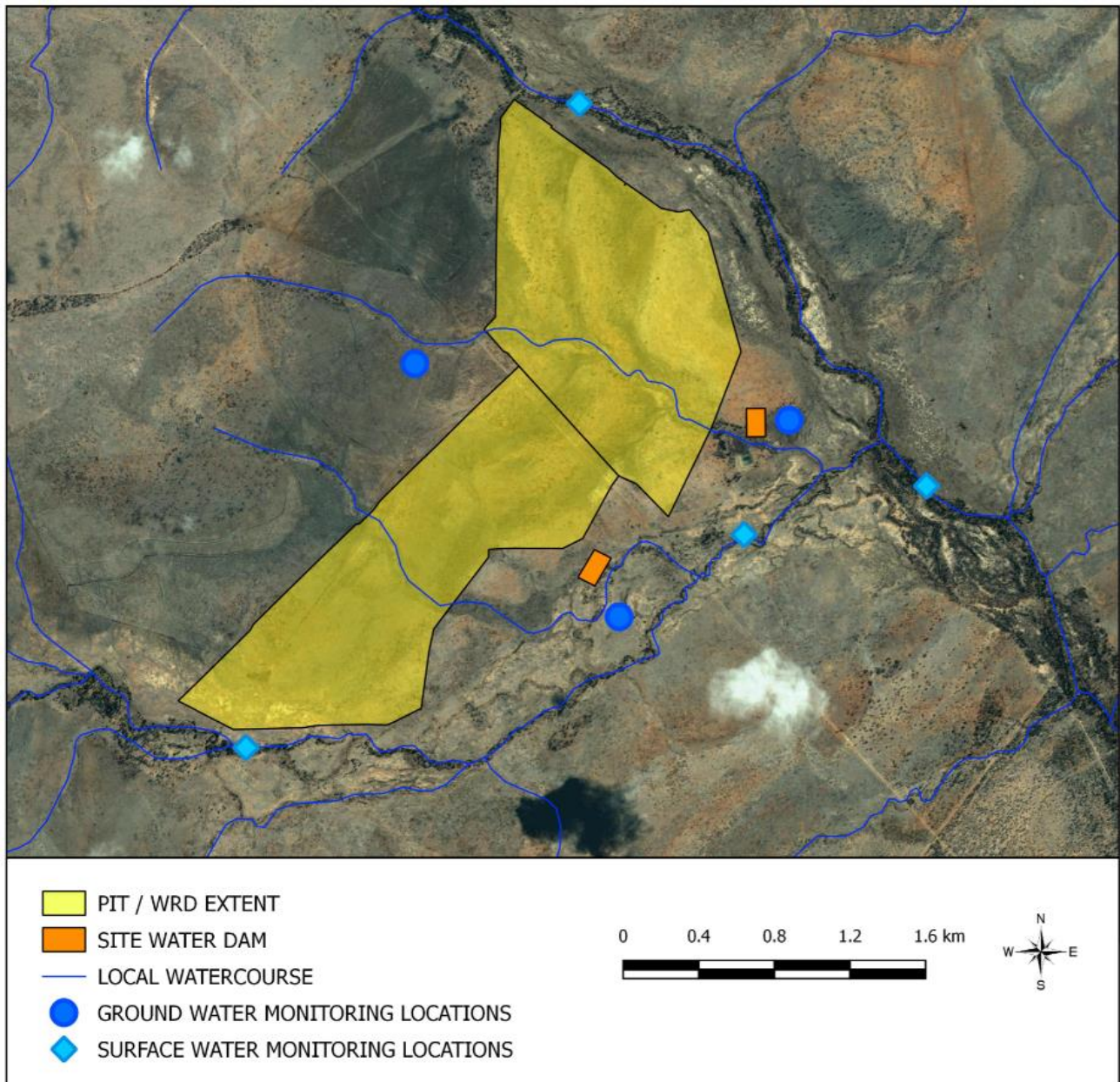
The water quality monitoring program will comprise sampling from the following locations:

CWSs	-	Receiving environment discharge points for Clean Water Sumps
Sediment Ponds	-	Pre-strip area sediment ponds prior to release to downstream point
SWDs	-	Receiving environment discharge point for Site Water Dams

The monitoring locations shall be selected so as to ensure sufficient mixing of flows is able to occur prior to sampling. These nominal monitoring locations are shown on Plate 25.

Water flows will also be measured through constructed V-notch weirs on dam outflows and flow meters on pipeline transfers.

Plate 25
Monitoring Locations



7.1.2 Monitoring Parameters

Initial surface water quality monitoring at sites indicated on Plate 25 would be undertaken for a full suite of parameters, as follows:

- | | |
|-------------------------------------|--------------------|
| • pH (in-situ) | • Total Phosphorus |
| • Electrical Conductivity (in-situ) | • Manganese |
| • Dissolved Oxygen (in-situ) | • Zinc |
| • Turbidity (in-situ) | • Iron |
| • Sulphate | • Nitrite |
| • Bicarbonate | • Alkalinity |

- Magnesium
- Sodium
- Potassium
- Calcium
- Chloride
- Nitrate
- Cadmium
- Chromium
- Cobalt
- Copper
- TOC
- Ammonia
- Aluminium
- Arsenic
- Boron
- Fluoride
- Lead
- Mercury
- Molybdenum
- Nickel
- Selenium
- Silver
- Petroleum Hydrocarbons
- Uranium
- Vanadium

The list of parameters will be reduced based on the initial surface water quality results.

7.1.3 Monitoring Analyses

Surface water quality monitoring results would be assessed against exceedance and trigger value limits identified in the environmental authority conditions, as well as the Water Quality Objectives listed in Section 2.5.

7.2 Groundwater Quality Monitoring Approach

Groundwater quality monitoring within the and around the project site would be undertaken to examine groundwater levels and water quality at the site. Groundwater monitoring would be undertaken on a quarterly (3-monthly) basis during mine operations and annually post-closure.

7.2.1 Monitoring Locations

Groundwater monitoring locations would be determined based on the hydrogeological investigation undertaken, with background monitoring bores (hydraulically upgradient from the mine) and detection monitoring bores (located hydraulically downgradient) would be constructed in order to identify any groundwater impacts occurring as a result of mining activities. It is expected that groundwater flow would generally occurring in a west to east direction with nominal background and detection sites shown on Plate 25.

7.2.2 Groundwater Level Monitoring

Groundwater level monitoring would be undertaken prior to sampling for groundwater quality data analyses. The purpose of groundwater level monitoring would be to confirm the groundwater flow direction, through inference of groundwater contours.

7.2.3 Monitoring Parameters

Initial groundwater quality monitoring would be undertaken for a full suite of parameters, as follows:

- pH (in-situ)
- Electrical Conductivity (in-situ)
- Dissolved Oxygen (in-situ)
- Turbidity (in-situ)
- Nitrate
- TOC
- Sulphate
- Chloride
- Bicarbonate
- Ammonia
- Mercury
- Molybdenum
- Nickel
- Selenium
- Silver
- Petroleum Hydrocarbons
- Uranium
- Vanadium
- Total Phosphorus
- Magnesium
- Sodium
- Potassium
- Calcium
- Manganese
- Zinc
- Iron
- Nitrite
- Alkalinity
- Aluminium
- Arsenic
- Boron
- Cadmium
- Chromium
- Cobalt
- Copper
- Fluoride
- Lead

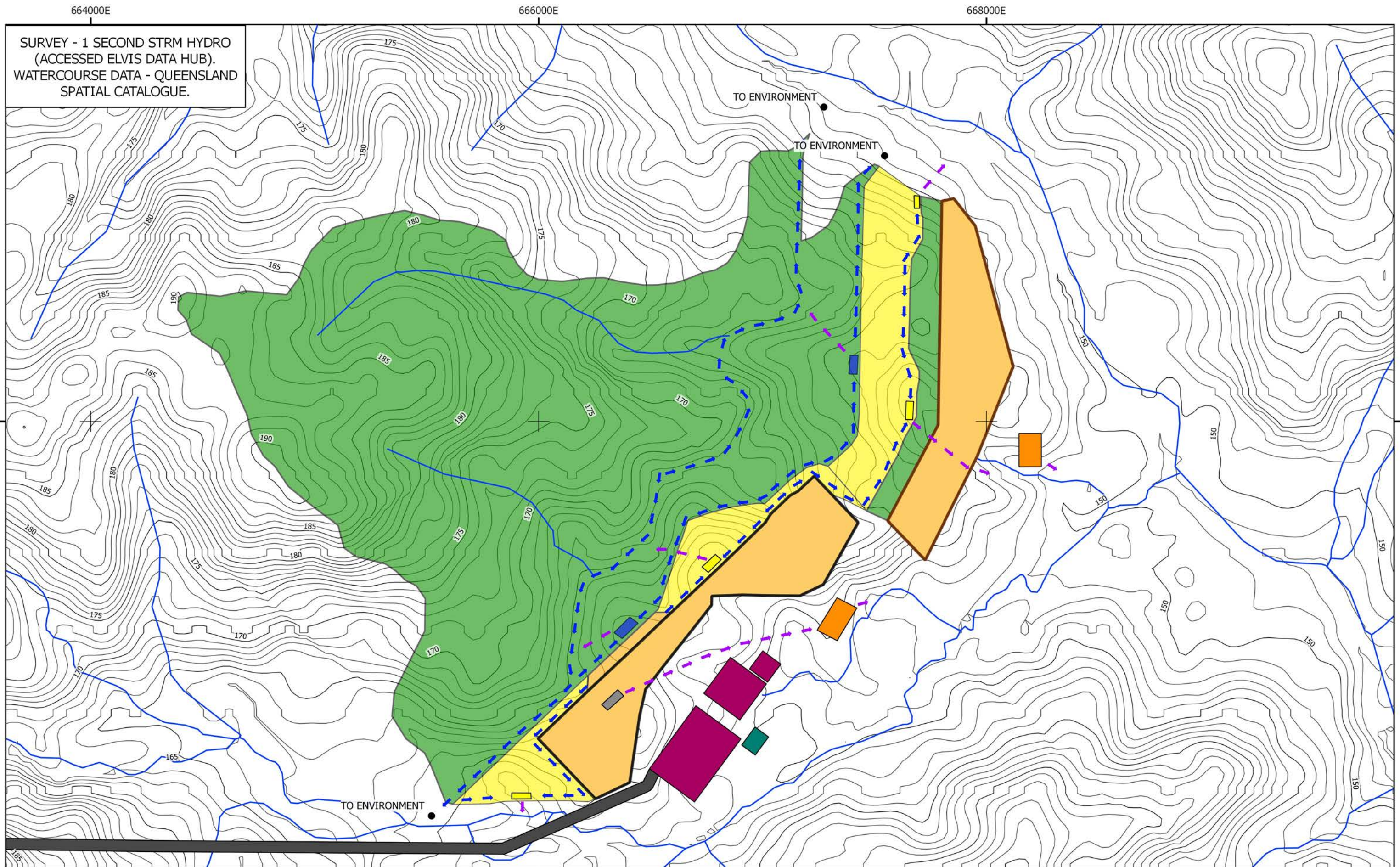
This list of parameters will be reduced based on the initial groundwater quality results.

7.2.4 Monitoring Analyses

Groundwater quality monitoring results would be assessed against exceedance and trigger value limits identified in the environmental authority conditions, as well as the Water Quality Objectives listed in Section 2.5.

REFERENCES

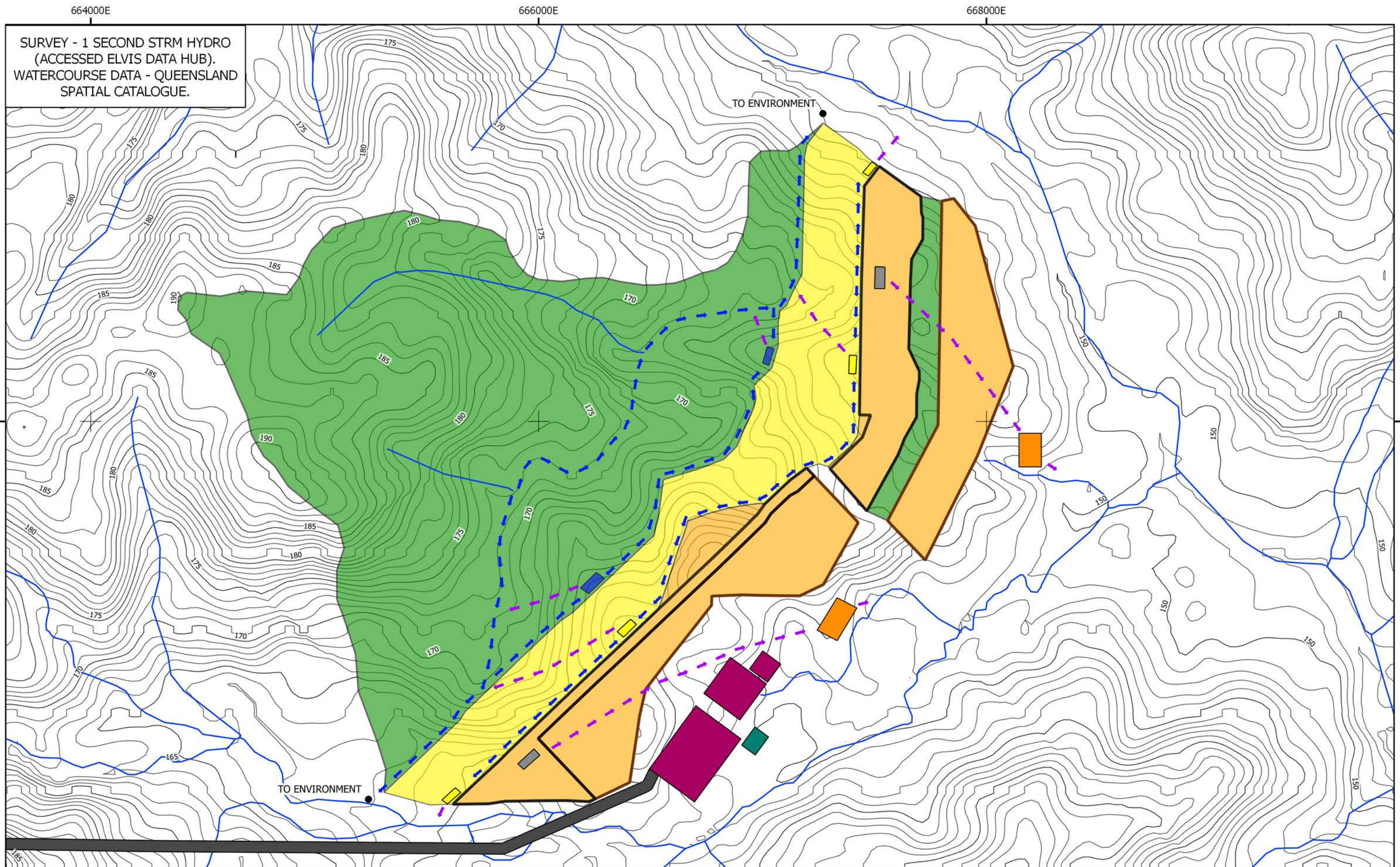
- [1] ANCOLD, *Guidelines on Dam Safety Management*, August 2003.
- [2] Department of Environment and Heritage Protection, *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures*, 2016.
- [3] Geoscience Australia, 2011. 1 Second SRTM Derived Products User Guide. Version 1.0.4. October 2011.
- [4] Mining Atlas. 2017. *Fairhill- Mining Atlas*. [ONLINE] Available at: <https://mining-atlas.com/project/Fairhill-Coal-Mine-Project.php>. [Accessed 9 October 2017].



SURVEY - 1 SECOND STRM HYDRO
(ACCESSED ELVIS DATA HUB).
WATERCOURSE DATA - QUEENSLAND
SPATIAL CATALOGUE.

- LEGEND
- | | | | |
|--------------------|--------------|-----------------------|---------------------------------|
| — 5m CONTOURS | ▭ PIT EXTENT | ▭ PIT SUMP | ▭ PRE-STRIP SEDIMENT TRAP |
| — DRAINAGE FEATURE | ▭ WRD EXTENT | ▭ SITE WATER DAM | ▭ CLEAN WATER CATCHMENT |
| → DIVERSION DRAIN | ▭ ROM DAM | ▭ CLEAN WATER SUMP | ▭ PRESTRIP WATER CATCHMENT |
| → WATER TRANSFER | ▭ HAUL ROAD | ▭ SITE INFRASTRUCTURE | ▭ MINE AFFECTED WATER CATCHMENT |

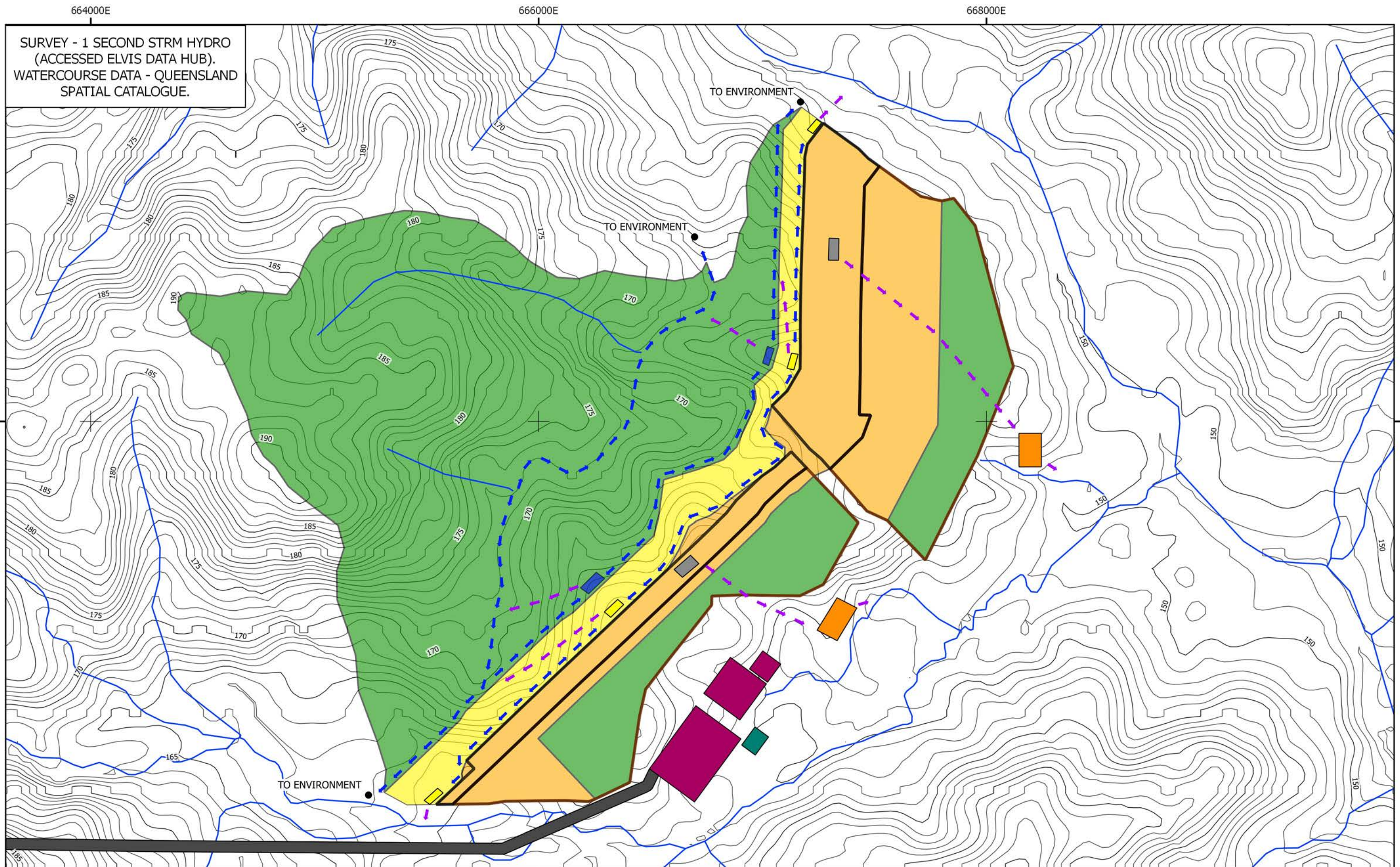
FIGURE 001
FAIRHILL PROJECT
CONCEPTUAL WATER MANAGEMENT SYSTEM
YEAR 1



SURVEY - 1 SECOND STRM HYDRO
(ACCESSED ELVIS DATA HUB).
WATERCOURSE DATA - QUEENSLAND
SPATIAL CATALOGUE.

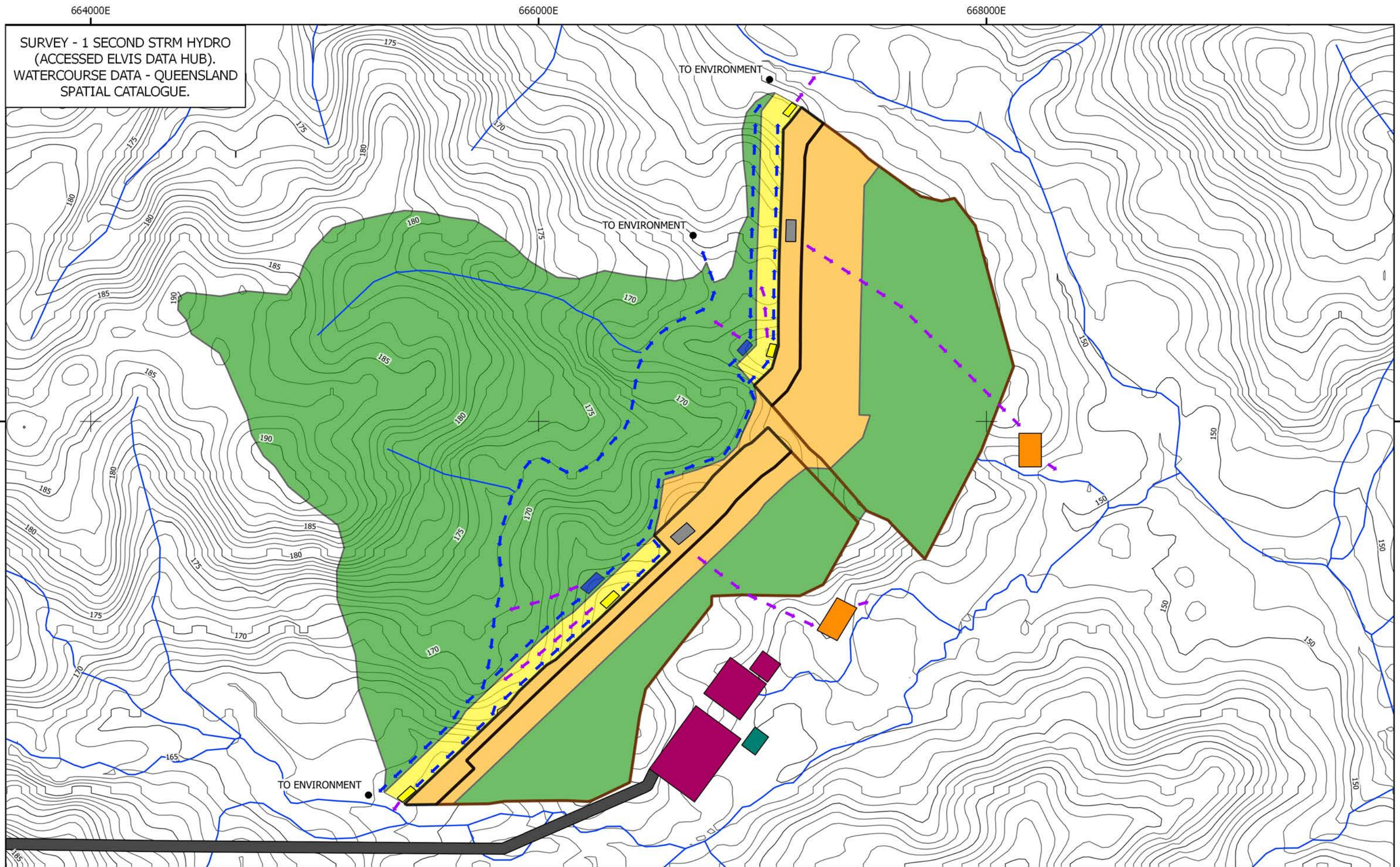
- LEGEND
- | | | | |
|------------------|------------|---------------------|-------------------------------|
| 5m CONTOURS | PIT EXTENT | PIT SUMP | PRE-STRIP SEDIMENT TRAP |
| DRAINAGE FEATURE | WRD EXTENT | SITE WATER DAM | CLEAN WATER CATCHMENT |
| DIVERSION DRAIN | ROM DAM | CLEAN WATER SUMP | PRESTRIP WATER CATCHMENT |
| WATER TRANSFER | HAUL ROAD | SITE INFRASTRUCTURE | MINE AFFECTED WATER CATCHMENT |

FIGURE 002
FAIRHILL PROJECT
CONCEPTUAL WATER MANAGEMENT SYSTEM
YEAR 2



- LEGEND
- | | | | |
|------------------|------------|---------------------|-------------------------------|
| 5m CONTOURS | PIT EXTENT | PIT SUMP | PRE-STRIP SEDIMENT TRAP |
| DRAINAGE FEATURE | WRD EXTENT | SITE WATER DAM | CLEAN WATER CATCHMENT |
| DIVERSION DRAIN | ROM DAM | CLEAN WATER SUMP | PRESTRIP WATER CATCHMENT |
| WATER TRANSFER | HAUL ROAD | SITE INFRASTRUCTURE | MINE AFFECTED WATER CATCHMENT |

FIGURE 003
FAIRHILL PROJECT
CONCEPTUAL WATER MANAGEMENT SYSTEM
YEAR 3



LEGEND

— 5m CONTOURS	▭ PIT EXTENT	▭ PIT SUMP	▭ PRE-STRIP SEDIMENT TRAP
— DRAINAGE FEATURE	▭ WRD EXTENT	▭ SITE WATER DAM	▭ CLEAN WATER CATCHMENT
➡ DIVERSION DRAIN	▭ ROM DAM	▭ CLEAN WATER SUMP	▭ PRESTRIP WATER CATCHMENT
➡ WATER TRANSFER	▭ HAUL ROAD	▭ SITE INFRASTRUCTURE	▭ MINE AFFECTED WATER CATCHMENT

FIGURE 004
FAIRHILL PROJECT

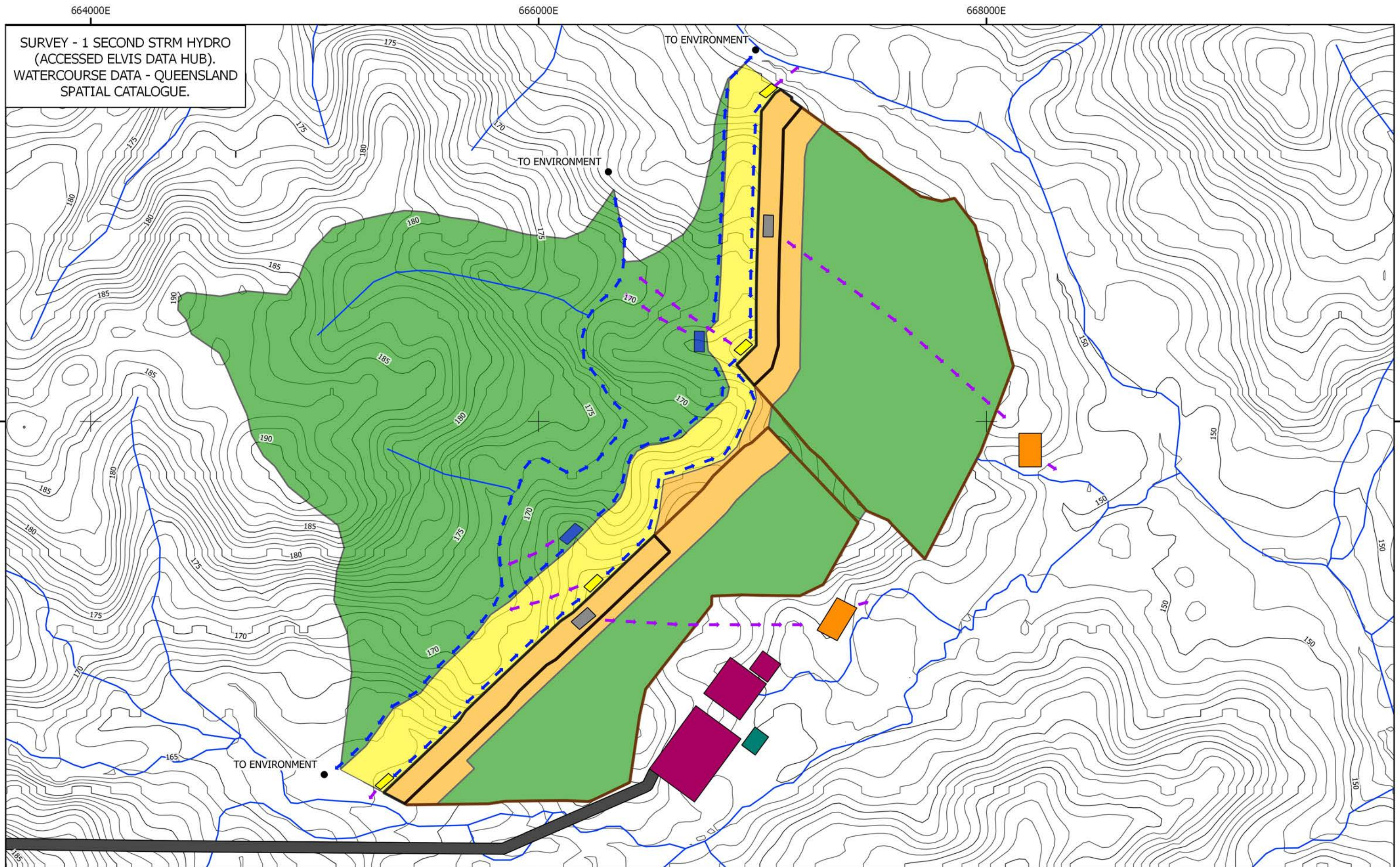
CONCEPTUAL WATER MANAGEMENT SYSTEM
YEAR 4

0 200 400 600 800 m

ATC Williams

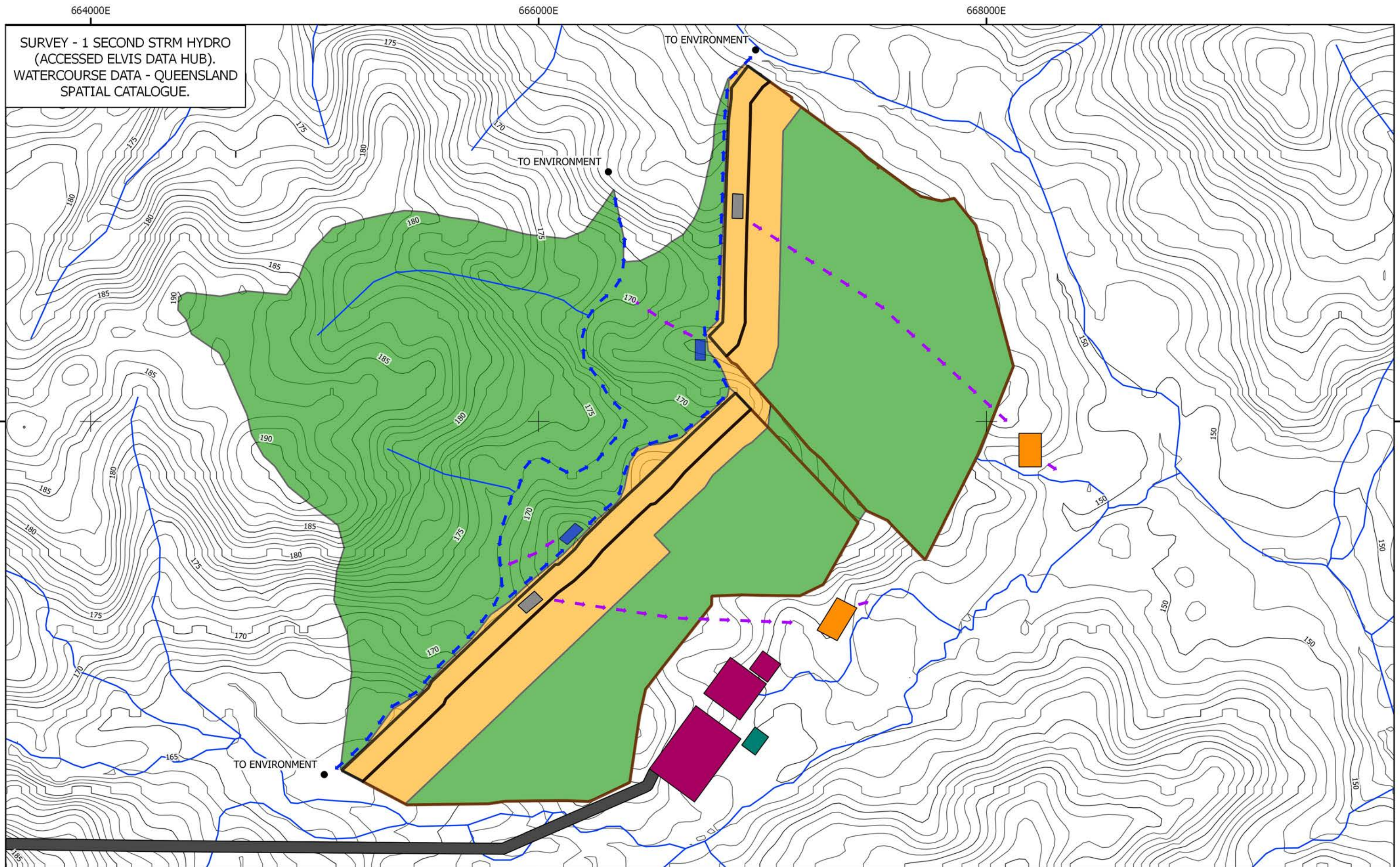
DATE: 2019-06-11

CRS: GDA94 / MGA Zone 55



- LEGEND
- | | | | |
|------------------|------------|---------------------|-------------------------------|
| 5m CONTOURS | PIT EXTENT | PIT SUMP | PRE-STRIP SEDIMENT TRAP |
| DRAINAGE FEATURE | WRD EXTENT | SITE WATER DAM | CLEAN WATER CATCHMENT |
| DIVERSION DRAIN | ROM DAM | CLEAN WATER SUMP | PRESTRIP WATER CATCHMENT |
| WATER TRANSFER | HAUL ROAD | SITE INFRASTRUCTURE | MINE AFFECTED WATER CATCHMENT |

FIGURE 005
FAIRHILL PROJECT
CONCEPTUAL WATER MANAGEMENT SYSTEM
YEAR 5



SURVEY - 1 SECOND STRM HYDRO
(ACCESSED ELVIS DATA HUB).
WATERCOURSE DATA - QUEENSLAND
SPATIAL CATALOGUE.

- LEGEND
- | | | | |
|--------------------|--------------|-----------------------|---------------------------------|
| — 5m CONTOURS | ▭ PIT EXTENT | ▭ PIT SUMP | ▭ CLEAN WATER CATCHMENT |
| — DRAINAGE FEATURE | ▭ WRD EXTENT | ▭ SITE WATER DAM | ▭ MINE AFFECTED WATER CATCHMENT |
| → DIVERSION DRAIN | ▭ ROM DAM | ▭ CLEAN WATER SUMP | |
| → WATER TRANSFER | ▭ HAUL ROAD | ▭ SITE INFRASTRUCTURE | |

FIGURE 007
FAIRHILL PROJECT
CONCEPTUAL WATER MANAGEMENT SYSTEM
YEAR 7

FAIRHILL COAL PROJECT

Guideline Response for Activities with Impacts to Water APPENDIX A

Prepared for:

Fairhill Coking Coal Pty Ltd
GPO Box 225
SYDNEY NSW 2001

PREPARED BY

SLR Consulting Australia Pty Ltd
ABN 29 001 584 612
Level 1, 514 Sturt Street
Townsville QLD 4810 Australia
(PO Box 1012 Townsville QLD 4810 Australia)
T: +61 7 4722 8000
E: townsville@slrconsulting.com www.slrconsulting.com

BASIS OF REPORT

This report has been prepared by SLR Consulting Australia Pty Ltd with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with Fairhill Coking Coal Pty Ltd (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of the Client. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR

SLR disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
623.17171-R01-v0.1	28 June 2019	M Jha	F McPherson	D Taylor

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1 Introduction

Fairhill Coking Coal Pty Ltd (Fairhill Coking Coal), a wholly owned subsidiary of Futura Resources Ltd (Futura) is applying for an Environmental Authority (EA) for its Fairhill coal project (FHCP). This report is a response to the application requirements for activities with impacts to water (ESR/2015/1837, Version 4.00). In addition, this guideline response has been updated in accordance with the Information Request from the Department of Environment and Science provided to Futura dated 04 March 2019, reference ZENDESK 11657.

1.1 Background

The FHCP is located within the Isaac Regional Council. It is located approximately 55km northeast of Emerald and 195km west of Rockhampton in Queensland's Bowen Basin. The project is in close proximity to other coal mines, coal mining infrastructure and coal deposits. Surrounding mines and resources as shown in **Figure 1** include:

- Ensham's Yongala Mine, 18km to the southwest
- Kestrel (25km), Crinum and Gregory (32km) Mines to the west
- Oaky Creek Mine, 24km to the northwest and
- Mackenzie Coal Project, 33km to the east.

A staged open cut seven year mine plan has been developed for FHCP that targets an annual run-of-mine (ROM) coal production rate of up to 1.7 million tonnes per annum (Mtpa) after an initial ramp up during year one.

Mining will occur by conventional truck/excavator to recover over burden mineral waste material, with thin seam coal recovered using surface miners. Excavated mineral waste will be hauled and placed over the dozer push spoil piles during steady state strip mining to backfill the pit to approximately the original topography, creating a low-cost rehabilitated landform.

This report has been prepared in accordance with the Queensland Department of Environment and Science (DES) guideline ESR/2015/1837 "*Application requirements for activities with impacts to water*". The main objective of this report is to provide information set out in sections 3–6 of the guideline. It focuses on the impacts that environmentally relevant activities (ERAs) proposed as part of FHCP will have on receiving waters.

1.2 Legislative Context

Impacts to receiving waters from undertaking ERAs are regulated in Queensland by the:

- *Environmental Protection Act 1994 (EP Act)*
- *Environmental Protection Regulation (EP Reg) and*
- *Environmental Protection (Water) Policy 2009 (EPP Water)*

The EP Act sets out the criteria for ERAs. Environmental values (EVs) of waters are broadly defined in the EP Reg. The EPP (Water) defines sub-basin level EVs of the receiving waters and corresponding water quality objectives. Groundwater and surface water EVs and water quality objectives (WQOs) have been developed for Nogoa and Mackenzie River sub-catchments (EHP, 2011a and EHP, 2011b) under the EPP Water.

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FAIRHILL

FIGURE 1
FAIRHILL
REGIONAL CONTEXT

Legend

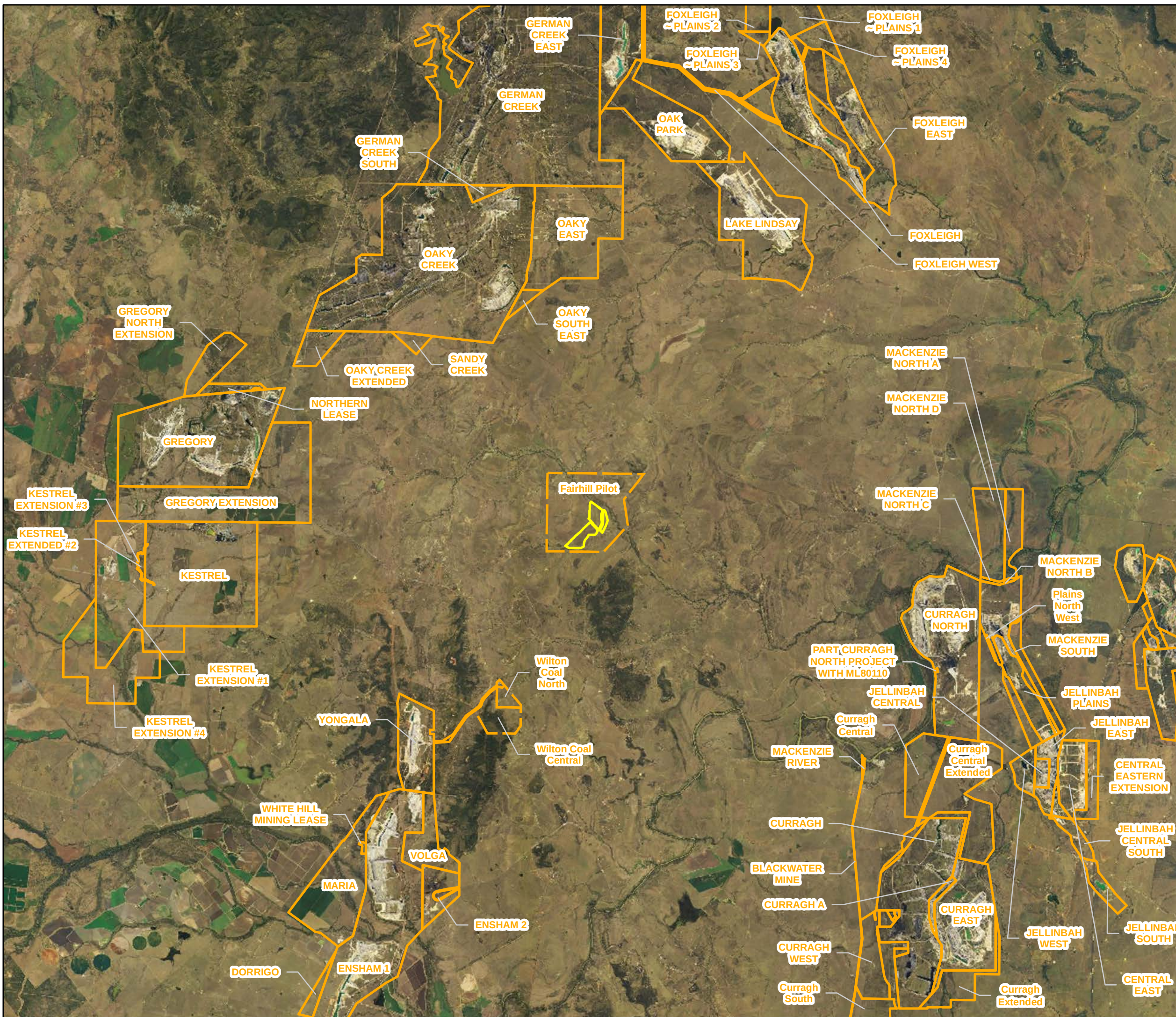
-  Mining Lease (Application)
-  Mining Lease (Granted)
-  7 Year Pit Shell

Data Sources:
Mining Lease dataset: © State of Queensland (Department of Natural Resources, Mines, and Energy) 2019; 7 Year Pit Shell and Proposed Site Infrastructure datasets: derived from client data on file (SLR Consulting) 2019.
Imagery Source: 70cm Bowen Basin SISP PeriUrban 2012 Orthophoto Image Service: © State of Queensland (Department of Natural Resources, Mines, and Energy) 2019.
Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator
Datum: GDA 1994
Date: 31/05/2019



0 2.5 5 7.5 10
Kilometres

Scale: 1:250,000 at A3



1.3 Report structure

This report follows the structure of sections 3–6 of the DES guideline ESR/2015/1837:

- The second section of this report identifies environmental values of the receiving waters that can be potentially impacted due to ERAs proposed for the FHCP.
- The next section outlines possible impacts to identified environmental values
- The last section of this report provides details of proposed rehabilitation of FHCP

1.4 Topography and land use

The FHCP area consists of a west–east running ridge through the centre of the tenement. The elevation of the area ranges from approximately 215mAHD at the western boundary to 150mAHD within the bed of Cooroora Creek in the south-eastern corner of the tenement. The ridge slopes gently to the east, north and south, with slopes of generally less than 1%.

The majority of the project site has been altered by agricultural practices (light to medium density cattle grazing) and associated road and rail tracks. The impacts of these activities, including land clearing, weed invasion and accelerated erosion processes are observed in the project area.

1.5 Hydrology

The FHCP area is positioned within the upper reaches of Mackenzie River sub-catchment of the Fitzroy Basin. It is located close to the catchment divide between Mackenzie and Nogoa rivers as shown on the map “Drainage Basin Sub-catchments” in **Appendix A**. The drainage network at FHCP is ephemeral.

FHCP site is drained by Cooroora Creek and two of its tributaries, Back Creek and Sandy Creek. Cooroora Creek traverses the eastern half of the tenement flowing in a northwest to southeast direction. Sandy Creek traverses most of the southern part of the site in a west to east direction while Back Creek drains the northern part of the FHCP tenement. Cooroora Creek joins the Mackenzie River about 19km southeast of the FHCP.

1.6 Wetlands

The state-wide wetlands map on the Queensland Government Information Service website shows all wetlands of significance in Queensland. There are no wetlands of significance in the FHCP area or in close proximity to the proposed disturbance areas.

1.7 Rivers in strategic environmental areas

There are no strategic environmental areas in close proximity to the FHCP site as determined through an online search of the area on the Queensland Government Development Assessment Mapping System.

1.8 Groundwater bores

A review of the DNRME groundwater database (Queensland Government, 2018) revealed 11 registered groundwater bores within 10 km of the FHCP. The bores are presented in **Table 1** and shown in **Figure 2**. It should be noted that seven of the 11 registered bores are monitoring bores installed by Fairhill Coking Coal Pty Ltd (**Table 2**).

Airlift yields were available for 7 out of 11 registered bores. Measurable yields ranged from <0.1L/s to 2.5L/s (**Table 1** and **Table 2**). Some bores had very low yields that could not be measured reliably.

Out of the 11 bores, one bore (RN 67080) reported moderately fresh water (3,460 $\mu\text{S}/\text{cm}$). Saline water was encountered in eight out of 11 bores. No water quality details were recorded for RN 89347. RN165599 was dry at the time of drilling and has not made any water since.

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FIGURE 2
DNRME AND MINE
MONITORING BORES

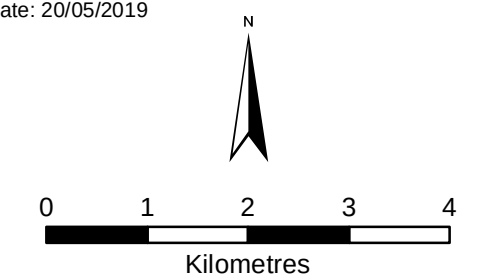
Legend

-  Mining Lease Permit (Application)
-  Proposed Site Infrastructure
-  7 Year Pit Shell

Bore Types

-  DNRME Registered Bores
-  FHCP Bores
-  WCP Bores

Data Sources:
DNRME Bores and Mining Lease datasets: the State of Queensland (Department of Natural Resources, Mines, and Energy) 2019; Fairhill Infrastructure datasets: SLR Consulting 2019.
Imagery Sources: 70cm Bowen Basin SISP PeriUrban 2012 Orthophoto Image Service: © State of Queensland (Department of Natural Resources, Mines, and Energy) 2019.
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Projection: Transverse Mercator
Datum: GDA 1994
Date: 20/05/2019



Scale: 1:75,000 at A3

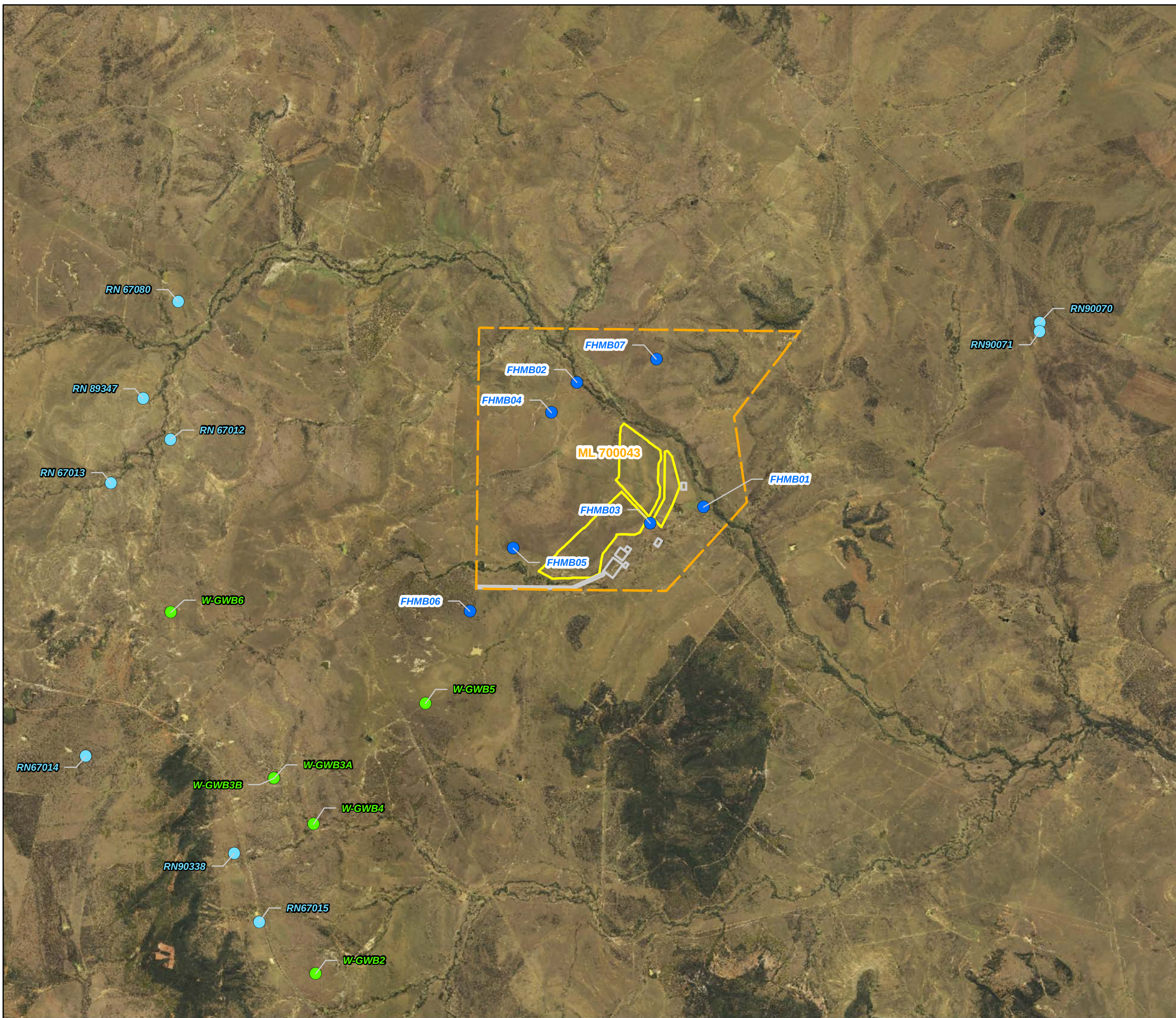


Table 1: Details of DNRME registered bores within 10km of the FHCP site

Bore	Year Drilled	Easting	Northing	Depth (M)	Yield (L/S)	water Quality	SWL (m below TOC) *	Source Aquifer
RN 67080	1900	657474	7434160	30.5	-	3, 460 µS/cm	-	-
RN 89347	1992	656726	7432113	26	0.27	-	-	Water in Basalt
Monitoring bores installed by Fairhill Coking Coal								
RN 165594	2018	FHMB06 (alternative name) – details provided in Table 2						
RN 165595	2018	FHMB05 (alternative name) – details provided in Table 2						
RN 165596	2018	FHMB04 (alternative name) – details provided in Table 2						
RN 165597	2018	FHMB02 (alternative name) – details provided in Table 2						
RN 165598	2018	FHMB07 (alternative name) – details provided in Table 2						
RN 165599	2018	FHMB03 (alternative name) – details provided in Table 2						
RN 165600	2108	FHMB01 (alternative name) – details provided in Table 2						
Abandoned and destroyed								
RN 67012	1920	657309	7431237	18.28	0.5	Very saline	6	Water in sandstone 6m below ground level
RN 67013	1920	656042	7430316	24.38	0.5	Very saline	6	water in sandstone 6 m below ground level
*SWL = Standing Water Level; TOC = top of casing								

Table 2: Details of existing monitoring bores at the FHCP site

Bore ID	Easting (GDA94 Zone 55)	Northing (GDA94 Zone 55)	Depth (m)	ELEVATION TOC (mAHD)	Screened interval (m)	Water struck (m)	Water encountered lithology	SWL (m bTOC)	RWL (m AHD)	Yield (L/S)	EC (µS/cm)
FHMB01	668618	7429805	24	151*	10 to 20	9	Alluvium/weathered basement	9.36	141.64	<0.1	44,600
FHMB02	665931	7432447	18.5	153.38	8 to 18.5	11	Coal/siltstone	7.73	151.27	1	25,300
FHMB03	667489	7429461	20	158.95	12 to 20	Dry	Screened in sandstone/siltstone	Dry	Dry	N/A	N/A
FHMB04	665391	7431805	29.5	168.34	18 to 29.5	24	Tuffaceous siltstone	21.43	148.57	0.44	16,400
FHMB05	664578	7428931	23.5	165.15	7.5 to 23.5	16	Coal/tuff	11.09	155.91	Too low to measure	15,400
FHMB06	663663	7427594	41	179.77	11 to 41	22	Sandstone, mudstone/coal	14.05	167.95	<0.1	24,600
FHMB07	667620	7432945	48	167.29	37 to 48	36	Sandstone, mudstone/coal	16.14	152.86	Too low to measure	17,900
RWL = reduced water level; SWL = Standing water level; m bTOC = meter below top of casing *FHMB01 top of casing elevation has not been surveyed. An approximate elevation from Google Earth has been used.											

1.9 Conceptual groundwater model

A conceptual groundwater model has been developed to visualise the hydrogeology around the mining lease and immediately surrounding, as well as the surface activities with potential impact to groundwater. The conceptual model is presented as a 2D map and a cross section in **section 4.4** of the “*Underground Water Impact Report*” attached as **Appendix A1** of this report.

1.10 Local stratigraphy

The local stratigraphy is shown in **Table 3**. It is composed of the Late Permian Burngrove, Fairhill, MacMillan and German Creek Formations. At the FHCP site, the Burngrove Formation is only present at the surface in the western section of the tenement. Tertiary material only covers a small mesa in the north-eastern corner of the tenement. Alluvium is common within the creek beds.

Cainozoic laterite cover is commonly found in the surrounding region capping ridges. Where present, the laterite presents as a hardened siliceous/ferrous cap to higher ground. Distinct laterite layers have not been reported from within the project area.

The strata in the region generally strike north-south and generally dip at angles of approximately three degrees to the west of the FHCP (ROM Resources, 2013). Dips can vary locally due to the presence of a series of synclines and anticlines. These smaller synclines and anticlines relate directly to structural deformation which occurred during the formation of the Comet Ridge and share a north-south axial strike. The nearest identified regional geological structures are an accurately mapped anticline situated to the northwest and an approximate anticline mapped to the east of the FHCP. These structures trend predominantly north-south. Folding has also caused strata to plunge at similar angles to the dips, from the northern and southern extents of the site towards the centre of the FHCP (**Figure 3**).

Table 3: Local stratigraphy of the FHCP. Adopted from Environmental Earth Sciences (2012), Scott *et al.* (1995) and Xstrata Coal (2012)

Age	Group	Formation	Description	Coal Seams
Quaternary	-	-	Unconsolidated sand and clay, with basal gravel and pebbles	-
Tertiary	-	Emerald Formation	Claystone and siltstone, sandstone, interbedded basalt (deeply weathered in outcrop)	-
<i>Unconformity</i>				
Permian	Blackwater Group	Burngrove Formation	Mudstone, siltstone, sandstone, coal and tuff	Pisces Virgo Libra Leo Aquarius Scorpio Centaur
		Fairhill Formation	Lithic and feldspathic labile sandstone with minor siltstone, mudstone, and coal seams	Phoenix Pegasus Hercules Canis Lepus Fairhill Fairhill Lower
	<i>Unconformity</i>			
	Back Creek group	Mac Millan Formation	Sandstone, siltstone, shale, mudstone	-
		German Creek Formation	Sandstone, siltstone, mudstone, coal seams	Pleiades Aquila Tier 1 Tier 2 Corvus Corvus 2 German Creek
		Ingelara Formation	Conglomeratic sandy siltstone, sandstone and mudstone	-
		Freitag Formation	Thin interbedded sandstone, siltstone, mudstone and minor coal seams	-

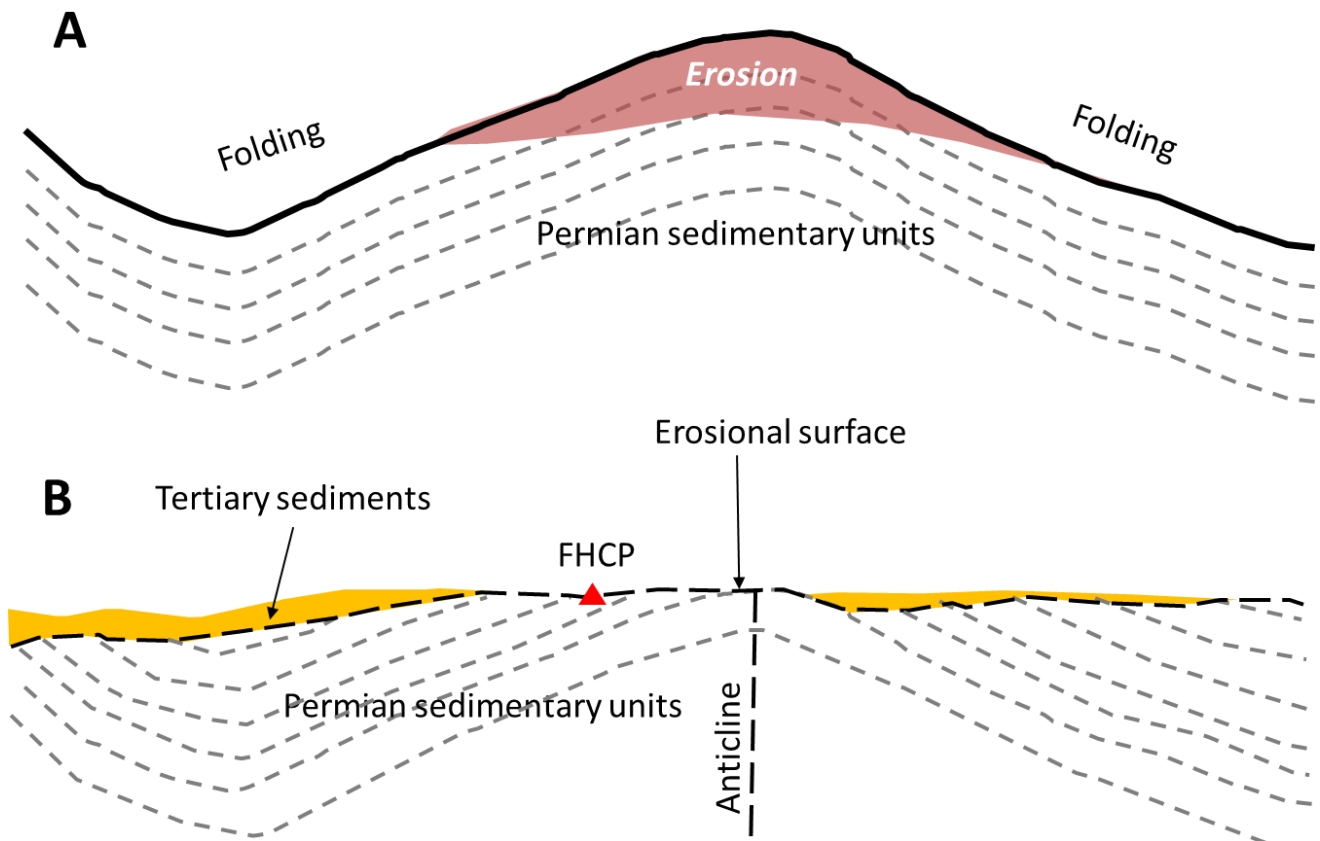


Figure 3: Conceptual diagram showing A: deformation and erosional processes and B: depositional processes that have occurred in the past in the region (not to scale; FHCP shown as red triangle)

1.11 Hydrogeology

Regionally, groundwater can potentially occur within the following Bowen Basin geological units:

- Quaternary alluvium.
- Tertiary sediments.
- Permian coal measures.

Within the FHCP, availability of water in geological strata is limited to coal measures.

1.11.1 Quaternary alluvial aquifers

Regionally, the main resource aquifers are located within the Quaternary alluvial deposits that occur in discontinuous lenses along major streams and rivers throughout the Nogoia and Mackenzie River sub-catchments. Locally, at the FHCP site, the thickness of Quaternary alluvium at the FHCP site is variable based lithology log of exploration hole FH006, and monitoring bores FHMB02 and FHMB01. The alluvium layer extends to approximately 11.5m deep at FH006, 6 m deep at FHMB02, and 10 m at FHMB01. The permeability of this unit is also variable depending on the proportion of coarse grained material. FHMB01 is the only registered bore in the vicinity of FHCP that intercepts groundwater from an alluvial aquifer overlying clay. Measured yield from this bore was limited (<0.1L/s) and groundwater was highly saline (44,600 $\mu\text{S}/\text{cm}$).

1.11.2 Tertiary sedimentary aquifers

As shown in **Figure 3**, the FHCP site consists mostly of the eroded Permian sedimentary units. Tertiary sediments are expected to have been deposited away from FHCP. Exploration and monitoring bore drill logs confirm this hypothesis.

1.11.3 Permian-Triassic strata aquifers and aquitards

Groundwater in the region exists in the confined Permian sandstone, siltstone and mudstone units and associated coal seams of the Burngrove and Fairhill Formations. The sedimentary units tend to be tuffaceous in nature with high clay content. The fine grains and lithified nature of these sedimentary strata results in low aquifer potential and much of the water-bearing units act as aquitards. Aquifer potential increases where there is contact between different rock types, e.g. sandstone, siltstone or coal—yields and permeability tend to increase. Deformation and fracturing in these units also increases aquifer potential. The coal seams can act as effective water-bearing and permeable units due to its low strength and high fracture potential. Un-fractured aquitards prevent vertical inter-mixing between aquifer layers. The MacMillan Formation mudstone and siltstones underlying the Fairhill Formation likely act as a regional aquitard, confining the even deeper German Creek Formation coal measures.

At FHCP, all of the monitoring bores have been installed to monitor groundwater in the Fairhill Formation. The Burngrove Formation occurs only as a thin, weathered layer covering part of the western portion of the tenement which does not hold groundwater. Therefore, no aquifers of the Burngrove Formation are likely to be found within FHCP.

1.11.4 Groundwater yields and flow direction

Airlift yield in the monitoring bores at FHCP were measured and ranged from <0.1 L/s to 1 L/s. Out of the seven existing bores at FHCP, two bores reported yield values 'too low to measure'. Hydraulic conductivity values were also estimated. The airlift yield and hydraulic conductivity values from each of the bores are presented in **Table 4** and shown in **Figure 4**.

The hydrologic cycle at the FHCP site is dominated by low rainfall, high evaporation rates and limited diffuse recharge, which largely occurs uniformly over the landscape (Scanlon *et al.*, 2002). Therefore, groundwater in the region is generally brackish to saline with only a few isolated locations able to produce small pockets of fresh groundwater. The Department of Environment and Heritage Protection (EHP) published a selection of maps (EHP, 2011) visualising a number of groundwater characteristics for the greater Fitzroy Basin. The maps confirm that the FHCP site is placed into a low rainfall, low recharge area of the Highlands Groundwater Management Area of the Water Plan (Fitzroy Basin) 2011.

Table 4 Yield rate and hydraulic conductivity values for existing monitoring bores at FHCP

Bore ID	Easting (GDA94 Zone 55)	Northing (GDA94 Zone 55)	SWL (m bTOC)	Yield (L/S)	Hydraulic Conductivity (m/D)
FHMB01	668618	7429805	9.36	<0.1	Not recorded
FHMB02	665931	7432447	7.73	1	1.732
FHMB03	667489	7429461	Dry	Dry	Not recorded
FHMB04	665391	7431805	21.43	0.44	0.303
FHMB05	664578	7428931	11.09	Too low to measure	0.016
FHMB06	663663	7427594	14.05	<0.1	0.002
FHMB07	667620	7432945	16.14	Too low to measure	0.001

1.11.5 Springs

There are no registered springs in the vicinity of the FHCP area and the geological strata hosting the targeted coal seams are not known to support spring flow on any scale. The nearest springs are located approximately 80 km south-east of the project area and originate from strata not associated with the FHCP (palustrine spring wetland associated with the Springsure Spring Supergroup). An unregistered spring used for cattle drinking was identified approximately 16 km south-southwest of the FHCP, adjacent to the proposed Wilton Coal Project. This spring seeps out at the contact between outcropping Permian sedimentary bedrock in the base of a gully and relatively permeable overlying Quaternary-aged colluvial material. It is believed that recharge of this spring occurs from rainfall at higher elevations to the north and west of the spring. Flow of seepage follows the slope of the topography. Low permeability of the strata enables prolonged seepage throughout the year.

1.12 Flooding potential at the site

The extents of a 1% annual exceedance probability flood and probable maximum flood are shown on maps titled Q100 flood extent and probable maximum flood extent in **Figure 5** and **Figure 6** respectively. A detailed flood assessment of the project area undertaken by ATC Williams (2019) is attached as **Appendix A2**. Modelled flood depths and velocities indicate that key development areas within the project site are at risk from flooding associated with Cooroora Creek and Sandy Creek, for the AEP 1% and above events.

Note that to mitigate the safety and operational risks associated with potential flood impacts of site infrastructure, detailed design of the project will require consideration of flood protection bunds and armouring of embankments and batter slopes, and/or the possibility of relocating infrastructure to ensure an acceptable risk from flood immunity.

1.13 Environmentally sensitive places within or adjacent to the mining lease

A map of environmentally sensitive areas as described in the *Environmental Protection Regulation 2008* within or adjacent to the mining lease has been obtained from DES's database. A full description of environmentally sensitive areas and regional ecosystems are described in the Guideline response to Land submitted with this application, together with the associated flora and fauna technical report.

FUTURA RESOURCES

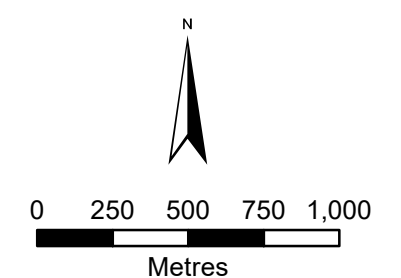
FAIRHILL

FIGURE 4
RECEIVING ENVIRONMENT
MONITORING PROGRAM

Legend

- Receiving Environment Monitoring Program (REMP) Sample Sites
- Watercourse
- Mining Lease (Application)
- 7 Year Pit Shell
- Proposed Site Infrastructure

Data Sources:
Watercourse and Mining Lease datasets: the State of Queensland (Department of Natural Resources, Mines, and Energy) 2019; REMP sites dataset: derived from client EA on file.
Imagery Sources: 70cm Bowen Basin SISP PeriUrban 2012 Orthophoto Image Service: © State of Queensland (Department of Natural Resources, Mines, and Energy) 2019.
Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator
Datum: GDA 1994
Date: 28/05/2019



Scale: 1:25,000 at A3

FAIRHILL COKING COAL PTY LTD

FAIRHILL FIGURE 5 Q100 FLOOD EXTENT

Legend

Proposed Site Infrastructure

7 Year Pit Shell

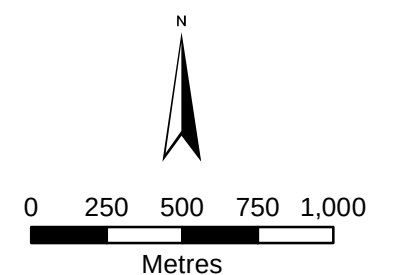
Mining Lease (Application)

Q100 Flood Peak Extent (mAHD)

High : 5.41

Low : 0.10

Data Sources:
Watercourse, Q100 Flood Extent (Queensland Flood Mapping Program - Flood Investigation - Fitzroy Basin 2015), and Mining Lease datasets: the State of Queensland (Department of Natural Resources, Mines, and Energy) 2019; Fairhill 7 Year Pit Shell dataset: SLR Consulting 2019.
Imagery Sources: 70cm Bowen Basin SISP PeriUrban 2012 Orthophoto Image Service: © State of Queensland (Department of Natural Resources, Mines, and Energy) 2019.
Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator
Datum: GDA 1994
Date: 29/05/2019



Scale: 1:25,000 at A3



FAIRHILL COKING COAL PTY LTD

FAIRHILL FIGURE 6 EXTREME PEAK FLOOD EXTENT

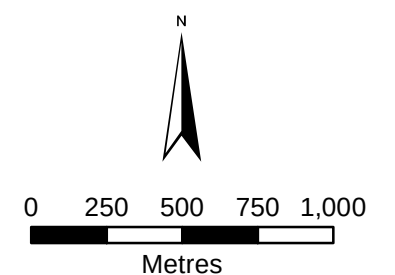
Legend

- Proposed Site Infrastructure
- 7 Year Pit Shell
- Mining Lease (Application)

Extreme Peak Flood Extent (mAHD)

- High : 9.46
- Low : 0.10

Data Sources:
Watercourse, Extreme Peak Flood Extent (Queensland
Flood Mapping Program - Flood Investigation - Fitzroy
Basin 2015), and Mining Lease datasets: the State of
Queensland (Department of Natural Resources, Mines,
and Energy) 2019; Fairhill 7 Year Pit Shell dataset: SLR
Consulting 2019.
Imagery Sources: 70cm Bowen Basin SISP PeriUrban
2012 Orthophoto Image Service: © State of
Queensland (Department of Natural Resources, Mines,
and Energy) 2019.
Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator
Datum: GDA 1994
Date: 29/05/2019



Scale: 1:25,000 at A3



2 Environmental Values of Receiving Waters

2.1 Background quality of surface waters

The primary goal of baseline monitoring is to document the temporal and spatial variations in surface water availability and quality at unimpacted reference locations. Baseline monitoring data can be used for deriving site-specific guideline values for surface water quality if the chosen reference locations meet the criteria specified in the Queensland water quality guideline (QWQG) (DEHP, 2009). QWQG recommends 18 sets of monitoring data be collected over at least a 12 month period, preferably 24 months, from suitable reference locations.

Currently, surface water is sampled from the receiving streams only during the Receiving Environment Monitoring Program (REMP), which is conducted twice a year (wet season and dry season) at locations shown in **Figure 4**. Monthly monitoring of surface water streams at FHCP is not possible due to ephemeral nature of the creeks and short-lived flow regime due to the sites proximity in the upper reaches of the catchment.

Three surface water sampling locations in Cooroora Creek and Sandy Creek are monitored as part of REMP to assess surface water quality.

During the wet season REMP sampling in March 2018, all three sites in Cooroora Creek had sufficient water for surface water sampling, while the three sites in Sandy Creek were dry (NRC, 2018c). Laboratory reports on surface water quality are included in **Appendix C3** and discussed below.

2.1.1 pH

The pH of surface water samples was reported to be almost neutral, ranging from 7.4 to 7.5 (NRC, 2018c). The sediments collected from the surface water sampling locations were also assessed for pH. The pH in soil (1:2) was observed to range from 6.9 to 8.4 (NRC, 2018c). Although slightly alkaline, the pH observed from the sediments was within the acceptable range.

2.1.2 Electrical conductivity

Electrical conductivity (EC) observed in surface water samples during the recent REMP (NRC, 2018c) ranged from 130 $\mu\text{S}/\text{cm}$ to 200 $\mu\text{S}/\text{cm}$. The low EC indicates the freshness of surface water around the FHCP site.

2.1.3 Dissolved oxygen and turbidity

Dissolved oxygen (DO) observed in the surface water samples at the Cooroora Creek sites were below the regional guideline values (90% saturation) for upland streams in the Central Coast Region (EHP, 2009). Turbidity was elevated above the QWQG regional guideline value (110 NTU), particularly at site FHCC3 where turbidity was over 1,000 NTU (NRC, 2018c).

2.1.4 Metals and metalloids

According to the REMP report in March 2018, the surface water at FHCP exceeded ANZECC/ARMCANZ (2000) default aquatic ecosystem protection guideline values for the following metals:

- Dissolved aluminium and copper concentrations at FHCC1 and FHCC2; however, dissolved copper was below the hardness modified trigger value (HMTV) at FHCC2.
- The concentration of dissolved zinc exceeded the ANZECC/ARMCANZ (2000) guideline value at FHCC2. However, it was below the HMTV.

2.1.5 Hydrocarbons

All reported hydrocarbon concentrations were below detection limits.

2.1.6 Overview of surface water quality

The surface water quality at FHCP exceeds default ANZECC guideline values for aquatic ecosystem protection for dissolved aluminium, copper and zinc (NRC, 2018c). Small pools of water remain in the watercourses after the short-lived flow event. These pools are characterised by high turbidity (high amount of fine sediments and/or interference from animal disturbance; NRC, 2018c) and low DO.

All hydrocarbon and hydrocarbon group concentrations in surface waters were below reporting limits, indicating the absence of these chemicals in the watercourses sampled.

2.2 Environmental values of surface water

2.2.1 Established environmental values for waters in the region

EVs are the identified qualities of waterways that need to be protected from the effects of pollution, waste discharges and other threats.

The FHCP is located in rural landscape, and therefore the majority of the site has been altered by agricultural practices. Furthermore, light to medium intensity of cattle grazing and associated road and rail tracks have also contributed to land disturbance in the area. The impacts of these activities, including land clearing, weed invasion and accelerated erosion processes are observed in the project area.

Environmental Protection (Water) Policy 2009, Mackenzie River Sub-basin Environmental Values and Water Quality Objectives, Basin No. 130 (part), including all waters of the Mackenzie River Sub-basin, dated September 2011 sets out the EVs for the waters connected to the FHCP, which relate to the Mackenzie north-western tributaries (EHP, 2011). These values are reproduced here in **Table 5**.

Table 5: EVs for the surface waters and groundwater of the Mackenzie north-western tributaries

Waters	Mackenzie north-western tributaries—developed areas	Fresh waters in undeveloped areas	Groundwaters
Aquatic ecosystems	✓	✓	✓
Irrigation	✗	✗	✓
Farm supply / use	✗	✗	✓
Stock water	✓	✓	✓
Aquaculture	✗	✗	✗
Human consumer	✓	✓	✗
Primary recreation	✓	✓	✗
Secondary recreation	✓	✓	✗

Waters	Mackenzie north-western tributaries—developed areas	Fresh waters in undeveloped areas	Groundwaters
Visual recreation	✓	✓	✗
Drinking water	✓	✓	✓
Industrial use	✓	✗	✓
Cultural and spiritual values	✓	✓	✓

2.2.2 Applicability of the designated environmental values to the waterways around the Fairhill coal project

2.2.2.1 Aquatic ecosystems

The aquatic ecosystems of the Mackenzie River northern tributaries in the vicinity of the FHCP site is “*slightly to moderately disturbed*” due to modifications made to the catchment for or by means of intensive cattle grazing. Table 2 of the EPP Water for the Mackenzie River sub-basin describes WQOs to protect aquatic ecosystem EVs under baseflow (and, where specified, high flow) as follows:

- ammonia N: <20 µg/L
- oxidised N: <60 µg/L
- organic N: <420 µg/L
- total nitrogen: <775 µg/L
- filterable reactive phosphorus (FRP): <20 µg/L
- total phosphorus: <160 µg/L
- chlorophyll a: <5.0 µg/L
- dissolved oxygen: 85%–110% saturation
- turbidity: <50 NTU
- suspended solids: <110 mg/L
- pH: 6.5–8.5
- conductivity (EC) baseflow: <310 µS/cm
- conductivity (EC) high flow: <210 µS/cm
- sulfate: <10 mg/L
- macroinvertebrates:
 - Taxa richness (composite): 12–21
 - Taxa richness (edge habitat): 23–33
 - PET taxa richness (composite): 2–5
 - PET taxa richness (edge habitat): 2–5

- SIGNAL index (composite): 3.33–3.85
- SIGNAL index (edge habitat): 3.31–4.20.

An aquatic ecology survey has been designed for FHCP in accordance with Australian River Assessment System (AUSRIVAS) as part of the REMP.

2.2.2.2 Irrigation

There is no cropping within or in the vicinity of the FHCP. Additionally, the waterways around the FHCP are ephemeral and therefore have limited utility for irrigation. Environmental values for irrigation will be considered for surface water on site as it applies to waterways further downstream of the project.

2.2.2.3 Farm water supply/use

In terms of farm water supply and use, again, the waterways around the FHCP are too ephemeral to be of use in farm supply or irrigation. This value will be considered as it applies to waterways further downstream of the project. Where ephemeral waterways may have use for watering cattle, that EV is addressed under stock watering.

2.2.2.4 Recreation – primary, secondary and visual

The waters in the immediate vicinity of the mine are ephemeral and are not used for recreation.

2.2.2.5 Stock watering

The ephemeral waters around the FHCP have EV for stock watering and can act as water supply during times of flow. The land around the vicinity of the mine is predominantly used for beef cattle grazing. In accordance with the guideline, WQOs for stock watering are as per the Australian and New Zealand guidelines for fresh and marine water quality (AWQG), including median faecal coliforms <100 organisms per 100mL. WQOs for total dissolved solids and metals are also based on the AWQG.

2.2.2.6 Human consumers of aquatic foods

The ephemeral waterways around FHCP do not support aquatic food production. There are no aquaculture farms in the vicinity or downstream of the project. The Mackenzie River supports recreational fishing. Therefore, this EV applies to surface waters of FHCP.

2.2.2.7 Industrial use

The area includes a number of other coal mines in proximity to the project. Mining is the primary industrial activity in proximity to the site.

2.2.2.8 Drinking water supply

The waterways immediately around the FHCP are not suitable as a drinking water supply and none of the nearby landholders rely on surface water for household supply.

2.2.2.9 Cultural, spiritual and ceremonial values

The Kangoulou people recognise the cultural, spiritual and ceremonial value of the waters of the Mackenzie River.

2.3 Background quality and environmental values of groundwater

Section 8.1 of the “Underground Water Impact Report” attached as **Appendix B** of this report discusses baseline groundwater quality at FHCP in detail. Environmental values of the groundwater are discussed in section 9.1 of the same report.

A Durov diagram presented in Figure 7 provides a summary of physicochemical and ionic information about the groundwater from FHCP monitoring bores. Major ion proportions indicate that all bores at FHCP monitor water of sodium-chloride type, which is the dominant water type in the region.

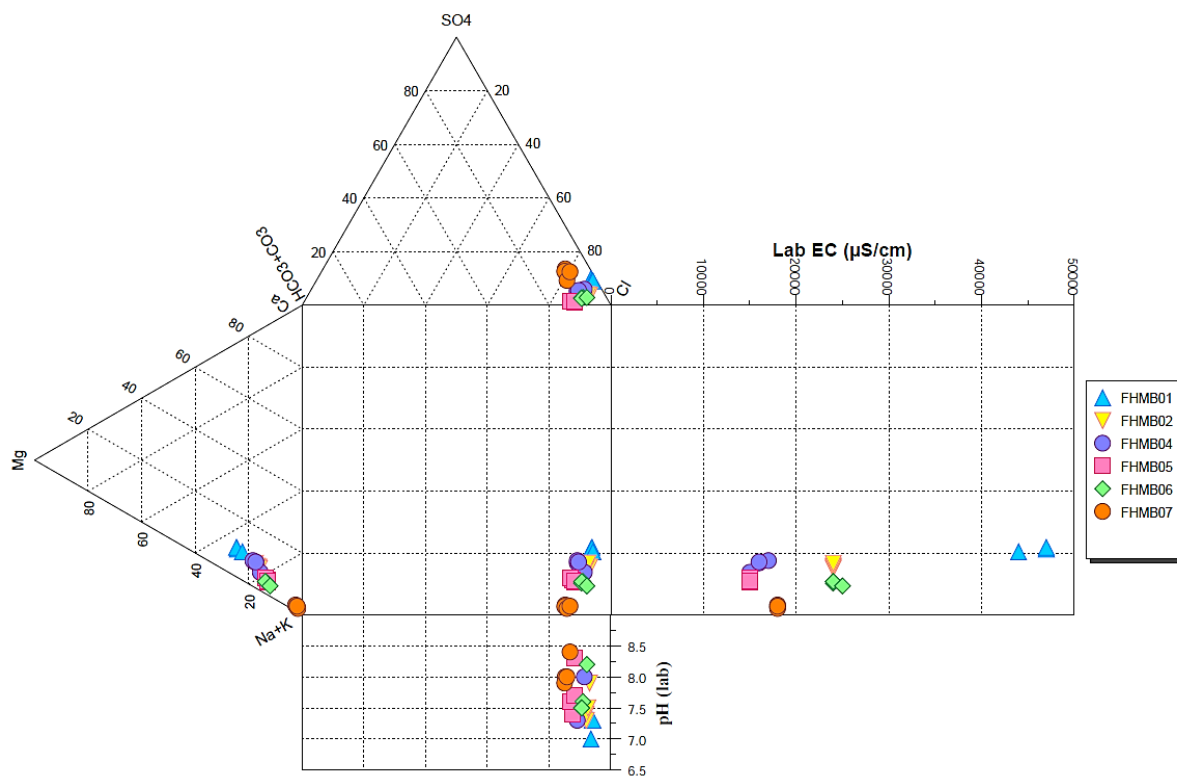


Figure 7: Durov diagram showing different water types in groundwater at FHCP

At neighbouring site for the proposed Wilton Coal Project, some bores are installed in the Permian Burngrove Formation, most bores located within 12 km from FHCP (i.e. WGWB1, WGWB2, WGWB4, WGWB5, WGWB6) are also of sodium-chloride type similar to the Permian Fairhill Formation at FHCP, suggesting little variability between these two Permian coal bearing formations. Exceptions are brackish water bores WGWB3A and WGWB4A, which are of sodium-bicarbonate-chloride type.

Median groundwater EC at FHCP for the monitoring period ranges from 15,000 to 47,000 $\mu\text{S}/\text{cm}$. This large variability in EC could be the result of several different sources of salinity (e.g. dissolution of evaporite minerals, weathering of aquifer minerals etc.). It is noted that the groundwater in the Cooroora Creek alluvium is significantly more saline than any other bores at FHCP.

Groundwater pH values at FHCP are between pH 6.5 and 8.5. It should be noted that FHCP monitoring bores initial samples from June 2018 are generally higher in pH compared to subsequent samples, most likely due to insufficient development of bores following drilling.

Metal and metalloid concentrations in groundwater are typically higher than in surface water due to increased contact with the local geology. At FHCP and nearby WCP, the significantly low permeability of the water-bearing strata allows even more contact time for mineral dissolution to occur.

A number of metals and metalloids in the groundwater samples were found to be in exceedance of local (DEHP, 2011) and regional (ANZECC & ARMCANZ, 2000) trigger values for species protection (95%) in slightly to moderately disturbed aquatic ecosystems (Aquatic ecosystems trigger). The 99% species protection trigger levels are used to compare against selenium and mercury due to potential for bioaccumulation. Total selenium concentrations are used rather than dissolved for the same reason. The following bores and metals exceeded the Aquatic ecosystems trigger:

- FHMB01: Boron, manganese, selenium and zinc.
- FHMB02: Boron, and zinc.
- FHMB04: Boron and selenium.
- FHMB05: Boron, selenium and zinc.
- FHMB06: Aluminium, boron, copper, selenium and zinc.
- FHMB07: Boron, arsenic, chromium and selenium.

Comparison with existing baseline data show that metal and metalloids sampled at FHCP bores (80th percentile of current data) are all below the recommended stock watering values, except for Aluminium. The 80th percentile for total aluminium in bores FHMB01 and FHMB04 are above the recommended values. Additionally, FHMB05, FHMB06 and FHMB07 have exceeded the recommended value at least once since monitoring started. However, most of the exceedance occurred at the first sampling event, likely indicating that the groundwater sampled was impacted by the drilling operations as discussed earlier.

2.4 Water quality objectives

The primary aim of environmental protection objectives is to prevent the degradation of water quality in the ephemeral creeks downstream of the project site and the local groundwater aquifer. WQOs are the quantitative measures established to protect the EVs of waters (EPP Water). The purpose of WQOs is to act as a general tool for assessing water quality (ANZECC/ARMCANZ, 2000). Where appropriate, WQOs are based on Australian (ANZECC/ARMCANZ, 2000) and QWQG (EHP, 2009); however, some might be modified by social and economic inputs (EPP Water). The EPP Water provides a framework for defining the EVs of all inland water bodies (surface water, groundwater and coastal water bodies) in Queensland and sets guidelines for their water quality. The WQOs for the FHCP will adhere to the management objectives listed in the *Environmental Protection (Water) Policy 2009, Mackenzie River Sub-basin Environmental Values and Water Quality Objectives, Basin No. 130 (part), including all waters of the Mackenzie River Sub-basin* (EHP, 2011).

3 Potential impacts to environmental values

3.1 Discharges and releases

3.1.1 Lateral seepage

Mine affected water (MAW) dams proposed for FHCP are designed to contain stormwater runoff from cleared and stockpiled areas and are depicted on the infrastructure layout on Figure 4. The waste rock characterisation completed as part of the Guideline response for impacts to land indicates runoff from the overburden dumps is expected to be moderately fresh and alkaline. This suggests that the water in the containment dams will be of relatively good quality and intended for use for site dust suppression activities. The expected water quality poses a very low risk of environmental harm through lateral seepage.

3.1.2 Groundwater mounding

MAW dams proposed for FHCP have a very small footprint compared to the open pit. The pit is expected to remain a groundwater sink for the entire course of mining. Hence groundwater mounding underneath the MAW dams is not expected to occur.

3.2 Unplanned and uncontrolled releases

Detailed modelling regarding unplanned and uncontrolled releases is provided in the ATC Williams Water Management Assessment (2019) report for the FHCP (**Appendix A2**).

The preliminary results of water balance modelling indicated that, on average, water accumulation over the life of the project would occur.

This was expected given that demand for stored water was limited assuming that no onsite coal processing operations that require water use are planned, and that the open cut pits would receive inflow from direct rainfall and upstream catchments that is unable to be diverted due to the natural topography. As such, additional use of water to reduce this accumulation of water volumes is required to ensure that water within the pit remains below operational constraints.

In addition to the use of site water for dust suppression, this reduction of water accumulation was achieved through the incorporation of three site water use requirements (totalling 1 ML/day) that work in conjunction to reduce overall volumes as follows:

- irrigation of vegetation on rehabilitated surfaces
- enhanced evaporation of water contained within the MAW dams.

The overall site water demand (including water used for dust suppression) reduces the water accumulating in the pit sumps, of which the modelled water volumes for the 95th percentile result is generally between 60ML and 140ML during the wet season, with a maximum volume result of 270ML.

Modelled storage volumes within the MAW dams are limited to below full supply capacity resulting in a <1% spill risk. These results also indicate that storage capacities (detailed in ATC Williams, 2018), would be adequate to achieve the site water objective of ensuring that no uncontrolled releases of mine-affected water occur from the site. This reflects operational management of the dams to ensure that the pit water is not pumped to the MAW dams when full.

The modelled spill risk of the clean water sumps (CWSs) and sediment ponds over the 5-year modelled period is up to 4.1% depending on the pump transfer capacities used. The layout and configuration of these structures means that spills would ultimately enter the pits, and therefore no uncontrolled releases off site would occur. Furthermore, these spill volumes are minor and would subsequently be managed in the pit sumps as mine-affected water.

3.3 Water infrastructure

The ATC Williams Water Management Assessment report (ATC Williams, 2019; **Appendix A2**) details water infrastructure proposed to be utilised at the FHCP. It includes a number of water management facilities to adequately manage water needs for the site listed in **Table 7** of **Appendix A2**.

It is also noted that the site water infrastructure will be optimised during detailed design of the final layout of the infrastructure to ensure optimal and cost effective management of all site water, both clean and mine affected.

3.4 Groundwater-surface water interaction

3.4.1 Alluvium

Groundwater monitoring bore FHMB02 was installed adjacent to Cooroora Creek to target the potential alluvial aquifer at FHCP. This bore did not encounter groundwater within the top 6 m of strata (alluvium). The alluvium comprised 2 m of clay-rich topsoil and 4 m of clayey silt with extremely weathered sandstone inclusions. Instead, water was encountered in siltstone and coal at a depth of 11–12 m. Alluvium in the vicinity of FHMB02 appears to consist of predominantly clay and silt, which would act as aquitards or confining layers to the underlying water-bearing sedimentary units.

FHMB01 was also installed close to Cooroora Creek to target the potential alluvial aquifer. This bore encountered 2 m of clay-rich soil, followed by silt and fine sand. Below these units were sand, gravel and clay. Water was encountered at 9m within this stratum. Underlying this stratum is grey clay that is expected to be the lower confining unit to the alluvial aquifer.

Judging from these two bores, it appears that the water-bearing potential of alluvium is variable across the site. High potential occurs where sandy and gravelly alluvial deposits were deposited. Low potential occurs where clay and silt predominate. The more recent deposits of alluvium are predominantly clay and silt-rich; therefore, surface water flowing through Cooroora Creek has a low potential of recharging groundwater. These clay and silt-rich deposits would also prevent groundwater stored within underlying coarse-grained alluvium from discharging into the stream. Furthermore, baseline wet season receiving environment monitoring conducted at the end of January 2018 found all three sites monitored along Sandy Creek to be dry and pooling water in Cooroora Creek at three sites were significantly fresh, resembling recent rainfall (NRC, 2018c). If there was alluvial groundwater discharge into the creeks occurring, surface water should retain the highly saline nature of the groundwater in the underlying strata (e.g. EC of 44,600 $\mu\text{S}/\text{cm}$ at FHMB01), which is not the case at FHCP.

3.4.2 Fairhill Formation aquifer

Groundwater in the Fairhill Formation coal seams has EC ranging from 15,400 to 25,300 $\mu\text{S}/\text{cm}$.

Monitoring bore FHMB05 was drilled near Sandy Creek close to the southern tenement boundary. The water level in this bore was measured at approximately 11 m below ground level. The significant depth of groundwater below the lowest point of the adjacent Sandy Creek and the lack of water in the creek indicates a lack of groundwater expressing to surface water.

It is more likely that following significant rainfall during the wet season, the Quaternary alluvium (mainly silt and clay generally 2 m in thickness) becomes saturated and provides limited amounts of recharge to the underlying hard rock aquifers via very slow downwards leakage.

3.5 Impacts on ecology and hydrology of receiving waters

Groundwater investigations and background water quality in the region suggests that concentrations of a few trace metals are above the ANZECC/ARMCANZ (2000) Aquatic ecosystems 95% protection guideline triggers (mainly boron and zinc, and in some cases arsenic, chromium, copper and potentially manganese); therefore, rendering natural groundwater unsuitable for more than 5% aquatic species. High EC of groundwater in the region also exceeds the recommended guideline values for aquatic ecosystem protection, drinking water or livestock watering.

It is recommended that the WQO for some parameters such as EC and metals such as boron and zinc should be to maintain a suitable reference background level. For parameters that do not exceed the Aquatic ecosystems protection guideline values, WQOs should still apply. It is recommended that baseline data continue to be collected until sufficient sample size has been attained so that more suitable limits can be derived from the data.

Surface water in the FHCP exists mainly as seasonal rainfall runoff, channelled through the FHCP site via ephemeral creeks.

Surface water impacts would be mainly through accidental discharge from any mine dams, minor regular dewatering activities or dewatering following potential seasonal flooding. The mine plan aims to contain all encountered water on site with zero discharge to the surface environment being the goal. Site water will be used for dust suppression and excess water will be stored in mine dams and evaporation ponds. Surrounding surface water sites will be monitored for potential impacts to water and sediment quality at designated monitoring sites.

3.6 Potential impacts on groundwater quality

3.6.1 Impacts due to storage of waste rock or overburden

Groundwater quality can be potentially impacted due to infiltration through the overburden or waste rock dump. Characterisation of the overburden/waste rock dump indicates that rainwater encountering overburden/waste rock will most likely be alkaline with moderate EC (100–780 $\mu\text{S}/\text{cm}$). All waste rock overburden associated with the proposed mining operations were classified as non-acid forming (NRC, 2018b). Metalliferous drainage should not be of concern owing to the high acid-neutralising capacity of the overburden samples (NRC, 2018b).

3.6.2 Impacts due to storage of mine-affected water

Three types of water are expected to be produced at the proposed FHCP and will require management as follows (ATC Williams 2019):

- Clean water derived from runoff in areas upstream of the disturbance or stabilised/rehabilitated areas within the mine. Water deemed unaffected by mine operations and suitable for direct off-site release into the receiving environment.
- Sediment laden water associated with runoff from cleared areas. Sediments in water need to be settled and captured in sediment basins/dams prior to release to the clean water system and receiving environment.
- Mine-affected water from runoff in contact with disturbed areas within pit, overburden or waste rock dumps and groundwater dewatered from the pit. Containment of this water, especially dewatered groundwater, should not be released unless sufficient flow events and volumetric flow ratio are met. Enhanced evaporation may be required to remove water.

During mining a number of mining infrastructures pose a risk of infiltration of mine-affected water into groundwater, including the following:

- Containment dams proposed to store mine-affected water dewatered from the pit.
- Runoff and seepage collected from waste rock/overburden dumps.
- In the event of high rainfall, the open pit (only if filled up to a level higher than the surrounding groundwater levels).

Due to the presence of low permeability strata (as evident from the low yields and hydraulic conductivity values of strata at FHCP), the rate of infiltration is expected to be very low in those circumstances. Due to the high salinity of existing groundwater at FHCP, it is also expected that infiltration of rainfall runoff in the pit into surrounding groundwater would improve groundwater quality (i.e. dilute the EC and potentially other elevated constituents in groundwater). However, this would not support the WQO of maintaining a suitable background water quality. Therefore, management measures such as pumps installed in in-pit sumps should be used to control pit water levels, especially during the wet season. Lining of containment dams may be utilised to prevent infiltration and seepage from containment dams into groundwater.

3.7 Risk assessment

3.7.1 Methodology

For each of the identified potential impacts for FHCP, a likelihood rating and consequence rating have been applied using the following matrix (**Table 6**). The initial risk rating has been determined prior to the implementation of control measures. Control measures have been developed as required for the environmental risks to ensure that the level of risk is maintained at an acceptable level. The risk methodology applied has been developed based on the Australian and New Zealand Standard AS/NZS for Risk Management – Principles and Guidelines (ISO 31000:2018) (**Table 7**).

Table 6: Risk assessment matrix used for FHCP

Risk Assessment Matrix					
LIKELIHOOD OF OCCURRENCE	SEVERITY OF CONSEQUENCES				
	Catastrophic (5)	Major (4)	Moderate (3)	Minor (2)	Insignificant (1)
Almost certain (5)	10	9	8	7	6
Likely (4)	9	8	7	6	5
Possible (3)	8	7	6	5	4
Unlikely (2)	7	6	5	4	3
Rare (1)	6	5	4	3	2

Table 7: Assessment of risk scores for the FHCP risk assessment

Risk Score	Risk Rating	Action Required
9 – 10	Extreme	Immediate.
7 – 8	High	Action plan required. Senior management attention.
5 – 6	Moderate	Specific monitoring or procedures required.
2 – 4	Low	Management through routine procedures.

3.8 Risk assessment matrix

The risks posed to water by the proposed FHCP were assessed using the methodology described above. The results of that assessment are included in this document as **Table 8**. Control strategies are included in the table and post-control risks reassessed. The control strategies within the table are reflected in the management and mitigation strategies included in this report.

Table 8: Risk assessment for construction and operation phases of FHCP

Event / Circumstance	Potential impact to water	Risk Rating			Risk Controls	Residual risk rating			Treatment/ Contingencies	Monitoring Activities
		L	C	T		L	C	T		
Construction Risks										
Stormwater event during construction before containment structures are in place	High levels of sediment are washed into drainage channels at site	3	3	6	Build containment structures before the bulk of stripping and stockpiling commences. Monitor daily rainfall forecasts before clearing.	2	2	4	In the event a major rainfall event strikes unexpectedly during construction of containment structures, site should use temporary bunding wherever possible to limit sediment laden runoff to the receiving environment	Water quality monitoring will be conducted in accordance with the overall REMP for the project.
Hydrocarbon spillage	Hydrocarbon spillage resulting from vehicle malfunction contaminates land subject to stormwater runoff	4	2	6	Vehicles will be maintained in accordance with manufacturer’s instructions. Spills will be cleaned up in accordance with the standard operating procedure (SOP) for spills at site.	2	2	4	In the event of a major hydrocarbon spillage (e.g. greater than 200L), an investigation shall be conducted and recommendations to remediate impacted area developed.	Monthly review of hydrocarbon spill occurrence frequency.
Dust generated by the operation falls on drainage channels	Heavy dust burden on drainage channels causes contaminants to be washed downstream in flow events	4	3	7	Ensure containment structures are maintained with capacity to manage designed rainfall events. Monitor daily rainfall forecasts and conduct repairs as required.	1	3	4	In the event a major rainfall event strikes unexpectedly, site should use temporary bunding wherever possible to limit sediment laden runoff to the receiving environment	Weekly inspection of drainage lines to ensure operational functionality is maintained.
Dam breach resulting in an unplanned or uncontrolled release surface water	Release of non-compliant water quality to downstream receptors	3	4	7	Ensure that dam structure is constructed according to engineered design and inspected regularly. Conduct repairs and maintenance on dam structures where identified to maintain functionality of structures.	1	3	4	In the event of a major rainfall event, transfer of water to minimise risk of dam breach shall be undertaken as soon as possible.	Monthly on-site inspection and annual third-party inspection of dam infrastructure to be conducted.
Dam overtopping resulting in an unplanned or uncontrolled release surface water	Release of non-compliant water quality to downstream receptors	3	4	7	Ensure appropriate water level monitoring is conducted with adequate freeboard maintained in line with engineering design requirements. Transfer of water between water management structures in accordance with engineering design capacity. Regular inspections and monitoring to be conducted and where appropriate (and in accordance with EA conditions).	1	3	4	In the event of a major rainfall event at a point where water quality is unable to be met for release, transfer of water to adequate holding structures shall be undertaken.	Daily inspection of dam infrastructure freeboard level.
Failure of pumping equipment resulting in an unplanned or uncontrolled release to surface water	Release of non-compliant water quality to downstream receptors	4	4	8	Ensure that pumping infrastructure is inspected regularly and maintained in accordance with manufacturer’s specifications.	1	3	4	In the event of significant pump failure, released water to be diverted to containment structures and emergency pumping equipment established.	Regular inspection and maintenance of pumping equipment according to manufacturer’s requirements.
Dam seepage resulting in an unplanned or uncontrolled release to groundwater	Release of non-compliant water quality to groundwater	3	4	7	Ensure that dam structure is constructed according to engineered design and inspected regularly. Conduct repairs and maintenance on dam structures where identified to maintain functionality of structures.	1	3	4	In the event that significant seepage is identified, an investigation is to be conducted by an appropriately qualified person and include recommendations to prevent harm.	Monthly on-site inspection and annual third-party inspection of dam infrastructure to be conducted.
Operation Risks										
Dam breach resulting in an unplanned or uncontrolled release to surface water	Release of non-compliant water quality to downstream receptors	3	4	7	Ensure that dam structure is constructed according to engineered design and inspected regularly. Conduct repairs and maintenance on dam structures where identified to maintain functionality of structures.	1	3	4	In the event of a major rainfall event, transfer of water to minimise risk of dam breach shall be undertaken as soon as possible.	Monthly on-site inspection and annual third-party inspection of dam infrastructure to be conducted.

Event / Circumstance	Potential impact to water	Risk Rating			Risk Controls	Residual risk rating			Treatment/ Contingencies	Monitoring Activities
		L	C	T		L	C	T		
Dam overtopping resulting in an unplanned or uncontrolled release	Release of non-compliant water quality to downstream receptors	3	4	7	Ensure appropriate water level monitoring is conducted with adequate freeboard maintained in line with engineering design requirements. Transfer of water between water management structures in accordance with engineering design capacity. Regular inspections and monitoring to be conducted and where appropriate (and in accordance with EA conditions).	1	3	4	In the event of a major rainfall event at a point where water quality is unable to be met for release, transfer of water to adequate holding structures shall be undertaken.	Daily inspection of dam infrastructure freeboard level.
Dam seepage resulting in an unplanned or uncontrolled release to surface water	Release of non-compliant water quality to downstream receptors	3	4	7	Ensure that dam structure is constructed according to engineered design and inspected regularly. Conduct repairs and maintenance on dam structures where identified to maintain functionality of structures.	1	3	4	In the event that significant seepage is identified, an investigation is to be conducted by an appropriately qualified person and include recommendations to prevent harm.	Monthly on-site inspection and annual third-party inspection of dam infrastructure to be conducted.
Hydrocarbon spillage	Hydrocarbon spillage resulting from vehicle malfunction contaminates land subject to stormwater runoff	4	2	6	Vehicles will be maintained in accordance with manufacturer's instructions. Spills will be cleaned up in accordance with the SOP for spills at site.	2	2	4	In the event of a major hydrocarbon spillage (e.g. greater than 200L), an investigation shall be conducted and recommendations to remediate impacted area developed.	Monthly review of hydrocarbon spill occurrence frequency.
Dust generated by the operation falls on drainage channels	Heavy dust burden on drainage channels causes contaminants to be washed downstream in flow events	4	3	7	Ensure containment structures are maintained with capacity to manage designed rainfall events. Monitor daily rainfall forecasts and conduct repairs as required.	1	3	4	In the event a major rainfall event strikes unexpectedly, site should use temporary bunding wherever possible to limit sediment laden runoff to the receiving environment	Weekly inspection of drainage lines to ensure operational functionality is maintained.
Failure of pumping equipment resulting in an unplanned or uncontrolled release	Release of non-compliant water quality to downstream receptors	4	4	8	Ensure that pumping infrastructure is inspected regularly and maintained in accordance with manufacturer's specifications.	1	3	4	In the event of significant pump failure, released water to be diverted to containment structures and emergency pumping equipment established.	Regular inspection and maintenance of pumping equipment according to manufacturer's requirements.
Dam seepage resulting in an unplanned or uncontrolled release to groundwater	Release of non-compliant water quality to groundwater	3	4	7	Ensure that dam structure is constructed according to engineered design and inspected regularly. Conduct repairs and maintenance on dam structures where identified to maintain functionality of structures.	1	3	4	In the event that significant seepage is identified, an investigation is to be conducted by an appropriately qualified person and include recommendations to prevent harm.	Monthly on-site inspection and annual third-party inspection of dam infrastructure to be conducted.
Excessive rainfall resulting in release of sediment laden water	Release of non-compliant water quality to downstream receptors	4	4	8	Ensure containment structures are maintained with capacity to manage designed rainfall events. Monitor daily rainfall forecasts and conduct repairs as required.	1	3	4	In the event of a major rainfall event at a point where water quality is unable to be met for release, transfer of water to adequate holding structures shall be undertaken.	Weekly inspection of drainage lines to ensure operational functionality is maintained.
Excessive rainfall resulting in flooding of mining infrastructure and uncontrolled release of mine affected water.	Release of non-compliant water quality to downstream receptors	3	4	7	Ensure there are pit flood protection bunds with armoured embankments around the northern and southern pit extents. Armouring of waste rock dump batter slopes within inundation areas. Upstream clean water diversions adequately designed to cope with a 1% AEP event.	1	3	4	In the event of a major rainfall event at a point where water quality is unable to be met for release, transfer of water to adequate holding structures shall be undertaken.	Regular inspection of clean water diversions to ensure operational functionality is maintained. Regular inspection of pit flood protection bunds and armoured embankments. Monitor daily rainfall forecasts.

4 Proposed Management Practices

4.1 Site water quality management

Evaluation of risk of impact to downstream waterways from unplanned or uncontrolled release has been rated as low. Control strategies for the containment of mine impacted water are discussed at length in the ATC Williams Water Management Assessment report in **Appendix A2** (ATC Williams, 2019; Appendix C).

The key objectives with respect to site water management are to:

- minimise mine-affected (disturbed) areas and divert clean water around the development area for ultimate discharge to receiving waters
- control the release of impacted water from the site to the extent that the EVs of the receiving environment are not detrimentally impacted.

For the purpose of site water management system design, three types of water will exist in relation to the development: clean, sediment laden and mine affected. Management approaches to the water types for the FHCP are described in **Table 9**.

Table 9: Water types and management approaches for FHCP

Water type	Description	Management approach
Clean water	Runoff derived from areas: - Upstream of the mine development footprint or - Stabilised/rehabilitated surfaces within the footprint. This water is considered to be unaffected by mine operations and therefore clean.	Direct off-site release via diversion drains, bunds and/or CWS and pump systems to defined discharge locations without causing excessive erosion of the receiving environment and sediment discharge.
Sediment laden water	Runoff coming into contact with disturbed earth surfaces associated with cleared areas ahead of active strip mining. Contact with these surfaces is considered likely to mobilise sediments and therefore requires capturing of the sediments prior to release to the clean water system.	Minimise extent of disturbed surfaces. Divert runoff from these surfaces to sediment basins for capture and settlement/treatment (flocculation if required) of sediments prior to release by transfer or release to the clean water system and the receiving environment.

Water type	Description	Management approach
Mine-affected water	Runoff coming into contact with disturbed/unstabilised earth surfaces located within the open cut pits or unstabilised surfaces of the overburden dumps. Contact with these surfaces is considered to increase the potential for mobilisation of sediments and other diffuse source contaminants and as such is considered to be 'mine affected'. This would include any groundwater that reports to the mine pits.	Minimise extent of areas of disturbance. Capture and contain runoff from these areas, for release to the environment subject to sufficient flow events and in accordance with predetermined volumetric flow ratio. Further settlement/treatment (including flocculation) of sediments or other contaminants (including salinity) might be required prior to release to the clean water system and the receiving environment. Enhanced evaporation may also be required to remove water.

There is no requirement for process water for the FHCP as ROM coal is to be transported offsite for processing. Demand for site water is therefore limited to that required for dust suppression or irrigation (for vegetation establishment during rehabilitation) purposes. Subject to acceptable water quality, it is envisaged that MAW could be used for dust suppression and irrigation, which would preferentially be taken from the MAW dams described in **Section 4.2** of **Appendix A2**.

4.2 Monitoring program – surface water

The proposed surface water monitoring program aims to reduce the risk to the receiving environment and to ensure that EVs will remain at a standard established prior to the commencement of mining and construction activities at the FHCP site.

Baseline surface water monitoring at the FHCP site commenced in March 2018 and comprises six surface water sampling locations being sampled under the REMP (NRC, 2018c). In addition to that, Fairhill Coking Coal is committed to establishing site impact monitoring that will include additional locations to monitor the potential impact of waste rock lay down areas and mine dams on surface water quality in the area.

To supplement the monitoring program, the proponent of Fairhill Coking Coal will install an on-site weather monitoring station. The weather monitoring station will record site-specific rainfall data, which will aid understanding of the site water balance.

4.2.1 Surface water impact monitoring

Surface water site impact monitoring comprises monitoring of potential environmental receivers including creeks and dams on the FHCP site. Surface water monitoring sites in the future will include all mine dams and associated drainage lines. **Table 10** provides a list of surface water monitoring locations currently being sampled under the REMP. Each of these sites are also provided in **Figure 4**.

Table 10: FHCP surface water monitoring locations

Site	Stream	Description	Easting	Northing
FHCC1	Cooroora Creek	Approximately 650m upstream of the proposed disturbance footprint.	666753	7431925
FHCC2	Cooroora Creek	Approximately 840m downstream of the proposed disturbance footprint.	668365	7430784
FHCC3	Cooroora Creek	Approximately 2.3km downstream of the proposed disturbance area and 430m downstream of the Cooroora Creek and Sandy Creek confluence.	669187	7429429
FHWC1	Sandy Creek	Approximately 750m upstream of the proposed disturbance footprint.	664771	7428603
FHWC2	Sandy Creek	Immediately adjacent to the southern portion of the proposed disturbance footprint.	666439	7428117
FHWC3	Sandy Creek	Approximately 780m downstream of the proposed disturbance footprint.	667505	7428620

4.2.2 Monitoring frequency

Currently, surface water monitoring at the FHCP is conducted only during the REMP (twice a year). However, the proposed surface water monitoring program will monitor surface water on a monthly basis. A continuous high frequency record of surface water occurrences and EC around the proposed FHCP mine pit will aid the understanding of potential surface water impacts.

4.2.3 Trigger levels and contingency criteria

To identify mine impacts on the existing surface water monitoring locations, trigger levels are assessed against a benchmark of the natural conditions. These natural conditions have been established through the ANZECC/ARMCANZ (2000) criteria. However, some of these trigger values will be modified based on the results from baseline monitoring at FHCP. The proposed interim trigger values at this stage are presented in **Table 11**.

Table 11: Proposed interim trigger values for FHCP surface water monitoring sites

Parameter	Measure	Interim Trigger level
Physico-chemical	EC (µS/cm)	baseflow: <445 µS/cm ^D high flow: <250 µS/cm ^D
	pH (pH units)	6.5 (lower trigger); 8.5 (upper trigger)
	TSS (mg/L)	110 ^B
	Turbidity (NTU)	50 ^B
Chemical (dissolved except for selenium)	Nitrate + Nitrite (mg/L)	0.7
	Ammonia (mg/L)	0.9
	Aluminium (mg/L)	TBD ^A
	Arsenic (mg/L)	0.013
	Barium (mg/L)	TBD ^A
	Boron (mg/L)	0.37
	Cadmium (mg/L)	0.0002
	Chromium (mg/L)	0.001
	Cobalt (mg/L)	TBD ^A
	Copper (mg/L)	0.0014
	Lead (mg/L)	0.0034
	Manganese (mg/L)	1.9
	Mercury (mg/L)	0.00006 ^C
	Nickel (mg/L)	0.011
	Selenium (total; mg/L)	0.005 ^C
	Uranium (mg/L)	TBD ^A
	Vanadium (mg/L)	TBD ^A
	Zinc (mg/L)	0.008
Organics	Total BTEX (µg/L)	TBD ^A
	Total Xylenes (µg/L)	TBD ^A
	TRH (C6-C10) (µg/L)	TBD ^A
Default ANZECC & ARMCANZ (2000) Freshwater Aquatic ecosystems trigger value for 95% species protection used with exception of the following: ^A To be determined: Insufficient number of samples to determine interim trigger. ^B WQO to protect aquatic ecosystem EVs under baseflow for Mackenzie River. ^C 99% species protection used due to potential for bio-accumulation. ^DWQO to protect aquatic ecosystem EVs under baseflow for Fitzroy River		

4.3 Monitoring program – groundwater

The proposed groundwater monitoring program aims at early detection of any potential impacts to groundwater resources at FHCP to maintain groundwater at a suitable background quality.

Baseline groundwater monitoring at FHCP commenced in June 2018 with seven groundwater monitoring bores established that have been monitored every 2 months.

In addition to current baseline monitoring, Fairhill Coking Coal Pty Ltd is committed to establishing a groundwater impact monitoring network. It will consist of the seven existing groundwater bores and be supplemented by additional shallow bores to monitor the potential impact of waste rock lay down areas and containment dams. The existing and proposed monitoring bores at the FHCP are detailed in **Table 12** and shown in **Figure 2**.

To supplement the monitoring program, Fairhill Coking Coal will install an on-site weather monitoring station. The weather monitoring station will record site-specific rainfall data, which will aid understanding of the site water balance.

Table 12: Existing and proposed monitoring bore network at FHCP

Bore ID	Easting	Northing	Depth (m)	Purpose
Existing monitoring bores				
FHMB01	668618	7429805	24	Baseline groundwater monitoring. Detect shallow seepage from containment dam (northeast of site)
FHMB02	665931	7432447	18.5	Baseline groundwater monitoring. Reference bore.
FHMB03	667489	7429461	20	Baseline groundwater monitoring. Detect impact from pit.
FHMB04	665391	7431805	29.5	Baseline groundwater monitoring. Detect impact from potential seepage from containment dam (northwest of site) on groundwater.
FHMB05	664578	7428931	23.5	Baseline groundwater monitoring. Detect pit impacts on groundwater.
FHMB06	663663	7427594	41	Baseline groundwater monitoring. Reference bore.
FHMB07	667620	7432945	48	Baseline groundwater monitoring. Reference bore.
Proposed monitoring bores				
FHMB08	TBD	TBD	15	Detect shallow seepage towards Sandy Creek from containment dam (centre of site) and waste rock dumps.

Bore ID	Easting	Northing	Depth (m)	Purpose
FHMB09	TBD	TBD	15	Detect shallow seepage from containment dam (northwest of site). Nested bore with FHMB04.

4.3.1 Baseline monitoring

The primary goal of the baseline monitoring is to ensure that sufficient baseline data is collected to:

- document the temporal and spatial variations in groundwater levels and quality
- detect any early potential impacts to groundwater levels and groundwater quality.

Baseline monitoring typically requires the collection of at least 12 months of dry and wet season data and as such will identify any key issues with regards to groundwater.

Current parameters and analytes at the FHCP site include field measurements of pH, EC, DO and ORP, and laboratory analysis of pH, EC, TSS, alkalinity, major cations and anions, nutrients (total N, NO_x and ammonia), selected dissolved metals (aluminium, arsenic, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, selenium, uranium, vanadium and zinc), total metals (aluminium, arsenic, barium, boron, cadmium, chromium, cobalt, copper, lead, mercury, nickel, selenium, uranium, vanadium and zinc), volatile organic compounds, volatile petroleum hydrocarbons and total recoverable hydrocarbons.

Baseline monitoring at FHCP is currently being conducted in accordance with the sampling protocol of the Queensland Department of Environment and Science's Monitoring and Sampling Manual (DES, 2018).

The method of groundwater monitoring follows the procedure outlined below:

1. Depth to water table is measured using a calibrated water dipper.
2. A bore is either low flow pumped from the level of groundwater inflow or alternatively at least three bore volumes are purged using a submersible pump or bailer.
3. Measurements of field parameters are undertaken during the purging of each bore using a calibrated water quality meter. Calibration records are kept as part of the QA/QC program. Effective purging of the bore is demonstrated by the stabilisation of field parameters. Repeated measurements of field parameters are recorded as part of the QA/QC program.
4. Samples for dissolved metals are field filtered and, similar to samples for total metals, major ions and hydrocarbons are collected in laboratory supplied sampling containers. Samples are kept cool and submitted for analysis to a NATA accredited laboratory within the recommended holding times with completed chain of custody documentation. Duplicate and blank samples are included as part of the QA/QC program.

4.3.2 Groundwater impact monitoring

The impact monitoring program is aimed at detecting any impact to prevailing background groundwater level and quality due to potential impact from any environmentally relevant mining activity. Locations and installation depths for impact monitoring bores are shown in **Table 12**.

4.3.2.1 Pit impact monitoring

Monitoring of potential pit impact on groundwater will occur at bore FHMB05 and FHMB03.

4.3.2.2 Infrastructure and impact monitoring bores

Monitoring of potential seepage from containment dams and waste rock dumps will occur at proposed bores FHMB08 and FHMB09, and at existing monitoring bore FHMB01. The two proposed infrastructure monitoring bores will be installed to a depth of approximately 15m. These bores will act as early warning stations to quickly identify key groundwater issues. The exact number and locations of these bores will be provided by the proponent at a later date

4.3.2.3 Reference bores

Monitoring bores FHMB06 and FHMB07 that are situated at suitable distances away from proposed mining disturbances and infrastructure have been installed within the Fairhill Formation. As such, these two bores should be suitable as reference bores. Further assessment of reference bores will be required once sufficient data has been collected.

4.3.3 Monitoring frequency

Current baseline groundwater monitoring is to be conducted on a monthly basis. It is proposed to continue monitoring on a monthly basis until 12 continuous sets of monitoring data is obtained from each bore. After that, a quarterly monitoring frequency should be adopted. Data loggers to obtain real-time groundwater level and EC measurements should be installed in the monitoring bores. A continuous high frequency record of groundwater levels and EC around the proposed FHCP pit will greatly aid the understanding of potential groundwater impacts.

5 References

- ATC Williams. (2018). Fairhill coal project water management assessment. Prepared for Fairhill Coking Coal Pty Ltd, November 2018.
- Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resources Management Council of Australia and New Zealand (ARMCANZ). (2000). Australian and New Zealand guidelines for fresh and marine water quality.
- Ayaz, S. A. (2015). Stratigraphic architecture and coal character of Late Permian Fort Cooper coal measures, Bowen Basin, Queensland. PhD thesis, The University of Queensland, School of Earth Sciences.
- Bureau of Meteorology (BoM). (2018). Groundwater dependent ecosystems atlas. Retrieved from <http://www.bom.gov.au/water/groundwater/gde/map.shtml>.
- Department of Environment and Heritage Protection (EHP). (2009). *Queensland Water Quality Guidelines*, Version 3.
- EHP. (2011a). Environmental Protection (Water) Policy 2009 Nogoa River Sub-basin Environmental Values and Water Quality Objectives Basin No. 130 (part), including all waters of the Nogoa River Sub-basin.
- EHP. (2011b). Environmental Protection (Water) Policy 2009 Mackenzie River Sub-basin Environmental Values and Water Quality Objectives Basin No. 130 (part), including all waters of the Mackenzie River Sub-basin.
- Department of Environment and Science. (DES). (2018). Monitoring and sampling manual: Environmental Protection (Water) Policy. Brisbane: Department of Environment and Science Government.
- Department of State Development, Manufacturing, Infrastructure and Planning. (2018). *Areas of regional interest*. Retrieved from <https://planning.dsdmip.qld.gov.au/planning/regional-planning-interests-act/areas-of-regional-interest>
- Dickins, J.M & Malone, E.J. (1973). *Geology of the Bowen Basin. Queensland*. Department of Minerals and Energy Bureau of Mineral Resources Geology and Geophysics, Bulletin 130.
- Environmental Earth Sciences. (2012). Soil and land capability assessment: Wilton coal project. Report to Northern Resource Consultants March 2012, Version 1 (unpublished Report)
- Galloway, R.W. (1967a). Summary description of the Isaac-Comet Area. Chapter 2 of Lands of the Isaac-Comet Area, Queensland, Land Research series No.19. CSIRO.
- Galloway, R.W. (1967b). Geology of the Isaac-Comet Area. Chapter 5 of Lands of the Isaac-Comet Area, Queensland, Land Research series No.19. CSIRO.
- Geoscience Australia. (2018). Australian stratigraphic units database. Retrieved from http://dbforms.ga.gov.au/pls/www/geodx.strat_units.sch_full?wher=stratno=6127
- Jensen, A. R. (1975). Permo Triassic stratigraphy and sedimentation in the Bowen Basin, Queensland. BMR Bulletin 154, AGP S Canberra.
- Northern Resource Consultants Pty Ltd (NRC). (2012). Wilton preliminary groundwater report – Draft. Prepared for the Coal of Queensland, June 2012.
- NRC. (2018a) Fairhill coal project groundwater technical report. Prepared for Fairhill Coking Coal Pty Ltd, November 2018.
- NRC. (2018b). Fairhill coal project overburden and potential coal reject characterisation report. Prepared for Fairhill Coking Coal Pty Ltd, November 2018.

NRC. (2018c). Wet season 2018 aquatic ecology monitoring report: Fairhill. Prepared for Fairhill Coking Coal Pty Ltd. March 2018 (Unpublished)

Prouza, V. (1977). Coal exploration, South Central Bowen Basin, Mt. Stuart-Comet Area, Geological Survey Queensland, Record 1977/27.

Queensland Government. (2018) Groundwater Database – Queensland. Retrieved from:
<https://data.qld.gov.au/dataset/groundwater-database-queensland>

Raymond, M. A. A. & V. H. McNeil. (2011). Regional chemistry of the Fitzroy Basin groundwater. Brisbane: Department of Environment and Resource Management, Queensland Government.

Raymond, M. A. A. & V. H. McNeil. (2011). Regional Chemistry of the Fitzroy Basin Groundwater. Brisbane: Department of Environment and Resource Management, Queensland Government.

Richardson, S., Irvine, E., Froend, R., Boon, P., Barber, S., & Bonneville, B. (2011). Australian groundwater-dependent ecosystem toolbox part 1: assessment framework. Waterlines report, National Water Commission, Canberra.

ROM Resources. (2013). Minescape model report and 2012 JORC resource statement. Report prepared for Fairhill Coking Coal Pty Ltd.

Scanlon, B. R., Healy, R. W., & Cook, P. G. (2002). Choosing appropriate techniques for quantifying groundwater recharge. *Hydrogeology Journal* 10, 18–39.

Scott, S.G., Beeston, J.W., & Carr, A.F. (1995). Galilee Basin. In: Ward CR, Harrington HJ, Mallett CW and Beeston JW (eds) *Geology of Australian Coal Basins. Geological Society of Australia – Coal Geology Group 1*, 341–353.

Xstrata Coal. (2012). Xstrata Coal Oaky Creek underground water impact report –Petroleum Lease 237 and 324. Published report prepared by Xstrata Coal Oaky Creek, December 2012.

APPENDIX A1

Underground Water Impact Report

APPENDIX A2

Surface Water Management Assessment

ATC Williams (2019)

APPENDIX A3

Surface water Quality Laboratory Analysis Results

ASIA PACIFIC OFFICES

BRISBANE

Level 2, 15 Astor Terrace
Spring Hill QLD 4000
Australia
T: +61 7 3858 4800
F: +61 7 3858 4801

MACKAY

21 River Street
Mackay QLD 4740
Australia
T: +61 7 3181 3300

SYDNEY

2 Lincoln Street
Lane Cove NSW 2066
Australia
T: +61 2 9427 8100
F: +61 2 9427 8200

AUCKLAND

68 Beach Road
Auckland 1010
New Zealand
T: +64 27 441 7849

CANBERRA

GPO 410
Canberra ACT 2600
Australia
T: +61 2 6287 0800
F: +61 2 9427 8200

MELBOURNE

Suite 2, 2 Domville Avenue
Hawthorn VIC 3122
Australia
T: +61 3 9249 9400
F: +61 3 9249 9499

TOWNSVILLE

Level 1, 514 Sturt Street
Townsville QLD 4810
Australia
T: +61 7 4722 8000
F: +61 7 4722 8001

NELSON

6/A Cambridge Street
Richmond, Nelson 7020
New Zealand
T: +64 274 898 628

DARWIN

5 Foelsche Street
Darwin NT 0800
Australia
T: +61 8 8998 0100
F: +61 2 9427 8200

NEWCASTLE

10 Kings Road
New Lambton NSW 2305
Australia
T: +61 2 4037 3200
F: +61 2 4037 3201

GOLD COAST

Ground Floor, 194 Varsity Parade
Varsity Lakes QLD 4227
Australia
M: +61 438 763 516

PERTH

Ground Floor, 503 Murray Street
Perth WA 6000
Australia
T: +61 8 9422 5900
F: +61 8 9422 5901

FAIRHILL COAL PROJECT

Underground Water Impact Report

Prepared for:

Fairhill Coking Coal Pty Ltd
Level 54,
111 Eagle Street
Brisbane QLD 4000

PREPARED BY

SLR Consulting Australia Pty Ltd
ABN 29 001 584 612
12 Cannan Street
South Townsville QLD 4810 Australia
(PO Box 1012 Townsville QLD 4810 Australia)
T: 07 4772 6500
E: townsville@slrconsulting.com

BASIS OF REPORT

This report has been prepared by SLR Consulting Australia Pty Ltd (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with Fairhill Coking Coal Pty Ltd (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

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DOCUMENT CONTROL

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623.171171-R01-v1.0	24 May 2019	Louis Bouchet	Derwin Lyons	Derwin Lyons

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1 Introduction

Fairhill Coking Coal Pty Ltd (FCC) submitted an application for a site specific Environmental Authority (EA) on 19 of December 2018. On 4 of March 2019, the Department of Environment and Science (DES) requested further information needed to assess the application. Request number 3.7 states:

“New projects within a regulated groundwater area have a statutory right to take underground water (‘associated water’) under section 334ZP of the Mineral Resources Act 1989. The project is subject to the underground water obligations set out in Chapter 3 of the Water Act 2000, including the requirement to prepare Underground Water Impact Reports (UWIR) and Baseline Assessment Plans (BAP) before dewatering begins. Make good provisions under Chapter 3 of the Water Act 2000 also apply.

The application form indicated that the FHCP will not be exercising their right to take or interfere with underground water, the application supporting documentation however states that ‘groundwater bore yields were either too low to measure or ranged from 0.001 to 1.732m³/day’ indicating that groundwater take or interference would result from carrying out the resource activity. While initial sampling may indicate low to no yields at locations sampled to date, even these low yields are considered to be underground water take. Therefore the Department considers that FHCP is subject to the underground water obligations set out in Chapter 3 of the Water Act 2000. Section 126A of the Environmental Protection Act 1994 (EP Act) outlines the information requirements which must accompany a site specific application where a resource activity involves the exercise of underground water rights and ensures that upfront assessment of the impacts to environmental values from the exercise of these underground water rights has been undertaken.

The information requirements detailed in the guideline Requirements for site-specific and amendment applications – underground water rights, V1.01 (ESR/2016/3275) (the guideline), are required to be met for the FHCP application. The guideline suggests specific methods and information that the department believes to be appropriate to meet the requirements of 126A of the EP Act, and types of EV’s that the department believes to potentially be affected by the exercise of underground water rights.

Information required:

a) Address and provide the information requirements in the guideline Requirements for site-specific and amendment applications – underground water rights, V1.01 (ESR/2016/3275)

FCC has engaged SLR Consulting Pty Ltd (SLR) to provide the response to the information request received from DES. This standalone report was developed to address request 3.7, in accordance with the *Guideline Requirements for site-specific and amendment applications – underground water rights*.

2 PART A—A STATEMENT THAT THE APPLICANT PROPOSES TO EXERCISE UNDERGROUND WATER RIGHTS

FCC proposes to exercise underground water rights during the period of operations proposed for the Fairhill Coal Project.

3 PART B—A DESCRIPTION OF THE AREA/S IN WHICH UNDERGROUND WATER RIGHTS ARE PROPOSED TO BE EXERCISED

3.1 Project location

The Fairhill Coal Project (FHCP) is located in Central Queensland, approximately 195km west of Rockhampton and 50km northeast of Emerald in the Bowen Basin (**Figure 1**). The FHCP tenement covers a total exploration area of approximately 3,045ha. FHCP is planned to be an open cut mine, predicted to produce a maximum of 1.7 million tonnes per annum of primarily coking coal extracted from coal seams of the Fairhill Formation.

The project site is situated in close proximity to a number of existing coal mines. Ensham's Yongala mine is located approximately 10km southwest of FHCP, Kestrel Mine lies approximately 18km to the west, Oakey Creek Mine and Gregory Crinum Mine are approximately 18km north and northwest, respectively, and Yarrabee is approximately 25km to the east.

3.2 Proposed mining activities

There is no on-site coal processing proposed for FHCP. Instead, the proponent is seeking agreement from nearby owner operators of coal washing infrastructure, with the intention of shipping raw coal products to nearby operations and utilising existing coal handling preparation plants and tailings infrastructure under agreement.

Mining operations proposed at the FHCP site are scheduled for seven years and will include the development of a shallow greenfield open cut mine targeting coal from the Fairhill 1 and 2 coal seams. The operation will be by cut and fill method with the mine excavation progressing from east to west. The pit will reach a maximum depth of 130m AHD, leaving a final void 20 to 30m deep.

The mining infrastructure proposed for FHCP includes two Waste Rock Dumps (WRDs) with associated infrastructure for capture and storage of drainage from the dumps. Yearly progression of the mining operation and location of mine infrastructure are presented from **Figure 2** to **Figure 8**.

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FIGURE 1
REGIONAL CONTEXT

Legend

- Town
- Major Road
- Watercourse
- Protected Area
- Mining Lease Permit (Application)

Data Sources:
Topographic basemap and Mining Lease datasets: the
State of Queensland (Department of Natural
Resources, Mines, and Energy) 2019.

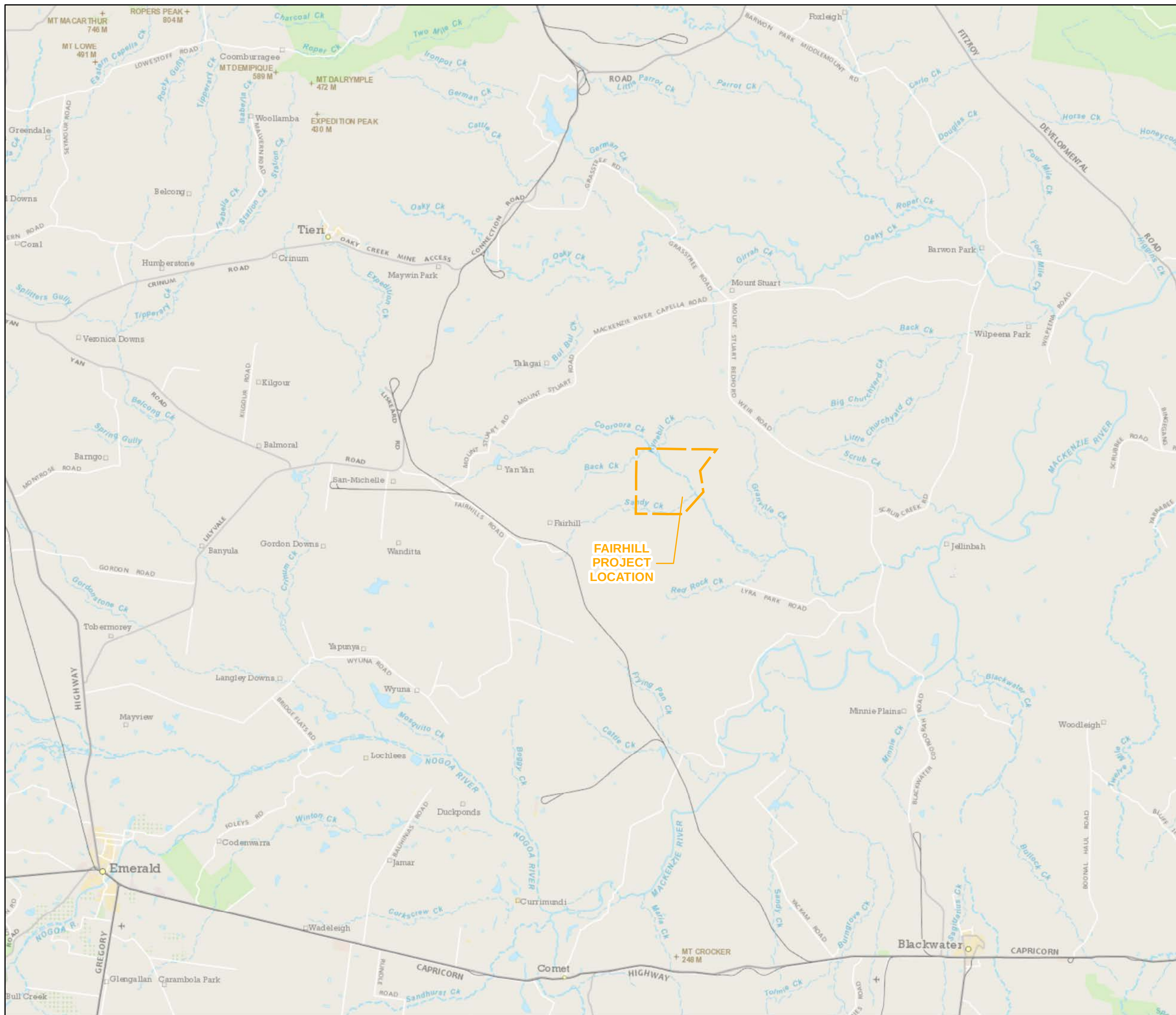
Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator
Datum: GDA 1994
Date: 3/05/2019



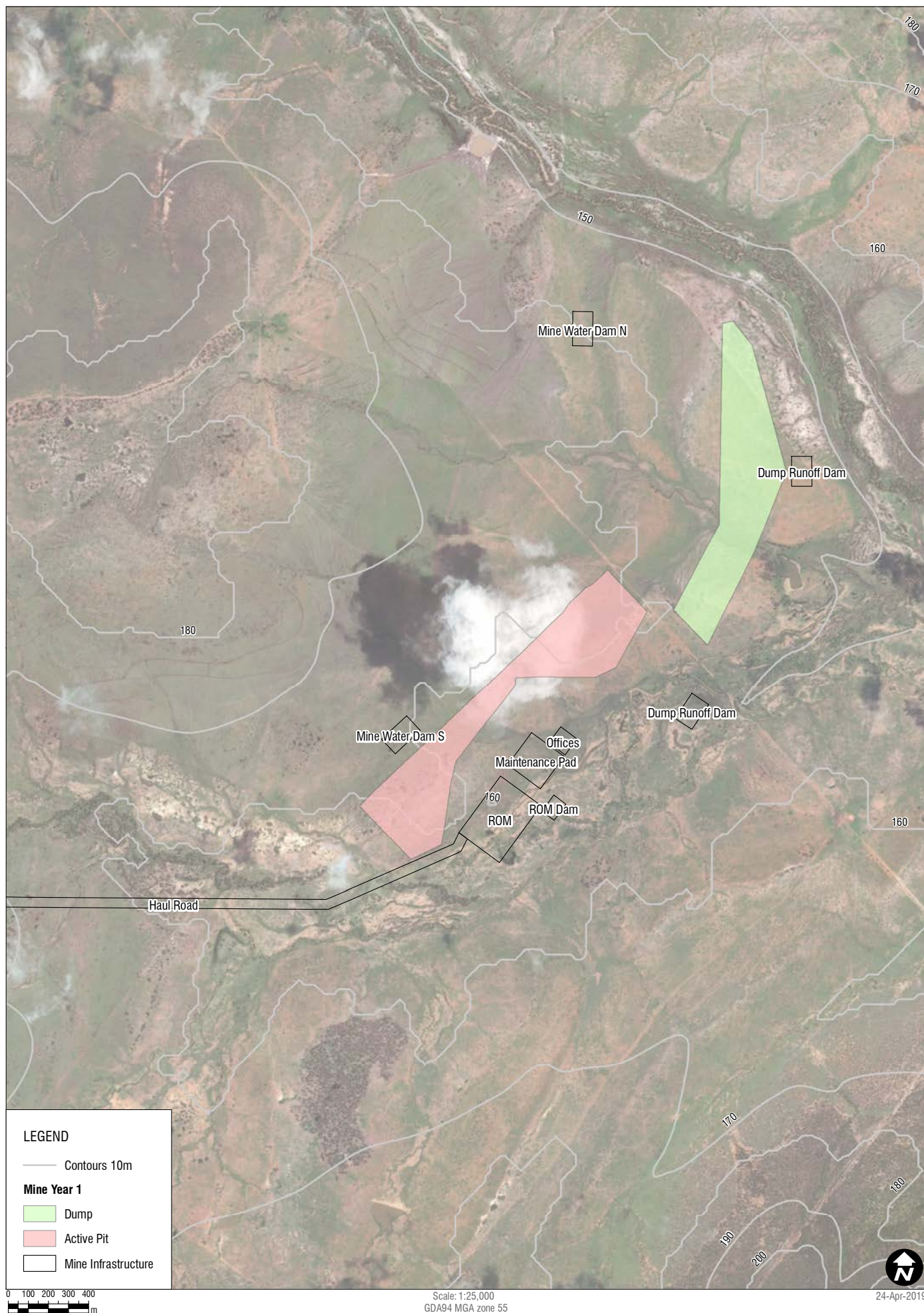
0 2.5 5 7.5 10

Kilometres

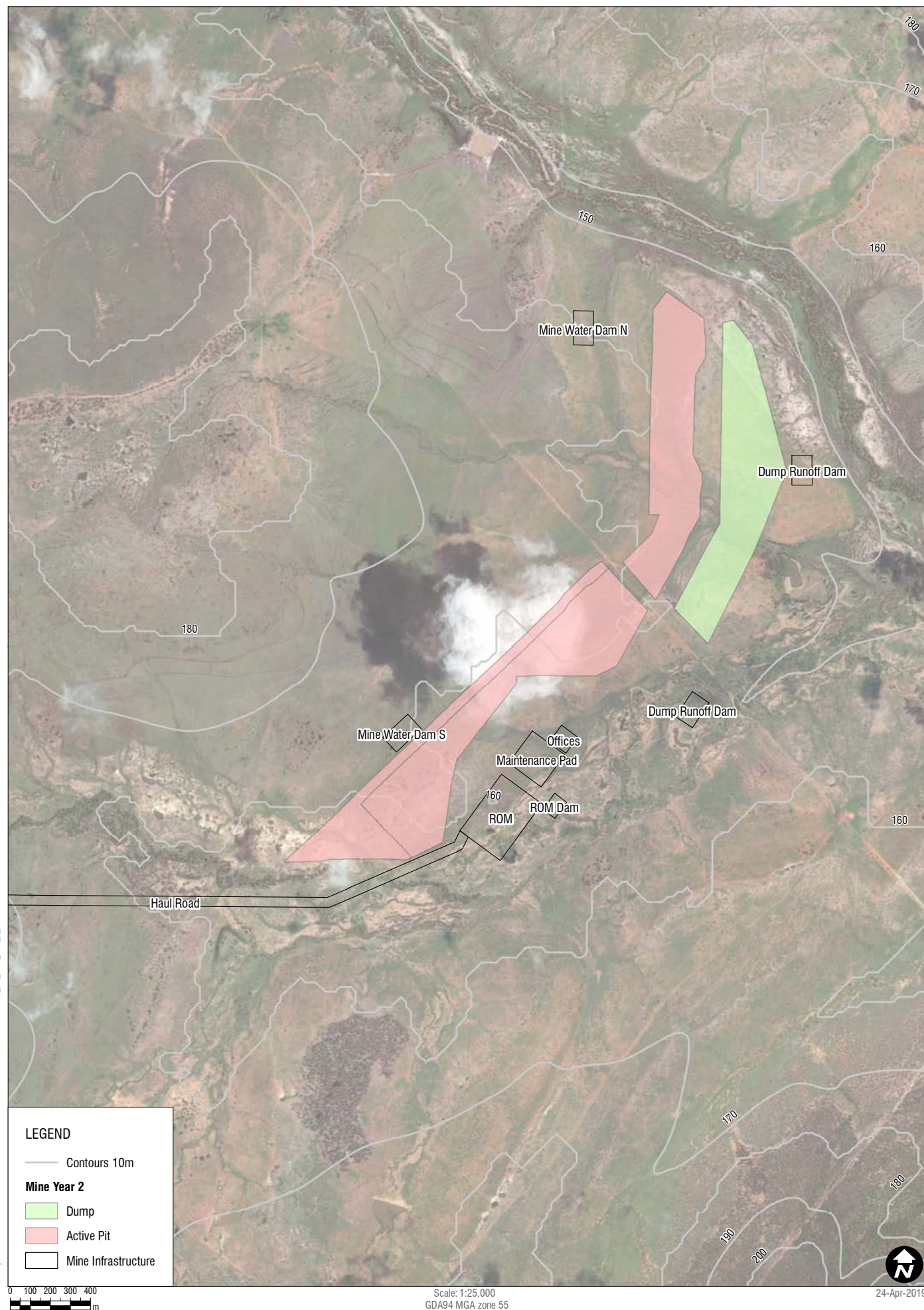
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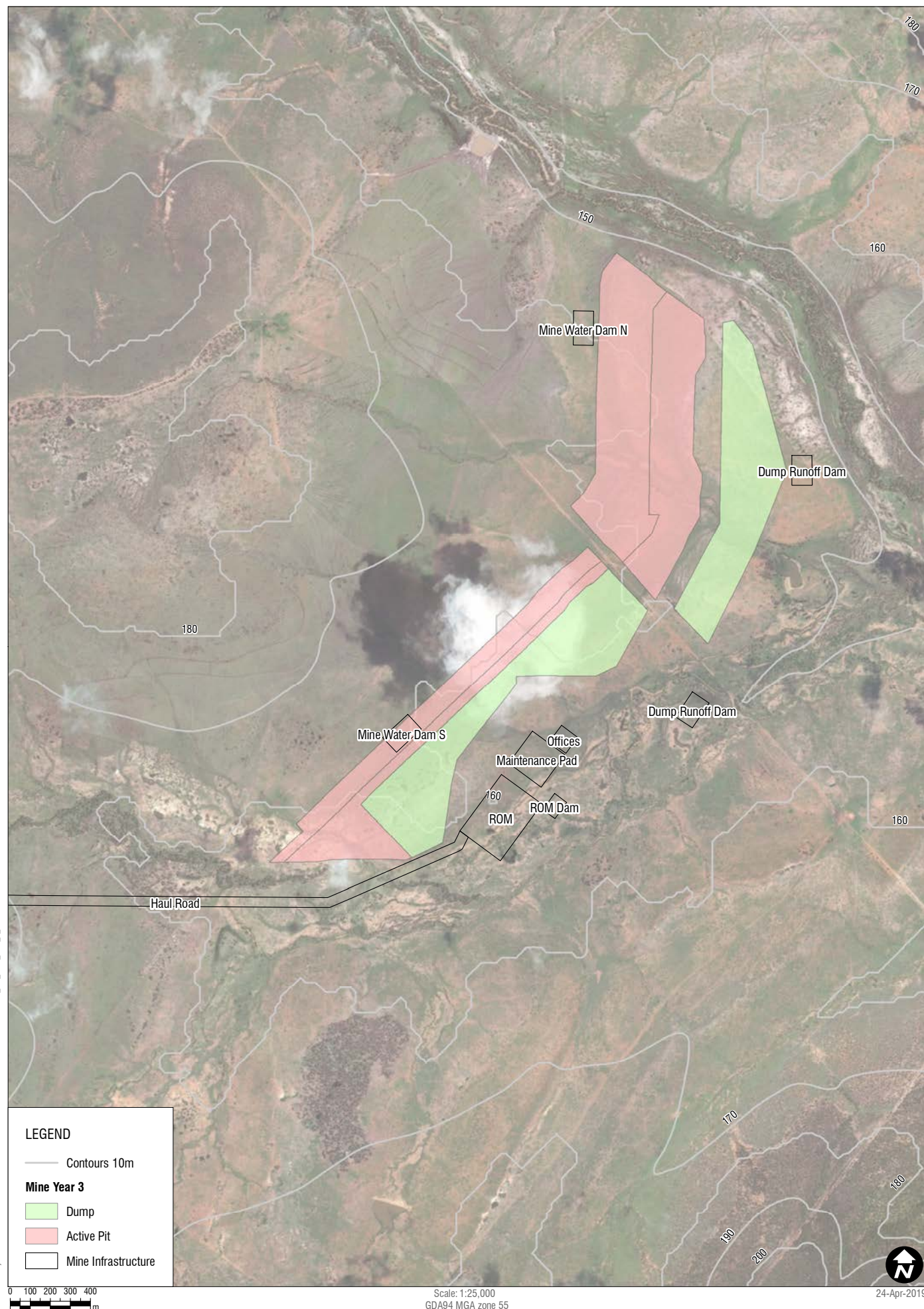
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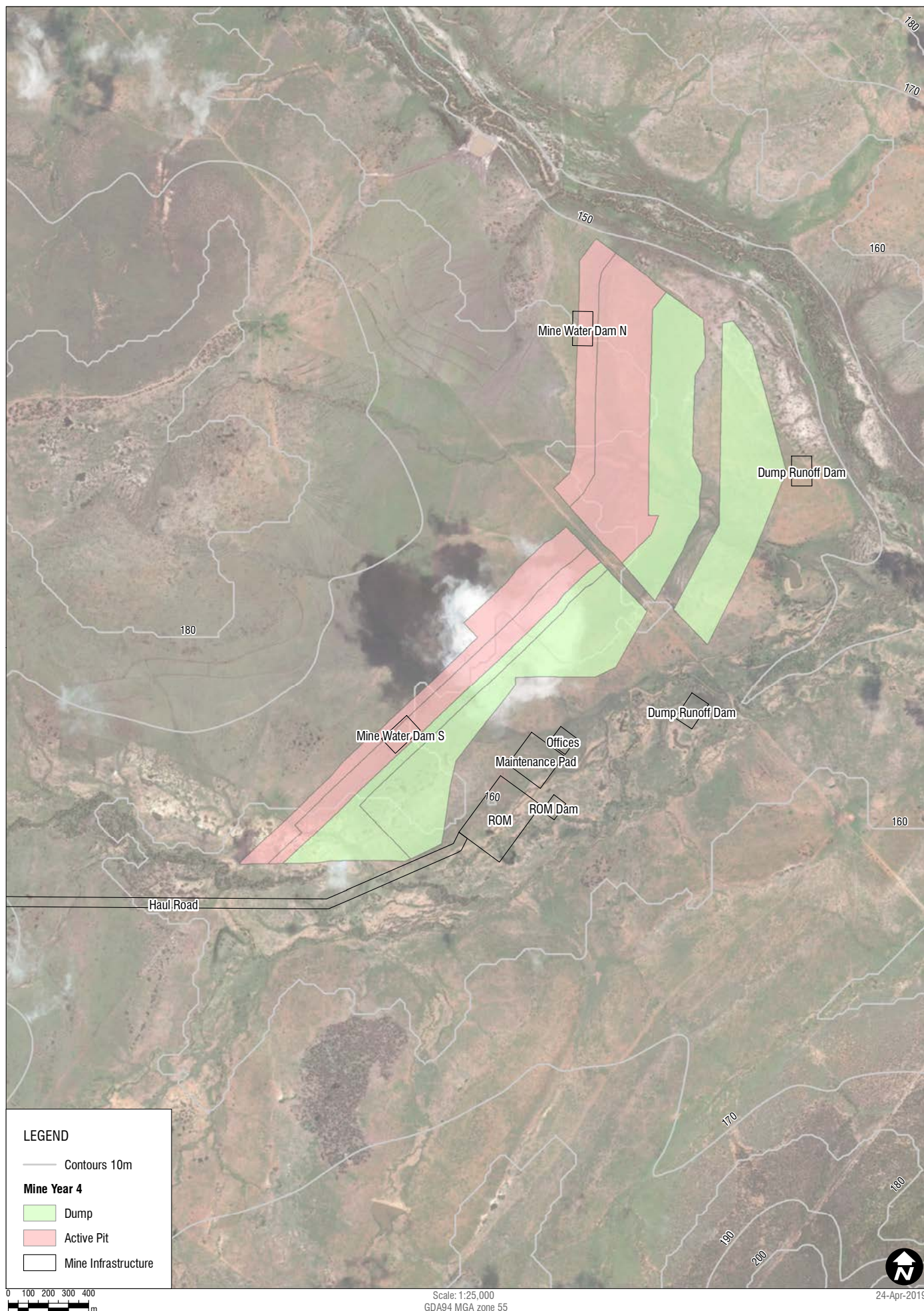
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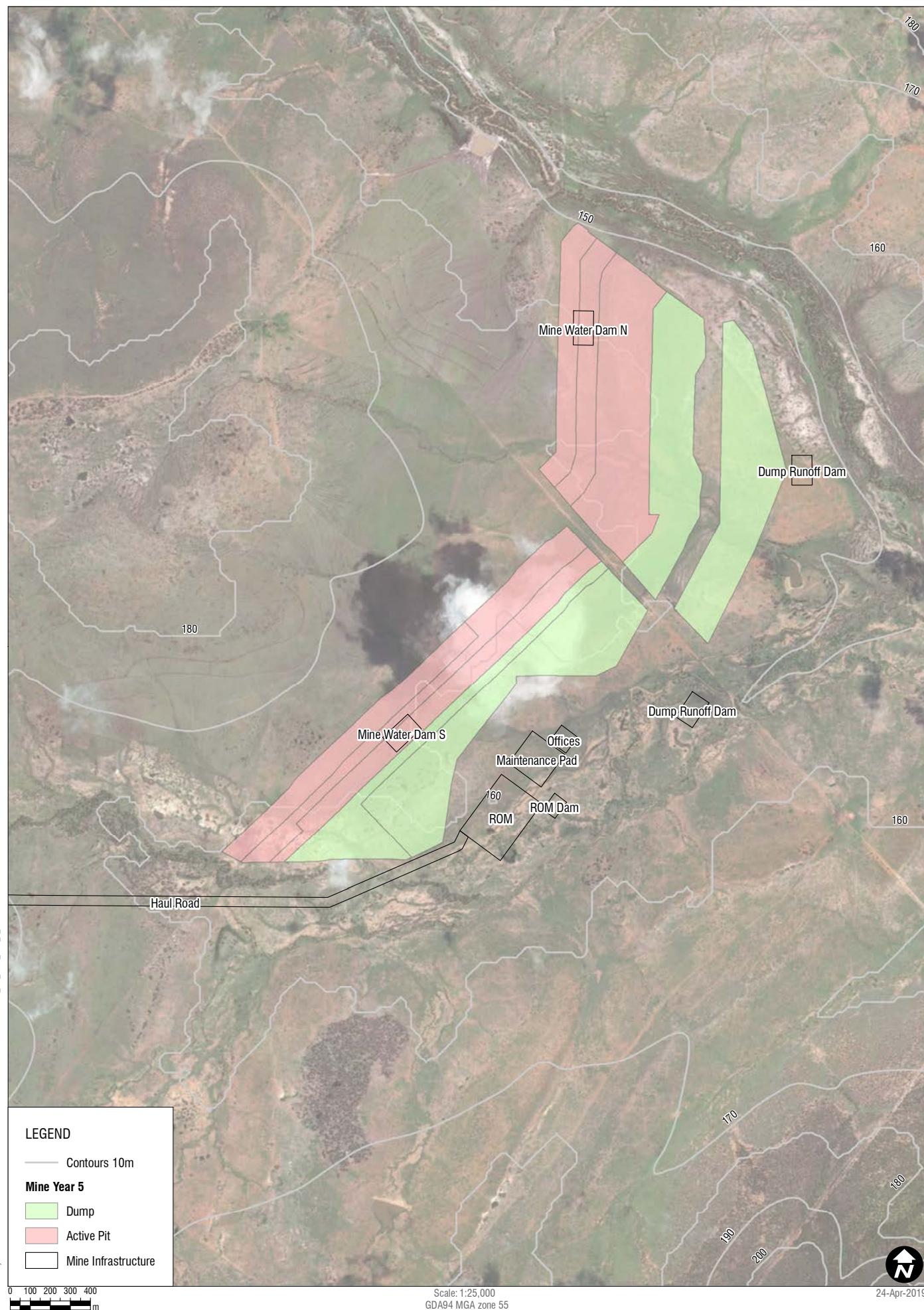
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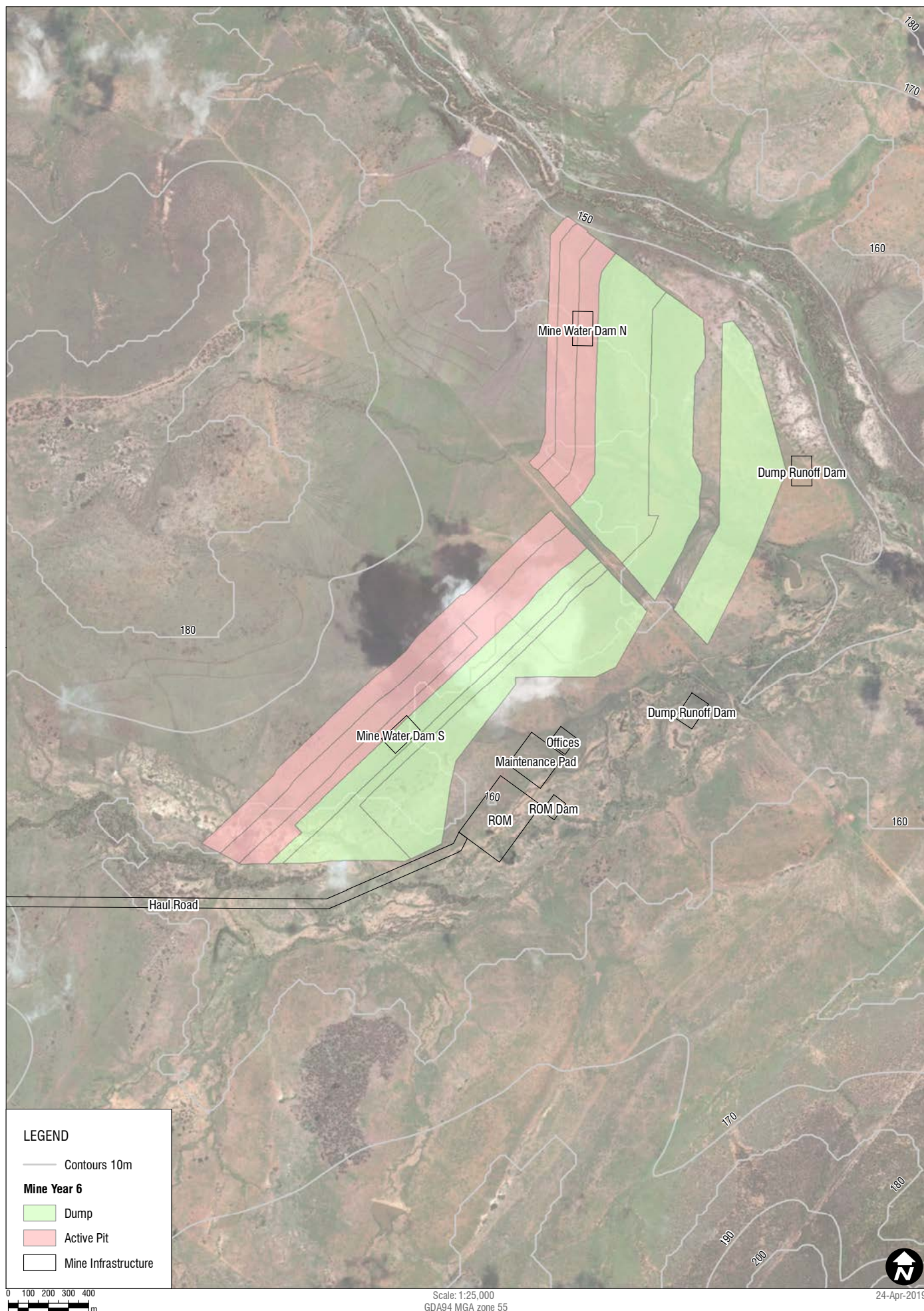
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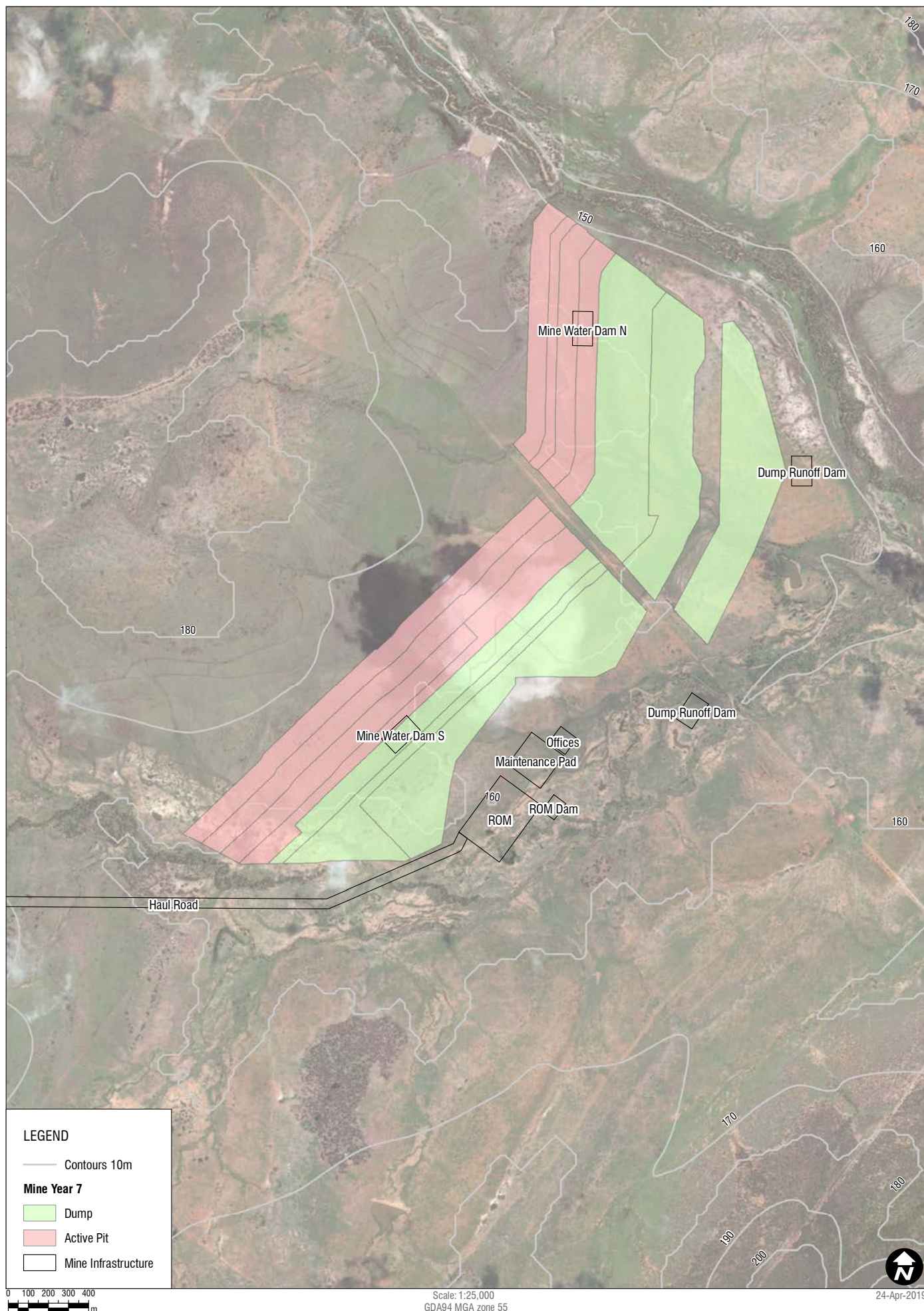
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4 PART C—A DESCRIPTION OF THE AQUIFER/S AFFECTED OR LIKELY TO BE AFFECTED

There are no significant groundwater aquifers in the vicinity of the FHCP site, due to the relatively small size and lack of continuity between water-bearing zones. This is supported by site-specific water quality data (high variability in EC), and, low and variable yield and transmissivity values reported across the site and in nearby mines (e.g. Wilton). The data is presented in the below section. A conceptual model of the hydrogeology of the mining lease has been developed to best visualise water bearing zones likely to be affected by the FHCP.

4.1 Local geology

The local stratigraphy is composed of the Late Permian Burngrove, Fairhill, MacMillan and German Creek Formations (**Table 1**). At the FHCP site, the Burngrove Formation is not present. Tertiary material only covers a small area in the north-eastern corner of the tenement. Alluvium of limited extent is common within the creek beds (**Figure 10**).

The strata in the region generally strike north-south and generally dip at angles of approximately 3 degrees to the west of the FHCP (ROM Resources, 2013). Dips can vary locally due to the presence of a series of synclines and anticlines. These smaller synclines and anticlines relate directly to structural deformation which occurred during the formation of the Comet Ridge and share a north-south axial strike. The nearest identified regional geological structures are an accurately mapped anticline situated to the northwest and an approximate anticline mapped to the east of the FHCP. These structures trend predominantly north-south. Folding has also caused strata to plunge at similar angles to the dips, from the northern and southern extents of the site towards the centre of the FHCP (**Figure 9**).

Figure 9 Conceptual diagram showing A: deformation and erosional processes and B: depositional processes that have occurred in the past in the region (not to scale; FHCP shown as red triangle)

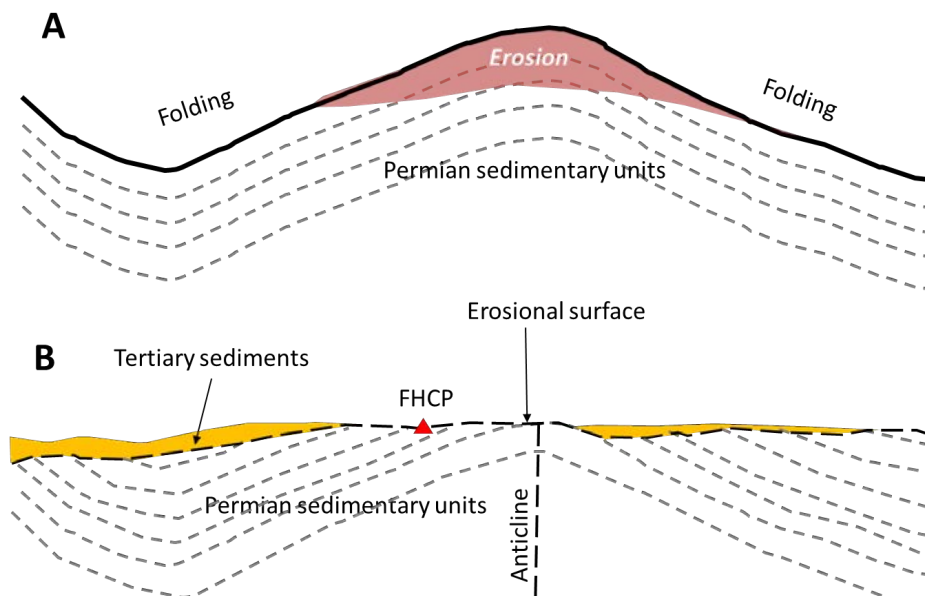


Table 1 Local stratigraphy of the FHCP. Adopted from Environmental Earth Sciences (2012), Scott *et al.* (1995) and Xstrata Coal (2012)

Age	Group	Formation	Description	Coal Seams
Quaternary	-	-	Unconsolidated sand and clay, with basal gravel and pebbles	-
Tertiary	-	Emerald Formation	Claystone and siltstone, sandstone, interbedded basalt (deeply weathered in outcrop)	-
<i>Unconformity</i>				
Permian	Blackwater Group	Burngrove Formation	Mudstone, siltstone, sandstone, coal and tuff	Pisces Virgo Libra Leo Aquarius Scorpio Centaur
		Fairhill Formation	Lithic and feldspathic labile sandstone with minor siltstone, mudstone, and coal seams	Phoenix Pegasus Hercules Canis Lepus Fairhill Fairhill Lower
	<i>Unconformity</i>			
	Back Creek group	Mac Millan Formation	Sandstone, siltstone, shale, mudstone	-
		German Creek Formation	Sandstone, siltstone, mudstone, coal seams	Pleiades Aquila Tieri 1 Tieri 2 Corvus Corvus 2 German Creek
		Ingelara Formation	Conglomeratic sandy siltstone, sandstone and mudstone	-
		Freitag Formation	Thin interbedded sandstone, siltstone, mudstone and minor coal seams	-

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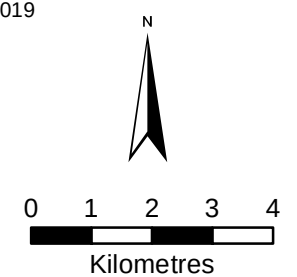
FIGURE 10
LOCAL GEOLOGY

Legend

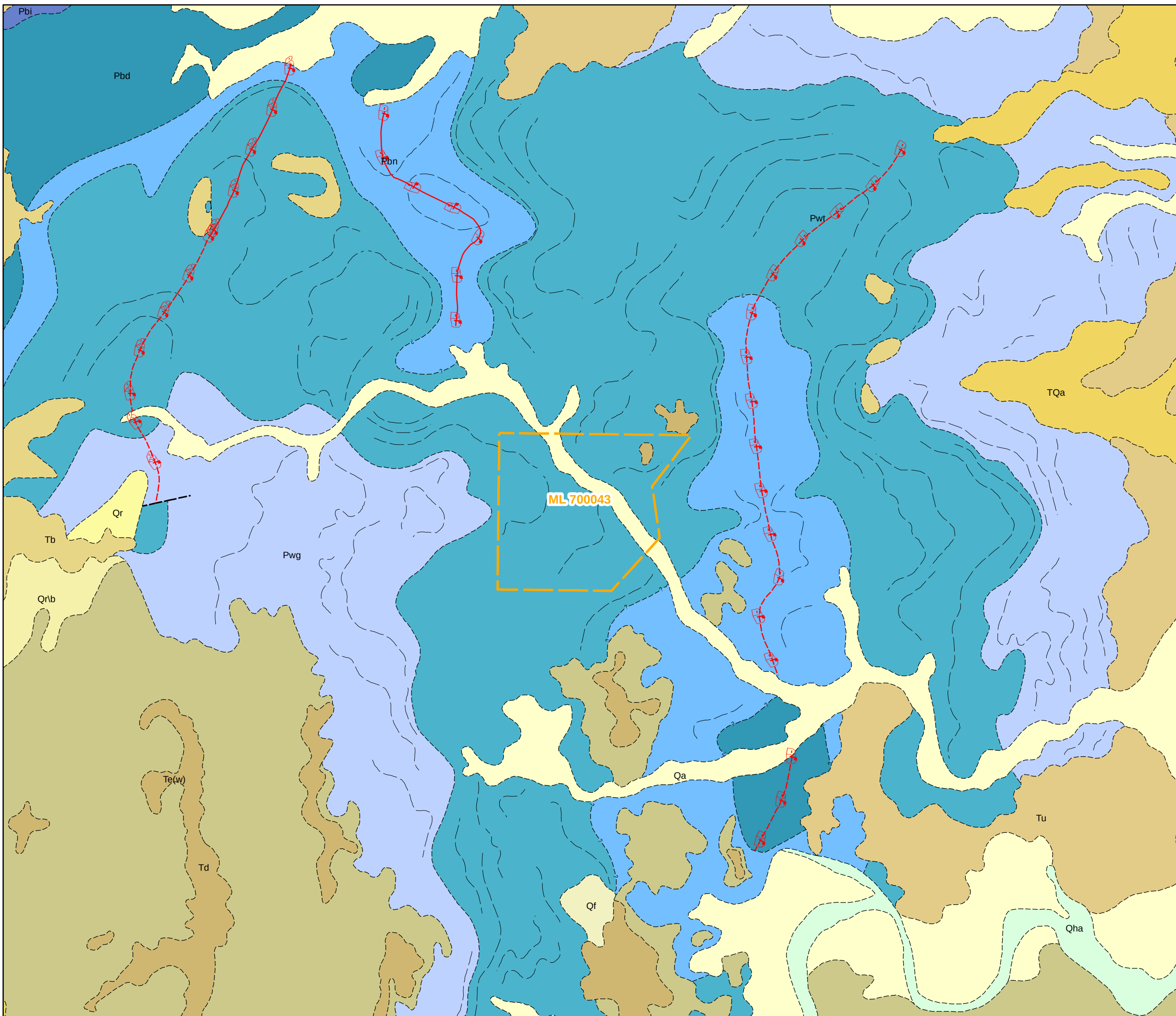
 Mining Lease Permit (Application)	Detailed Surface Geology
 Anticline accurate	 Burngrove Formation
 Anticline approximate	 Duaringa Formation
 Fault approximate	 Emerald Formation(w)
 Geological boundary (conformable) approximate	 Fair Hill Formation
 Geological boundary (conformable) inferred	 German Creek Formation
 Geological boundary (disconformable) approximate	 MacMillan Formation
 Geological boundary (disconformable) inferred	 Maria Formation
 Geological boundary (stratigraphic) approximate	 Qa-QLD
 Geological boundary (unconformable) approximate	 Qf-QLD
 Geological boundary (unconformable) inferred	 Qha-QLD
 Syncline accurate	 Qr-QLD
 Syncline approximate	 Qr/b-QLD
 Trend line	 TQa-QLD
	 Tb-QLD
	 Td-QLD

Data Sources:
Detailed Surface Geology, Detailed Geological Structures, and Mining Lease datasets: the State of Queensland (Department of Natural Resources, Mines, and Energy) 2019.

Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator
Datum: GDA 1994
Date: 3/05/2019



Scale: 1:125,000 at A3



4.2 Groundwater bores

A review of the DNRME groundwater database on Queensland Globe (Queensland Government, 2019) revealed 16 registered groundwater bores within 13km of the FHCP. Additionally, six monitoring bores from the nearby Wilton Coal Project (WCP) area also present within 13km of the FHCP. The bore details are presented in **Table 2** and the bore locations are shown on **Figure 12**. Drilling logs are included in **Appendix A**. Seven of the 16 registered bores are monitoring bores installed at FHCP to monitor groundwater levels and water quality. Out of these seven bores, five monitoring bores (FHMB03, FHMB04, FHMB05, FHMB06 and FHMB07) are targeted to monitor deep strata, whereas the other two monitoring bores are shallow and located close to Cooroora Creek to monitor potential groundwater-surface water interaction.

Measurable yields during drilling range from 0.03L/s to 2.5L/s and some yields were too low to be measured—these bores became dry in a matter of minutes suggesting limited aquifer capacity. Within 9km from the centre of the FHCP tenement, all bores show saline groundwater (i.e. EC > 15,000µS/cm). Further away, bores are brackish (i.e. EC > 800µS/cm) to saline with the freshest bores being WGWB3A (2,200µS/cm) and WGWB3B (2,350µS/cm). FHMB03 was dry at the time of drilling and has not made any water since.

Groundwater levels in FHCP monitoring bores recorded from June 2018 indicate that standing water levels (SWLs) are relatively constant and do not appear to be affected by seasonal changes in rainfall (**Figure 11**). It is likely that most bores at FHCP monitor confined or at least semi-confined water bearing zones.

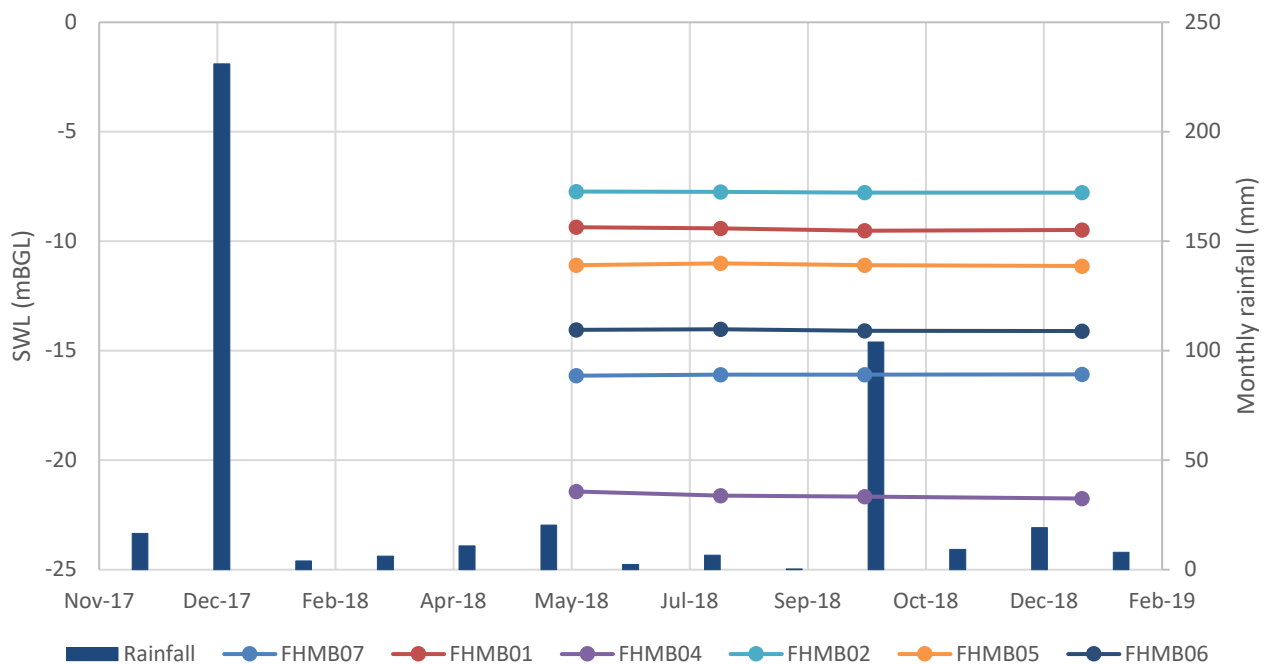


Figure 11 Groundwater elevation in FHCP monitoring bores and rainfall data

Table 2 Details of all available bores (DNRME registered bores and mining bores) within 13km of FHCP

DNRME Bore ID	Mine Bore ID	Year drilled	Easting	Northing	Depth (m)	Elevation TOC (mAHD)	Screened interval (m)	Water struck (m)	Aquifer lithology [formation]	SWL (mbgl)	RWL (m AHD)	Yield (L/s)	Quality (EC - μ S/cm; or comment from DNRME)
RN90070	-	1993	675756	7433719	57	-	-	21	Mudstone [Fairhill]	-	-	0.6	saline
RN90071	-	1993	675753	7433523	63	-	-	-	Sandstone [Fairhill]	-	-	0.8	saline
RN67015	-	1958	659192	7421000	24	-	-	-	Sandstone [Burngrove]	6	-	0.5	<i>Very saline</i>
RN90338	-	1994	658660	7422460	36	-	-	24	Basalt [Tertiary]	-	-	1	<i>Potable</i>
RN67014	-	1979	655510	7424516	79	-	-	52	Gravel [Burngrove]	45.7	210	2.5	<i>Very saline</i>
RN 67080	-	1900	657474	7434160	30.5	-	-	-	-	-	-	-	3,460
RN 89347	-	1992	656726	7432113	26	-	-	-	Basalt [Tertiary]	-	-	0.27	-
RN 67012	-	1920	657309	7431237	18.3	-	-	-	Sandstone [Burngrove]	6	-	0.5	<i>Very saline</i>
RN 67013	-	1920	656042	7430316	24.4	-	-	-	Sandstone [Burngrove]	6	-	0.5	<i>Very saline</i>
RN 165600	FHMB01	2018	668618	7429805	24	151	10 - 20	9	Alluvium/weath- ered basement [Quaternary]	9.36	141.64	<0.1	44,600

DNRME Bore ID	Mine Bore ID	Year drilled	Easting	Northing	Depth (m)	Elevation TOC (mAHD)	Screened interval (m)	Water struck (m)	Aquifer lithology [formation]	SWL (mbgl)	RWL (m AHD)	Yield (L/s)	Quality (EC - μ S/cm; or comment from DNRME)
RN 165597	FHMB02	2018	665931	7432447	18.5	153.4	8 - 18.5	11	Coal/siltstone [Fairhill]	7.73	151.27	1	25,300
RN 165599	FHMB03	2018	667489	7429461	20	158.9	12 - 20	Dry	Screened in sandstone/siltstone [Fairhill]	Dry	Dry	N/A	N/A
RN 165596	FHMB04	2018	665391	7431805	29.5	168.3	18 - 29.5	24	Tuffaceous siltstone [Fairhill]	21.43	148.57	0.44	16,400
RN 165595	FHMB05	2018	664578	7428931	23.5	165.2	7.5 - 23.5	16	Coal/tuff [Fairhill]	11.09	155.91	Too low	15,400
RN 165594	FHMB06	2018	663663	7427594	41	179.8	11 - 41	22	Sandstone, mudstone/coal [Fairhill]	14.05	167.95	<0.1	24,600
RN 165598	FHMB07	2018	667620	7432945	48	167.3	37 - 48	36	Sandstone, mudstone/coal [Fairhill]	16.14	152.86	Too low	17,900
-	WGWB2	2011	660390	7419905	103	196.5*	67 - 103	56	Sandstone [Fairhill]	18.77	177.7	0.5	4,600
-	WGWB3 A	2011	659505	7424053	31	207.3	13 - 31	14	Sandstone [Fairhill]	11.1	196.2	1.2	2,200
-	WGWB3 B	2011	659505	7424053	103	207.3	16 - 100	14	Sandstone [Fairhill]	8.68	198.6	2	2,350
-	WGWB4	2011	660346	7423079	103	186.3	18 - 98	22	Sandstone [Fairhill]	4.21	182.1	0.1	7,300

DNRME Bore ID	Mine Bore ID	Year drilled	Easting	Northing	Depth (m)	Elevation TOC (mAHD)	Screened interval (m)	Water struck (m)	Aquifer lithology [formation]	SWL (mbgl)	RWL (m AHD)	Yield (L/s)	Quality (EC - μ S/cm; or comment from DNRME)
-	WGWB5	2011	662720	7425642	103	186.8	61 - 103	64	Sandstone [Fairhill]	21.46	165.3	0.1	29,500
-	WGWB6	2011	657316	7427571	103	215.8	73 - 103	84	Sandstone [Fairhill]	37.88	177.9	0.03	8,100

*Elevation estimated from 10m contour (QLD Globe data set)

SWL measured in DNRME registered bores (excluding FHCP bores) have been measured at various dates. SWL for all FHCP bores (FHMBx bores) are from August 2018. SWL for all Wilton bores (WGWBx bores) are from 2012.

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FIGURE 12
DNRME AND MINE
MONITORING BORES

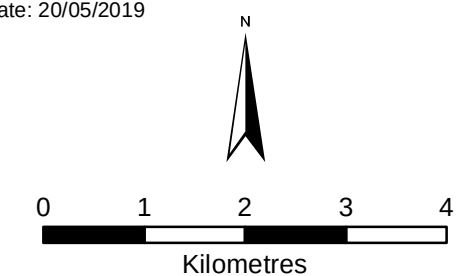
Legend

-  Mining Lease Permit (Application)
-  Proposed Site Infrastructure
-  7 Year Pit Shell

Bore Types

-  DNRME Registered Bores
-  FHCP Bores
-  WCP Bores

Data Sources:
DNRME Bores and Mining Lease datasets: the State of Queensland (Department of Natural Resources, Mines, and Energy) 2019; Fairhill Infrastructure datasets: SLR Consulting 2019.
Imagery Sources: 70cm Bowen Basin SISP PeriUrban 2012 Orthophoto Image Service: © State of Queensland (Department of Natural Resources, Mines, and Energy) 2019.
Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator
Datum: GDA 1994
Date: 20/05/2019



Scale: 1:75,000 at A3

4.3 Aquifer characteristics

Regionally, groundwater can potentially occur within the following Bowen Basin geological units:

- Quaternary alluvium;
- Tertiary sediments/basalt; and
- Permian coal measures (dominantly within the coal seams themselves).

4.3.1 Quaternary alluvial

Regionally, the main resource aquifers are located within the Quaternary alluvial deposits that occur in discontinuous lenses along major streams and rivers throughout the Nogoa and Mackenzie River sub-catchments. The nearest major occurrence of alluvium with the potential to form a significant aquifer is associated with the Mackenzie River approximately 13km southeast of the FHCP. Regionally, groundwater in the alluvium is unconfined and known to be strongly linked to ephemeral surface water flow; at certain times and locations, alluvium may only be partially saturated or even dry.

Locally, at the FHCP site, Quaternary floodplain alluvium associated with the northwest to southeast flowing Cooroora Creek (a tributary of the Mackenzie River) has been mapped, and consist of clay, silt, sand and gravel. This alluvium extends up to 16.5km upstream of the northern tenement boundary, with a width that can range from 200m in upstream sections to 800m in middle and downstream sections. Further downstream of the FHCP site, along the Mackenzie River that Cooroora Creek flows into, the Quaternary alluvium becomes significantly wider—exceeding 8km in some parts.

The thickness of the Cooroora Creek alluvium at the FHCP site is variable, based on the results of the three project drillholes that intersected the unit (exploration hole FH006, and groundwater monitoring bores FHMB02 and FHMB01). At FH006, the alluvium extends to approximately 10.5m deep, comprising approximately 4m of soil, 1.5m of clay, 3.5m of sand and 1.5m of gravel at the base, overlying 5.5m of coal. At FHMB02, alluvium consists of 2m of clay soil and 4m of clayey silt, overlying weathered sandstone. Generally speaking, the permeability of this unit will be controlled by sediment grain size distribution, with groundwater flow controlled by the extent and inter-connectivity of the more permeable lenses. At FHMB02, no water was encountered in the alluvium. At FH006, it is unclear if the water level reported is the depth at which water was intercepted during drilling or the SWL measured after drilling. Nevertheless, considering that the SWL is about 2m above the base of the alluvium, which is in direct contact with weathered coal bellow, it is likely that some connectivity exists between both units at FH006.

There is only one bore (FHMB01) in the vicinity of FHCP that accesses groundwater from the Cooroora Creek alluvium, at the downstream end of the Creek close to the southeastern lease boundary. At FHMB01, the alluvium consists of 2m of clay soil overlying approximately 8m of clayey sands and gravels. Water was first encountered in the drillhole at the very base of the alluvium directly overlying the highly weathered bedrock (clay). The SWL was measured at 9.36mBGL, indicating that the saturated thickness of the alluvium at FHMB01 is about 0.6m. Measured yield from this bore was very low (<0.1L/s) and water quality was highly saline (44,600µS/cm), suggesting that the aquifer potential of the Cooroora Creek alluvium is very limited.

4.3.2 Tertiary sediments

At FHCP, no bores have intercepted Tertiary sediments or basalt, and the local surface geology mapping (**Figure 10**) shows that Tertiary material only covers a small area in the north-eastern corner of the tenement. Exploration and monitoring bore drill logs from across the FHCP site indicate that the Permian strata is generally overlain by a thin (< 10m thick) layer of colluvium or in-situ weathered sandstone (i.e. weathering derived regolith), rather than Tertiary sediments. Therefore, it can be assumed that the FHCP site does not host any Tertiary aquifers. Regionally outside of the FHCP extent, pockets of fresh to brackish groundwater have been identified in Tertiary basalts. This include bores RN 90338 (12km south west of FHCP) and RN 89347 (10km west of FHCP). These bores have yields <1L/s and monitor small, likely semi-confined aquifers.

4.3.3 Permian coal measures

Groundwater in the region exists in the confined Permian sandstone, siltstone and mudstone units and associated coal seams of the Burngrove and Fairhill Formations. Regionally, coal seams themselves are considered to form the more dominant groundwater transmissive units of the Permian sequence. The non-coal sedimentary units tend to be tuffaceous in nature with high clay content. The fine grain size and well consolidated and lithified nature of these non-coal sedimentary strata results in low aquifer potential and much of the water-bearing units act as aquitards. Aquifer potential increases where there is contact between different rock types, e.g. sandstone, siltstone or coal, where yields and permeability tend to increase. Deformation and fracturing in these units also increase aquifer potential. The coal seams themselves can act as effective water-bearing and permeable units due to their low strength and high fracture potential. The interburden units generally form un-fractured aquitards that limit vertical inter-mixing between aquifer layers. The MacMillan Formation mudstone and siltstones underlying the Fairhill Formation likely act as a regional aquitard, confining the even deeper German Creek Formation coal measures.

In the area surrounding FHCP, very saline groundwater is found in shallow sandstone of the Burngrove Formation (see **Table 2**, bores RN67012, RN67013 and RN67015). However, within the FHCP tenement, the Burngrove Formation does not appear to be present, with the Fairhill Formation forming the shallowest Permian unit.

As noted above, the coal seams themselves represent the main, generally confined aquifers within the Permian Formations. The depth to and thickness of the coal seams are spatially variable. Coal seams average 12m in thickness with seams up to 20m thick. The depth to groundwater in the Fairhill Formation at FHCP is on average 14mBGL. The highest yielding bore (FHMB02) intercepted water in a coal seam at 11mBGL.

Groundwater flow directions in the Permian coal measures are discussed in **Section 4.4.1.3**.

4.4 Conceptual groundwater model

A conceptual groundwater model was developed to visualise the hydrogeology around the mining lease and immediate surrounding as well as the surface activities with potential impact to groundwater. The conceptual model is presented as a 2D map and a cross section. The 2D map (**Figure 13**) shows surface geology, hydrology, groundwater flow direction, monitoring bores and exploration holes, mining infrastructure and location of cross section; while the cross section (**Figure 14**) include lithology, groundwater level, groundwater flow direction, geological units, coal seams and pit and rock dump locations.

The components of the conceptual groundwater model are discussed below.

4.4.1 Methodology and data sources

The conceptual model was developed using site data, where available and regional dataset obtained through the Queensland Globe database. An overview of the methodology, data and references used to develop the conceptual model is provided below.

4.4.1.1 Model extent

The map is scaled to provide a regional context while the cross section is limited to the mining lease to allow better resolution of the groundwater system within and in close vicinity of the mining infrastructure.

4.4.1.2 Stratigraphy

To robustly represent the site geology in the conceptual model, a fence diagram (**Appendix B**) was developed using drill logs from the exploration holes, groundwater monitoring bores and DNRME registered bores. In areas where no drilling data was available, the detailed geology map from DNRME (**Figure 10**) was used to identify the formations present.

The base of weathering was inferred at 9m from the median depth of weathering observed in monitoring bores FHMB02 through to FHMB07. The location of the Tertiary unit was inferred from the QLD globe detailed geological map. The contact between the Fairhill Formation and the MacMillan Formation was inferred from the location of the Fairhill 2 coal seam (derived from the exploration holes drill logs), which is located at the bottom of the Fairhill Formation. The MacMillan Formation was assumed to be of a constant thickness ~70m (Prouza, 1977); and the German Creek formation is assumed as a basement unit. The general dip angles for the Permian formations were inferred from the conceptual geological diagram presented in **Figure 9**.

The thickness of the alluvium along Cooroora Creek is represented as 10m based on borelogs from FHMB01 (10m) and FH006 (10.5m). No alluvium is represented along Sandy Creek as the detailed DNRME geological map does not indicate any alluvium unit along Sandy Creek, and none of the bores drilled on either side of Sandy Creek (FHMB05 and FHMB06) intercepted alluvial deposits.

4.4.1.3 Groundwater level and flow direction

For the conceptual model, the groundwater level in the Cooroora Creek alluvium was determined using the SWL measured at bore FHMB01 (9.4m BGL). The potentiometric levels in the Permian coal measures were determined using the water levels measured in site bores installed in the Permian Fairhill Formation (see **Figure 17**). Toward the east of the site, where a lack of Permian bores means that no potentiometric surface could be generated, the groundwater level in the Permian unit was projected from that measured in bore FHMB07 (i.e. under the assumption that the Permian groundwater level and the alluvium groundwater level are in equilibrium at the eastern part of the lease).

The groundwater flow direction across the site was determined from the potentiometric surface generated from measured groundwater levels in the FHCP and WCP bores (**Figure 17**).

4.4.1.4 Mining infrastructure

The location of mining infrastructure during the seven-year period was provided by FCC (**Figure 2** to **Figure 8**). To visualise the total extent of the pit in the cross section, the total extent of excavation was considered from year 1 to year 7. Similarly, the final extent of the rock dump is displayed.

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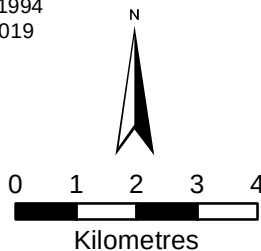
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FIGURE 13
CONCEPTUAL MODEL
REFERENCE

Legend

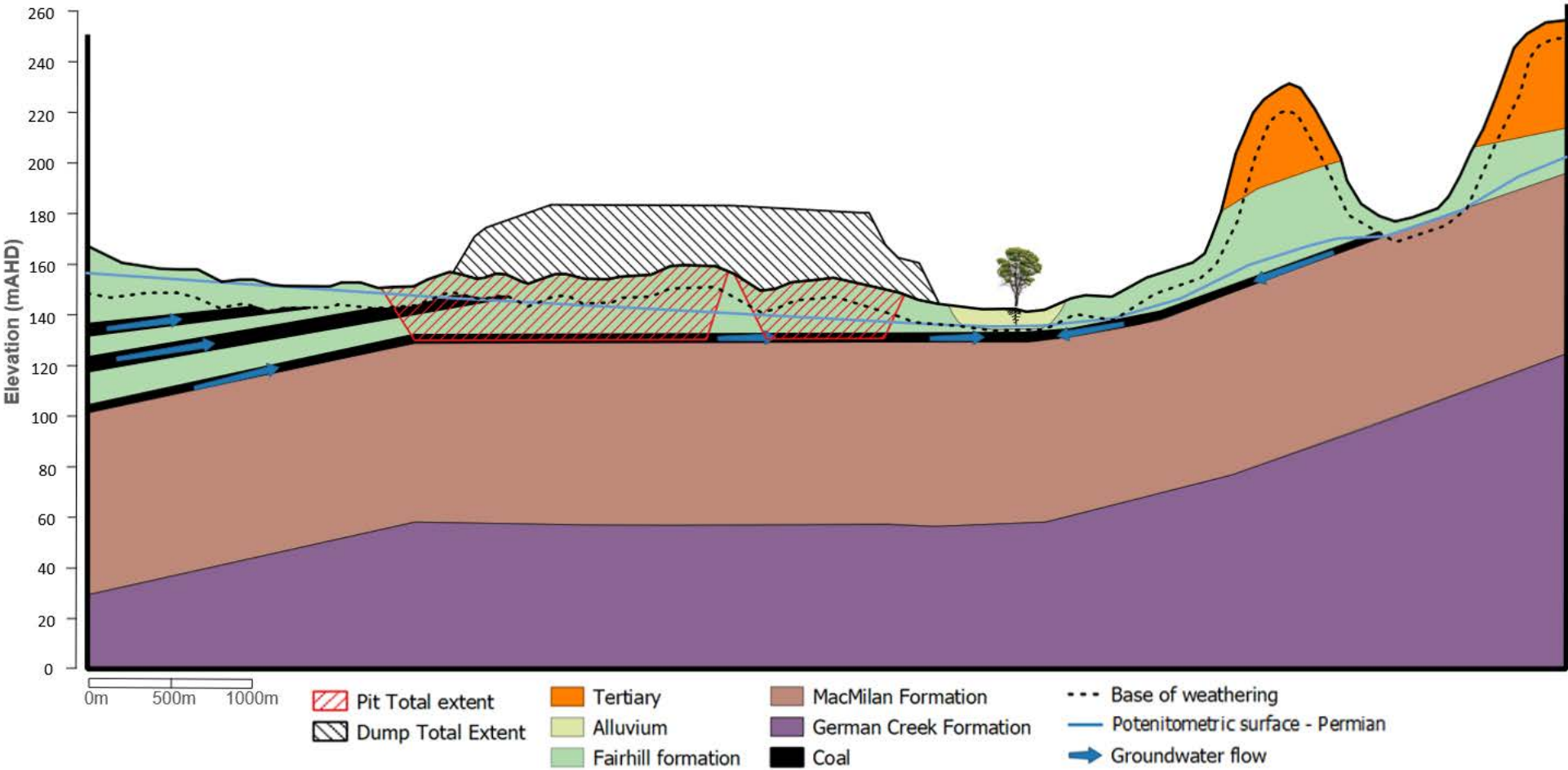
- | | |
|-----------------------------------|--|
| Cross section A-A' | Anticline accurate |
| Groundwater flow direction | Anticline approximate |
| Mining Lease Permit (Application) | Fault approximate |
| Proposed Site Infrastructure | Geological boundary (conformable) approximate |
| 7 Year Pit Shell | Geological boundary (conformable) inferred |
| Bore Types | Geological boundary (disconformable) approximate |
| DNRME Registered Bores | Geological boundary (disconformable) inferred |
| FHCP Bores | Geological boundary (stratigraphic) approximate |
| WCP Bores | Geological boundary (unconformable) approximate |
| Detailed Surface Geology | Geological boundary (unconformable) inferred |
| Burngrove Formation | Geological boundary approximate |
| Duaringa Formation | Syncline accurate |
| Emerald Formation(w) | Syncline approximate |
| Fair Hill Formation | Trend line |
| German Creek Formation | |
| MacMillan Formation | |
| Maria Formation | |
| Qa-QLD | |
| Qf-QLD | |
| Qha-QLD | |
| Qr-QLD | |
| Qrb-QLD | |
| TQa-QLD | |
| Tb-QLD | |
| Td-QLD | |

Data Sources:
Detailed Surface Geology, Detailed Geological Structures, DNRME Bores, and Mining Lease datasets: the State of Queensland (Department of Natural Resources, Mines, and Energy) 2019; Other Bores, Cross Section A - A', Groundwater Flow, and Fairhill Infrastructure datasets: SLR Consulting 2019.
Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator
Datum: GDA 1994
Date: 27/05/2019



Scale: 1:125,000 at A3

Figure 14 Conceptual model - Cross section AA'



5 PART D—AN ANALYSIS OF THE MOVEMENT OF UNDERGROUND WATER TO AND FROM THE AFFECTED OR POTENTIALLY AFFECTED AQUIFER/S

5.1 Inputs/Outputs

The hydrologic cycle at the FHCP site is dominated by low rainfall, high evaporation rates and limited diffuse recharge, which largely occurs uniformly over the landscape (Scanlon et al., 2002). Therefore, groundwater in the region is generally brackish to saline with only a few isolated locations able to produce small pockets of fresh groundwater. EHP published a selection of maps (EHP, 2011) visualising a number of groundwater characteristics for the greater Fitzroy Basin. The maps confirm that the FHCP site is placed into a low rainfall, low recharge area of the Highlands Groundwater Management Area of the Water Plan (Fitzroy Basin).

5.1.1 Recharge

The region has a sub-humid, sub-tropical climate, with distinct wet and dry seasons. Long-term rainfall and temperature data sourced from the Bureau of Meteorology (BOM) now obsolete weather station 035027, located at the Emerald Post Office shows a long-term average rainfall of 475mm, with the majority of precipitation occurring during the summer months of December, January and February. The latest available rainfall data available from the Emerald airport weather station 035264 is presented in **Figure 15**. The average rainfall recorded at Emerald airport weather station from 1993 to 2018 is 540mm.

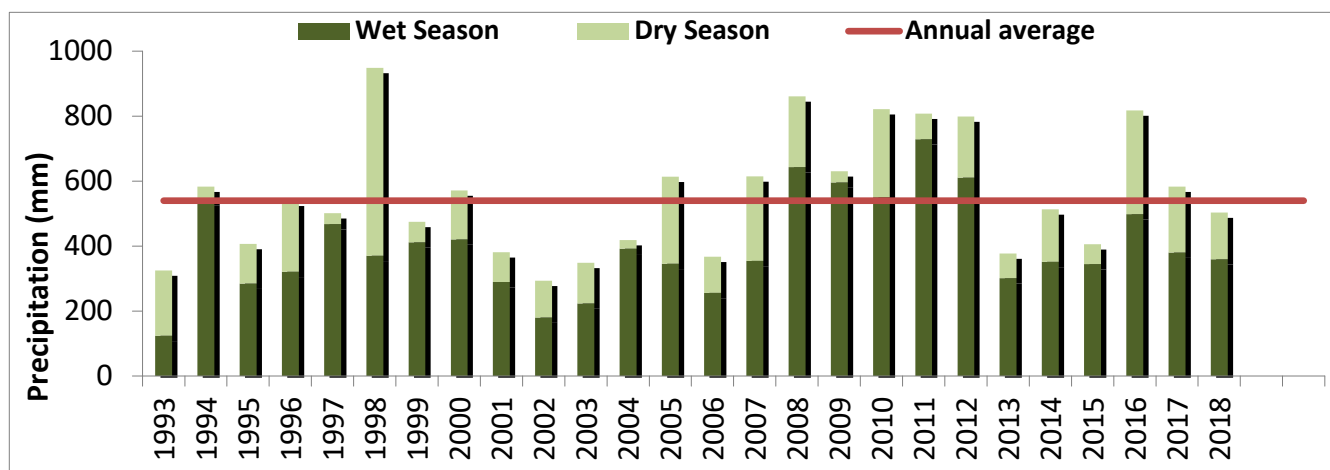


Figure 15 Annual precipitation (1993-2017) divided between wet and dry season records from the Emerald airport weather station (BoM, 2018)

Recharge of groundwater is likely to occur predominantly through infiltration of rainfall in areas of elevated topography (e.g. 2km north-northeast of the proposed FHCP pit). Minor recharge may occur through slow infiltration of pooled surface water along the Cooroora Creek stream bed and floodplain. Evidence of significant pooling over clay-rich alluvium adjacent to Cooroora Creek can be seen in aerial imagery. Significant evaporation/evapotranspiration in pools above surficial clays and subsequent slow infiltration may be one of the mechanisms resulting in salinisation of groundwater in the region. Some recharge may also occur through surface water infiltration into Sandy Creek.

5.1.2 Discharge

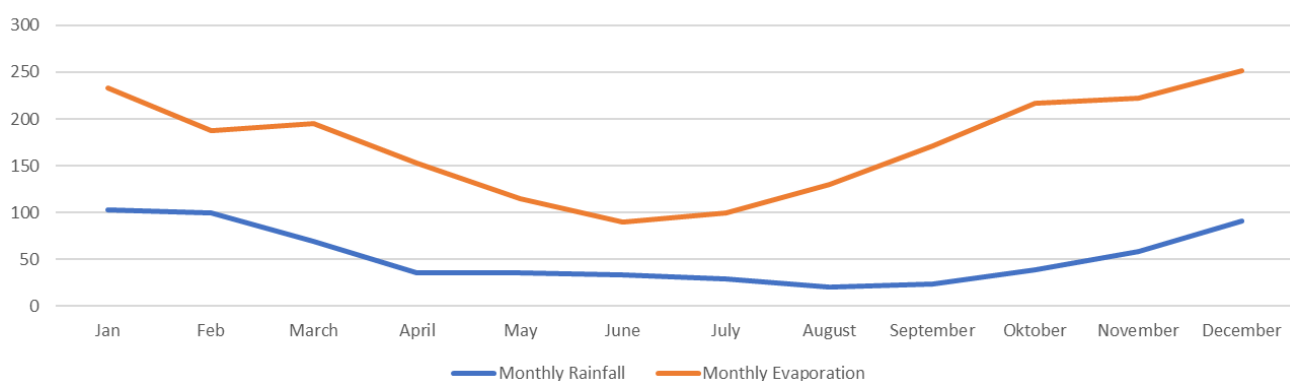
Within the study area (i.e. extent shown on **Figure 13**) there are two potential outputs of groundwater: Evapotranspiration and extraction from water bores within the surrounding area.

5.1.2.1 Evapotranspiration

Evapotranspiration takes place where water table is close to ground surface and/or within root zone depths (typically 1-2m away from creek lines). Within the study area the highest rates of potential evapotranspiration are along creek lines, in particular Cooroora Creek, where the water table is closer to ground surface and deeper rooting vegetation exists.

Neither Emerald Post Office nor Emerald Airport have information on evaporation rates; therefore, evaporation data has been sourced from the nearest suitable location (Clermont Post Office, BOM station 035019). On a monthly basis, evaporation is approximately two to three times greater than monthly rainfall (**Figure 16**). Therefore, groundwater recharge will be limited to areas with greater permeability or locations where rainwater can be stored for a greater amount of time, e.g. semi-permanent water bodies such as dams or river channels.

Figure 16 Mean monthly rainfall for Emerald (BoM station 035027) and Evaporation for Clermont (BoM station 035027)



5.1.2.2 Extraction from Water Bores

There are no known groundwater bores within the FHCP tenement that are used for stock watering or human consumption. The nearest bores that have water quality suitable for stock watering are mine monitoring bores W-GWB3A and W-GWB3B, which are outside the FHCP tenement, more than 7km away from the proposed mining activities. The nearest identified bore that is actively pumped is a farm bore (RN89380) located 15km south west of FHCP.

5.2 Underground water elevations

Groundwater elevations from site monitoring bores in the alluvium and Permian units indicate that groundwater flow generally follows topographic gradients (refer Section 4.4.1.3). Within the tenement, groundwater flows converge toward the topographic low formed by Cooroora Creek. Groundwater elevations in the Fairhill Formation at FHCP range between 148 and 156 mAHD, with only one bore along Cooroora Creek recording saturated alluvium with a groundwater elevation of approximately 141.6 mAHD. The potentiometric surface in the Permian units (Burngrove and Fairhill formations) was generated from the WCP and FHCP bores (**Figure 17**).

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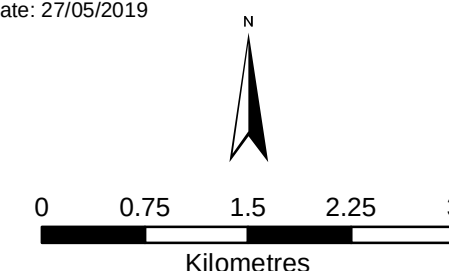
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FIGURE 17
GROUNDWATER
FLOW CONTOURS
PERMIAN
(FAIRHILL FORMATION)

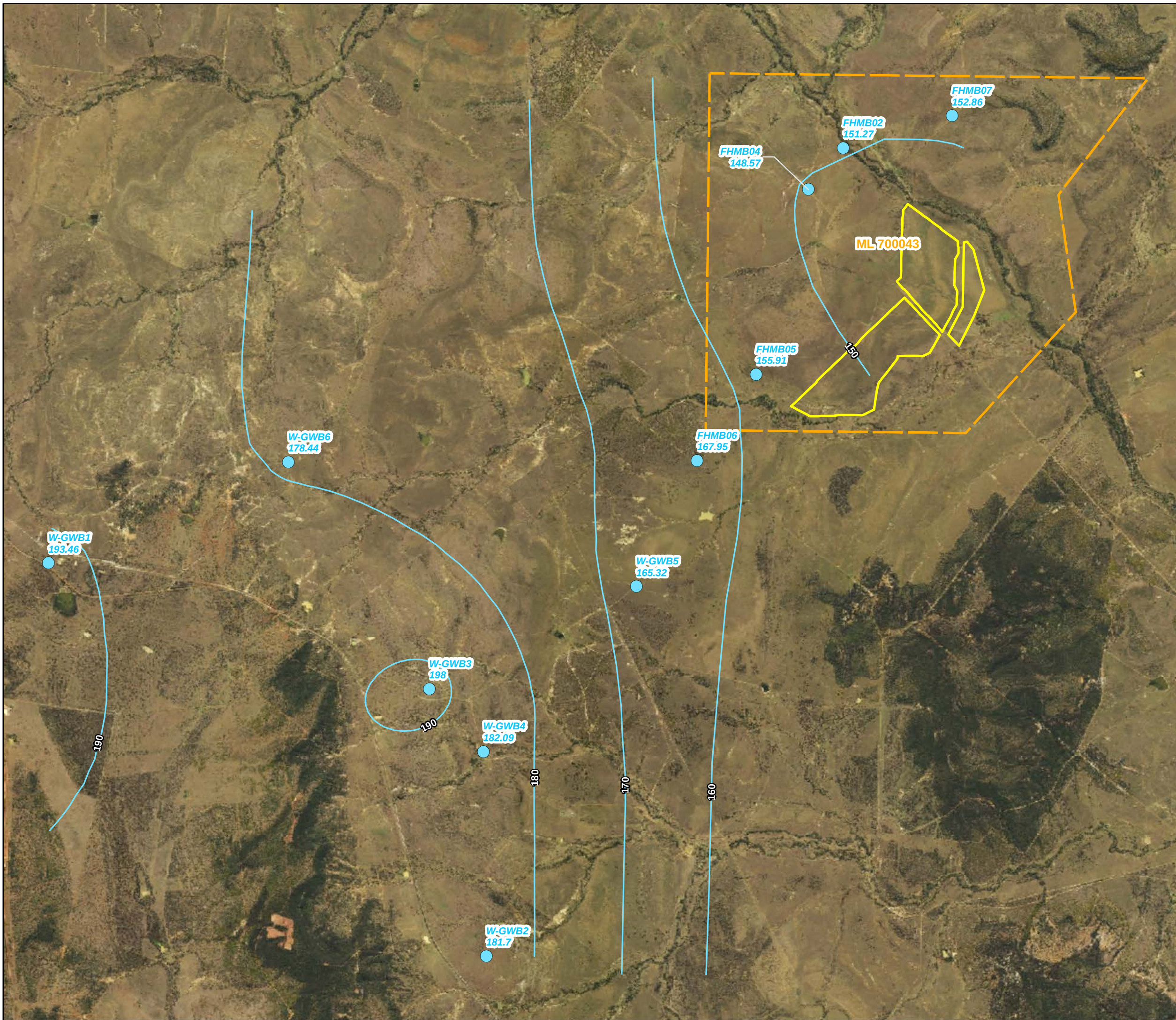
Legend

- Groundwater Bores (RL mAHd)
- Groundwater Level Contours (RL mAHd)
- Mining Lease Permit (Application)
- 7 Year Pit Shell

Data Sources:
Mining Lease dataset: the State of Queensland (Department of Natural Resources, Mines, and Energy) 2019; Fairhill Infrastructure and Groundwater Bore and Contour datasets: SLR Consulting 2019.
Imagery Sources: 70cm Bowen Basin SISP PeriUrban 2012 Orthophoto Image Service: © State of Queensland (Department of Natural Resources, Mines, and Energy) 2019.
Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator
Datum: GDA 1994
Date: 27/05/2019



Scale: 1:55,000 at A3



5.3 Connectivity

5.3.1 Surface water - groundwater connectivity

A review of drillhole lithology, water level and water quality data suggest little potential for surface water – groundwater connectivity.

Groundwater monitoring bore FHMB02 was installed adjacent to Cooroora Creek in the north of the FHCP (i.e. upstream) to target the potential alluvial aquifer at FHCP. This bore did not encounter groundwater within the top 6m of strata (alluvium). The alluvium here comprised 2m of clay-rich topsoil and 4m of clayey silt with extremely weathered sandstone inclusions. Water was first encountered at this location in Permian siltstone and coal at a depth of 11–12m. Alluvium in the vicinity of FHMB02 appears to consist of predominantly non-water bearing clay and silt, which would act as aquitards or confining layers to the underlying water-bearing Permian units and restrict hydraulic connection between the alluvium and the underlying Permian strata should the alluvium become saturated.

FHMB01 was also installed close to Cooroora Creek to target the potential alluvial aquifer, in the southeast of the FHCP (i.e. downstream). This bore encountered 2m of clay-rich soil, followed by silt and fine sand. Below these units were coarser alluvial material including sand and gravel, as well as more clay, down to a depth of 10m. Water was encountered at approximately 9m within this alluvial stratum, suggesting there is approximately 1m of saturated alluvium lying above the Permian bedrock at this location. Underlying the alluvium was a grey clay (weathered Permian) that is expected to be the lower confining unit to the alluvial aquifer, restricting hydraulic connection between the alluvium and the underlying Permian units.

The data from these two bores shows that the water-bearing potential of alluvium is variable across the site, and where groundwater does occur in the alluvium in the southeast of the FHCP, it remains significantly below the ground surface (stream bed) elevation.

The more recent (i.e. shallower) deposits of alluvium associated with Cooroora Creek are predominantly clay and silt-rich, limiting the potential for ephemeral surface water flowing through Cooroora Creek to recharge alluvial groundwater locally. These clay and silt-rich deposits would also prevent groundwater stored within underlying coarse-grained alluvium from discharging into the stream even if hydraulic gradients were sufficient to allow this to occur.

Baseline wet season receiving environment monitoring conducted at the end of January 2018 found pooling water in Cooroora Creek at three sites were significantly fresh, resembling recent rainfall (NRC, 2018a). If there were alluvial groundwater discharge into the creeks occurring, surface water should retain the highly saline nature of the groundwater in the underlying strata (e.g. electrical conductivity (EC) of >44,000µS/cm at FHMB01). Likewise, the fact that underlying groundwater is significantly more saline than the surface water pools supports the concept of limited localised groundwater recharge. This is also true for groundwater in the Fairhill Formation coal seams, which ranges in EC from 15,400 to 25,300µS/cm.

Monitoring bore FHMB05 drilled near Sandy Creek close to the southern tenement boundary shows water levels at approximately 11m below ground. The significant depth of groundwater below the lowest point of the adjacent Sandy Creek and the lack of water in the creek also indicates a lack of groundwater interaction with this surface water feature.

5.3.2 Aquifer connectivity

Even where hydrogeologic data suggests that saturated alluvium may exist at the downstream portion of Cooroora Creek adjacent the southeastern lease boundary, there is no indication of connectivity between the Permian coal measures and the alluvium. As detailed above, a confining layer of clay appear to be present between the alluvium and the underlying Permian strata. It remains possible that following significant rainfall during the wet season and there are ephemeral creek flows, the Quaternary alluvium becomes partially saturated and provides limited amounts of recharge to the underlying hard rock aquifers via very slow downwards leakage. Similarly, although upward hydraulic gradients may exist between the Fairhill Formation aquifer and the alluvium in Cooroora Creek, this clay layer at the base of the alluvium likely inhibits any significant groundwater movement from the Permian strata to the alluvium. The only exception to this is exploration hole FH006, which indicate that when coal is in direct contact with the alluvium (i.e. with no clay layer separating the two units) and when the head in the Permian unit is greater than the bottom elevation of the alluvium, there is potential for groundwater movement from the Permian strata to the alluvium. However, as indicated by the lack of water presence in the alluvium at FHMB002, which was drilled in the alluvium 800m downstream of FH006, connectivity between both units is likely limited to isolated pockets in the alluvium.

5.3.3 Great Artesian Basin

The nearest section of the Great Artesian Basin (GAB) to FHCP occurs approximately 60km southeast of the site. The aquifers of the GAB are of Jurassic and Cretaceous age (i.e. Mesozoic) while the FHCP is to be developed in rocks of late Permian to Permian age (i.e. Palaeozoic). There is neither lateral nor stratigraphic connection between the Fairhill geological sequence and the GAB sequence.

5.4 Preferential flow paths

No significant faults have been identified within the tenement. Preferential flow paths between surface water and groundwater may exist where exploration holes have not been rehabilitated. SLR understand that all known exploration holes have been rehabilitated. However, it remains possible that there are some historical drillholes that have been left open in which case they will be cased on the top 2m with a capping. Considering that the shallowest groundwater SWL in the Permian coal unit recorded is 7.7m at FHMB02, it is unlikely that artesian conditions will develop where an exploration hole as not been rehabilitated. Contamination of groundwater quality from infiltration in exploration holes is also unlikely given that all mining impacted water will be diverted to containment dams (refer **section 8.4**).

5.5 Springs

There are no registered springs in the vicinity of the FHCP area and the geological strata hosting the targeted coal seams are not known to support spring flow on any scale. The nearest publicly recorded springs are located approximately 80km southeast of the project area and originate from strata not associated with the FHCP (palustrine spring wetland associated with the GAB Springsure Spring Supergroup).

An unregistered spring used for cattle drinking was identified approximately 16km south-southwest of FHCP, adjacent to the neighbouring WCP. This spring seeps out at the contact between relatively permeable Quaternary-aged colluvial material and underlying outcropping Permian sedimentary bedrock in the base of a gully and is therefore likely sourced from groundwater in the Quaternary material. It is believed that recharge of this spring occurs from rainfall at higher elevations to the north and west of the spring, and flow of seepage follows the slope of topography. Due to its distance from FHCP, it is considered that there is very limited likelihood that mining activities at FHCP will have an impact on the spring.

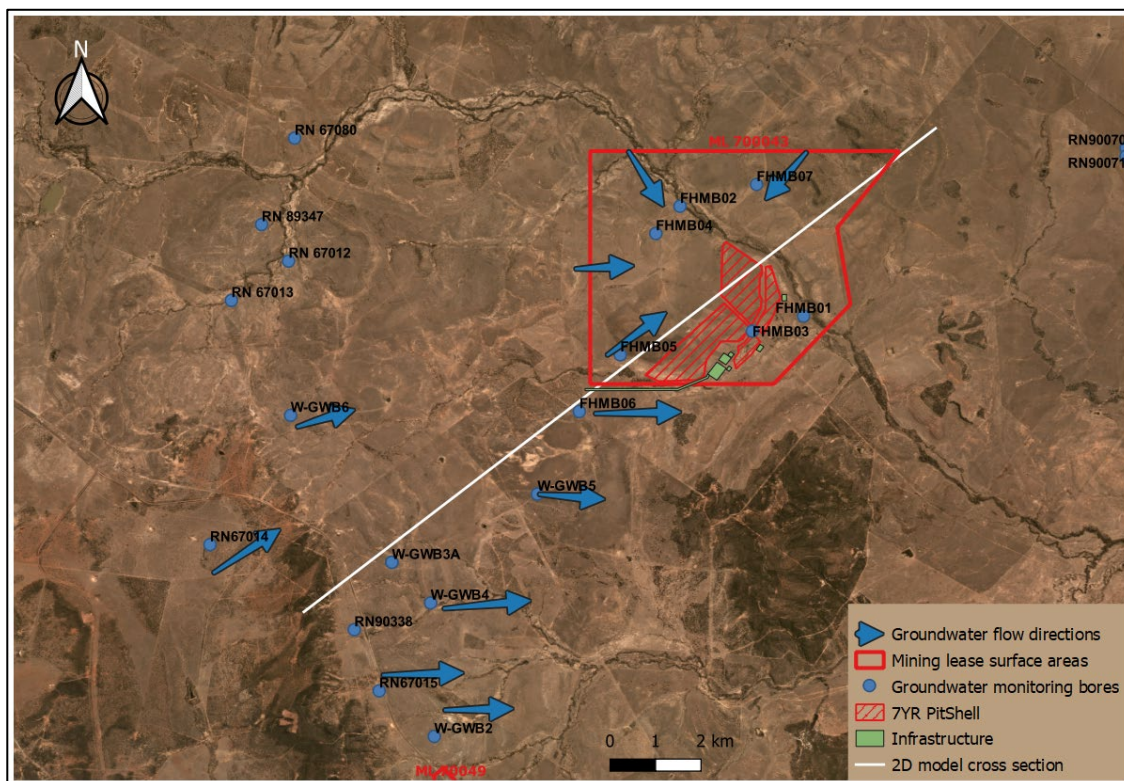
6 PART E—A DESCRIPTION OF THE AREA OF THE AQUIFER WHERE THE WATER LEVEL IS PREDICTED TO DECLINE BECAUSE OF THE EXERCISE OF UNDERGROUND WATER RIGHTS

6.1 2D numerical model

6.1.1 Model design

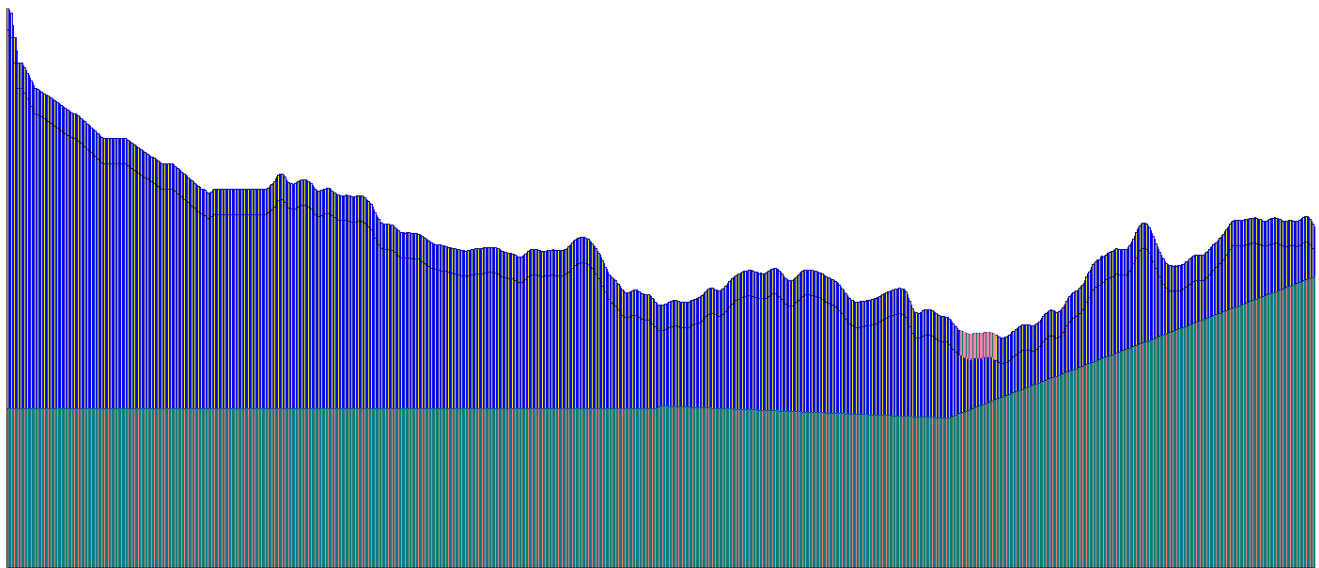
A 2D numerical model using MODFLOW-SURFACT was used to assess the potential drawdown from the FHCP pit excavation. The model was developed based on the conceptual model detailed in the previous section (Figure 14). The cross section was rotated slightly to be best aligned with groundwater flow directions and extended to allow capturing the full extent of drawdown (Figure 18).

Figure 18 Horizontal extent of the model



The ground surface elevation was generated using 5m contour files provided to SLR by FCC. The depth and extent of the geological formations were replicated from the conceptual model. The model comprises three layers; the first layer is uniform 10m thick and includes the alluvium and upper parts of the Fairhill Formation. The second layer (Fairhill Formation) varies in thickness, from 150m toward the west to 10m in the east. The third layer represent the MacMillan Formation, which is the basement of the model with a bottom elevation of 50mAHD (**Figure 19**).

Figure 19 Caption of the 2D MODFLOW-SURFACT model showing the 3 layers and different formations (Fairhill Formation in blue, MacMillan Formation in green and Cooroora Creek alluvium in pink)



General Head Boundaries (GHB) were used as boundary conditions on both end of the cross sectional model. The GHB is used to estimate the flux between a model cell and a body of water at a certain distance. GHB are used in the model to simulate the groundwater head at the boundary. The flux (recharge or discharge) across the model boundary (Q_B) is proportional to the difference in head ($h_B - h$) between the surrounding cells and the boundary: $Q_B = C_B \times (h_B - h)$

The conductance term (C_B), expressed in m^2/day is a function of the hydraulic conductivity (K) of the assumed uniform media, the distance (D) between the model and the boundary and the model cell geometry (Width (W) and length (L)):

$$C_B = K \times W \times \frac{L}{D}$$

GHBs heads were initially selected based on surrounding bores elevations, with upper and lower bounds to allow better calibration of the model (**Table 3**). The distance from the model boundary was selected at 1m and the hydraulic conductivity set at the corresponding layer value.

A GHB boundary was also placed in the middle of the Cooroora Creek alluvium to simulate throughflow to the southeast (i.e. perpendicular to the 2D model section) in the alluvium. The head at this boundary was set up based on the only bore intercepting alluvium (FHMB01 at 9.4m BGL). A GHB head was placed at the same location in the second layer (Fairhill Formation) to also simulate southeasterly throughflow in the Permian unit and allow groundwater in the Permian unit to exit the model below Cooroora Creek, in accordance with the conceptual model. The flux at this boundary is thus expected to be a sink. The head in the second layer was assumed to be the same as in the alluvium, considering the potential for connectivity between both units.

6.1.2 Calibration and sensitivity analysis

6.1.2.1 Calibration objectives and process

The model was calibrated to meet the following objectives:

- Establish a combination of parameters that both satisfy the conceptual model assumptions and match calibration objectives with the lowest error limit;
- Evaluate the sensitivity of the model calibration; and
- Run a steady state model that allows:
 - Estimation of the spatial distribution of groundwater levels;
 - Estimation of the parameters that have the greatest influence on groundwater levels within the model framework; and
 - Visualize drawdown from pit excavation

Model calibration involves refining the hydrogeological framework, hydraulic properties and boundary conditions of the model to achieve the desired degree of correspondence between the model simulations and observations of the groundwater flow system (Aquaterra, 2000). Calibration of the model using both the automated calibration tool PEST (Doherty et al., 2010) and a second manual calibration step followed the following process:

- Generation of an initial dataset within parameter bounds and constraints determined from the conceptual hydrogeological model and relevant data sources (**Table 3**);
- Water level target selection for both the alluvium and the Fairhill Formation (**Table 4**);
- Automated calibration using PEST;
- Review of the PEST calibration parameters for consistency with the conceptual model assumptions;
- Second manual calibration to obtain a combination of parameters that both satisfy the conceptual model assumptions and match calibration objectives with the lowest error limit.

6.1.2.2 Initial dataset

The initial dataset, including parameter bounds and constraints is shown in **Table 3**.

Table 3 Model inputs

Parameter	Description	Initial value	Min	max	data source
Kx1	Horizontal hydraulic conductivity - MacMillan Formation	5.00E-03	5.00E-05	5.00E-02	text book value
Kx2	Horizontal hydraulic conductivity - Alluvium	0.1	0.01	1	text book value/estimate
Kx3	Horizontal hydraulic conductivity - Fairhill Formation	0.016	0.0016	0.16	slug tests median
Kz1	Vertical hydraulic conductivity - MacMillan Formation	5.00E-04	5.00E-06	5.00E-03	ratio of Kx
Kz2	Vertical hydraulic conductivity - Alluvium	1.00E-02	1.00E-03	1.00E-01	ratio of Kx
Kz3	Vertical hydraulic conductivity - Fairhill Formation	1.60E-03	1.60E-04	1.60E-02	ratio of Kx
r1	Recharge - Fairhill Formation	6.50E-06	6.50E-07	6.50E-05	0.5% rainfall
r2	Recharge – Alluvium	6.50E-05	6.50E-06	6.50E-04	5% rainfall
et1	Evapotranspiration - Fairhill Formation	0.001	0.0001	0.01	estimate
et2	Evapotranspiration – Alluvium	0.002	2.00E-04	2.00E-02	estimate
etd1	Evapotranspiration depth - Fairhill Formation	2.00E+00	1.00E+00	4.00E+00	estimate
etd2	Evapotranspiration depth - Alluvium	4.00E+00	1.00E+00	6.00E+00	estimate
ghc1	GHB conductance - Alluvium	0.016	1.00E-04	10	slug tests median
ghc2	GHB conductance - Eastern boundary	0.016	1.00E-04	0.1	slug tests median
ghc3	GHB conductance - Western boundary	0.016	0.0001	0.1	slug tests median
ghc4	GHB conductance - Fairhill Formation below alluvium	0.1	0.0001	10	text book value/estimate
ghh1	GHB head – Alluvium (m AHD)	134.2	134.2	134.2	FHMB01
ghh2	GHB head - Eastern boundary (m AHD)	172.5	160	180	Median SWL in Permian
ghh3	GHB head- Western boundary (m AHD)	220	200	240	RN67014
ghh4	GHB head - Fairhill Formation below alluvium (m AHD)	134.2	134.2	134.2	FHMB01

6.1.2.3 Water level targets

Nine water level targets were used to calibrate the model. Without existing bores in the cross section selected, hypothetical water target levels were set up using the following general assumptions, in accordance with the conceptual model presented in **section 4.4.1.3**:

1. Water level along Cooroora Creek (i.e. In the alluvium) is equal to 9.4m BGL;
2. Water level in the Permian coal measures is based on the potentiometric water contours (**figure 17**). Toward the east where no contours are available, a target point was set based on FHMB07; and

3. Targets are located at regular intervals.

Targets sets in the alluvium and within the pit footprint were prioritised for calibration for the model to best reproduce water levels in the pit area and any associated drawdown in the alluvium (**Table 4**).

Table 4 Water level targets

Target name	Location (horizontal)	Layer (Vertical)	Water level (mBGL)	Water Level (mAHD)	Weight
T1	In the Fairhill Formation, 8.5km west of Cooroora Creek	2	14	190	1
T2	In the Fairhill Formation, 7.5km west of Cooroora Creek	2	14	177	1
T3	In the Fairhill Formation, 6.5km west of Cooroora Creek	2	14	169	1
T4	In the Fairhill Formation, 5.5km west of Cooroora Creek	2	14	163	1
T5	In the Fairhill Formation, within the pit footprint	2	14	157.5	1
T6	In the Fairhill Formation, within the pit footprint	2	14	152	4
T7	In the alluvium, to the west	1	8.5	134.6	6
T8	In the alluvium, to the east	1	8.5	132.9	6
T9	In the Fairhill Formation, 1.5km east of Cooroora Creek	2	14	160	1

6.1.2.4 Calibrated parameters

The model was first calibrated using PEST. The following parameter were then changed manually for consistency purposes:

- *r2* was changed to a higher (double) value than *r1* since recharge in the alluvium is expected to be higher than in the rest of the model domain.
- *et1* was changed to its original value since evapotranspiration in the alluvium is expected to be higher than in the rest of the model domain.

Table 5 Calibrated parameters

Parameter	Description	PEST result	Final calibrated model
Kx1	McMillan Formation	5.00E-05	5.00E-05
Kx2	Alluvium	0.375703	0.375703
Kx3	Fairhill Formation	1.61E-03	1.61E-03
Kz1	McMillan Formation	5.00E-06	5.00E-06
Kz2	Alluvium	1.77E-02	1.77E-02
Kz3	Fairhill Formation	1.60E-03	1.60E-03
r1	Fairhill Formation	2.85E-07	2.85E-07
r2	Alluvium	2.75E-08	5.70E-07
et1	Fairhill Formation	0.1	1.00E-02

Parameter	Description	PEST result	Final calibrated model
et2	Alluvium	2.00E-02	2.00E-02
etd1	Fairhill Formation	4	4
etd2	Alluvium	5.27645	5.27645
ghc1	Alluvium	0.3	0.3
ghc2	Eastern boundary	0.00161	0.00161
ghc3	Western boundary	0.00161	0.00161
ghc4	Fairhill Formation bellow alluvium	0.00161	0.00161

6.1.2.5 Water balance

The water balance for the steady state model is presented on **Table 6**. Recharge comprises the majority of inflows, with the western GHB accounting for about 13% of total inflow. ET comprises the majority of outflows, with the GHB located along Cooroora Creek in the Fairhill Formation accounting for 30% of outflows.

As discussed previously (**section 6.1.1**), GHB are sensitive boundaries that can have a significant impact on model results. In the calibrated model, the input from GHBs to the model are negligible compared to recharge. The outflow along Cooroora Creek account for about a quarter of outflows, which is considered a significant component of the water balance. However, this is expected as discussed in **section 6.1.1**.

The Australian Groundwater Modelling Guidelines (Barnett et al, 2012) recommends for mass balance closure error criteria that “[a] value less than 1% should be achieved and reported at all times and cumulatively over the whole simulation.” The water balance discrepancy between calculated inflows and outflows is 0.02%, which meet the Australian Groundwater Modelling Guidelines criterion stated above.

Table 6 Water balance

	Inflow (m ³ /d)	Outflow (m ³ /d)
GHB1 (Layer 1; alluvium)	0	0.0001
GHB2 (Layer 1 and Layer 2; Eastern boundary)	0	0.0019
GHB3 (Layer 1 and Layer 2; Western boundary)	0.0136	0
GHB4 (Layer 2; Fairhill below alluvium)	0	0.0285
Total GHB	0.0131	0.0306
Recharge	0.0949	n/a
ET	n/a	0.0774
Total	0.1080	0.1081
Percent error	-0.02%	

6.1.2.6 Steady state water levels statistics

The model was calibrated against 9 water levels targets with a scaled RMS of 10% (**Table 7** and **Figure 20**) which is considered satisfactory. As discussed in **Section 6.1.2.3**, water level targets T6, T7 and T8 were prioritised for the model to best calibrated around the pit and Cooroora Creek. The residual on each target are as follows:

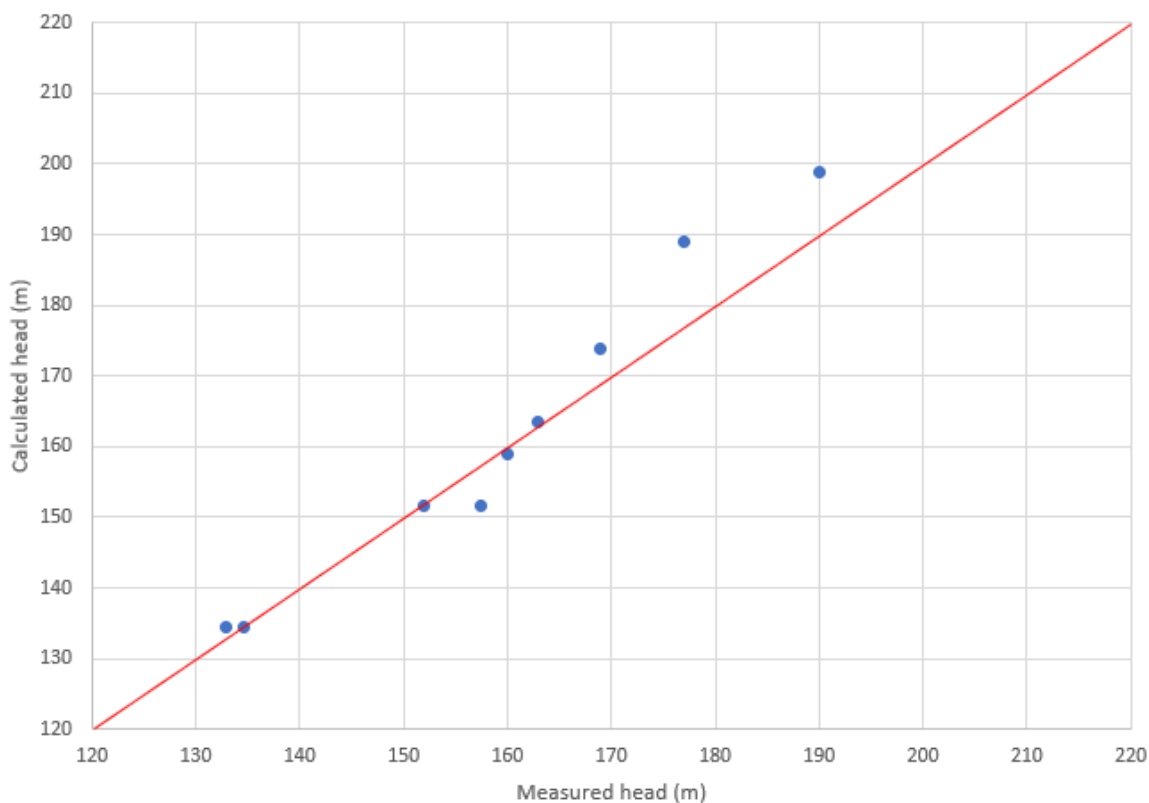
- T6 residual = +0.22m
- T7 residual = -0.05m
- T8 residual = -1.65m

The head residual in the alluvium (T7, T8) and within the pit (T6) is lower than the mean residual, indicating a better calibration around these targets.

Table 7 Water level calibration statistics

Calibration Statistics	
Number of observations	9
Residual mean	-2.38
Root Mean Square Error (RMSE)	5.73
Scaled RMSE	10%

Figure 20 Calculated versus observed water levels

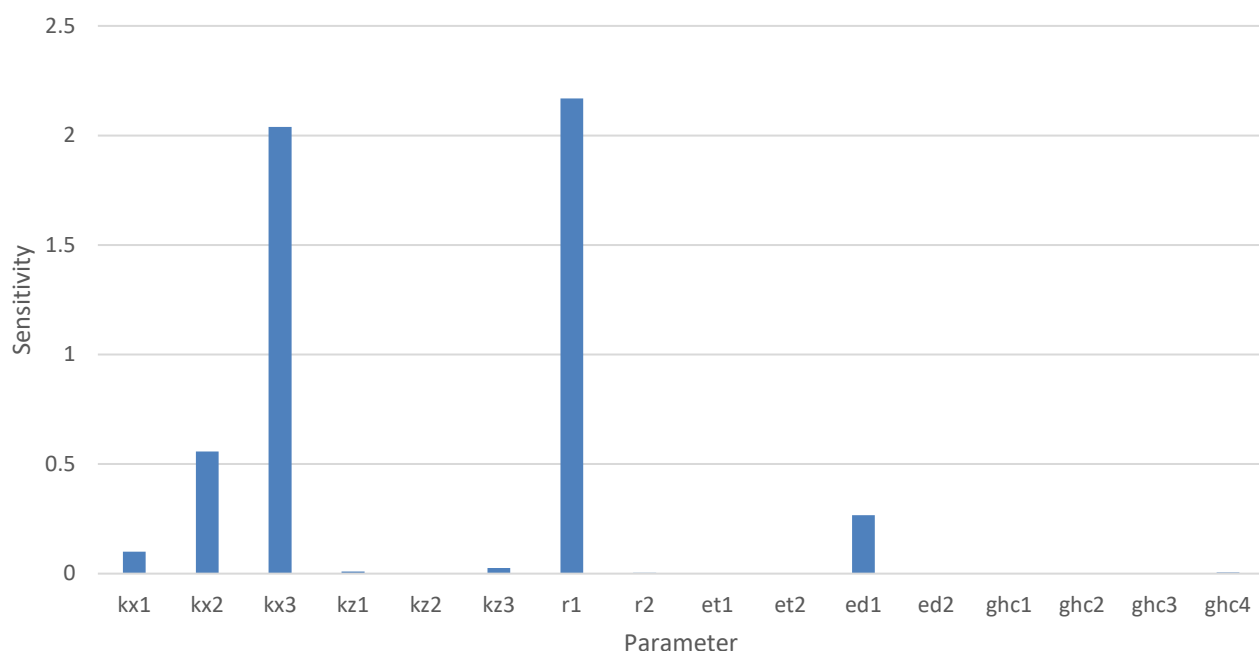


6.1.2.7 Sensitivity analysis

Sensitivity analysis provide an indication of how sensitive the model results are to variation of each input parameter. The sensitivity analysis helps calibration but also enables the conducting of uncertainty analysis on the model results. A sensitivity analysis was carried out as part of the PEST calibration process. In PEST, the sensitivity analysis compute sensitivities of the objective function to changes in all parameters.

The sensitivity analysis presented in **Figure 21** reveals that the main recharge zone (r1) and the horizontal hydraulic conductivity of the Fairhill Formation (Kx3) are the most sensitive parameter, followed by horizontal hydraulic conductivity of the alluvium (Kx2) and the evapotranspiration depth of the main recharge zone (ed1).

Figure 21 Sensitivity analysis from PEST run



Further sensitivity analysis was performed on the two most sensitive parameters. Each parameter was changed alternatively with the aim to obtain several calibrated models with different parameters. For Kx3, the calibrated anisotropy ratio ($Kz/Kx=1$) was applied to each scenario. Although the GHB conductance was not identified as a sensitive parameter, the hydraulic conductivity value in each GHB was attributed the value of the corresponding layer, for consistency purposes. The results are presented in **Table 8**. Uncalibrated models are highlighted in red. Models were deemed calibrated if the following conditions were met:

- SRMS <15% and
- Mean residual <6m and
- T6 residual <10m and
- T7 residual < 3m and
- T8 residual < 3m and
- Water balance < 1% and

- GHB boundary along Cooroora Creek are a sink, not a source

High residual error is accepted for the Fairhill Formation given the spatial variation observed at FHCP and associated uncertainty on the potentiometric surface. Doing so allows the generation of a confidence interval for the drawdown.

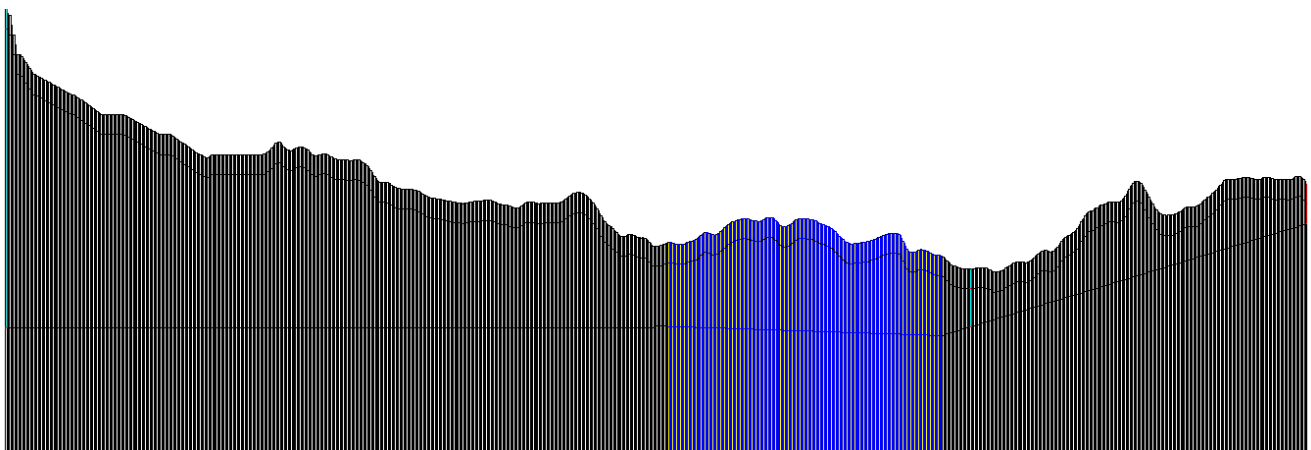
Table 8 manual sensitivity analysis

Run	Parameter variation	SRMS (%)	Mean residual (m)	T6 residual (m)	T7 residual (m)	T8 residual (m)	Water balance (%)
S1	0.2*Kx3	14.1	-5.09	-5.13	0.15	-1.47	-0.26
S2	5*Kx3	11.5	0.01	7.28	-0.29	-2.04	-0.02
S3	0.1*Kx3	15.9	-6.11	-6.42	0.21	-1.43	-0.13
S4	10*Kx3	12.6	0.55	8.31	-0.47	-2.18	-0.01
S5	0.2*r1	11.6	0.2	7.51	0.16	-1.55	-0.01
S6	5*r1	14.5	-5.47	-5.36	-0.31	-1.74	-0.05
S7	0.1*r1	12.7	0.80	8.66	0.19	-1.50	-0.01
S8	10*r1	16.8	-6.79	-7.01	-0.44	-1.80	-0.04

6.1.3 Pit drawdown simulation

In order to simulate the maximum drawdown from the pit, the total extent of excavation as represented in the conceptual model (**Figure 14**) was modelled using drain cells (**Figure 22**).

Figure 22 Caption of the 2D MODFLOW-SURFACT model showing the location of the drain cells



6.1.4 Predicted drawdown

Simulation results indicate that the predicted drawdown toward the west of the pit is <1m at a distance of 4.3km from the pit centre (**Table 9**). Toward the east in the Permian unit, the predicted drawdown is <1m at a distance of 2.1 km from the Pit centre. The maximum predicted drawdown in the alluvium is predicted to be 0.6m close to the western edge of Cooroora Creek (200m from the pit eastern wall) and is negligible on the eastern edge. The difference between predicted drawdown to the west and east of the pit is expected considering both the natural and mining influenced hydraulic gradients are greater toward the west:

- At 200m from the west of the pit wall, the natural groundwater level is 155mAHD. The pit excavation at 130mAHD create a hydraulic gradient of 0.125 over this distance.
- At 200m from the east of the pit wall, in the alluvium, the natural groundwater level is 141mAHD. The pit excavation at 130mAHD create a hydraulic gradient of 0.055 over this distance.

6.1.4.1 Sensitivity analysis

Additional drawdown simulations were performed to test the sensitivity of the model results and provide a confidence interval for the calculated drawdown. The six calibrated models from the uncertainty analysis (**Table 8**) were used to calculate drawdown. A 95% confidence interval was calculated for both 1m drawdown and 2m drawdown radius (**Table 9**).

Table 9 Uncertainty analysis for predicted drawdown in the Fairhill Formation

Model ID	Distance where drawdown is <1m west of the pit centre (m)	Distance where drawdown is <2m west of the pit centre (m)	Distance where drawdown is <1m east of the pit centre (m)	Distance where drawdown is <2m east of the pit centre (m)
Calibrated	4284	3870	2080	2050
S1	2480	2430	2080	2050
S2	4590	4230	2160	2090
S4	4640	4300	2230	2120
S5	4600	4270	2070	2030
S6	2460	2410	2080	2060
S7	4650	4540	2070	2020
median	3821	3610	2110	2060
95% confidence interval	702	624	42	24

6.1.5 Conclusion

The model was designed to provide an estimate of drawdown arising from the FHCP, including a range of possible drawdown radius, in both the Fairhill Formation and the Cooroora Creek alluvium. The results are coherent with the pre-mining hydraulic gradients measured at FHCP and the model is considered satisfactory in providing a range (95% confidence interval) of drawdown predictions in the Fairhill Formation and a maximum predicted drawdown in the Cooroora Creek alluvium.

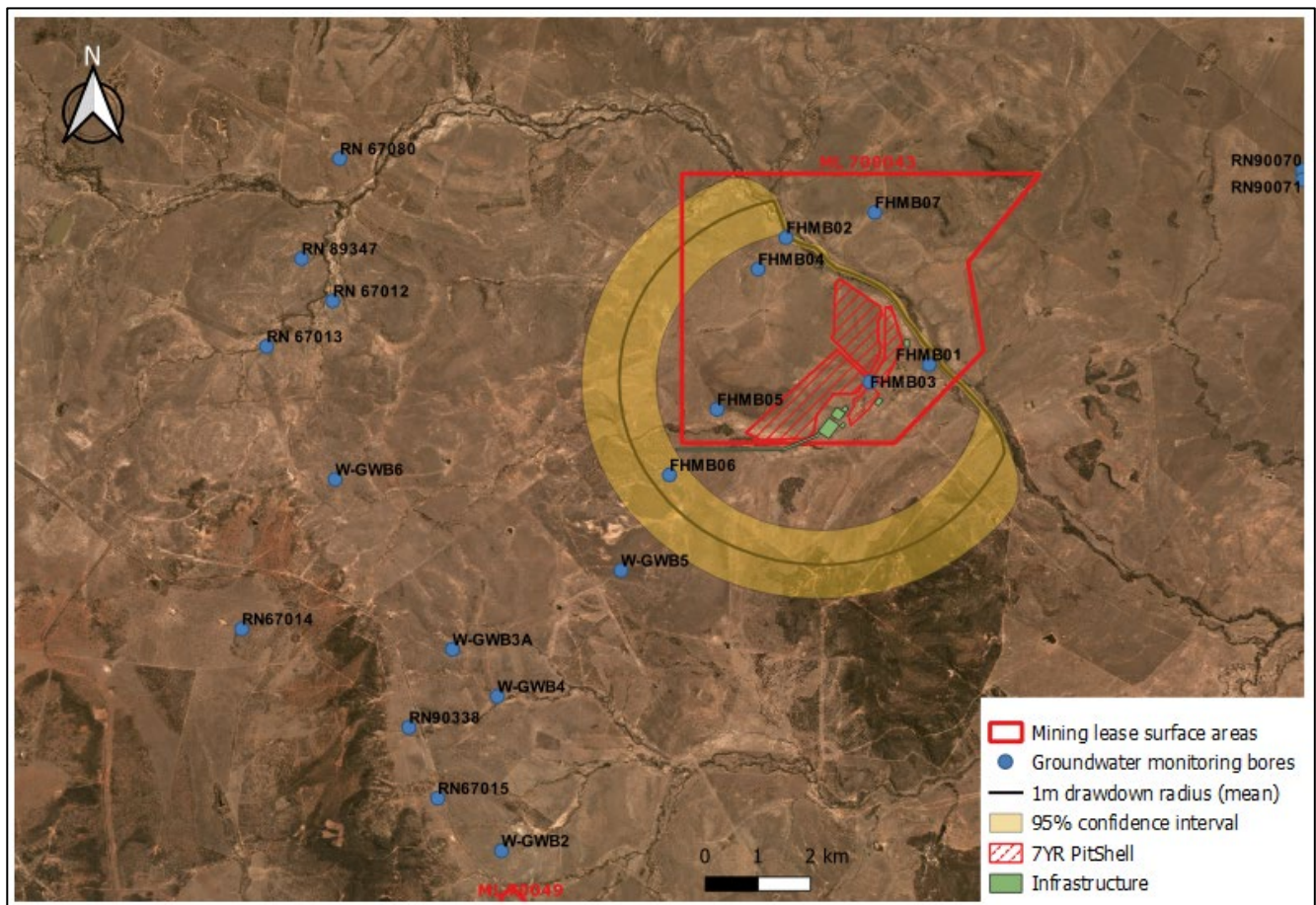
6.1.5.1 Permian coal measures drawdown

The model indicates that the drawdown radius (i.e. where drawdown is <1m) is predicted to be less than 4.5km from the pit centre toward to the south east of the pit (95% confidence). Toward the west, the drawdown radius is predicted to be less than 2.2km from the pit centre (**Figure 23**).

6.1.5.2 Alluvium drawdown

The maximum drawdown in the Cooroora Creek alluvium was simulated by model S2 at 0.6m in the most western cell of the alluvium. Model S2 shows that the predicted maximum distance from the western edge of the alluvium where the drawdown is <0.5m is 200m (2.2km from the pit centre).

Figure 23 1m drawdown radius (Fairhill formation)



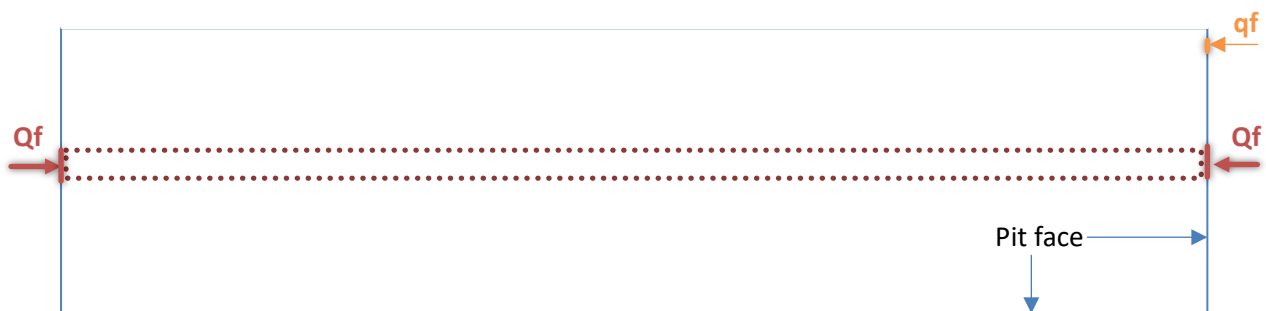
7 PART F—THE PREDICTED QUANTITIES OF WATER TO BE TAKEN OR INTERFERED WITH BECAUSE OF THE EXERCISE OF UNDERGROUND WATER RIGHTS

7.1 Total pit inflow

The estimated total pit inflow was calculated from the calibrated model predictions presented in the previous section (**Section 6**). The total predicted pit inflow from the 2D cross sectional calibrated model (i.e. model outflow through drain cells) is 0.0375 m³/day. Assuming a radial homogenous flow toward the pit, the flow of water Q_f (**Figure 24**) through each pit face of the 2D model is $Q_f = 0.0375/2 = 0.019$ m³/day. The model cells are homogenous 18m by 18m squares. Thus, the flux of water q_f for each 1m width of the pit face is $q_f = Q_f/18 = 0.001$ m³/day. The pit can be approximated as a rectangle of 3800m length by 1000m width.

The total pit inflow is $Q_p = q_f * 2 * (3800 * 1000) = 9.6$ m³/day

Figure 24 Schematic representation of Groundwater inflow to pit (not to scale)



7.2 Water outflow per aquifer

Predictions of water take per aquifer are summarised in **Table 10**. Under the conservative assumption that all inflow through the eastern face of the pit originates from the Cooroora Creek alluvium, the total volume of water to be taken from this unit is 1 m³/day. The total outflow from the Fairhill Formation to the pit is estimated to be 8.6 m³/day.

Table 10 Water take

	Cooroora Creek Alluvium	Permian coal measures (Fairhill Formation)
Water intake (m ³ /day)	1	8.6
Total pit intake (m ³ /day)	9.6	

8 PART G—INFORMATION ON PREDICTED IMPACTS TO THE QUALITY OF GROUNDWATER THAT WILL, OR MAY, HAPPEN BECAUSE OF THE EXERCISE OF UNDERGROUND WATER RIGHTS

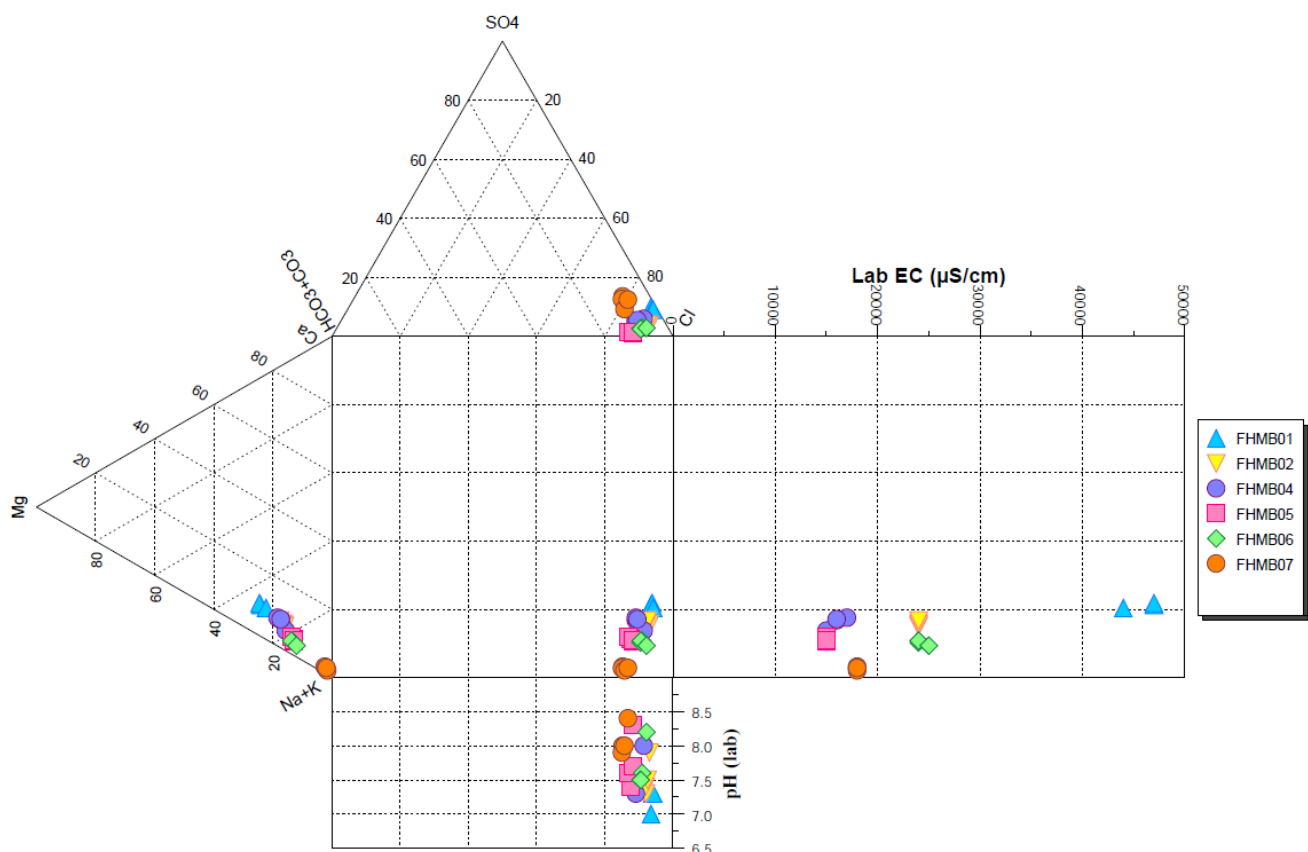
8.1 Baseline water quality

Baseline water quality is available for all FHCP bores except FHMB03, which was dry on all sampling events. Four sampling events have been recorded, from June 2018 until January 2019. Summary statistics are provided in **Appendix C** and the data is discussed below.

8.1.1 Physicochemical and ionic properties

A Durov diagram presented in **Figure 25** provides a summary of physicochemical and ionic information about the groundwater from FHCP monitoring bores. Major ion proportions indicate that all bores at FHCP monitor water of sodium-chloride type, which is the dominant water type in the region.

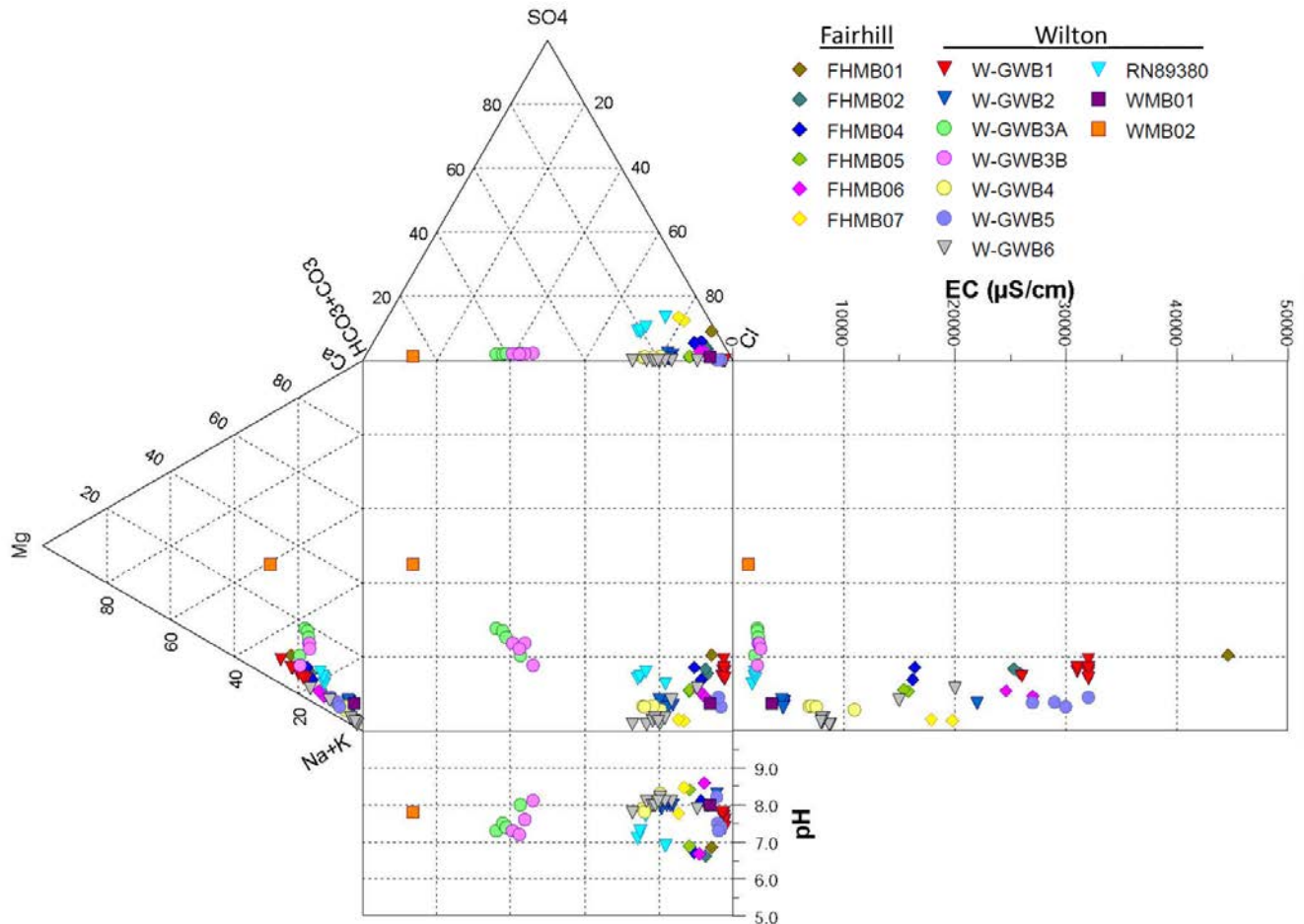
Figure 25 Durov diagram showing different water types in groundwater at FHCP



At neighbouring mine WCP, although some bores are installed in the Permian Burngrove Formation, most bores located within 12km from FHCP (i.e. WGWB1, WGWB2, WGWB4, WGWB5, WGWB6) are also of sodium-chloride

type (**Figure 26**) similar to the Permian Fairhill Formation at FHCP, suggesting little variability between these two Permian coal bearing formations. Exceptions are brackish water bores WGWB3A and WGWB4A, which are of sodium-bicarbonate-chloride type.

Figure 26 Durov diagram showing different water types in groundwater at FHCP and WCP

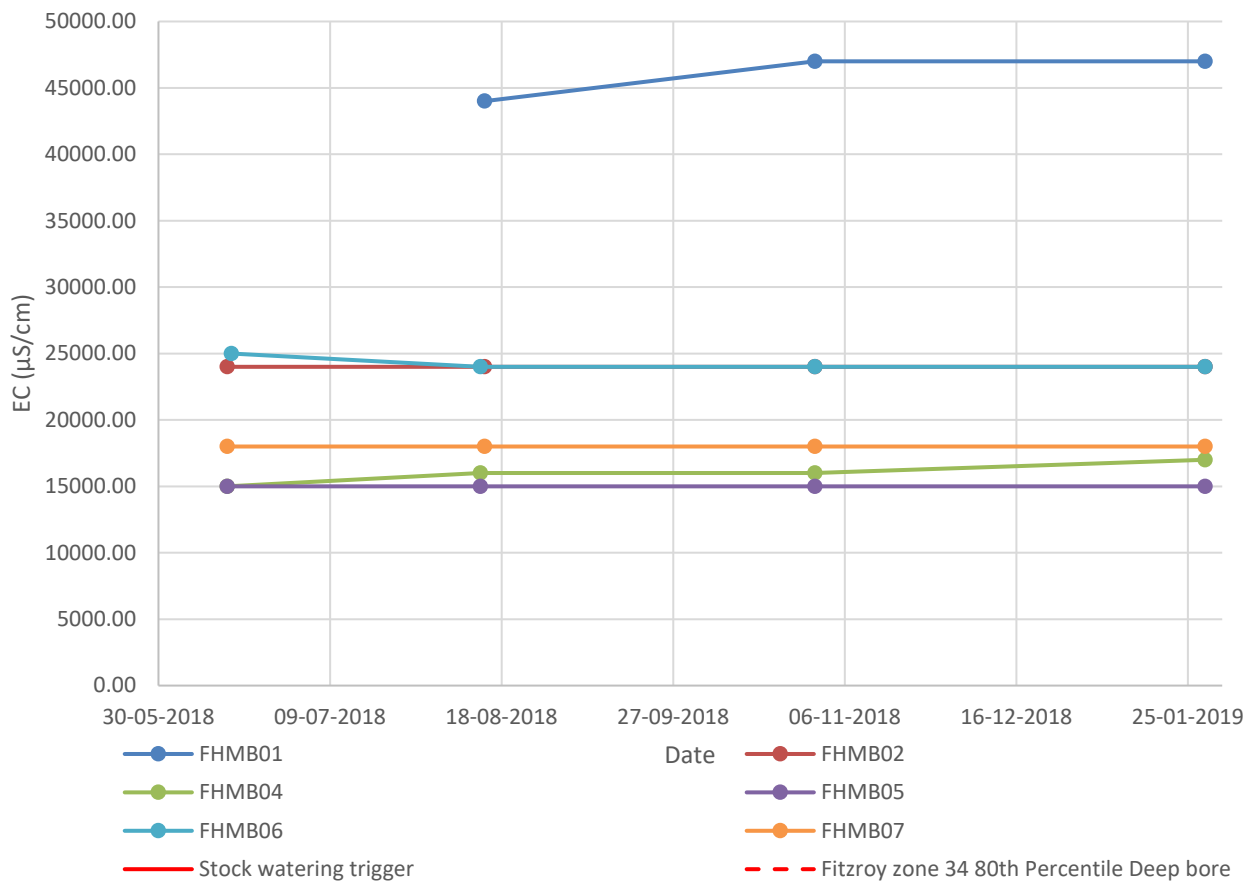


8.1.1.1 EC

Median groundwater EC at FHCP for the monitoring period ranges from 15,000 to 47,000µS/cm. This large variability in EC could be the result of several different sources of salinity (e.g. dissolution of evaporite minerals, weathering of aquifer minerals etc.). It is noted that the groundwater in the Cooroora Creek alluvium is significantly more saline than any other bores at FHCP (**Figure 25**). As detailed in **Section 5.1.1**, significant evaporation/evapotranspiration in the remnant pools that form above surficial clays during ephemeral flow events, and subsequent slow infiltration, may be one of the mechanisms resulting in salinisation of groundwater in the region.

Current monitoring (**Figure 27**) indicates that all bores at FHCP have EC levels higher than recommended for stock watering (ANZEEC&ARMCAZ, 2000) or local aquatic ecosystem protection (DEHP, 2011).

Figure 27 EC baseline monitoring

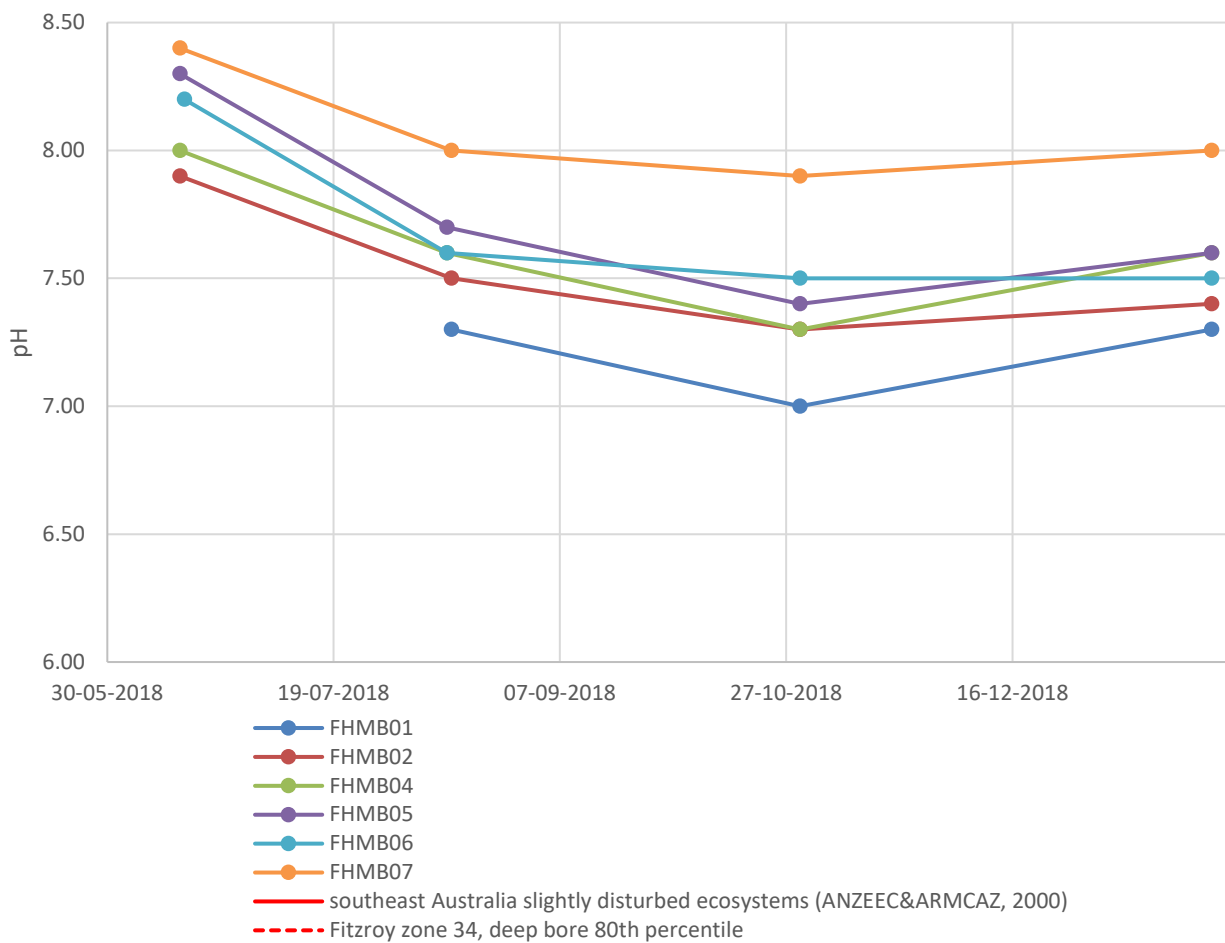


8.1.1.2 pH

Groundwater pH values at FHCP are between pH 6.5 and 8.5. It should be noted that FHCP monitoring bores initial samples from June 2018 are generally higher in pH compared to subsequent samples (**Figure 28**). This is most likely due to insufficient development of bores following drilling. The initial samples were collected at the time of bore development with compressed air. Therefore, samples were also significantly turbid and groundwater samples likely reacted with strata material with significant acid-neutralising capacity as demonstrated in the overburden/waste rock material assessment (NRC, 2018c). pH values dropped significantly between monitoring events to become closer to neutral (pH 7).

80th percentile pH values (i.e. based on only four samples) were compared against default trigger values for pH for southeast Australia slightly disturbed ecosystems (ANZECC&ARMCAZ, 2000) and the 20th and 80th percentile for deep bores in zone 34 of Fitzroy Groundwater (DEHP, 2011). To the exception of FHMB07, all bores pH are comprised between the lower limit of ANZECC&ARMCAZ (2000) – 6.5 and the 80th percentile of DEHP (2011) – 8.1. The 80th percentile of FHMB07 is slightly above the DEHP (2011) limit at 8.16.

Figure 28 pH baseline monitoring



8.1.2 Metals and metalloids

Metal and metalloid concentrations in groundwater are typically higher than in surface water due to increased contact with the local geology. At FHCP and nearby WCP, the significantly low permeability of the water-bearing strata allows even more contact time for mineral dissolution to occur.

8.1.2.1 Aquatic ecosystems triggers

A number of metals and metalloids in the groundwater samples were found to be in exceedance of local (DEHP, 2011) and regional (ANZECC & ARMCAZ, 2000) trigger values for species protection (95%) in slightly to moderately disturbed aquatic ecosystems (Aquatic ecosystems trigger). The 99% species protection trigger levels are used to compare against selenium and mercury due to potential for bioaccumulation. Total selenium concentrations are used rather than dissolved for the same reason. The following bores and metals exceeded the Aquatic ecosystems trigger:

- FHMB01: Boron, manganese, selenium and zinc.
- FHMB02: Boron, and zinc.
- FHMB04: Boron and selenium.

- FHMB05: Boron, selenium and zinc.
- FHMB06: Aluminium, boron, copper, selenium and zinc.
- FHMB07: Boron, arsenic, chromium and selenium.

Cadmium was unable to be appropriately assessed against the Aquatic ecosystems trigger level (95% species protection) due to the laboratory limit of reporting being too high (0.001mg/L). In future, laboratory analyses should have sufficient limit of reporting below the trigger level to determine background concentrations of cadmium.

Total selenium only exceeded the trigger level in the first sample taken at each bore with the exception of FHMB02. All dissolved selenium concentrations were below the trigger level. This points to elevated selenium concentrations as a result of high turbidity in the sample due to insufficient purging of the bore following drilling.

Boron and zinc appear to be abundant in the water-bearing strata at FHCP. Groundwater samples from most of the adjacent WCP monitoring bores are also elevated in these two metals (RN89380, W-GWB1, W-GWB2, W-GWB4 and W-GWB5 for boron; all bores except WMB02 for zinc). The baseline concentration of Boron might already be higher than ANZECC & ARMCANZ (2000) guideline values, and this should be taken into consideration when deriving trigger limits for the site. Although the baseline concentration of Zinc appears to be higher than ANZECC & ARMCANZ (2000) guideline values, analysis of the existing (limited) dataset indicates that it is likely to be below the local guidelines values for Fitzroy zone 34 (DEHP, 2011). Baseline data should continue to be collected until a sufficient sample size has been attained so that more suitable limits can be derived from the data.

FHMB07 appears to be the only bore with elevated dissolved arsenic concentrations in groundwater. Concentrations are almost three times the trigger level.

If groundwater is brought to the surface by artificial means during mining activities, it should not be discharged directly into surface water drainage channels without dilution since concentration of metals such as boron, arsenic and zinc are above Aquatic ecosystems trigger levels.

Other potential contaminants such as cadmium and chromium may occasionally exceed guideline values, but concentrations may be too low to become an ongoing concern.

8.1.2.2 Stock watering bore triggers

Stock watering water quality objectives (low risk trigger values) for heavy metals and metalloids is provided for the Mackenzie River Sub-basin in **Table 11**.

Table 11 Stock watering water quality objectives (low risk trigger values) for heavy metals and metalloids is for the Mackenzie River Sub-basin (DEHP, 2011)

Metal or metalloid	Trigger value (low risk) ^{1, 2} (mg/L)
Aluminium	5
Arsenic	0.5 (up to 5 ³)
Beryllium	ND
Boron	5
Cadmium	0.01
Chromium	1
Cobalt	1
Copper	0.4 (sheep), 1 (cattle), 5 (pigs), 5 (poultry)
Fluoride	2
Iron	not sufficiently toxic
Lead	0.1
Manganese	not sufficiently toxic
Mercury	0.002
Molybdenum	0.15
Nickel	1
Selenium	0.02
Uranium	0.2
Vanadium	ND
Zinc	20

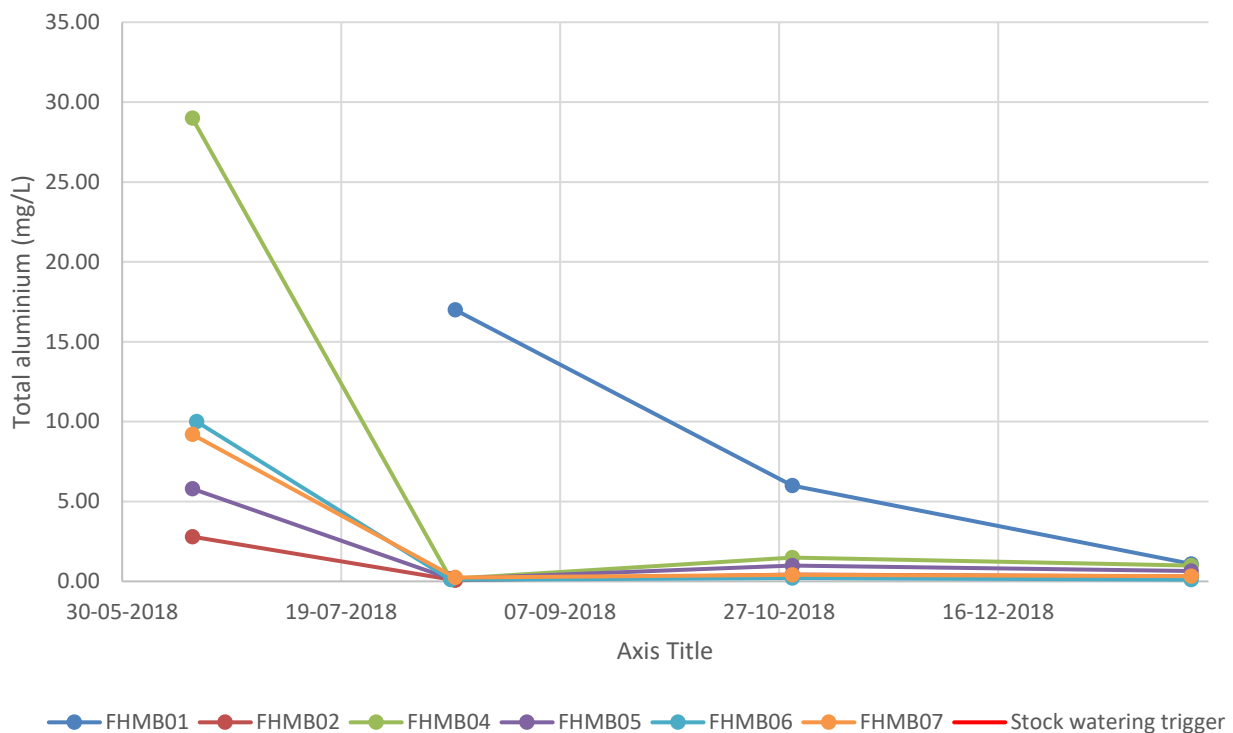
Source: AWQG, Volume 1, Section 4.3.4, Table 4.3.2.

Notes:

1. Higher concentrations may be tolerated in some situations (further details provided in AWQG, Volume 3, Section 9.3.5).
2. ND = not determined, insufficient background data to calculate.
3. May be tolerated if not provided as a food additive and natural levels in the diet are low.

Comparison with existing baseline data (Appendix C) show that metal and metalloids sampled at FHCP bores (80th percentile of current data) are all below the recommended stock watering values, except for Aluminium. The 80th percentile for total aluminium in bores FHMB01 and FHMB04 are above the recommended values. Additionally, FHMB05, FHMB06 and FHMB07 have exceeded the recommended value at least once since monitoring started. However, most of the exceedance occurred at the first sampling event, likely indicating that the groundwater sampled was impacted by the drilling operations as discussed earlier.

Figure 29 Total aluminium, baseline monitoring



8.2 Impacts due to drawdown from pit excavation

8.2.1 Change in groundwater flow regime

The drawdown expected as a result of the FHCP pit will increase the natural groundwater gradient towards the mine lease and alter flow directions to be radial to the pit in the area affected by drawdown. The Permian units present heterogenous groundwater quality, albeit mostly saline, occasionally brackish. Brackish bores (WGWB3A, WGWB3B, WGWB4, RN67080) are located upstream and well outside the predicted drawdown area and therefore, the changes in the groundwater gradient and local changes in groundwater flow directions are considered unlikely to affect groundwater quality in these bores.

To the east, the drawdown will be of limited extent due to a smaller gradient between the Cooroora Creek alluvium and the bottom of the pit. Since saline groundwater conditions are also present within the Cooroora Creek alluvium and underlying Permian coal measures, change in the groundwater flow gradient are considered unlikely to affect groundwater quality.

8.3 Impacts due to storage of waste rock

Groundwater quality can be potentially impacted due to infiltration through the overburden or waste rock dump. Characterisation of the overburden/waste rock dump indicates that rainwater encountering overburden/waste rock will most likely be alkaline with moderate EC (100–780µS/cm) (NRC, 2018c). All waste rock overburden and coal reject material associated with the proposed mining operations were classified as non-acid forming (NRC, 2018c). Metalliferous drainage should not be of concern owing to the high acid-neutralising capacity of the overburden samples (NRC, 2018c).

8.4 Impact due to storage of mine impacted water

Three types of water will be expected to be produced at the proposed FHCP site and will require management (ATC Williams, 2018) as follows:

- Clean water derived from runoff in areas upstream of the disturbance or stabilised/rehabilitated areas within the mine. Water deemed unaffected by mine operations and suitable for direct off-site release into the receiving environment.
- Sediment laden water associated with runoff from cleared areas. Sediments in water need to be settled and captured in sediment basins/dams prior to release to the clean water system and receiving environment.
- Mine-affected water from runoff in contact with disturbed areas within pit, overburden or waste rock dumps and groundwater dewatered from the pit. Containment of this water, especially dewatered groundwater, should not be released unless sufficient flow events and volumetric flow ratio are met. Enhanced evaporation may be required to remove water.

During mining, some mining infrastructure is considered to pose a risk of infiltration of mine-affected water into groundwater, including the following:

- Containment dams proposed to store mine-affected water dewatered from the pit.
- Runoff and seepage collected from waste rock/overburden dumps.
- In the event of high rainfall, the open pit (only if filled up to a level higher than the surrounding groundwater levels).

Due to the presence of low permeability strata of the Permian coal measures (as evident from the low bore yields and low hydraulic conductivity values of these strata at FHCP), the rate of infiltration is expected to be very low in those circumstances. Due to the high salinity of existing groundwater at FHCP, it is also expected that infiltration of rainfall runoff in the pit into surrounding groundwater may improve groundwater quality (i.e. dilute the EC and potentially other elevated constituents in the groundwater). However, this would not support the WQO of maintaining background water quality. As a result, management measures such as pumps installed in sumps within the base of the pit should be used to control in pit water, especially during the wet season. Lining of containment dams may be utilised to prevent infiltration and seepage from containment dams into groundwater.

9 PART H—INFORMATION ON THE ENVIRONMENTAL VALUES THAT WILL, OR MAY, BE AFFECTED BY THE EXERCISE OF UNDERGROUND WATER RIGHTS

9.1 Environmental values

9.1.1 Regional Environmental Values

The Mackenzie River sub-basin Environmental Values (EVs) and Water Quality Objectives (WQOs) designate the following EVs as applicable to groundwater in the FHCP area:

- aquatic ecosystem;
- irrigation;
- farm supply/use;
- stock water;
- drinking water;
- industrial water; and
- cultural and spiritual values.

Groundwater chemistry data from the Fitzroy Basin has been classified in a number of zones based on groundwater chemistry (DEHP, 2011). The proposed FHCP open cut pits are to be located in chemistry zone 34. A statistical summary of water chemistry data from this zone is presented in DEHP (2011). Zone 34 represents saline sodium-chloride dominant groundwater in sodic sequences. The median for EC for deep groundwater in zone 34 (more than 30m depth) was reported as 6,100µS/cm, whereas the median concentration for sodium and chloride was reported as 1,100mg/L and 1,900mg/L respectively.

9.1.2 Environmental values relevant to FHCP

The EVs that are relevant to FHCP are discussed below and summarised in **Table 12**. At FHCP and surrounding, the saline nature of groundwater limits the extent of service that groundwater can provide to local ecosystems and human communities. The lowest EC of groundwater recorded at FHCP is 15,000µS/cm and the lowest sodium and chloride concentrations recorded are 2,700mg/L and 4,400mg/L, respectively. This indicates that natural groundwater at FHCP is more than twice as saline as that of the median groundwater found within zone 34 of the Fitzroy Basin. It should also be noted that the lowest groundwater EC value recorded at FHCP is also more than two times that of the 80th percentile value of EC found within zone 34. High EC of groundwater in the region exceeds the recommended guideline values for aquatic ecosystem protection, drinking water or livestock watering.

Although saline, the groundwater at FHCP can potentially support a limited number of species adapted to these conditions. GDE are discussed in the following section.

While no groundwater bores within the FHCP tenement are used for stock watering or human consumption, two brackish bores that have water quality suitable for stock watering (W-GWB3A and W-GWB3B) have been identified some 7km away from the proposed mining activities. The nearest stock watering bore currently operating is RN67080, 15km south west of FHCP.

Table 12 Regional Environmental values for groundwater and their applicability to FHCP

Regional EV	Relevance to FHCP	Apply to FHCP?
Aquatic Ecosystem	Aquatic ecosystem includes all GDE and potential groundwater – surface water interaction	YES
Irrigation	No bore used for Farm supply has been identified within a 15km radius of FHCP	NO
Farm supply/use	No bore used for Farm supply has been identified within a 15km radius of FHCP	NO
Stock water	The closest bore used for stock watering in the vicinity of FHCP is located 15km southwest of the tenement. However, some monitoring bores 7km of FHCP have water quality potentially suitable for stock watering	YES
Drinking water	No drinking water bore has been identified in a 15km radius of FHCP. Given the saline nature of groundwater as reported regionally and at the FHCP site, groundwater suitable for drinking is unlikely to occur in the area	NO
Industrial water	There are no industry relying on groundwater within 15km of FHCP	NO
Cultural and spiritual values	No cultural or spiritual values pertinent to the FHCP site has been identified	NO

9.1.3 Groundwater Dependant Ecosystems (GDEs)

A groundwater dependent ecosystem (GDE) is an ecosystem that needs access to groundwater permanently or intermittently to maintain its communities of plants and animals, its ecological processes and its ecosystem services (Richardson et al., 2011).

9.1.3.1 Desktop review

A desktop review for potential GDEs in the vicinity of FHCP was conducted through two broad scale assessments presented in the GDE Atlas (BoM, 2018) and the Queensland Government online database (QLD Government, 2019). Results from each survey are presented in separate maps in Appendix D.

The potential for GDEs at FHCP is described as follows.

9.1.3.1.1 Terrestrial GDEs

Potential for terrestrial GDEs is identified in both assessments:

1. Potential terrestrial GDEs along Cooroora Creek:

- High potential terrestrial for GDEs in a large portion of Cooroora Creek within and downstream of the FHCP tenement (BoM, 2018);
- Moderate potential for GDEs along additional areas of Cooroora Creek within, upstream and downstream of the FHCP tenement (BoM, 2018); and

- Low confidence terrestrial GDEs along Cooroora Creek within, upstream and downstream of the FHCP tenement (QLD Government, 2019).
2. Potential terrestrial GDEs along Sandy Creek:
 - Low to moderate confidence GDEs along Sandy Creek upstream from tenement (QLD Government, 2019).
 3. Potential terrestrial GDEs along Back Creek:
 - Low confidence terrestrial GDEs along Back Creek upstream of the tenement (QLD Government, 2019).

9.1.3.1.2 Aquatic GDEs

No potential aquatic GDEs were identified in the QLD Globe database within or adjacent to FHCP. However, the potential for aquatic GDEs is identified in the GDE Atlas (BOM, 2018) area as follows:

Potential aquatic GDEs along Cooroora Creek:

- Low aquatic GDE potential both up and downstream of the FHCP tenement; and
- Moderate aquatic GDE potential within the FHCP tenement.

9.1.3.1.3 Subterranean GDE

No potential subterranean GDEs were identified in either assessment.

9.1.3.1.4 GDE aquifers

The QLD Government (2019) identify aquifers of large extent that potentially provide water ecological services to GDEs regionally. In the QLD Government (2019) assessment, all mapped aquifers in the vicinity of FHCP have an 'intermittent' groundwater connectivity regime meaning they may support GDEs seasonally. They include:

1. High confidence potential GDE aquifer associated with the alluvium of Cooroora Creek, Sandy Creek and Back Creek (Unconsolidated sedimentary aquifers).
2. Low confidence potential GDE aquifer associated with a consolidated sedimentary aquifer to the west of the tenement.

9.1.3.2 Source aquifers

The source aquifers for GDEs include the primary aquifer that the GDEs directly rely on (i.e. associated with the groundwater uptake from the GDE) and aquifers hydraulically connected to the primary aquifer.

At FHCP, the primary GDE aquifer is considered to be the alluvium aquifer associated with Cooroora Creek. Additionally, there is the much more limited potential for small alluvial aquifers to exist along Sandy Creek and Back Creek. The alluvium aquifer associated with Cooroora Creek is described in **section 4.3.1**. The SWL in the Cooroora Creek alluvium was recorded at 9.4mBGL (with 0.6m of saturation) at FHMB01 on the eastern side of the tenement, and the aquifer was recorded as dry elsewhere. Thus, any GDEs relying on this aquifer would likely be restricted to terrestrial vegetation along Cooroora Creek towards the eastern margins of the FHCP having rooting depths approaching 10 m or more.

As discussed in **section 5.3.2**, it is possible that some connectivity exists between the Permian coal measures and the alluvium aquifer where the hydraulic gradient and lithology permit that flow. The Permian coal measures are associated with the sedimentary aquifer identified by QLD Government (2019) and thus have some potential, albeit very low, to form a secondary source aquifer to any GDEs on Cooroora Creek, as well as a primary source aquifer elsewhere on the tenement.

9.1.3.3 Field survey

Several surveys have been conducted by NRC and SLR to assess flora and fauna in the area within and in close vicinity of the tenement. These include:

- The Terrestrial Flora and Fauna technical report – January 2018;
- The Terrestrial Flora and Fauna technical report – July 2018;
- The wet season 2018 aquatic ecology monitoring; and
- The wet season 2019 aquatic ecology monitoring.

These technical reports, along with groundwater monitoring data and analysis as presented in this report allows to investigate the likelihood of GDEs occurring within the tenement. Each potential GDE identified during the desktop review presented above is discussed below on the basis of the results of the field surveys.

9.1.3.3.1 Terrestrial GDE

Terrestrial GDEs are defined by DES (2019) as follows: *“Ecosystems dependent on the sub-surface presence of groundwater on a permanent or intermittent basis to meet all or some of their water requirements so as to maintain their communities of plants and animals, ecological processes and ecosystem services. Terrestrial GDE area features include riverine wetlands and treed (deep rooted) regional ecosystems that have some groundwater dependency”*.

For a terrestrial GDE to exist, some vegetation must be able to access moisture in the soil, at a depth close to the groundwater table. According to Richardson et. al (2011), potential GDEs are identified where root depth is within 1-2m of the water table. Across FHCP, the median water table is 14m below ground level, while along Cooroora Creek, the median water table depth calculated from FHMB01 (Permian), FHMB02 (alluvium) and FH006 (Permian) is 8.5m.

Cooroora Creek

Ground-truthed vegetation within the FHCP tenement along Cooroora Creek was similar to DNRME mapping (NRC, 2019). Two large polygons were mapped as mixed vegetation community where the canopy in the riparian area is dominated by *Acacia harpophylla* (Brigalow) and *Eucalyptus camaldulensis* (Red Gum).

A review of literature indicates that root systems for *Acacia harpophylla* consist of a tap vertical root and horizontal roots. As detailed in Bradley (2006), *Acacia harpophylla* is able to develop extensive horizontal root systems in order to intercept rainfall from large areas. Although it cannot be excluded that the tap vertical root of some trees can reach 6 to 7m depth, it is more likely that *Acacia harpophylla* relies on rainfall for most of its water requirement and thus does not form a GDE on the tenement.

Eucalyptus camaldulensis can develop deep roots (>10m vertically) and has been found to be resilient to saline groundwater conditions (Hulme, 2010). Therefore, it is likely that mature trees with root systems able to reach within 2m of the water table may rely on groundwater during periods of rainfall deficit. Therefore, mature examples of *Eucalyptus camaldulensis* on Cooroora Creek can not be ruled out as a temporal GDE component on the tenement.

Sandy Creek

Ground truthing of GDEs along Sandy Creek during the flora and fauna assessment indicate a low potential for GDEs to occur in this area. The majority of the vegetation present within Sandy Creek is not classified as riparian and is a continuation of vegetation communities in the broader area. Most of the study area was found to be non-remnant vegetation to the exception of two small areas of remnant vegetation (NRC, 2019). *Eucalyptus camaldulensis* was located immediately within the bed and bank of Sandy Creek, sparsely distributed within the two small areas of remnant vegetation. As with Cooroora Creek, only mature examples of *Eucalyptus camaldulensis* along Sandy Creek are considered to have any potential to form a temporal GDE.

Back Creek

Back Creek is located 5km north of the pit, in the northwestern corner of the tenement. It was outside the flora and fauna study area and was not ground truthed but is assumed to be similar in nature to Sandy Creek given its stream order.

9.1.3.3.2 Aquatic GDE

No aquatic GDEs were located during flora and fauna surveys at FHCP.

Surface water chemistry analysed by NRC/SLR (2018/2019) for the Receiving Environment Monitoring Program (REMP) at the FHCP indicates no groundwater expression at surface within Cooroora Creek or Sandy Creek. EC levels measured in the Cooroora Creek alluvium (bore FHMB01) are characteristic of highly saline water (47,000 $\mu\text{S}/\text{cm}$). Conversely, EC levels recorded within surface water found in watercourses at FHCP indicate a freshwater system, with low EC levels (140-250 $\mu\text{S}/\text{cm}$). The ephemeral nature of the streams in the area doesn't allow for water to be retained for long periods of time and no areas have been noted to contain surface water for extended periods of time. No changes in vegetation type were recorded throughout the creeks to indicate areas with water retention.

The only exception to a lack of permanent surface water on the tenement is in the northern part of Cooroora Creek (NRC, 2018d), where an artificial weir creates an artificial wetland upstream that is used as cattle watering point. Although surface water is retained in this area and some aquatic vegetation was noted here during site surveys, the feature is artificial and only influenced by rainfall in the catchment, not by groundwater expression.

9.1.3.4 Ecological water requirements and cumulative impacts for identified GDEs

9.1.3.4.1 Terrestrial GDEs

Ecological water requirements for GDEs are site specific and thus difficult to infer from existing data. Furthermore, there are limited research available on ecological water requirements of many types of GDEs including mature *Eucalyptus camaldulensis* that might be subject to impacts at FHCP.

Although no data was found for *Eucalyptus camaldulensis*, a study of phreatophytes of the Swan Coastal Plain in Western Australia conducted by Froend and Sommer (2010), reveal that *Eucalyptus rudis* can tolerate a high range of water levels, from 0.8m above ground to 11.7m below ground level. *Eucalyptus camaldulensis*, which belong to the same family as *Eucalyptus rudis*, is likely to have similar tolerances to changes in water levels. According to the Invasive Species Compendium (CABI, 2019), *Eucalyptus camaldulensis* is a “highly adaptable tree with ability to tolerate extreme conditions such as drought and soil salinity, coupled with prolific seed production, potentially rapid growth and the ability to reproduce at a young age. These characteristics contribute to its ability to become invasive and it is a declared invasive in a number of countries”.

Richardson (2011b) note that some species may be sensitive to the rate of watertable drop. According to Groom et al. (2000), Banksias growing over the Gngangara (groundwater) Mound in Western Australia were found to tolerate declines in groundwater level so long as they occur at a rate of less than 0.5 m per year. However, considering the highly adaptable nature of *Eucalyptus camaldulensis* and its intermittent reliance on groundwater, this figure is likely to be conservative for *Eucalyptus camaldulensis*.

In conclusion, it is inferred from the available literature that mature examples of *Eucalyptus camaldulensis* found on the FHCP tenure that might be intermittently reliant on groundwater for some of their water requirements are unlikely to be affected by groundwater drawdown at FHCP.

No additional potential impacts on GDEs were identified.

9.2 Nature and extent of the impacts on the environmental values

This report has detailed the aquifer characteristics at FHCP (section 4) and investigated the potential impacts that the mining activities may have on groundwater levels (section 6) and groundwater quality (section 8). Based on the above, the potential impacts to the receiving environment due to the exercise of underground water rights have been identified and described in the section below and presented on Figure 30.

9.2.1 Aquatic ecosystems

No naturally occurring aquatic ecosystems reliant on groundwater have been identified at FHCP.

9.2.2 Terrestrial ecosystems

9.2.2.1 Drawdown

Mature examples of Red Gum (*Eucalyptus camaldulensis*) have been identified as a potential terrestrial GDE at FHCP, primarily along Cooroora Creek and to a lesser extent in isolated areas along Sandy Creek.

9.2.2.1.1 Cooroora Creek

Within Cooroora Creek alluvium, the maximum predicted drawdown is 0.6m in the western edge of the alluvium and becomes negligible toward the east. The maximum drawdown predicted in the Permian unit bellow Cooroora Creek is 2m (model S2), i.e. a drawdown water table depth of 10m BGL.

The groundwater quality in the alluvium beneath Cooroora Creek is very saline, more so than that in the Permian unit below the alluvium. The only GDE that can potentially rely on this groundwater in FHCP are Red Gums. The impact that drawdown will have on these trees will depend on:

- The maturity of individual trees. Only the older and deeper-rooted trees with tap roots extending beyond approximately 8m depth may potentially intermittently access groundwater.
- Their proximity to the Pit. Trees that are located on the western edge of Cooroora creek could be impacted by drawdown whereas, the ones located at a distance greater than 200m from the western edge of the alluvium are unlikely to be impacted.

9.2.2.1.2 Sandy Creek

The Fairhill Formation underlying the downstream area of Sandy Creek is likely to be impacted by drawdown, although it is also considered unlikely that a shallower alluvial aquifer is developed along Sandy Creek. As illustrated in **Figure 30**, the extent of drawdown calculated for the Fairhill Formation reaches about halfway the length Sandy Creek. However, whilst the Fairhill Formation will be directly intercepted (i.e. drained) by the pit, any alluvium in Sandy Creek will not be disturbed by the pit foot print. Although considered very unlikely to occur, if any saturated alluvium exists along Sandy Creek the extent of drawdown within this alluvium will thus depend on its connectivity with the Fairhill Formation. Since the alluvium along Sandy Creek is likely to be of similar lithology than the nearby Cooroora Creek (i.e. high clay content) the connectivity with nearby Fairhill Formation is expected to be low. Therefore, in the event that some saturation exists in the Sandy Creek alluvium, it is likely that the drawdown within this alluvium will be very limited.

Drawdown impact on Sandy Creek ecosystems is predicted to be negligible given that only a limited number of Red Gums (*Eucalyptus camaldulensis*) have been found along Sandy Creek.

9.2.2.2 Water quality

As detailed in **section 8**, potential impact to groundwater and surface water quality have been identified along with management systems to avoid negative impacts. Therefore, no significant change in groundwater quality is expected to occur as a result of mining at FHCP.

9.2.3 Stock watering bores

9.2.3.1 Drawdown

RN67080 has been identified as a stock watering bore. This bore located more than 15km southwest of the FHCP tenement and will not be affected by drawdown arising from the FHCP. Bore WGWB3A, WGWB3B and WGWB4 have brackish water quality suitable for stock watering (**Table 2**). These bores are located upstream and four km away from the predicted drawdown radius and therefore no risk of impact to these bores has been identified.

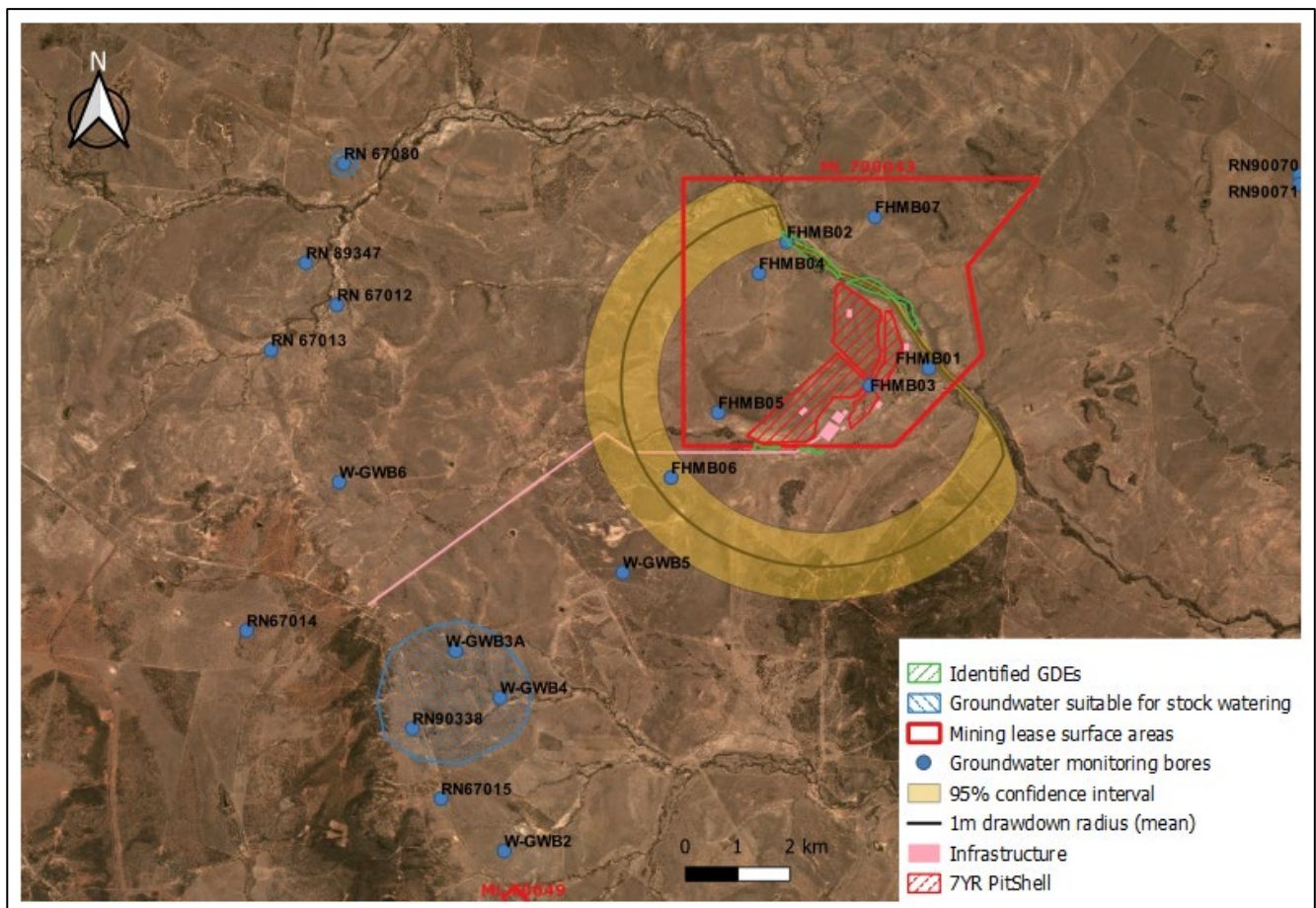
9.2.3.2 Water quality

As described in **section 8.2.1**, the drawdown expected as a result of the pit will increase groundwater gradient and change nearby flow direction to be radial to the pit. To the north, south and west, the Fairhill Formation contains heterogenous groundwater quality, albeit mostly saline, occasionally brackish. Brackish bores WGWB3A, WGWB3B, WGWB4 and RN67080 are located well outside the drawdown area and therefore, changes in the natural groundwater gradient is considered unlikely to affect groundwater quality in these bores.

9.3 Impacts to formation integrity and surface subsidence

The proposed operations are open cuts operations and as such are not anticipated to results in subsidence. Prediction indicate a small extent of drawdown (maximum extent of drawdown of 1m or more is 4km from the pit). Moreover, the impacted aquifers are mostly coal measures with a maximum thickness of 20m. Therefore, drawdown induced subsidence is not expected.

Figure 30 Drawdown impact on environmental values



10 PART I—INFORMATION ON STRATEGIES FOR AVOIDING, MITIGATING OR MANAGING THE PREDICTED IMPACTS ON THE ENVIRONMENTAL VALUES OR PREDICTED IMPACTS ON THE QUALITY OF GROUNDWATER

10.1 Mitigation and management

10.1.1 Cooroora Creek alluvium

As discussed in **section 9.2.2.1.1**, the small predicted groundwater drawdown within Cooroora Creek alluvium and the underlying Permian formation is likely to have a minimal impact on environmental receptors. Nevertheless, a drawdown trigger should be in place to monitor for and prevent impact on GDEs, should the drawdown be greater than expected. A new monitoring bore (FHMB09) will be placed on the eastern section of the alluvium, directly across the pit to monitor for drawdown in the alluvium immediately adjacent the pit (**Figure 31**).

A new set of nested bores (one bore screened in alluvium and one bore screened in Fairhill Formation) will be placed on the western edge of the alluvium, on the northern end of the predicted 1m drawdown radius – FHMB011A&B (**Figure 31**). This will provide an additional reference bore (since FHMB01 is likely to be impacted by drawdown) and will allow better understanding of the connectivity between the two units.

An adaptive management program will also be put in place. Regular monitoring of drawdown at FHMB09 will be compared against predictions. If the drawdown is greater than predicted (0.5m), an investigation should be prompted to assess the potential impact on GDEs. Additionally, monitoring of drawdown at bores FHMB02 and FHMB04 will provide additional triggers. If the drawdown at these bores is greater than predicted (**Table 14**), it is possible that the alluvium will also be affected to a greater extent than predicted.

Ongoing monitoring of water quality will also be continued at FHMB01 and commenced at FHMB09.

10.1.2 Sandy Creek alluvium

Drawdown in the Fairhill Formation is expected to extend beneath the alluvium within the lower half of Sandy Creek. As discussed in **section 9.2.2.1.2**, the impact on the receiving environment is expected to be minimal due to only a small number of trees identified as potentially relying on groundwater intermittently in this area (red gum) plus the absence of evidence of saturated alluvium in this area. A new set of nested bores (one bore screened in alluvium and one bore screened in Fairhill Formation) will be implemented along Sandy Creek to monitor water level, quality and connectivity between the two formations.

10.1.3 Mine impacted water

As described in **section 8.4**, any water contaminated by mining activities will require specific management. Surface water management measures have been identified by ATC Williams (2018). In addition, the following measures are proposed:

- Installation of pumps within sumps within the base of the pit to control pit water level (i.e. to be below surrounding groundwater) and avoid groundwater contamination;
- Dewatered water to be pumped into containment dams; and
- Lining of containment dams to prevent infiltration of contaminated water into groundwater;

Water level monitoring within the pit and adjacent monitoring bores will be undertaken regularly to ensure the pit remains a groundwater sink at all times during mining operations, i.e. to ensure there is no potential for mine impacted water in the pit to discharge to groundwater. The release of mine impacted water, especially dewatered groundwater (i.e. saline water with trace metals potentially above recommended values for aquatic ecosystem protection), will be subjected to specific water quality and volumetric flow ratio controls. Surface water management (i.e. including release) procedures are included within the surface water component of the EA application.

Monitoring of seepage from containment dams and trigger level for contaminants of concerns is discussed below.

10.1.4 WRD seepage

The characterisation of the waste rock indicate that acid mine drainage and saline drainage is unlikely to occur at FHCP (**section 8.3**). Nevertheless, all water runoff from the two waste rock dumps will be diverted to containment dams. The release of this water will be subjected to specific water quality and volumetric flow ratio controls as defined within the surface water component of the EA application.

Monitoring of seepage from the WRD and trigger level for contaminants of concerns is discussed below.

10.2 Monitoring and assessment criteria

10.2.1 Monitoring objectives

The proposed groundwater monitoring program is part of an adaptive management program which aims at early detection of any potential impacts to groundwater resources at FHCP to maintain groundwater at a suitable background quality. To supplement the monitoring program, FCC will install an on-site weather monitoring station. The weather monitoring station will record site-specific rainfall data, which will aid understanding of the site water balance.

10.2.1.1 Baseline monitoring and reference bores

The primary goals of the baseline monitoring are to ensure that sufficient baseline data is collected to:

- Document the temporal and spatial variations in groundwater levels and quality; and
- Detect any early potential impacts to groundwater levels and groundwater quality.

Baseline monitoring typically requires the collection of at least 12 months of dry and wet season data and as such will identify any key issues with regards to groundwater. Baseline monitoring bores that are not likely to be impacted by the mining operation will be selected as reference bores. This is further discussed in **section 10.2.2.4**.

10.2.1.2 Contaminants of concerns

Contaminants of concern associated with coal mining are linked to both mining waste water disposal (**section 8.3**) and WRD seepage (**section 8.4**). Both include potential change to salinity and pH, modification of the ionic composition of water and introduction of potential toxic level of metal and metalloids.

One objective of the baseline monitoring is to identify contaminants that are naturally present in the groundwater that will be intercepted by the pit. The current baseline monitoring thus covers a wide range of parameters pertinent to the environmental values identified in **section 9.1.2**. This include both dissolved metals (aquatic ecosystems) and total metals (stock watering).

Current parameters and analytes at the FHCP site include field measurements of pH, EC, dissolved oxygen (DO) and oxidation reduction potential and laboratory analysis of pH, EC, total dissolved solids, alkalinity, major cations and anions, nutrients (total N, NO_x and ammonia), selected dissolved metals (aluminium, arsenic, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, selenium, uranium, vanadium and zinc), total metals (aluminium, arsenic, barium, boron, cadmium, chromium, cobalt, copper, lead, mercury, nickel, selenium, uranium, vanadium and zinc), volatile organic compounds, volatile petroleum hydrocarbons and total recoverable hydrocarbons.

Once a sufficient number of samples have been collected, contaminants that are not naturally present in groundwater and that are not likely to be release from the exposed waste rock may not be analysed anymore.

Baseline monitoring at FHCP is currently being conducted in accordance with the sampling protocol of the Queensland Department of Environment and Science Monitoring and Sampling Manual (DES, 2018).

The method of groundwater monitoring follows the procedure outlined below:

1. Depth to water table is measured using a calibrated water dipper.
2. A bore is either low flow pumped from the level of groundwater inflow or alternatively at least three bore volumes are purged using a submersible pump or bailer.
3. Measurements of field parameters are undertaken during the purging of each bore using a calibrated water quality meter. Calibration records are kept as part of the quality assurance/quality control (QA/QC) program. Effective purging of the bore is demonstrated by the stabilisation of field parameters. Repeated measurements of field parameters are recorded as part of the QA/QC program.
4. Samples for dissolved metals are field filtered and, similar to samples for total metals, major ions and hydrocarbons are collected in laboratory supplied sampling containers. Samples are kept cool and submitted for analysis to a NATA accredited laboratory within the recommended holding times with completed chain of custody documentation. Duplicate and blank samples are included as part of the QA/QC program.

10.2.1.3 Groundwater impact monitoring

The impact monitoring program is aimed at detecting any impact to prevailing background groundwater level and quality due to potential impact from any environmentally relevant mining activity. Locations and installation depths for impact monitoring bores are shown in **Table 13**.

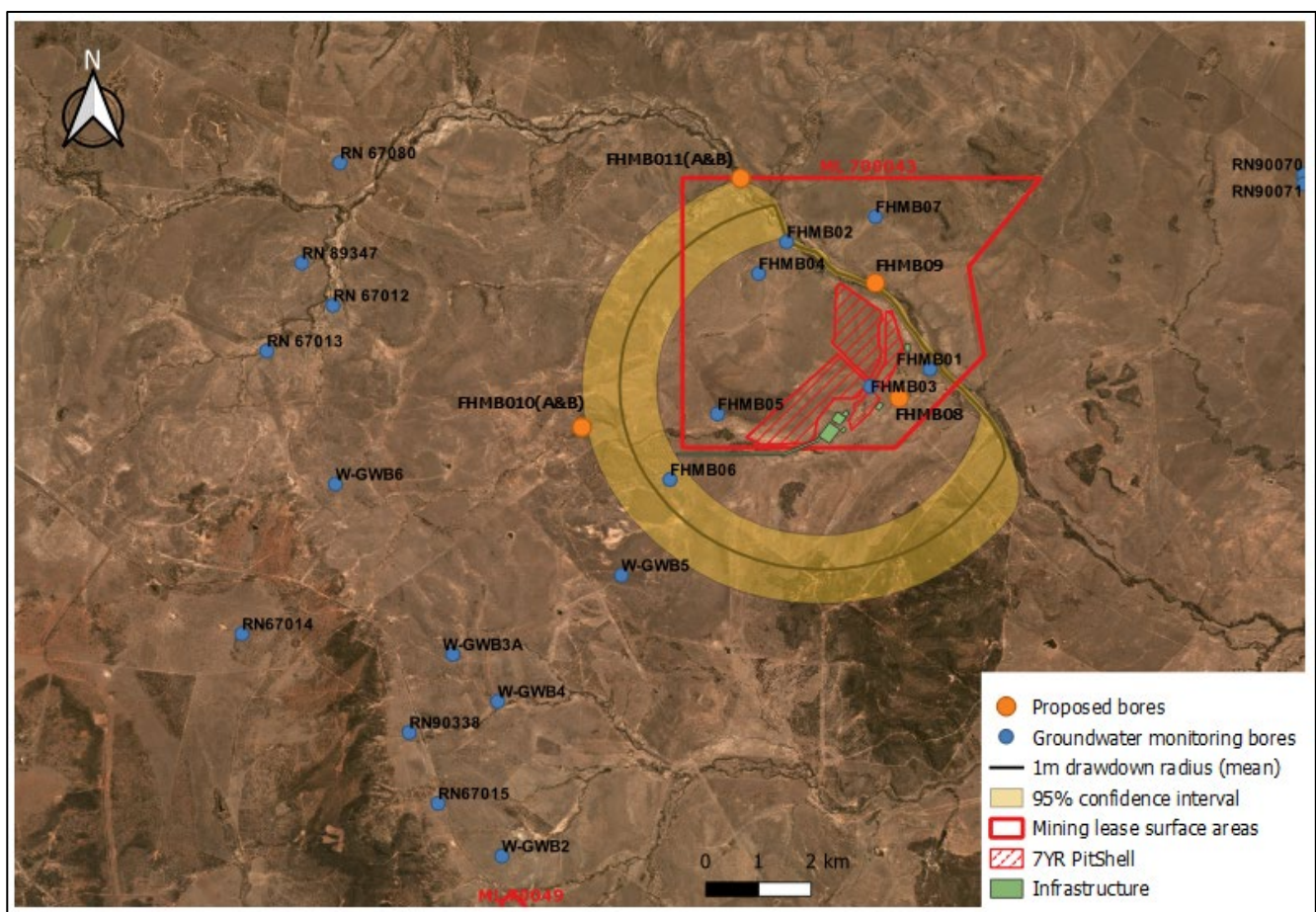
Seepage monitoring bores: Shallow bores in alluvium units (Cooroora Creek and Sandy Creek) will monitor potential seepage from containment dams and waste rock dumps where GDE have been identified (FHMB08, FHMB01). FHMB03 will monitor potential seepage from containment dams and waste rock dumps into the Permian unit.

Drawdown monitoring bores: Drawdown will be monitored in each aquifer (i.e. Cooroora Creek alluvium, Sandy Creek alluvium and Permian Coal measures) to ensure that levels are within the range of value presented in this report and thus that predicted impact and management measures are adequate.

10.2.2 Groundwater bores Location

The current monitoring network covers both the Permian coal measures of the Fairhill Formation and Cooroora Creek alluvium. Detailed of additional impact monitoring bores and reference bores are shown on **Table 13**. The location of existing and proposed bores is presented on **Figure 31**.

Figure 31 Location of existing (accurate) and proposed (approximate) monitoring bores



10.2.2.1 Cooroora Creek alluvium

FHMB01 monitors the alluvium within Cooroora Creek. It is located downstream of the mine infrastructure and will allow monitoring drawdown and unlikely seepage from the containment dam located on the eastern side of the pit (unlikely since the predicted drawdown indicate that potential seepage from all dams will be radial to the pit). Eventually, FHMB01 is expected to dry up as a result of drawdown.

Proposed bore FHMB09 will be located on the eastern section of the alluvium, directly adjacent the pit to monitor for any drawdown in the alluvium.

FHMB011A will be located in Cooroora Creek alluvium, outside the 0.5m drawdown radius in the alluvium. It will serve as a reference bore.

10.2.2.2 Sandy Creek alluvium

Two new shallow bores will be installed along Sandy Creek with the aim to intercept groundwater in the alluvium. FHMB08 will be located downstream of the second containment dam and waste rock dump to monitor potential seepage from these infrastructures. FHMB010A will be located upstream of the potential drawdown radius to serve as a reference bore.

10.2.2.3 Permian Coal measures (Fairhill)

Six bores currently monitor the Permian coal measures of the Fairhill formation. These bores currently provide baseline monitoring. FHMB02 and FHMB06 are located near the calculated 1m drawdown radius and will serve as early detection drawdown monitoring bores. FHMB03 is a currently dry and will allow monitoring potential seepage from nearby dam and rock dump.

Two additional bores, FHMB010B and FHMB011B will be nested with alluvium bores FHMB010A and FHMB011B to:

- Better understand the potential connectivity between alluvium and Permian units;
- Serve as additional reference bores; and
- Monitor potential drawdown outside of the predicted radius.

10.2.2.4 Reference bores

Wilton bore WGBW5 from nearby mine WCP is recommended as a reference bore for the Permian Coal measures of the Fairhill Formation. This bore is of the same water type than all bores at FHCP and is unlikely to be impacted by drawdown. FHMB07 should also serve as a reference bore on the other side of Cooroora Creek. Additional bores FHMB010B and FHMB011B will allow to increase spatial coverage of reference bores and provide additional baseline data.

A new bore (FHMB010A) will target the alluvium formation along Sandy Creek upstream of the potential drawdown radius to serve as a reference bore for water quality and level.

A new bore (FHMB011A) will target Cooroora Creek alluvium nearby monitoring bore FHMB02, upstream of the mine to serve as a reference bore in this unit.

Table 13 Existing and proposed monitoring bore network

Bore ID	Easting	Northing	Depth (m)	Formation	Purpose
Existing monitoring bores					
FHMB01	668618	7429805	24	Cooroora Creek alluvium	Baseline/seepage
FHMB02	665931	7432447	18.5	Permian Coal Measures (Fairhill)	Baseline/drawdown
FHMB03	667489	7429461	20	Permian Coal Measures (Fairhill)	Baseline/seepage
FHMB04	665391	7431805	29.5	Permian Coal Measures (Fairhill)	Baseline /drawdown
FHMB05	664578	7428931	23.5	Permian Coal Measures (Fairhill)	Baseline/drawdown
FHMB06	663663	7427594	41	Permian Coal Measures (Fairhill)	Baseline/drawdown
FHMB07	667620	7432945	48	Permian Coal Measures (Fairhill)	Baseline/reference bore
WGWB5	662720	7425642	103	Permian Coal Measures (Fairhill)	Reference bore
Proposed new monitoring bores					
FHMB08	TBD	TBD	15	Sandy Creek alluvium	Seepage
FHMB09	TBD	TBD	15	Cooroora Creek alluvium	Drawdown
FHMB010A	TBD	TBD	15	Sandy Creek alluvium	Baseline/reference bore
FHMB011A	TBD	TBD	15	Cooroora Creek alluvium	Baseline/reference bore
FHMB010B	TBD	TBD	50	Permian Coal Measures (Fairhill)	Baseline/reference bore
FHMB011B	TBD	TBD	40	Permian Coal Measures (Fairhill)	Baseline/reference bore

10.2.3 Monitoring frequency

The proposed groundwater monitoring program aims at early detection of any potential impacts to groundwater resources at FHCP to maintain groundwater at a suitable background quality.

10.2.3.1 Baseline monitoring

Baseline groundwater monitoring at FHCP commenced in June 2018 with seven groundwater monitoring bores established. Although a two monthly monitoring frequency was established, wet weather conditions have hampered monitoring efforts for early 2019. A total of four monitoring events have been conducted since the first monitoring event in June 2018.

Once monitoring activities resume, baseline groundwater monitoring is to be conducted on a monthly basis. It is proposed to continue monitoring on a monthly basis until 12 continuous sets of monitoring data are obtained from each bore.

10.2.3.2 Ongoing mining monitoring

From the start of ongoing mining operation, a monthly monitoring frequency should be adopted. Data loggers to obtain real time groundwater level and EC measurements should be installed in the monitoring bores. A continuous high frequency record of groundwater levels and EC around the proposed FHCP pit will greatly aid the understanding of potential groundwater impacts.

10.3 Trigger levels and contingency criteria

To identify mine impacts, groundwater quality in monitoring bores constituting the groundwater impact monitoring network should be assessed against the natural background groundwater quality.

Background groundwater quality can be tentatively established after obtaining at least eight sets of monitoring data from baseline monitoring bores via the baseline monitoring program. At this stage, only four set of data has been collected. Interim trigger values for a wide range of parameters (as discussed in section 10.2.1.2) are proposed for freshwater aquatic ecosystem protection (95% of species) or stock watering as follows:

Interim values have been sourced, when available from regional groundwater quality guidelines (Fitzroy groundwaters chemical zone 34, 80th percentile, deep bore – DEHP (2011)) or from ANZECC & ARMCANZ (2000) trigger levels for freshwater aquatic ecosystems protection. Less conservative stock watering trigger values (DEHP, 2011) were used when no value for aquatic ecosystem protection was available (**Table 14**).

Drawdown triggers have been selected to ensure no further impact from the mining operation other than those identified in this report.

Table 14 Interim trigger values

Parameter	Measure	Trigger value*	Source
SWL	FHMB09 (Cooroora Creek alluvium)	0.5m below baseline value	Predicted drawdown at FHMB09
	FHMB02 (Drawdown Permian)	9mBGL (or 1.2m below baseline value)	Predicted drawdown at FHMB02
	FHMB04 (Drawdown Permian)	31.5mBGL (or 10.5m below baseline value)	Predicted drawdown at FHMB04
	FHMB05 (Drawdown Permian)	24mBGL (or 13m below baseline value)	Predicted drawdown at FHMB05

Parameter	Measure	Trigger value*	Source
	FHMB06 (Drawdown Permian)	19mBGL (or 5m below baseline value)	Predicted drawdown at FHMB06
Physico-chemical	pH	6.5–8.1	ANZECC & ARMCANZ (2000)) – DEHP (2011)
	EC	To be based on references bores data ³	derive individual bore limits from background data
Major cations Major anions	Na, Ca, Mg, K Cl, HCO ₃ , CO ₃ , SO ₄	Interpretation purposes only	N/A
Other ions	F	2	Stock watering - DEHP (2011)
	Nitrate	0.7	ANZECC & ARMCANZ (2000)
	Nitrite	Interpretation purposes only	N/A
Metals and metalloids	Al (dissolved)	0.055	ANZECC & ARMCANZ (2000)
	Ba (dissolved)	TBD	TBD
	B (total)	5	Stock watering - DEHP (2011)
	Mn (dissolved)	1.9 ²	ANZECC & ARMCANZ (2000)
	Zn (dissolved)	0.06	DEHP (2011)
	Cu (dissolved)	0.03	DEHP (2011)
	Pb (dissolved)	0.0034	ANZECC & ARMCANZ (2000)
	As (dissolved)	0.013	ANZECC & ARMCANZ (2000)
	V (dissolved)	0.005	LOR
	Ni (dissolved)	0.011	ANZECC & ARMCANZ (2000)
	Co (total)	1	Stock watering - DEHP (2011)
	Cr (dissolved)	0.001	ANZECC & ARMCANZ (2000)
	Se (dissolved)	0.005	Aq. Eco 99%
	Cd (dissolved)	0.0002	ANZECC & ARMCANZ (2000)
	U (total)	0.2	Stock watering - DEHP (2011)
	Hg (dissolved)	0.00006	ANZECC & ARMCANZ (2000)

¹Value likely too conservative for most bores based on existing data. Interim local limits should be derived based on DITSI (2017) once at least 8 samples have been collected.

² Value likely too conservative for FHMB01 based on existing data. Interim local limits should be derived based on DITSI (2017) once at least 8 samples have been collected.

³ Based on four measurements, these are likely to be: FHMB02/FHMB06 = 25,000µS/cm; FHMB01 (To be replaced by FHMB011) = 48,000 µS/cm; FHMB07/FHMB04 = 18,000 µS/cm

11 References

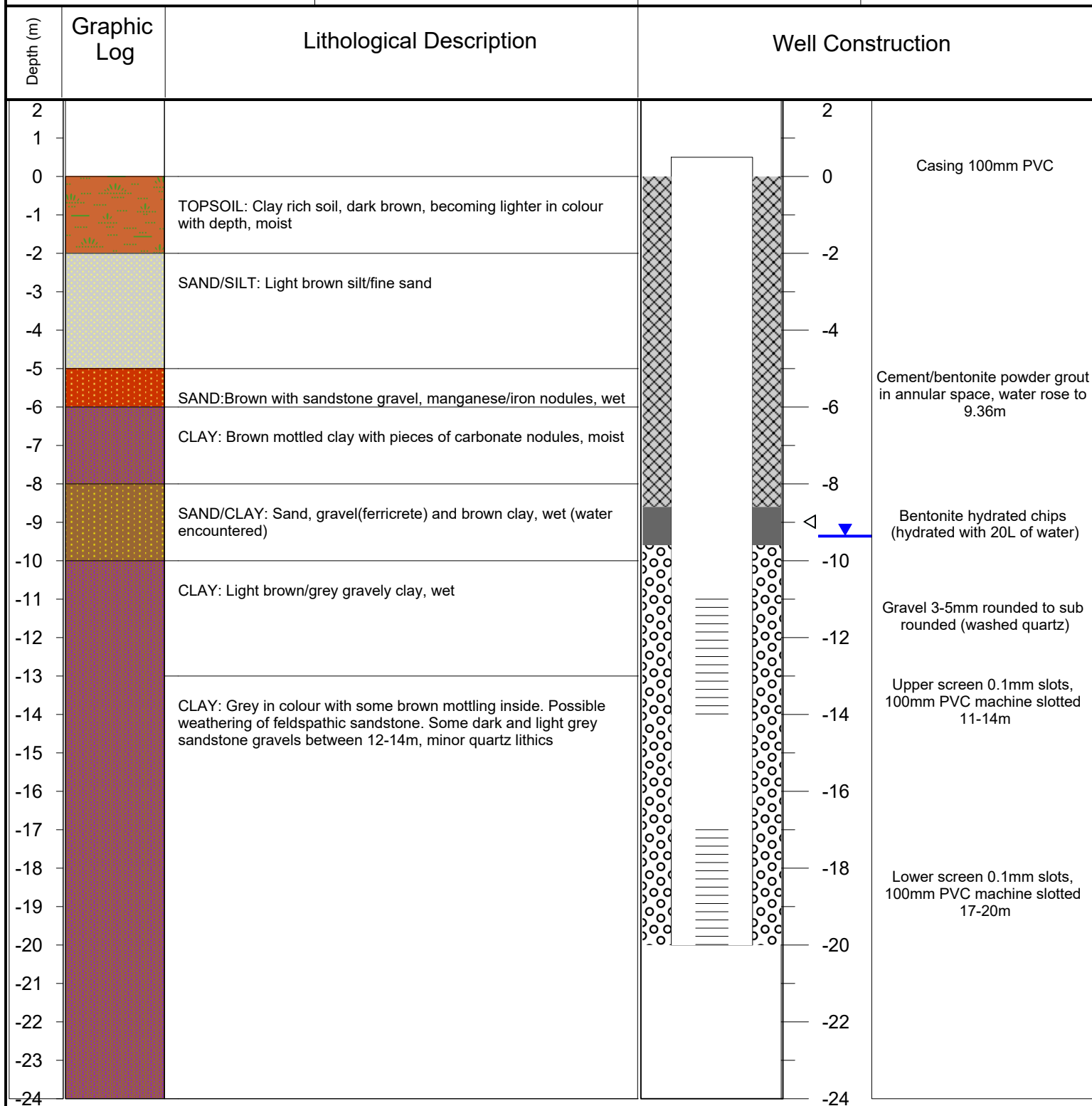
- Aquaterra Consulting. (2000). Groundwater flow modelling guideline. Murray-Darling Basin Commission.
- ATC Williams. (2018). Fairhill Coal Project water management assessment. Prepared for Fairhill Coking Coal Pty Ltd, September 2018.
- Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resources Management Council of Australia and New Zealand (ARMCANZ). (2000). Australian and New Zealand guidelines for fresh and marine water quality.
- Barnett, B., Townley, L. R., Post, V., Evans, R. E., Hunt, R. J., Peeters, L., Richardson, S., Werner, A. D., Knapton, A., & Boronkay, A. (2012). Australian groundwater modelling guidelines. National Water Commission, Canberra.
- Bradley, M. (2006). Integration of brigalow (*Acacia harpophylla*) vegetation with dryland cropping in south-east Queensland: agronomic, hydrological, ecological and Goethean perspectives (Doctoral dissertation, PhD Thesis, Griffith University, Gold Coast, Queensland, Australia).
- Bureau of Meteorology (BOM). (2018). Groundwater dependent ecosystems atlas. Retrieved from <http://www.bom.gov.au/water/groundwater/gde/map.shtml>.
- CABI. (2019). Datasheet: *Eucalyptus camaldulensis*, Invasive Species Compendium. Accessed online on 22nd of April 2019, <https://www.cabi.org/isc/datasheet/22596>
- Department of Environment and Heritage Protection (DEHP). (2011). Mackenzie River sub-basin environmental values and water quality objectives. Re-published in July 2013.
- Doherty, J. (2010). PEST: Model independent parameter estimation, Watermark Numer. Comput., Brisbane, Queensland, Australia.
- Environmental Earth Sciences. (2012). Soil and land capability assessment: Wilton coal project. Report to Northern Resource Consultants March 2012, Version 1 (unpublished Report).
- Froend, R., & Sommer, B. (2010). Phreatophytic vegetation response to climatic and abstraction-induced groundwater drawdown: examples of long-term spatial and temporal variability in community response. *Ecological Engineering*, 36(9), 1191-1200.
- Hulme, K. A. (2010). *Eucalyptus camaldulensis* (river red gum) biogeochemistry: an innovative tool for mineral exploration in the Curnamona Province and adjacent regions (Doctoral dissertation).
- Groom, B. P. K., Froend, R. H., & Mattiske, E. M. (2000). Impact of groundwater abstraction on a Banksia woodland, Swan Coastal Plain, Western Australia. *Ecological Management & Restoration*, 1(2), 117-124.
- National Health and Medical Research Council (NHMRC). (2018). National water quality management strategy: Australian drinking water guidelines 6 – 2011. Version 3.5 updated August 2018.
- Norther Resource Consultants Pty Ltd (NRC). (2018a). Wet season 2018 aquatic ecology monitoring: Fairhill. Prepared for Futura Resources Limited, March 2018.

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- NRC. (2018b). Wilton Coal Project groundwater technical report. Prepared for Futura Resources Ltd, September 2018.
- NRC. (2018c). Fairhill Coal Project waste rock characterisation report. Prepared for Fairhill Coking Coal Pty Ltd, August 2018.
- NRC. (2018d). Wet Season 2018 Aquatic Ecology Monitoring. Prepared for Fairhill Coking Coal Pty Ltd, March 2018.
- NRC. (2019). Flora and Fauna Technical Report. Prepared for Fairhill Coking Coal Pty Ltd, May 2019.
- Prouza, V. (1977). Coal exploration, South Central Bowen Basin, Mt. Stuart-Comet Area, Geological Survey Queensland, Record 1977/27.
- Queensland Government. (2019). Queensland Globe. Retrieved from <https://qldglobe.information.qld.gov.au>
- Richardson S, et al 2011. Australian groundwater-dependent ecosystems toolbox part 2: assessment tools, Waterlines report, National Water Commission, Canberra.
- Richardson S, et al 2011b. Australian groundwater-dependent ecosystems toolbox part 1: assessment framework, Waterlines report, National Water Commission, Canberra.
- ROM Resources. (2013). Minescape model report and 2012 JORC resource statement. Report prepared for Fairhill Coking Coal Pty Ltd.
- Scanlon, B. R., Healy, R. W., & Cook, P. G. (2002). Choosing appropriate techniques for quantifying groundwater recharge. *Hydrogeology Journal* 10, 18–39.
- Scott, S.G., Beeston, J.W., & Carr, A.F. (1995). Galilee Basin. In: Ward CR, Harrington HJ, Mallett CW and Beeston JW (eds) *Geology of Australian Coal Basins*. Geological Society of Australia – Coal Geology Group 1, 341–353.
- Sliwa, R., Hamilton, S., Hodgkinson, J., & Draper, J. (2008). Bowen Basin structural geology: An interpretation based on airborne geophysics and open file exploration data. Queensland Department of Mines and CSIRO.
- Xstrata Coal. (2012). Xstrata Coal Oaky Creek underground water impact report –Petroleum Lease 237 and 324. Published report prepared by Xstrata Coal Oaky Creek, December 2012.

APPENDIX A

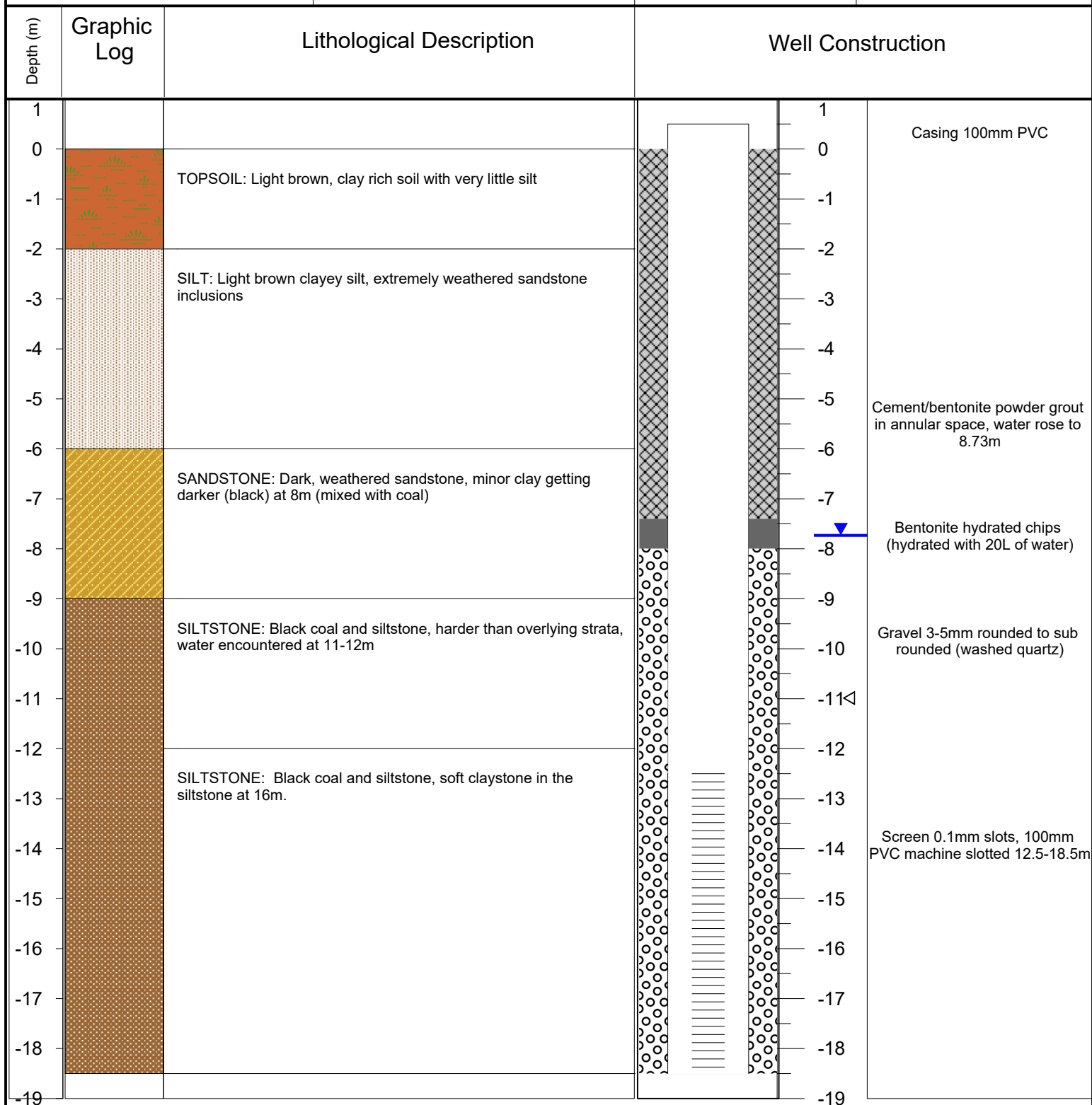
Bore logs

PROJECT: Fairhill	WELL ID: FHMB01	
LOCATION: Fairhill, QLD	DATE STARTED: 15/06/2018	DATE COMPLETED: 15/06/2018
DRILLING CONTRACTOR: Wizard Drilling	NORTHING: 7429810 mS	EASTING: 668268 mE
DATUM: GDA94 ZONE 55K	GROUND SURFACE ELEV.: TBD mAHD	TOC ELEVATION: TBD mAHD
LOGGED BY: SL&MT	DRILLING METHOD: Rotary Air	TOTAL DEPTH: 24 m
		DEPTH TO WATER: 9 m



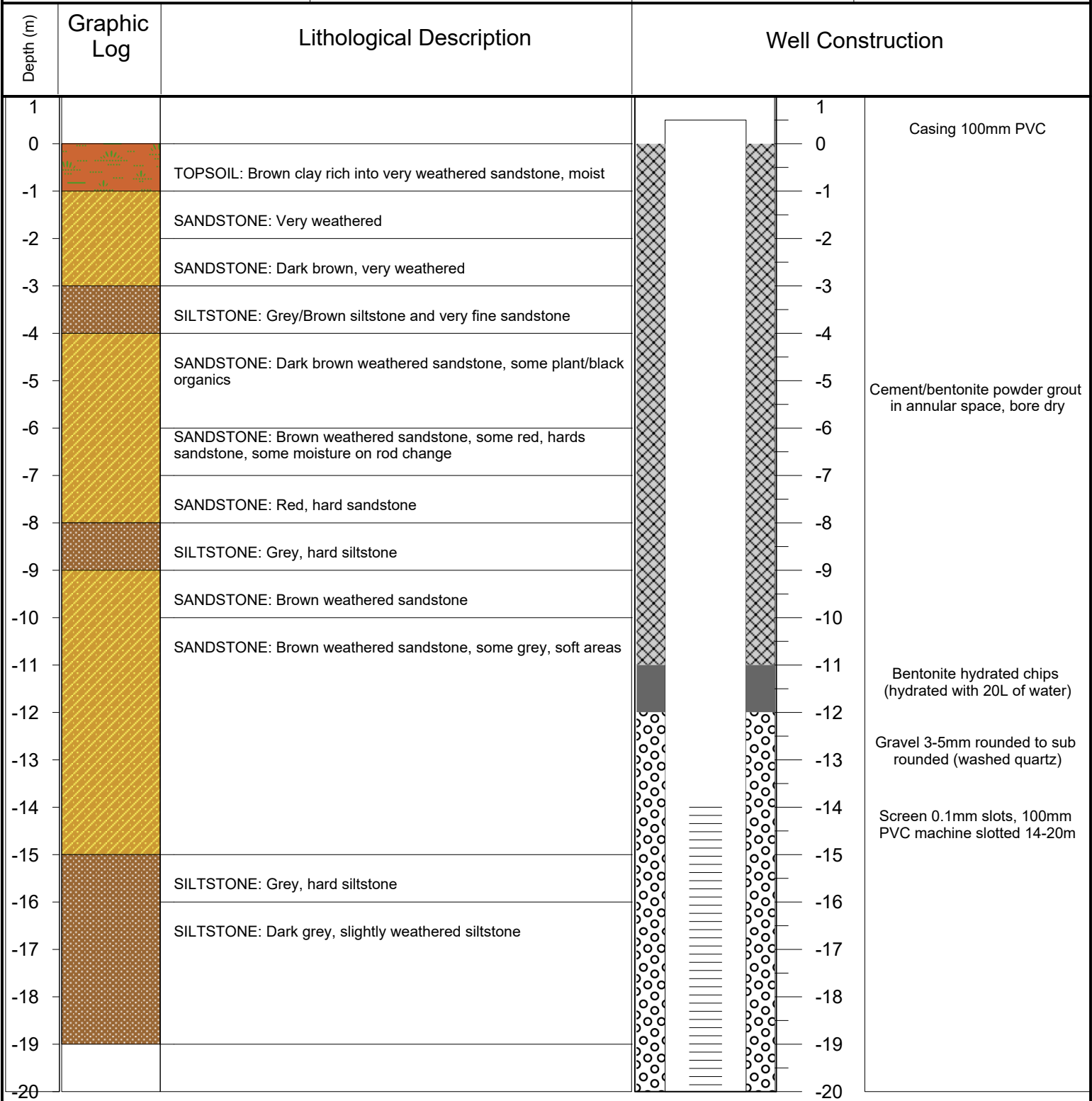
NOTES: Mud mixture used to drill bore due to copllapse of gravel/clay bed. Bore sampled on the 16/6/18 and an SWL of 9.36 recorded.

PROJECT: Fairhill	WELL ID: FHMB02	
LOCATION: Fairhill, QLD	DATE STARTED: 01/06/2018	DATE COMPLETED: 01/06/2018
DRILLING CONTRACTOR: Wizard Drilling	NORTHING: 7432461 mS	EASTING: 665930 mE
DATUM: GDA94 ZONE 55K	GROUND SURFACE ELEV.: TBD mAHD	TOC ELEVATION: TBD mAHD
LOGGED BY: MJ	DRILLING METHOD: Rotary Air	TOTAL DEPTH: 18.5 m
		DEPTH TO WATER: 11 m

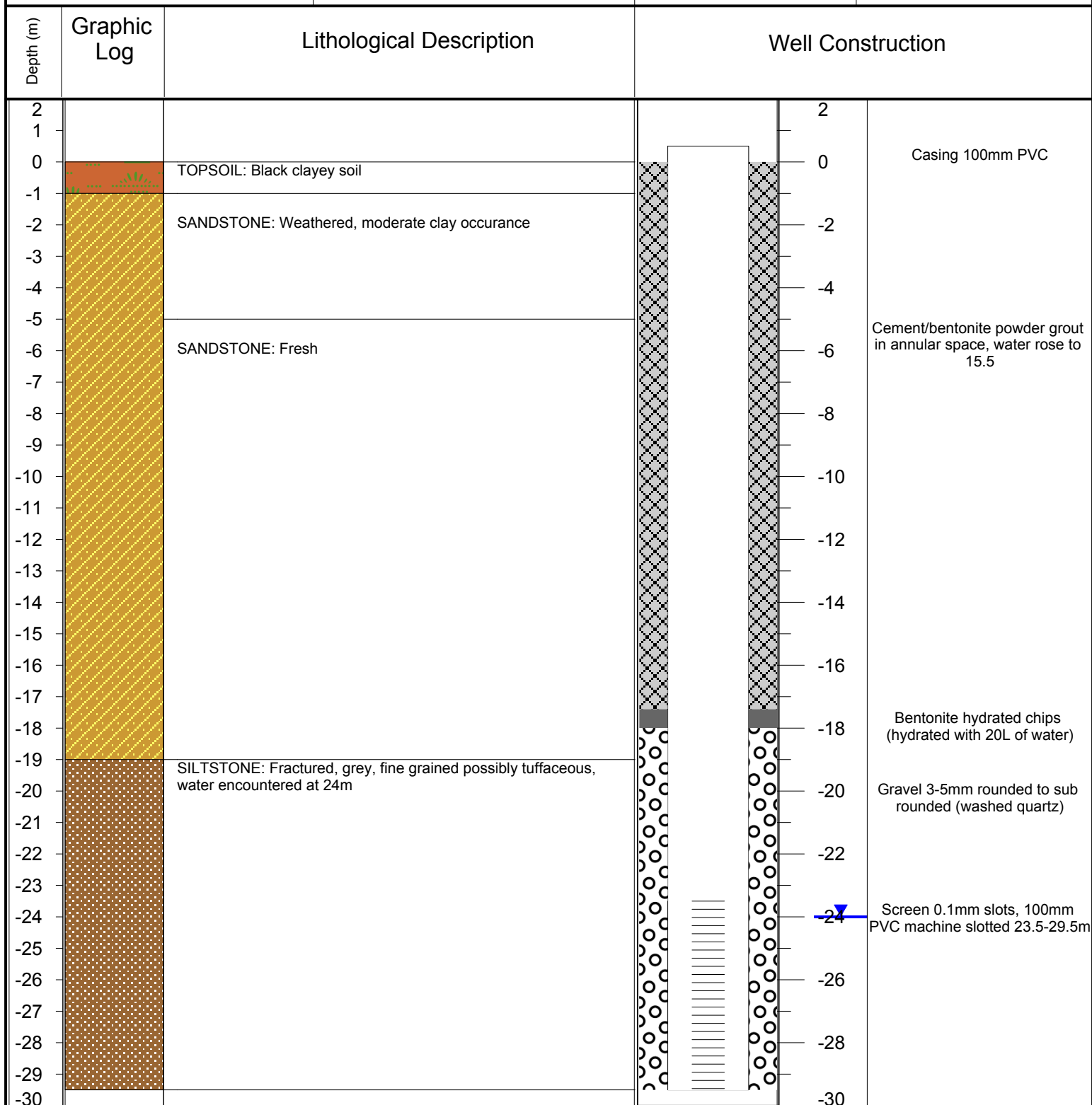


NOTES: Water flow rate ~0.97-1L/s, water quality 25.4 mS/cm; 6.71pH. Bore was sampled on the 15/06/18 and an SWL of 7.73 was recorded, water EC:25.9mS/cm pH:7.99.

	PROJECT: Fairhill	WELL ID: FHMB03	
	LOCATION: Fairhill, QLD	DATE STARTED: 14/06/2018	DATE COMPLETED: 14/06/2018
	DRILLING CONTRACTOR: Wizard Drilling	NORTHING: 7429461 mS	EASTING: 667489 mE
	DATUM: GDA94 ZONE 55K	GROUND SURFACE ELEV.: TBD mAHD	TOC ELEVATION: TBD mAHD
LOGGED BY: SL&MT	DRILLING METHOD: Rotary Air	TOTAL DEPTH: 20 m	DEPTH TO WATER: Dry m

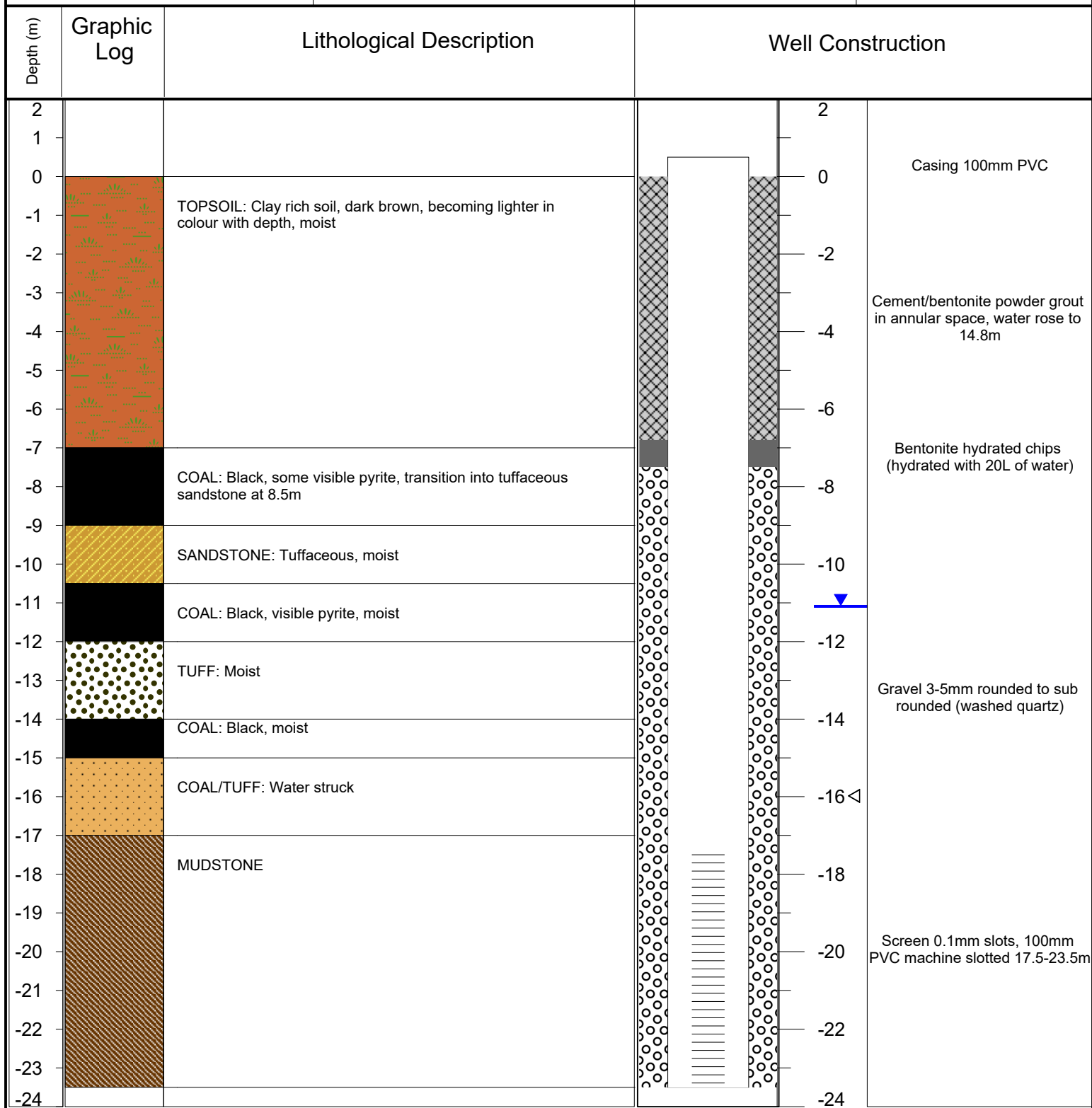


PROJECT: Fairhill	WELL ID: FHMB04	
LOCATION: Fairhill, QLD	DATE STARTED: 30/05/2018	DATE COMPLETED: 31/05/2018
DRILLING CONTRACTOR: Wizard Drilling	NORTHING: 7431805 mS	EASTING: 665391 mE
DATUM: GDA94 ZONE 55K	GROUND SURFACE ELEV.: TBD mAHD	TOC ELEVATION: TBD mAHD
LOGGED BY: MJ	DRILLING METHOD: Rotary Air	TOTAL DEPTH: 29.5 m
		DEPTH TO WATER: 24 m



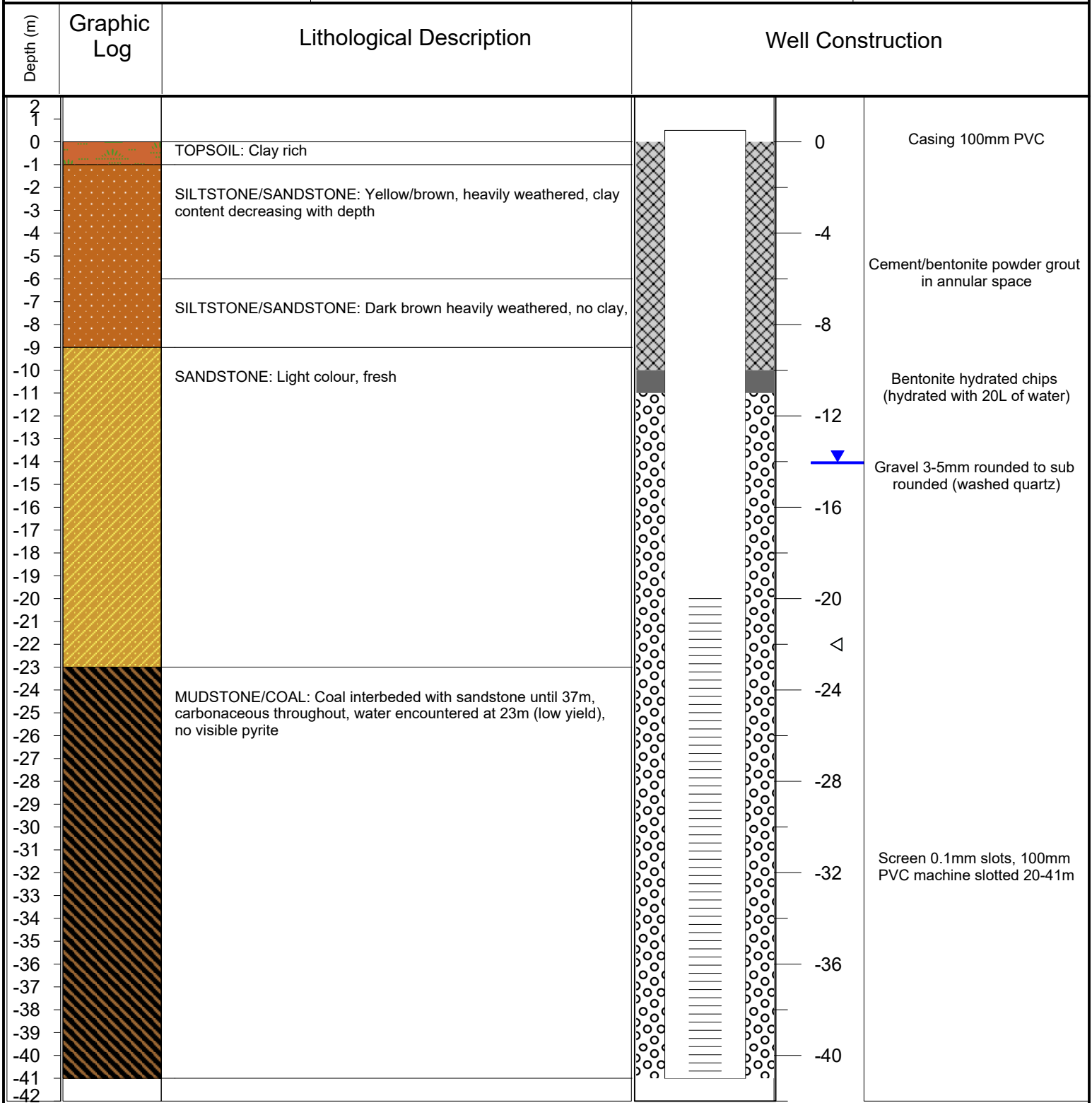
NOTES: Water flow rate of 0.44L/s achieved, water quality 15.3mS/cm;6.76pH

PROJECT: Fairhill	WELL ID: FHMB05	
LOCATION: Fairhill, QLD	DATE STARTED: 30/05/2018	DATE COMPLETED: 30/05/2018
DRILLING CONTRACTOR: Wizard Drilling	NORTHING: 7428931 mS	EASTING: 664578 mE
DATUM: GDA94 ZONE 55K	GROUND SURFACE ELEV.: TBD mAHD	TOC ELEVATION: TBD mAHD
LOGGED BY: MJ	DRILLING METHOD: Rotary Air	TOTAL DEPTH: 23.5 m
		DEPTH TO WATER: 16 m



NOTES: No airlift done, water quality 16.8mS/cm; 6.77pH. Bore was sampled on the 15/06/18 and an SWL of 11.09m was recorded, water EC:15.8mS/cm, pH:8.41.

	PROJECT: Fairhill	WELL ID: FHMB06	
	LOCATION: Fairhill, QLD	DATE STARTED: 29/05/2018	DATE COMPLETED: 29/05/2018
	DRILLING CONTRACTOR: Wizard Drilling	NORTHING: 7427594 mS	EASTING: 663663 mE
	DATUM: GDA94 ZONE 55K	GROUND SURFACE ELEV.: TBD mAHD	TOC ELEVATION: TBD mAHD
LOGGED BY: MJ	DRILLING METHOD: Rotary Air	TOTAL DEPTH: 41 m	DEPTH TO WATER: 23 m



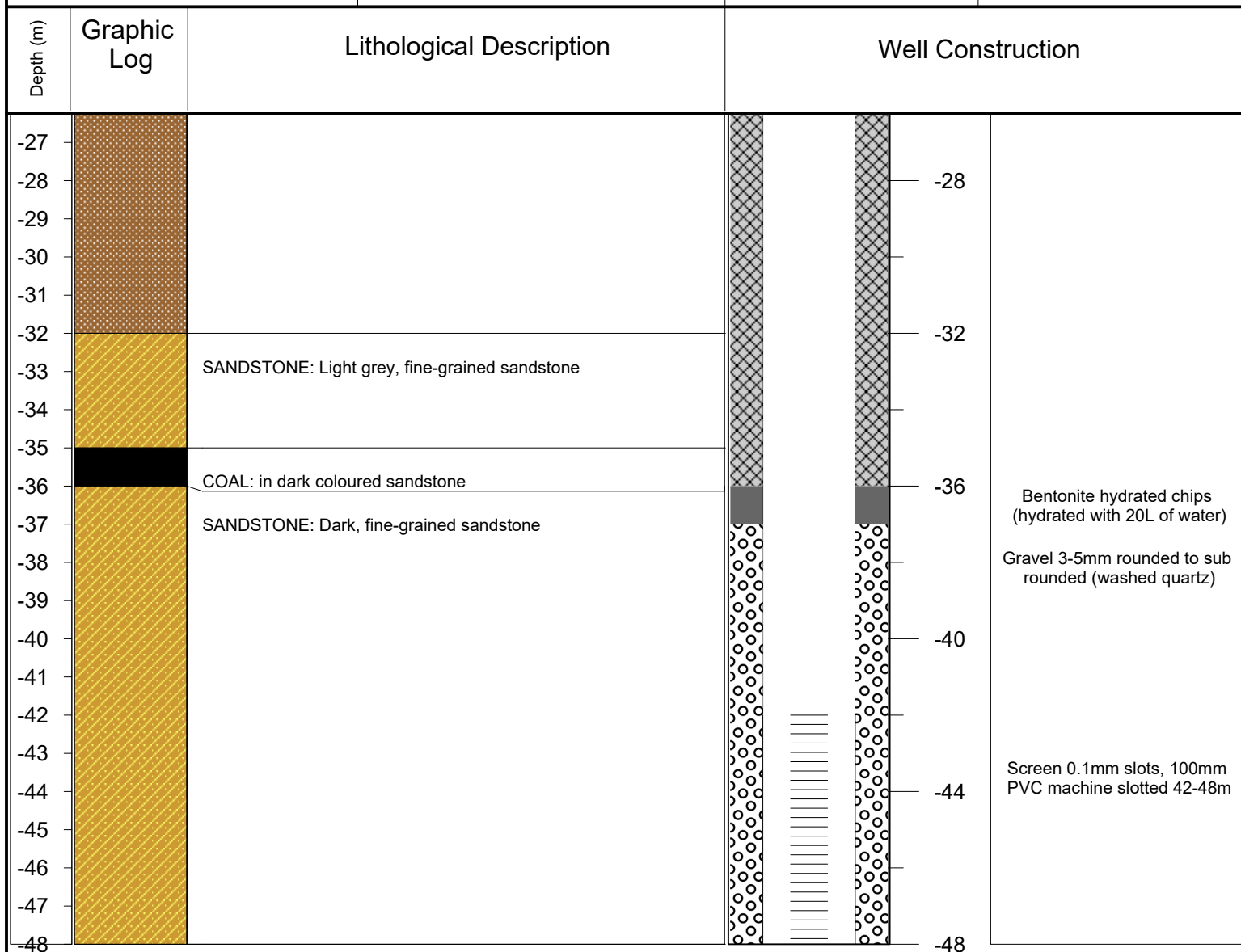
NOTES: Achieved a flow rate of 0.038L/s, watre quality 24.2mS/cm; 7.34pH. Bore was sampled on the 15/06/18 and an SWL of 14.05 was recorded, water EC:27mS/cm, pH 8.59.

	PROJECT: Fairhill	WELL ID: FHMB07	
	LOCATION: Fairhill, QLD	DATE STARTED: 02/06/2018	DATE COMPLETED: 02/06/2018
	DRILLING CONTRACTOR: Wizard Drilling	NORTHING: 7432945 mS	EASTING: 667620 mE
	DATUM: GDA94 ZONE 55K	GROUND SURFACE ELEV.: TBD mAHD	TOC ELEVATION: TBD mAHD
LOGGED BY: MJ	DRILLING METHOD: Rotary Air	TOTAL DEPTH: 48 m	DEPTH TO WATER: undetermined m

Depth (m)	Graphic Log	Lithological Description	Well Construction	
4			4	
3				
2				
1				
0			0	Casing 100mm PVC
-1		TOPSOIL: Black, clay rich		
-2		TOPSOIL: Light brown, clay rich, completely weathere sandstone		
-3				
-4		SILT: Light colour, clay rich	-4	
-5				
-6		SANDSTONE: Coarse-grained, relatively fresh, minor weathering		
-7				
-8			-8	
-9				
-10				Cement/bentonite powder grout in annular space, water level TBD
-11				
-12			-12	
-13				
-14		SANDSTONE: Fresh, coarse-grained sandstone		
-15				
-16			-16	
-17				
-18				
-19		SILTSTONE/MUDSTONE: Dark coloured, fine grained, coal at 20m	-20	
-20				
-21		SANDSTONE: Coarse-grained sandstone		
-22				
-23				
-24			-24	
-25				
-26		SILTSTONE: Black, fine-grained siltstone		

NOTES: No airlift, only a trickle of water. Bore was sampled on the 15/06/18 and an SWL of 16.14m was measured, water EC: 19.8mS/cm and pH:8.47.

PROJECT: Fairhill	WELL ID: FHMB07	
LOCATION: Fairhill, QLD	DATE STARTED: 02/06/2018	DATE COMPLETED: 02/06/2018
DRILLING CONTRACTOR: Wizard Drilling	NORTHING: 7432945 mS	EASTING: 667620 mE
DATUM: GDA94 ZONE 55K	GROUND SURFACE ELEV.: TBD mAHD	TOC ELEVATION: TBD mAHD
LOGGED BY: MJ	DRILLING METHOD: Rotary Air	TOTAL DEPTH: 48 m
		DEPTH TO WATER: undetermined m



NOTES: No airlift, only a trickle of water. Bore was sampled on the 15/06/18 and an SWL of 16.14m was measured, water EC: 19.8mS/cm and pH:8.47.

APPENDIX B

Fence Diagram

Figure 1 Reference map

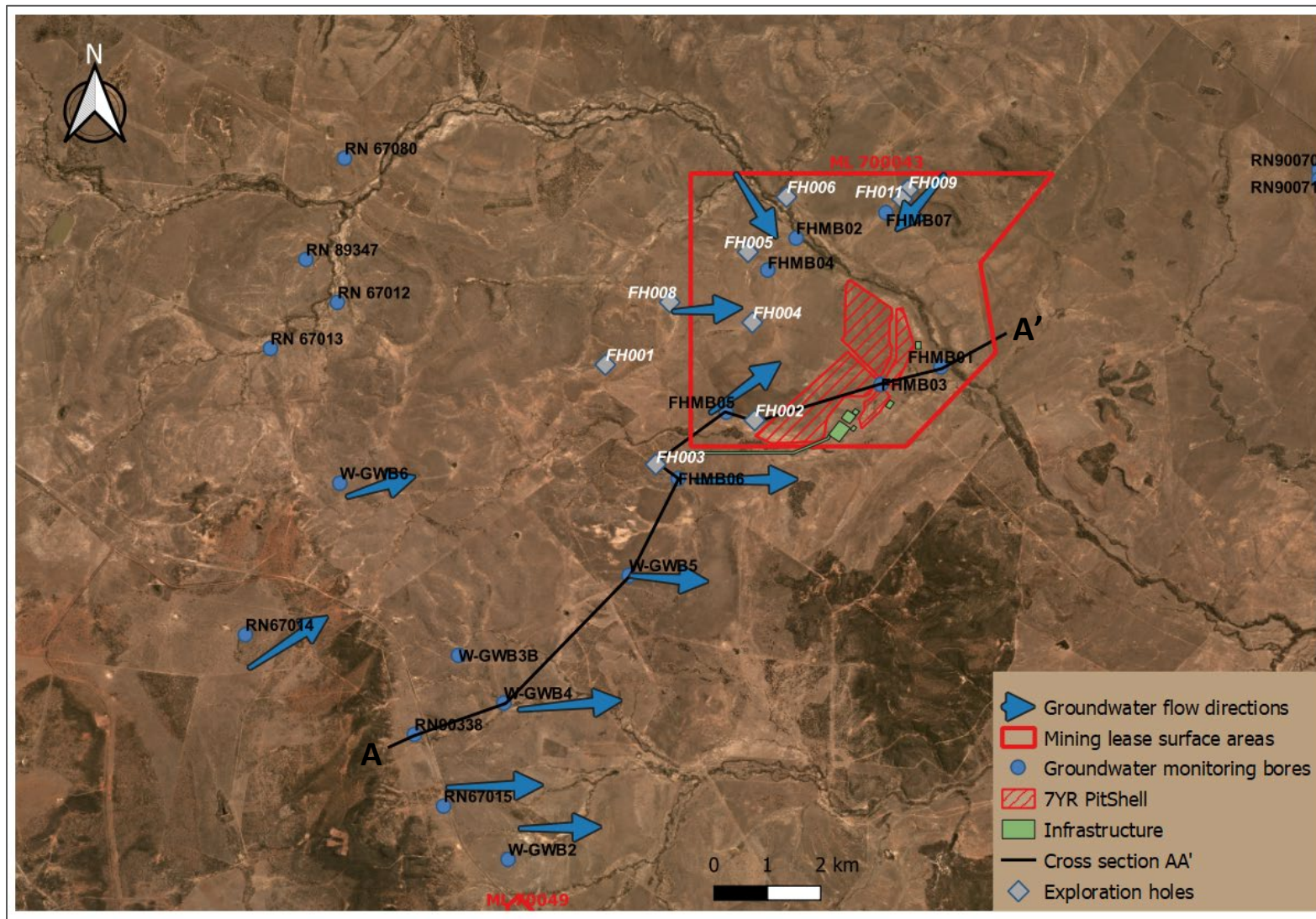


Figure 2 Cross Section A-A'

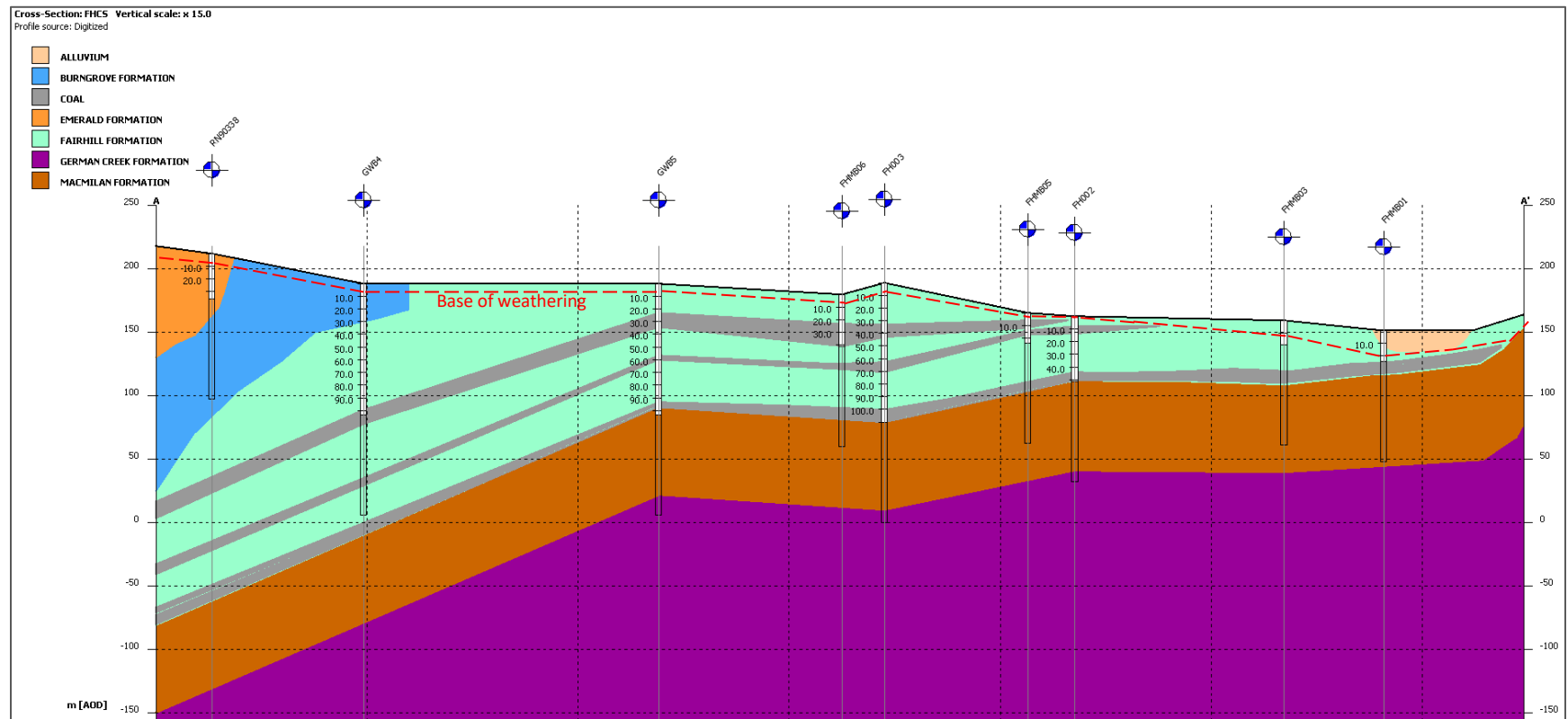


Figure 3 Zoom on bores FHMB03 and FHMB01

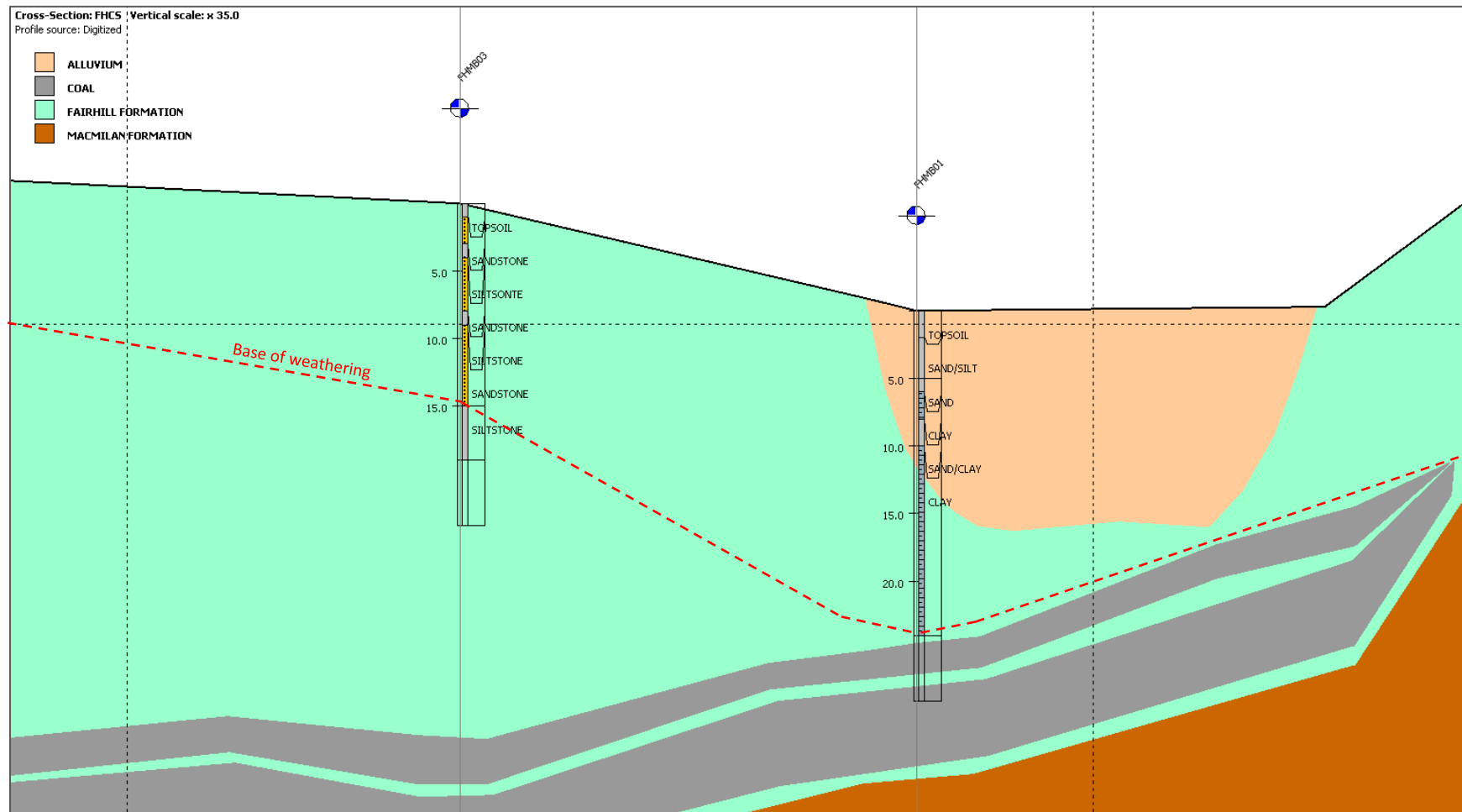


Figure 4 Zoom on bore FHMB05 and exploration hole FH002

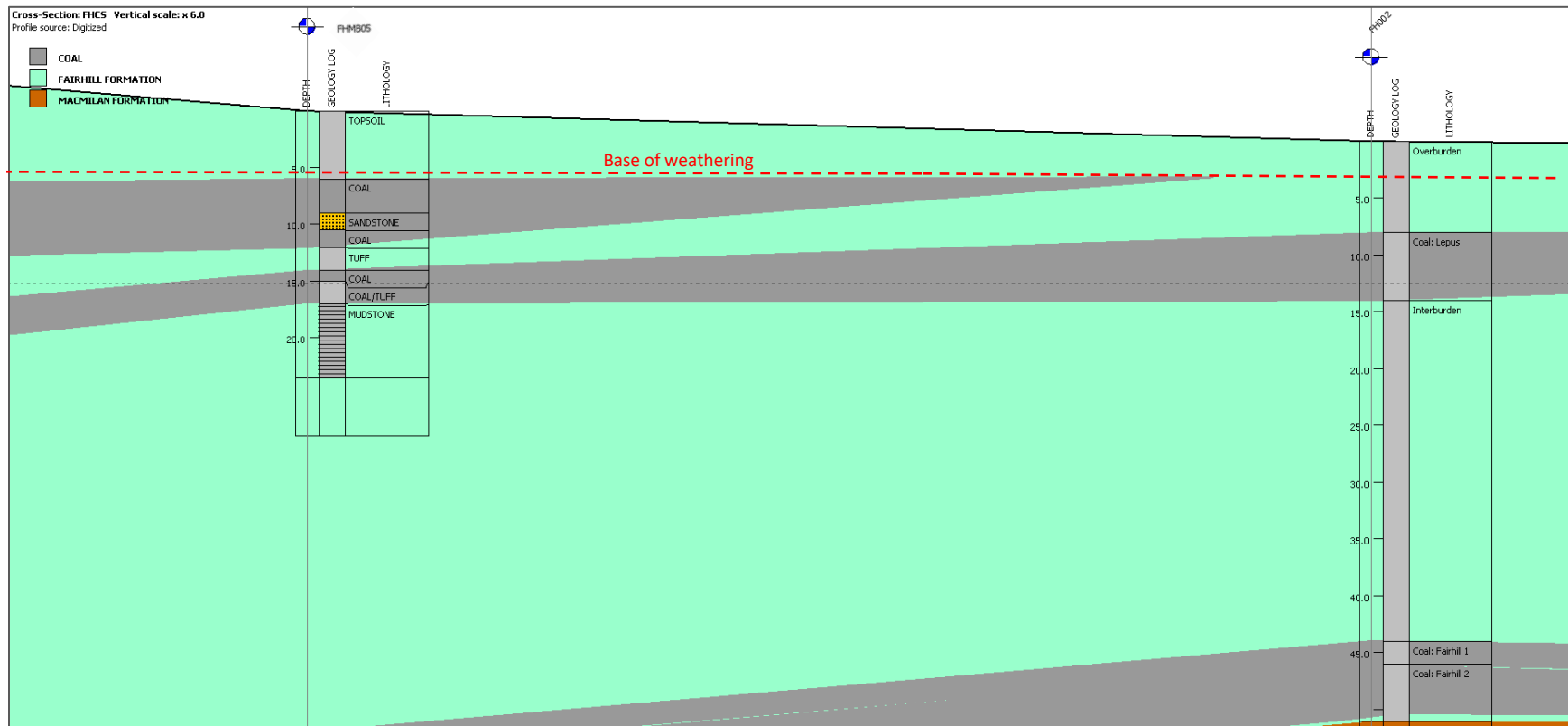


Figure 5 Zoom on bore FHMB06 and exploration hole FH003

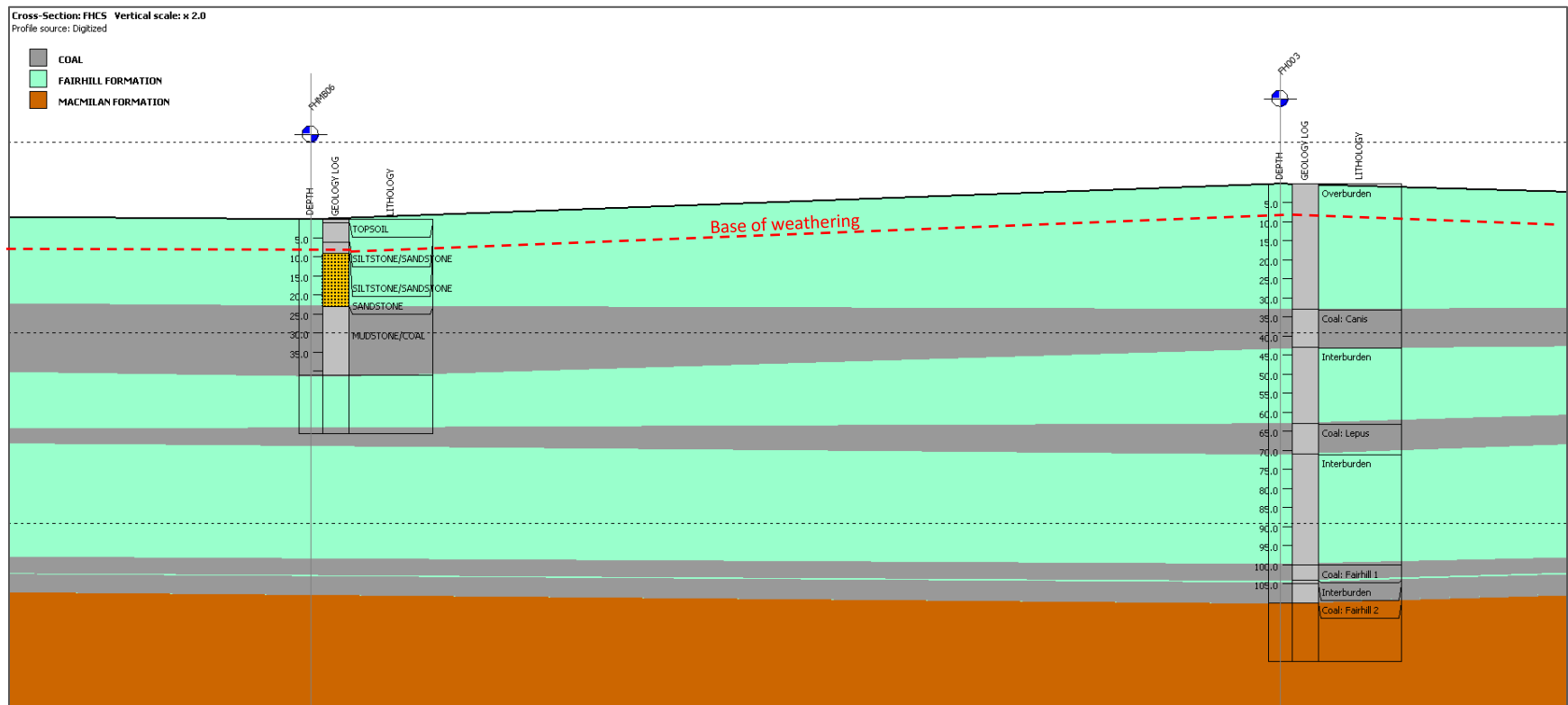
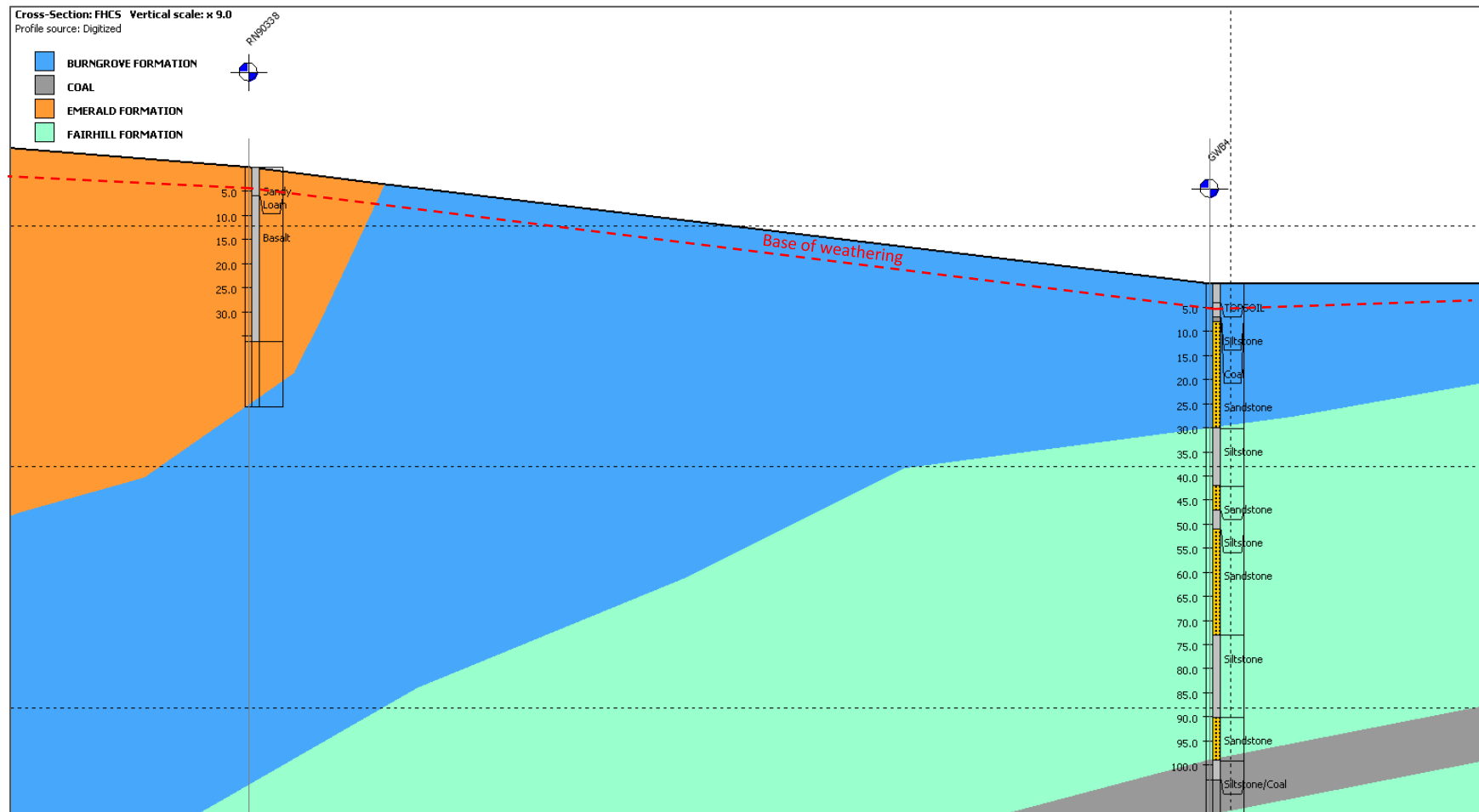


Figure 6 Zoom on bores RN90338 and W-GWB4



APPENDIX C

Summary statistics

Bore ID	Parameter Unit	pH	EC µS/cm	TDS mg/L	F mg/L	N mg/L	SO4 mg/L	Al mg/L	As mg/L	Ba mg/L	B mg/L	Cd mg/L	Co mg/L	Cr mg/L	Cu mg/L	Fe mg/L	Hg mg/L	Pb mg/L	Mn mg/L	Ni mg/L	Se mg/L	Va mg/L	Zn mg/L	U mg/L	Total Al mg/L	Total Ba mg/L	Total Fe mg/L	Total Mn mg/L	Total Hg mg/L	Total As mg/L	Total Cd mg/L	Total Co mg/L	Total Cr mg/L	Total Cu mg/L	Total Pb mg/L	Total Ni mg/L	Total Se mg/L	Total Va mg/L	Total Zn mg/L	Total U mg/L		
FHMB01	Count	3	3	3	3	3	3	3	3	3	1	1	3	3	3	3	3	3	3	3	3	3	3	3	1	3	2	3	3	3	3	3	3	3	3	3	3	3	3	2	1	
FHMB01	min	7	44000	30000	0.3	0.0025	2200	0.0025	0.0005	0.25	0.54	0.0005	0.016	0.0005	0.0005	0.023	2.5E-05	0.0005	5.7	0.008	0.001	0.0005	0.0025	0.013	1.1	0.55	0.24	2.1	5.7	2.5E-05	0.001	0.0005	0.017	0.001	0.006	0.002	0.01	0.001	0.002	0.072	0.015	
FHMB01	5th Percentile	7.03	44300	30400	0.32	0.0025	2210	0.0083	0.0005	0.25	0.54	0.0005	0.0161	0.0005	0.0006	0.0236	2.5E-05	0.0005	5.85	0.0081	0.001	0.0005	0.0038	0.013	1.59	0.5585	0.254	2.6	5.9	2.5E-05	0.0012	0.0005	0.0179	0.0034	0.0085	0.0031	0.013	0.001	0.003	0.097	0.015	
FHMB01	10th Percentile	7.12	45200	31600	0.38	0.0025	2240	0.0255	0.0005	0.25	0.54	0.0005	0.0164	0.0005	0.0007	0.0254	2.5E-05	0.0005	6.3	0.0084	0.001	0.0005	0.0075	0.013	3.06	0.584	0.296	4.1	6.5	2.5E-05	0.0018	0.0005	0.0206	0.0106	0.016	0.0064	0.023	0.001	0.006	0.172	0.015	
FHMB01	Median	7.3	47000	34000	0.5	0.0025	2300	0.06	0.0005	0.25	0.54	0.0005	0.017	0.0005	0.001	0.029	2.5E-05	0.0005	7.2	0.009	0.001	0.0005	0.015	0.013	6	0.635	0.38	7.1	7.7	2.5E-05	0.003	0.0005	0.026	0.025	0.031	0.013	0.042	0.001	0.012	0.321	0.015	
FHMB01	80th Percentile	7.3	47000	37000	0.5	0.0025	2360	0.144	0.002	0.25	0.54	0.0005	0.0176	0.0005	0.0028	1.8716	2.5E-05	0.0005	8.34	0.0102	0.0046	0.0248	0.0462	0.013	12.6	0.686	0.464	8.3	8.6	0.00013	0.0078	0.0005	0.0284	0.0298	0.0538	0.028	0.049	0.007	0.0294	0.47	0.015	
FHMB01	95th Percentile	7.3	47000	38500	0.5	0.0025	2390	0.186	0.0028	0.25	0.54	0.0005	0.0179	0.0005	0.0037	2.7929	2.5E-05	0.0005	8.91	0.0108	0.0064	0.037	0.0618	0.013	15.9	0.7115	0.506	8.9	9.05	0.00018	0.0102	0.0005	0.0296	0.0322	0.0652	0.0355	0.053	0.01	0.0381	0.545	0.015	
FHMB01	max	7.3	47000	39000	0.5	0.0025	2400	0.2	0.003	0.25	0.54	0.0005	0.018	0.0005	0.004	3.1	2.5E-05	0.0005	9.1	0.011	0.007	0.041	0.067	0.013	17	0.72	0.52	9.1	9.2	0.0002	0.011	0.0005	0.03	0.033	0.069	0.038	0.054	0.011	0.041	0.57	0.015	
FHMB02	Count	4	4	4	4	4	4	4	4	4	2	2	4	4	4	4	4	4	4	4	4	4	4	2	4	3	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	2
FHMB02	min	7.3	24000	16000	0.4	0.0025	430	0.0025	0.001	0.13	0.43	0.0005	0.0005	0.0005	0.0005	0.047	2.5E-05	0.0005	0.31	0.0005	0.001	0.0005	0.0025	0.0005	0.07	0.42	0.13	2.6	0.32	2.5E-05	0.002	0.0005	0.0005	0.0005	0.001	0.0005	5E-04	0.001	0.0005	0.005	0.0005	
FHMB02	5th Percentile	7.315	24000	16000	0.415	0.0025	432	0.0053	0.001	0.13	0.43	0.0005	0.0005	0.0005	0.0006	0.37	2.5E-05	0.0005	0.3115	0.0005	0.001	0.0005	0.0029	0.0007	0.106	0.426	0.131	2.645	0.326	2.5E-05	0.0022	0.0005	0.0005	0.0006	0.001	0.0005	6E-04	0.001	0.0005	0.006	0.0005	
FHMB02	20th Percentile	7.306	24000	16000	0.406	0.0025	431	0.0036	0.001	0.13	0.43	0.0005	0.0005	0.0005	0.0005	0.1762	2.5E-05	0.0005	0.3106	0.0005	0.001	0.0005	0.0027	0.0006	0.084	0.4224	0.1304	2.618	0.322	2.5E-05	0.0021	0.0005	0.0005	0.0005	0.001	0.0005	5E-04	0.001	0.0005	0.005	0.0005	
FHMB02	Median	7.45	24000	16000	0.5	0.0043	440	0.0255	0.001	0.13	0.44	0.0005	0.0005	0.0005	0.001	2.3	2.5E-05	0.0005	0.345	0.0008	0.001	0.0005	0.007	0.0028	0.365	0.48	0.14	3.2	0.37	2.5E-05	0.003	0.0005	0.0005	0.001	0.0025	0.0005	0.001	0.002	0.013	0.014	0.0005	
FHMB02	80th Percentile	7.324	24000	16000	0.424	0.0025	432	0.0069	0.001	0.13	0.43	0.0005	0.0005	0.0005	0.0006	0.5637	2.5E-05	0.0005	0.3124	0.0005	0.001	0.0005	0.0031	0.0009	0.128	0.4296	0.1316	2.672	0.33	2.5E-05	0.0022	0.0005	0.0005	0.0006	0.001	0.0005	6E-04	0.001	0.0005	0.006	0.0005	
FHMB02	95th Percentile	7.84	24000	18550	0.5	0.0111	457	0.0776	0.0027	0.13	0.45	0.0005	0.0005	0.0005	0.0027	2.4	2.5E-05	0.0005	0.3785	0.001	0.0036	0.0035	0.0133	0.0048	2.443	0.525	1.67	3.755	0.389	2.5E-05	0.0039	0.0005	0.0005	0.0057	0.0159	0.0018	0.06	0.004	0.001	0.0097	0.031	0.0005
FHMB02	max	7.9	24000	19000	0.5	0.012	460	0.086	0.003	0.13	0.45	0.0005	0.0005	0.0005	0.003	2.4	2.5E-05	0.0005	0.38	0.001	0.004	0.004	0.014	0.005	2.8	0.53	0.17	3.8	0.39	2.5E-05	0.004	0.0005	0.0005	0.063	0.018	0.002	0.07	0.004	0.011	0.033	0.0005	
FHMB04	Count	4	4	4	4	4	4	4	3	4	2	2	4	4	4	4	4	4	4	4	4	4	4	2	4	3	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	2
FHMB04	min	7.3	15000	9700	0.3	0.011	410	0.02	0.0005	0.08	0.36	0.0005	0.0005	0.0005	0.0005	0.005	2.5E-05	0.0005	0.029	0.0005	0.001	0.0005	0.0025	0.0005	0.16	0.4	0.11	2.3	0.19	2.5E-05	0.001	0.0005	0.0005	0.0005	0.001	0.0005	0.001	0.001	0.001	0.011	0.0005	
FHMB04	5th Percentile	7.345	15150	9895	0.33	0.0181	410	0.0227	0.0006	0.082	0.36	0.0005	0.0005	0.0005	0.0006	0.3043	2.5E-05	0.0005	0.0502	0.0006	0.001	0.0005	0.0029	0.0006	0.286	0.407	0.122	2.465	0.193	2.5E-05	0.0012	0.0005	0.0005	0.0006	0.0013	0.0005	0.001	0.001	0.0013	0.011	0.0006	
FHMB04	20th Percentile	7.48	15600	10480	0.42	0.0392	410	0.0308	0.0008	0.086	0.37	0.0005	0.0005	0.0005	0.0008	1.202	2.5E-05	0.0005	0.1136	0.0008	0.001	0.0005	0.004	0.0008	0.664	0.428	0.158	2.96	0.202	2.5E-05	0.0016	0.0005	0.0005	0.0008	0.0022	0.0005	0.002	0.001	0.0022	0.012	0.0008	
FHMB04	Median	7.6	16000	11000	0.5	0.06	420	0.047	0.002	0.095	0.38	0.0005	0.0005	0.0005	0.001	2.15	2.5E-05	0.0005	0.19	0.001	0.001	0.0008	0.005	0.0013	1.25	0.47	0.23	3.45	0.23	2.5E-05	0.003	0.0005	0.0005	0.002	0.003	0.0008	0.003	0.001	0.0035	0.015	0.0013	
FHMB04	80th Percentile	7.76	16400	11800	0.5	0.1172	434	0.8188	0.0034	0.104	0.39	0.0005	0.0007	0.0005	0.0014	2.38	2.5E-05	0.0005	0.222	0.001	0.0022	0.0042	0.0062	0.0017	12.5	0.5	0.242	24.1	0.31	2.5E-05	0.0044	0.0005	0.0015	0.0066	0.0038	0.003	0.008	0.003	0.004	0.0064	0.021	0.0017
FHMB04	95th Percentile	7.94	16850	12700	0.5	0.1793	439	7.2047	0.0039	0.109	0.4	0.0005	0.0009	0.0005	0.0019	2.47	2.5E-05	0.0005	0.2355	0.001	0.0036	0.0078	0.0076	0.0019	24.88	0.515	0.248	47.28	0.378	2.5E-05	0.0049	0.0005	0.0026	0.0107	0.0047	0.0053	0.014	0.005	0.0091	0.026	0.0019	
FHMB04	max	8	17000	13000	0.5	0.2	440	8	0.004	0.11	0.4	0.0005	0.001	0.0005	0.002	2.5	2.5E-05	0.0005	0.24	0.001	0.004	0.009	0.008	0.0012	29	0.52	0.25	55	0.4	2.5E-05	0.005	0.0005	0.003	0.012	0.005	0.006	0.016	0.006	0.01	0.028	0.002	
FHMB05	Count	4	4	4	4	4	4	4	4	4	2	2	4	4	4	4	4	4	4	4	4	4	4	2	4	3	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	2
FHMB05	min	7.4	15000	9200	0.5	0.0025	74	0.02	0.003	0.93	0.46	0.0005	0.0005	0.0005	0.0005	0.015	2.5E-05	0.0005	0.34	0.0005	0.001	0.0005	0.0025	0.001	0.16	0.47	0.61	0.61	0.34	2.5E-05	0.003	0.0005	0.0005	0.0005	0.004	0.0005	0.001	0.001	0.001	0.012	0.001	
FHMB05	5th Percentile	7.43	15000	9200	0.5	0.0025	75.7	0.0215	0.0035	0.949	0.46	0.0005	0.0005	0.0005	0.0006	0.0683	2.5E-05	0.0005	0.34	0.0005	0.001	0.0005	0.0029	0.001	0.234	0.476	0.642	0.642	0.354	2.5E-05	0.0036	0.0005	0.0005	0.0005	0.004	0.0005	0.001	0.001	0.001	0.012	0.0011	
FHMB05	20th Percentile	7.52	15000	9200	0.5	0.0025	80.6	0.026	0.0048	1.004	0.47	0.0005	0.0005	0.0005	0.0008	0.228	2.5E-05	0.0005	0.34	0.0005	0.001	0.0005	0.004	0.001	0.454	0.494	0.738	0.736	0.394	2.5E-05	0.0054	0.0005	0.0005	0.0005	0.004	0.0005	0.002	0.001	0.001	0.012	0.0012	
FHMB05	Median	7.65	15000	9250	0.5	0.0173	88	0.033	0.0065	1.115	0.5	0.0005	0.0005	0.0005	0.001	0.47	2.5E-05	0.0005	0.38	0.0013	0.0015	0.0008	0.006	0.001	0.825	0.53	0.93	1.11	0.465	2.5E-05	0.0075	0.0005	0.0008	0.0023	0.0045	0.0018	0.004	0.002	0.001	0.017	0.0015	
FHMB05	80th Percentile	7.94	15000	9340	0.58	0.0344	91	4.0216	0.0078	1.226	0.52	0.0005	0.0011	0.0005	0.0018	0.722	2.5E-05	0.0005	0.448	0.002	0.0028	0.0042	0.013	0.001	2.92																	

APPENDIX D

GDE desktop review maps

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APPENDIX D1 STATE-MAPPED GROUNDWATER DEPENDENT ECOSYSTEMS

Legend

 Mining Lease Permit
(Application)

 7 Year Pit Shell

Surface GDE lines

 Derived GDE - moderate
confidence

 Derived GDE - low confidence

Terrestrial GDE areas

 81-100 Derived GDE -
Moderate Confidence

 81-100 Derived GDE - Low
Confidence

Potential GDE aquifers

 Unconsolidated sedimentary
aquifers

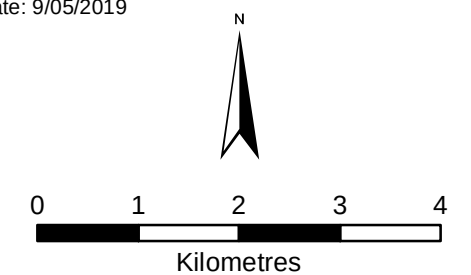
 Consolidated sedimentary
aquifers

 Igneous rock aquifers

 No identified aquifers

Data Sources:
Mining Lease and Groundwater Dependent Ecosystem
(GDE) datasets: the State of Queensland (Department
of Natural Resources, Mines, and Energy) 2019; Fairhill
Infrastructure dataset: SLR Consulting 2019.

Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator
Datum: GDA 1994
Date: 9/05/2019



Scale: 1:75,000 at A3



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APPENDIX D2 NATIONALLY-MAPPED GROUNDWATER DEPENDENT ECOSYSTEMS

Legend

-  Mining Lease Permit (Application)
-  7 Year Pit Shell

Aquatic GDE

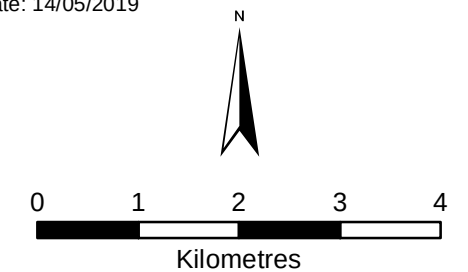
-  Moderate potential GDE - from national assessment
-  Low potential GDE - from national assessment

Terrestrial GDE

-  High potential GDE - from national assessment
-  Moderate potential GDE - from national assessment
-  Low potential GDE - from national assessment

Data Sources:
Mining Lease dataset: the State of Queensland (Department of Natural Resources, Mines, and Energy) 2019; Groundwater Dependent Ecosystem (GDE) datasets: the Commonwealth of Australia (Bureau of Meteorology) 2019; Fairhill Infrastructure dataset: SLR Consulting 2019.

Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator
Datum: GDA 1994
Date: 14/05/2019



Scale: 1:75,000 at A3



ASIA PACIFIC OFFICES

BRISBANE

Level 2, 15 Astor Terrace
Spring Hill QLD 4000
Australia
T: +61 7 3858 4800
F: +61 7 3858 4801

MACKAY

21 River Street
Mackay QLD 4740
Australia
T: +61 7 3181 3300

SYDNEY

2 Lincoln Street
Lane Cove NSW 2066
Australia
T: +61 2 9427 8100
F: +61 2 9427 8200

AUCKLAND

68 Beach Road
Auckland 1010
New Zealand
T: +64 27 441 7849

CANBERRA

GPO 410
Canberra ACT 2600
Australia
T: +61 2 6287 0800
F: +61 2 9427 8200

MELBOURNE

Suite 2, 2 Domville Avenue
Hawthorn VIC 3122
Australia
T: +61 3 9249 9400
F: +61 3 9249 9499

TOWNSVILLE

Level 1, 514 Sturt Street
Townsville QLD 4810
Australia
T: +61 7 4722 8000
F: +61 7 4722 8001

NELSON

6/A Cambridge Street
Richmond, Nelson 7020
New Zealand
T: +64 274 898 628

DARWIN

5 Foelsche Street
Darwin NT 0800
Australia
T: +61 8 8998 0100
F: +61 2 9427 8200

NEWCASTLE

10 Kings Road
New Lambton NSW 2305
Australia
T: +61 2 4037 3200
F: +61 2 4037 3201

GOLD COAST

Ground Floor, 194 Varsity Parade
Varsity Lakes QLD 4227
Australia
M: +61 438 763 516

PERTH

Ground Floor, 503 Murray Street
Perth WA 6000
Australia
T: +61 8 9422 5900
F: +61 8 9422 5901



Northern Resource
CONSULTANTS

Fairhill Coal Project

Overburden and Potential Coal Reject Characterisation Report

November 2018

prepared for
Fairhill Coking Coal Pty Ltd

Contact Information	Details
Organisation	Northern Resource Consultants Pty Limited
Contact Person	Marty Costello
Phone	07 4772 6500
Email	Marty@northres.com.au
Mail	12 Cannan Street, South Townsville QLD, 4810
ABN	55 126 894 693

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Client: Fairhill Coking Coal Pty Ltd

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Appendix B	Laboratory Results

Executive Summary

Northern Resource Consultants Pty Ltd was commissioned by Fairhill Coking Coal Pty Ltd to complete a geochemical assessment of overburden and potential coal reject material at the Fairhill coal project (FHCP). The FHCP is a proposed open cut mine located in Central Queensland, approximately 195km west of Rockhampton and 50km northeast of Emerald in the Bowen Basin.

Geochemical analyses and classifications undertaken at FHCP in conjunction with investigations at surrounding mine sites (Ensham, Washpool and Wilton) indicate that there is negligible potential for acid rock drainage to occur.

A total of 27 samples with a varied spatial distribution and drill depth indicated the following:

- A total of 100% of waste rock overburden and coal reject material associated with the planned mine operations are classified as non-acid forming. Some sandstones and siltstones have large acid neutralising capacity, which further limits the potential for acid production.
- Metalliferous runoff/seepage will not pose a problem to the receiving environment. The mobility of metals is greatly reduced by the alkaline conditions present within the overburden.
- Leachate electrical conductivity and pH of 1:2 analysis indicates that runoff/seepage associated with waste rock storage will be alkaline to moderately fresh. Salinity is not likely to pose a problem; however, specific actions for the management of alkaline waters may be necessary in the future. Ongoing analyses are recommended during the initial stages of operation.

Introduction

1. Objective

Northern Resource Consultants Pty Ltd (NRC) was commissioned by Fairhill Coking Coal Pty Ltd to assess the geochemical characteristics of any future overburden and potential coal reject material resulting from activities associated with coal mining in the Fairhill coal project (FHCP) area. The objective of this report is to assess the potential for acidic, metalliferous or saline drainage to occur as a result of overburden or coal reject material storage associated with proposed mining processes.

2. Background

The FHCP is located in Central Queensland, approximately 195km west of Rockhampton and 50km northeast of Emerald in the Bowen Basin. The FHCP tenement covers a total exploration area of approximately 6,360ha. Fairhill is planned to be an open cut mine, predicted to produce a maximum of 1.7 million tonnes per annum of primarily coking coal extracted from coal seams of the Fairhill Formation.

The FHCP site is situated in close proximity to a number of existing coal mines. Ensham's Yongala mine is located approximately 10km southwest of FHCP, Kestrel Mine lies approximately 18km to the west, Oakey Creek Mine and Gregory Crinum Mine are approximately 18km north and northwest, respectively and Yarrabee is approximately 25km to the east.

3. Proposed mining activities

There is no on-site processing proposed for the FHCP. Instead, the proponent is seeking agreement from nearby owner operators of coal washing infrastructure, with the intention of shipping raw coal products to nearby operations and utilising existing coal handling preparation plants and tailings infrastructure under agreement.

The mining infrastructure proposed for this project is shown on a map titled 'Proposed site infrastructure' in Appendix A of this report. It includes overburden and waste rock dumps with associated infrastructure for capture and storage of drainage from the dumps.

Mining operations proposed at the FHCP will include the development of a shallow green field open cut mine targeting coal from the Fairhill seam.

Onsite work during the construction of the proposed mine include the following:

- Topsoil removal and topsoil stockpiles.
- Extraction of coal and overburden materials.
- Establishment of an overburden storage dump.

- Construction of sediment control structures, including dams.
- Development of site access routes.
- Onsite operational infrastructure including a ROM pad.

4. Previous investigations

Considering the relatively homogenous nature of geology in the immediate region, studies of overburden characterisation from nearby sites surrounding FHCP will contribute significantly towards the characterisation of overburden at the FHCP site.

Therefore, the geochemical characteristics of waste rock for two mine sites and one proposed site surrounding FHCP have been undertaken in this report. These sites include neighbouring mines Ensham, Washpool, and the proposed Wilton coal project.

4.1 Ensham

The geochemistry of overburden at the Ensham mine, along with the extent of environmental risks and the potential for environmental impact was developed by URS Australia Pty Ltd (URS, 2006). A total of 49 overburden samples and 17 potential reject samples were analysed. Additional leach tests were carried out over a month to establish the effect of short-term weathering on acid rock drainage and the mobility of heavy metals.

Overburden samples

Overburden samples were found to be slightly alkaline, with total sulfur concentrations varying between 0.02 and 0.15wt%. Most sulfur was present as sulfide minerals and all samples were classified as non-acid forming (NAF).

Metal analyses indicated slightly elevated concentrations of manganese, molybdenum and selenium compared to ANZECC & ARMCANZ (2000) guidelines. Organic carbon was typically low. Total nitrogen concentrations varied between 210 and 730mg/kg and extractable phosphate varied between 7 and 29mg/kg. Overall, overburden soil was found to be dispersive, with calcium deficiencies.

Potential reject samples

Five coal seam samples and twelve roof/floor samples were analysed as potential reject samples. All samples were slightly alkaline with sulfur concentrations ranging from <0.02 to 0.74wt%. The majority of total sulfur was present as sulfide minerals, with coal seam samples exhibiting higher sulfur concentrations than roof/floor samples. All potential reject samples were classified as NAF.

The URS (2006) report predicted that all samples collected will generate slightly alkaline, low-salinity runoff and seepage. URS (2006) also advised that this seepage is unlikely to have any adverse effect on the receiving environment, including any rehabilitation/revegetation of overburden storage facilities and downstream water quality.

4.2 Washpool

Geochemical characterisation of waste rock was carried out in conjunction with the Washpool Environmental Impact Statement (EIS), submitted in 2011. Findings of research carried out by RGS Environmental Pty Ltd (RGS, 2010) indicated 97% of overburden samples were classified as NAF-Barren, with the remaining 3% were classified as NAF.

A total of 69% of potential coal reject samples collected were classified as NAF (NAF-Barren, NAF and NAF-uncertain), while the remaining 31% of samples were classified as potentially acid forming-low capacity-uncertain (PAF-LC-uncertain), PAF-uncertain and one sample as PAF. RGS (2010) concluded that only a very small portion of potential coal reject possesses the capacity to generate acid. The majority of potential coal reject samples have the capacity to buffer any acid produced during oxidation.

In addition to static tests, kinetic leach tests were carried out on coal reject material. Kinetic tests were conducted over a 3-month period with results indicating the following:

- Leachate from coal reject material has variable pH, ranging from acidic (pH 4.9) to alkaline (pH 8.9).
- Electrical conductivity (EC) values of 1,000µS/cm were considered as moderate in salinity.
- The sulfate generation rate of kinetic leach test samples varied from 62 to 117mg/kg/week.

This study suggests mine materials are unlikely to generate acid leachate over the short term but may become a source of acid in the long term (RGS, 2010).

The salinity of runoff and seepage associated with the waste materials is predicted to be low to moderate. The salinity of overburden material is expected to decrease over time, while the salinity of reject coal material may increase with time.

The potential impact of overburden material on both groundwater and surface water is expected to be low, while the impact of reject coal material is low to moderate (RGS, 2010).

4.3 Wilton coal project

The overburden at the Wilton coal project was geochemically assessed in a report by NRC (2017). A total of 82 waste rock and overburden samples were analysed.

Of the 82 samples analysed, 91% was classified as NAF. Although the coal and carbonaceous siltstone/mudstone have the potential to produce acid, the small quantity and the acid neutralising capacity of the majority of overburden waste reduces concerns.

Average EC and pH of 1:5 extract waters suggest runoff/seepage associated with waste rock storage will be alkaline and moderately fresh. Salinity is not likely to pose a problem throughout the site.

Geological Setting

1. Regional stratigraphy

Regionally, the Bowen Basin is a large synclinorium consisting primarily of Permian and Triassic rocks, and hosts coal reserves of significant economic importance. The Bowen Basin is overlain by semi-consolidated sediments of Quaternary age (Dickens & Malone, 1973; Galloway, 1967; RGS, 2010; NRC, 2017; URS, 2006).

The regional geology of the area is presented in order of youngest to oldest in Table 1 and as a surface geology map in Appendix A.

Table 1: Local stratigraphy of the FHCP (not to scale). Adapted from Environmental Earth Sciences (2012), Scott *et al.* (1995) and Xstrata Coal (2012)

AGE	GROUP	FORMATION	DESCRIPTION	COAL SEAMS
Quaternary	-	-	Unconsolidated sand and clay, with basal gravel and pebbles	-
Tertiary	-	Emerald Formation	Claystone and siltstone, sandstone, interbedded basalt (deeply weathered in outcrop)	-
Permian	Blackwater Group	Burngrove Formation	Terrestrial mudstone, siltstone, sandstone, coal and tuff	Pisces Virgo Libra Leo Aquarius Scorpio Centaur
		Fairhill Formation	Terrestrial lithic and feldspathic labile sandstone with minor siltstone, mudstone, and coal seams	Phoenix Pegasus Hercules Canis Lepus Fairhill Fairhill Lower
		Unconformity		

AGE	GROUP	FORMATION	DESCRIPTION	COAL SEAMS
	Back Creek group	Mac Millan Formation	Marine sandstone, siltstone, shale, mudstone	-
		German Creek Formation	Sandstone, siltstone, mudstone, coal seams	Pleiades Aquila Tieri 1 Tieri 2 Corvus Corvus 2 German Creek
		Ingelara Formation	Conglomeratic sandy siltstone, sandstone and mudstone	-
		Freitag Formation	Thin interbedded sandstone, siltstone, mudstone and minor coal seams	-

2. Local geology

The local stratigraphy is composed of Quaternary alluvium, Tertiary laterite material and the Late Permian Burngrove, Fairhill, MacMillan and German Creek Formations. A brief description of each of these stratigraphic layers is provided in the following sub-sections. The strata in the region generally strike north-south and dip gently to the southwest of the FHCP. Dips can vary locally due to the presence of a series of synclines and anticlines. These smaller synclines and anticlines relate directly to the structural deformation, which formed the Comet Ridge and share a north-south axial strike.

2.1 Cainozoic

Quaternary alluvium is present predominantly along the Cooroora Creek floodplain, which intersects the FHCP from the north of the exploration lease to the south-eastern corner. The width of the alluvium varies from approximately 450m to as much as 800m within the exploration lease.

Tertiary material only covers a small mesa in the north-eastern corner of the project site. Tertiary laterite cover is commonly found in the surrounding topographically elevated areas. Where present, the laterite presents as a hardened siliceous/ferrous cap over the top of ridges and plateaus. Distinct laterite layers have not been reported from within the project area. The higher ground and ridges running north-south throughout the centre of the adjacent Wilton coal project have been described as dermosol above the weathered early Tertiary sediments of the Emerald Formation (Environmental Earth Sciences, 2012).

2.2 Burngrove Formation

At the FHCP, the Burngrove Formation is only present at the surface in the western section of the site. It consists of mudstone and siltstone that can be siliceous and tuffaceous in parts. Interbedded with the dominant mudstone and siltstones are dark grey to black shales, labile sandstones and calcareous sandstones. A low-energy depositional environment is likely to have resulted in the lack of clastic material above silt-size in the formation. It is likely that these formations were deposited by lakes and swamps.

Although most of the coal occurs in the upper section of the Blackwater group, thin seams are present in the Burngrove Formation. A number of coal seams have been reported in this Late Permian-aged formation. These coal seams include Pisces, Virgo, Leo, Aquarius, Scorpio and Centaur in youngest to oldest stratigraphic order.

2.3 Fairhill Formation

The Fairhill Formation hosts the targeted coal seams for the FHCP. It is present at the surface across the majority of the site. Jensen (1975) described the Fairhill Formation located north of Cooroora homestead as coarse-grained, micaceous, calcareous sandstone, conglomeratic (in places), and interbedded with very minor brown calcareous mudstone. Fossil logs are common, generally replaced with siderite or limonite (Jensen, 1975). Prouza (1977) reported that thick banded coal seams with mudstone and tuffaceous mudstone interbeds occur in 'cyclothems' within the predominantly arenaceous formation. The seams were named based on correlations in government boreholes, in descending order as Phoenix, Pegasus, Hercules, Canis, Lepus and Fairhill. All these coal seams are interbedded with various amounts of layered sediments of non-coal material, generally siltstone and carbonaceous mudstone. The Fairhill Formation sequence of coal seams is found in a stratigraphic interval approximately 130m thick.

2.4 MacMillan Formation

The MacMillan Formation lies stratigraphically below the Fairhill Formation separating it from the German Creek Formation within the project area. The MacMillan Formation was interpreted by Prouza (1977) and others as a shallow marine incursion, barren of coal seams. In the area, the MacMillan Formation is approximately 70m thick (Prouza, 1977). Prouza (1977) outlined the formation suggesting a prominent massive dark grey to black mudstone in its lower part. Marine fossils and fawn biotitic tuff were also described in the lower MacMillan Formation. The mudstone sequence in the description of Prouza (1977) grades upwards to an interbedded, bioturbated, micaceous mudstone and siltstone, with arenites common at the top of the Formation. The boundary to the Fairhill Formation is often abrupt but can be gradational in places. The MacMillan Formation only outcrops in small areas at the southwestern corner and eastern extent of the site.

2.5 German Creek Formation

Prouza (1977) correlated the regional Crocker Formation with the upper, coal bearing part of the German Creek Formation. It is predominantly arenaceous, with coal forming cycles corresponding to those of the German Creek Formation. Historical drilling within the site has identified five seams within the German Creek Formation that are the Pleiades, Aquila, Tieri, Corvus and German Creek seams. The only outcrop of this unit is mapped approximately 5km southeast of the site.

Methodology

1. Sampling methodology

A total of 27 samples were collected from 7 drill holes (locations shown in Table 2 and in a map included in Appendix A). The samples collected represent a range in overburden and waste rock throughout the sites. The sampling strategy aimed to include the geological variability encountered within the drill holes, albeit, a lack of sample quantity has limited the analyses performed.

Table 2: Location of drill holes incorporated in water rock overburden sampling

DRILL HOLE ID	EASTING*	NORTHING*
FHMB01	668268	7429810
FHMB02	665930	7432461
FHMB03	667489	7429461
FHMB04	665391	7431805
FHMB05	664578	7428931
FHMB06	663663	7427594
FHMB07	667620	7432945

*Coordinates are in GDA94 Zone 55

1.1 Sample lithology description

Waste overburden samples were sampled in conjunction with water bore holes. Table 3 summarises the lithology and depth intervals of samples incorporated in this investigation.

Table 3: Lithology and depth intervals of samples included in this investigation

BORE HOLE	INTERVAL DEPTH (mBGL*)	DESCRIPTION
FHMB01	5–6	Sand
FHMB01	6–8	Clay
FHMB01	8–11	Sand and clay
FHMB01	11–13	Clay
FHMB01	13–20	Clay
FHMB02	0–3	Topsoil
FHMB02	4–7	Silt with extremely weathered sandstone inclusions
FHMB02	8–12	Weathered sandstone and carbonaceous siltstone
FHMB02	9–12	Carbonaceous siltstone and coal
FHMB02	13–18.5	Carbonaceous siltstone and coal
FHMB03	2–7	Sandstone and siltstone
FHMB03	10–15	Weathered sandstone
FHMB03	15–20	Siltstone
FHMB04	0–1	Topsoil
FHMB04	2–5	Weathered sandstone
FHMB04	6–19	Sandstone
FHMB04	19–29.5	Siltstone
FHMB05	0–6	Clay rich topsoil
FHMB05	7–14	Coal, sandstone and tuff
FHMB05	9–10 (+13)	Sandstone and tuff
FHMB05	17–23	Mudstone
FHMB06	1–6	Siltstone/sandstone (heavily weathered)
FHMB06	7–9	Siltstone/sandstone (heavily weathered)
FHMB06	10–22	Sandstone
FHMB06	23–33	Mudstone and coal, carbonaceous
FHMB06	33–41	Mudstone and coal, carbonaceous
FHMB07	32–35	Sandstone

*mBGL stands for metres below ground level.

2. Laboratory methodology

Samples were transferred to NATA accredited laboratory SGS. Sub-sample preparation involved crushing, splitting and pulverising rock chips collected infield.

2.1 Characteristics assessed

All 27 overburden samples were subjected to initial acid-base account (ABA) geochemical testing.

Specifically:

- pH (1:2)
- EC (1:2)
- total sulfur (wt%)
- Australian Standard Leaching Procedure (ASLP) metal concentrations
- bulk rock trace metals
- acid neutralising capacity (ANC)
- net acid producing potential (NAPP)
- net acid generation (NAG) pH 4.5
- NAG pH 7.

In addition, major ion analysis and heavy metal concentrations of EC 1:5 samples and a full metal suite of overburden samples were also conducted.

3. Assessment of soil physical characteristics

3.1 Exchangeable sodium percentage

The exchangeable sodium percentage (ESP) shows the amount of sodium as a proportion of all cations in a soil. This can be used to determine the sodicity of the soil. The implication of high sodic soils is the decreased structural integrity due to the swelling and dispersal of clay (Department of Primary Industries, 2018).

The ESP of soil can be calculated using the following equation:

$$ESP = \frac{Na^+}{CEC}$$

where, CEC is the cation exchange capacity.

4. Assessment of acid generation potential

4.1 Acid-base accounting

The most commonly-used static test is acid-base accounting (ABA; Ferguson & Erickson, 1988). ABA involves laboratory procedures that evaluate the balance between acid generation processes (oxidation of sulfide minerals) and acid neutralising processes (dissolution of alkaline carbonates, displacement of exchangeable bases and weathering of silicates).

ABA quantifies the acid producing potential using either total sulfur or sulfide-sulfur content to estimate the quantity of acid-producing minerals present. The total sulfur content will overestimate the actual acid producing potential of samples containing substantial non-acid-producing sulfate minerals (e.g. barite or gypsum). Conversely, the sulfide-sulfur measurement tends to underestimate the actual acid producing potential of samples containing substantial acid-producing sulfate minerals (e.g. melanterite or jarosite). Sulfur-sulfide measurements do not account for the variation in acid producing potential between different sulfide minerals. For example, metal sulfides including sphalerite and galena tend to produce less acid than pyrite during oxidation.

Knowledge of the mine waste sulfate mineralogy will indicate whether the sulfate minerals present are acid producing. This allows selection of the more appropriate quantification.

4.2 Net acid producing potential

NAPP is a theoretical calculation commonly used to indicate whether a material has the potential to produce acid. It represents the balance between the capacity of a sample to generate acid (maximum potential acidity (MPA)) and its capacity to neutralise acid (ANC). NAPP is expressed in units of kg H₂SO₄/t and is calculated as follows:

$$MPA \left(kg \frac{H_2SO_4}{t} \right) = (Oxidisable \%S) * 30.6$$

$$(NAPP = MPA - ANC)$$

If the MPA value is less than the ANC value then the NAPP is negative, which indicates that the sample may have sufficient ANC to prevent acid generation. Conversely, if the MPA exceeds the ANC then the NAPP is positive, which indicates that the material may be acid generating.

The ANC/MPA ratio is used as a means of assessing the risk of acid generation from mine waste materials. A positive NAPP is equivalent to an ANC/MPA ratio less than 1 and a negative NAPP is equivalent to an ANC/MPA ratio greater than 1. Generally, an ANC/MPA ratio of 2 or more signifies that there is a high probability that the material is not acid generating.

4.3 Net acid generation

The NAG test is used in association with NAPP to classify the acid generating potential of a sample. The NAG test involves the reaction of a sample with hydrogen peroxide to rapidly oxidise any sulfide minerals contained within a sample. During the NAG test, both acid generation and acid neutralisation reactions can occur simultaneously. Therefore, the end result represents a direct measurement of the net amount of acid generated by the sample. This value is commonly referred to as the NAG capacity and is expressed as kg H₂SO₄/t.

Using NAPP and NAG pH values, materials are classified into the following categories:

- NAF: suggests that the material cannot generate acid.
- PAF: suggests that the material can potentially generate acid.
- UC: the test is not certain about the material's potential to generate acid.

5. Assessment of metalliferous drainage potential

Metal concentrations in overburden samples were also analysed by inductively coupled plasma atomic emission spectroscopy methods. This technique ionises atoms in the leachate sample, which emits a characteristic spectrum. The spectrum is compared against matrix matched standards for quantification. These results are important to characterise the overall metal concentrations in the overburden and to identify enriched metals that can pose a risk of possible metalliferous drainage.

5.1 Geochemical abundance index

The geochemical abundance index (GAI) can be used to estimate the enrichment of metals in the overburden sample relative to average crustal concentration. The GAI is expressed on a log 2 scale. A GAI of zero indicates that the element is present at a concentration similar to or less than the average abundance whereas a GAI of three indicates a 12-fold enrichment above the average soil abundance. This is taken as the threshold for predicting potential metalliferous drainage from overburden material.

The GAI was developed by Förstner *et al.* (1993) and is defined as follows:

$$GAI = \log_2 \left(\frac{C}{(1.5B)} \right) \quad \begin{array}{l} C = \text{measured concentration in sample} \\ B = \text{average global soil content} \end{array}$$

The average crustal abundances used to compare results against in the GAI are provided in Table 4.

Table 4: Average crustal abundance for trace metals (Berkman & Ryall, 1976; Bowen, 1979)

NAME	SYMBOL	AVERAGE CRUSTAL ABUNDANCE (mg/kg)
Arsenic	As	6
Barium	B	500
Beryllium	Be	6
Cadmium	Cd	0.35
Cobalt	Co	8
Chromium	Cr	70
Copper	Cu	30
Manganese	Mn	1000
Nickel	Ni	50
Lead	Pb	35
Zinc	Zn	90
Selenium	Se	0.4
Vanadium	V	90
Mercury	Hg	0.06

6. Assessment of saline drainage

There are no standard methods to assess saline drainage in the AMIRA (2002) guidelines. However, the potential for saline drainage has been assessed using EC of a 1:5 (sample:water) suspension. Samples that exceed the contaminant limit for EC for onsite storages in the EA are considered saline.

Acid Generation Potential

1. Acid base accounting results

Chemical results of the 27 waste rock samples are provided in Appendix B, a summary has been included in Table 5.

Table 5: Summary of ABA results

PARAMETER	MIN	MEDIAN	MAX
pH	7.6	8.6	9.8
EC $\mu\text{S}/\text{cm}$	100	310	780
Total S ww%	0.008	0.032	0.480
ANC kg $\text{H}_2\text{SO}_4/\text{t}$	3	55	120
MPA kg $\text{H}_2\text{SO}_4/\text{t}$	0	1	15
NAG kg $\text{H}_2\text{SO}_4/\text{t}$	0.25	0.25	0.25
NAG pH	8	9	11

1.1 pH

The pH of 1:2 (soil:water) measures the activity of hydrogen ions in solution. This provides a proxy for the acidity/alkalinity of overburden/waste samples. The pH of overburden samples varies from 7.6 to 10.2 indicating samples are neutral to mildly alkaline in nature. The overburden waste collected from bore hole FHMB05 exhibited the lowest pH (7.6) and consisted primarily of coal, sandstone and tuff. The highest pH (9.8) reported was sampled from bore hole FHMB07, between 32 and 35m below the top of casing (m bTOC). The stratigraphy of this sample consisted of mudstone. Figure 1 demonstrates that 50% of samples have a pH greater than 8.5. Runoff with pH values exceeding 9 may have an adverse effect on the growth of native plants (Department of Environment and Resource Management (DERM), 1995).

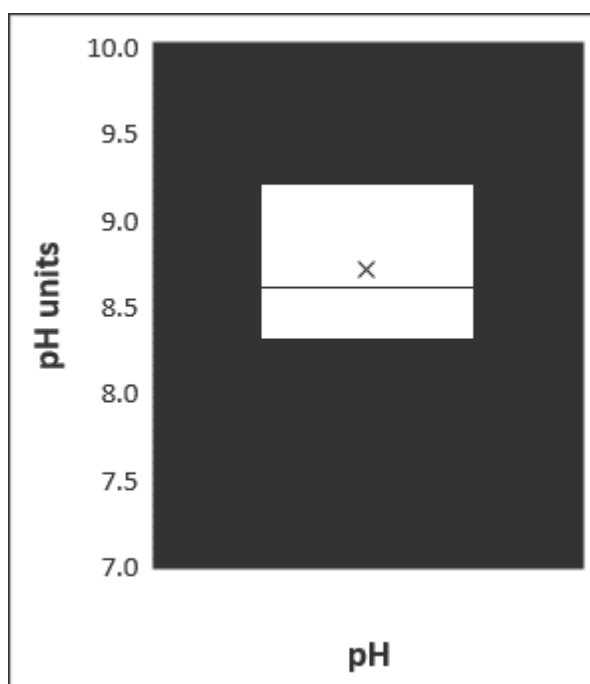


Figure 1: Box plot demonstrating variation in the pH of sample 1:2 extract

1.2 Total sulfur

The use of total sulfur (wt%) as an indication of the potential acidity is conservative. Sulfur exists at five different oxidation states (-2, 0, +2, +4 and +6). The oxidation state of a sulfur compound will affect its capacity to produce acid. Sulfide (S^{2-}) minerals (e.g. pyrite, galena, sphalerite) will react stoichiometrically with oxygen and water and form sulfuric acid, while oxidised forms of sulfur including sulfate (SO_4^{2-}) minerals (e.g. gypsum and epsomite) will not result in acidification.

The total sulfur concentrations varied from below the detection limit (<0.005) to 0.480 wt%. Out of 27 samples, 20 sample (74%) have total sulfur values less than 0.1%, rendering them as barren with respect to sulfur (Figure 2). The samples that had a total sulfur value over 0.1% (7 out of 27; 26%) were mostly in carbonaceous siltstone and mudstone.

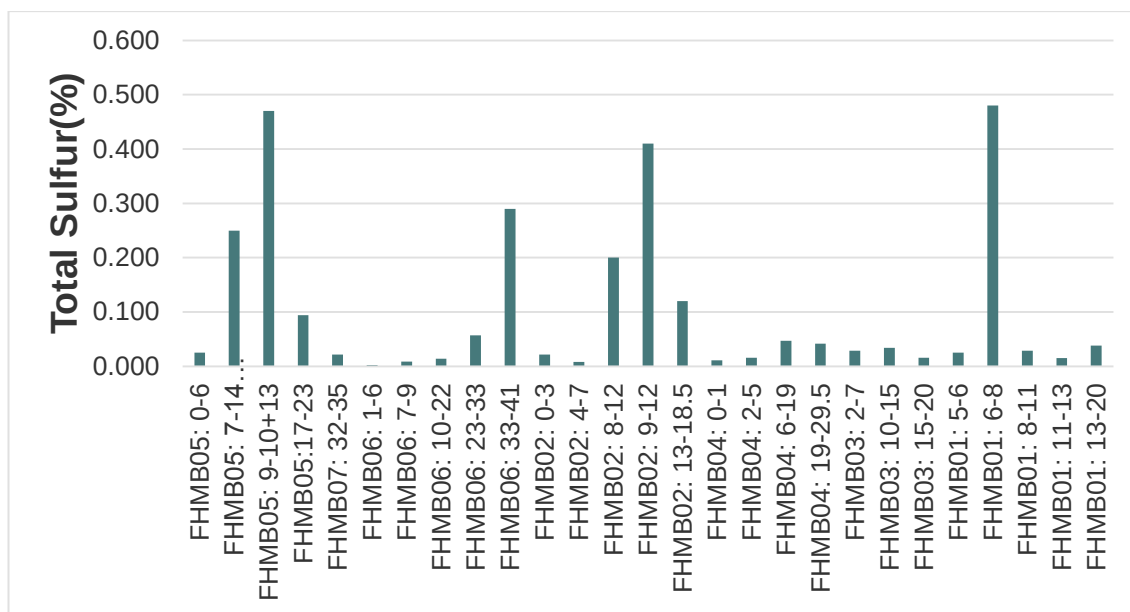


Figure 2: Total sulfur (wt%) in 27 samples from FHCP

1.3 Maximum potential acidity and acid neutralisation capacity

The total MPA varied from 0.000 to a maximum of 13.86 kg H₂SO₄/tonne. Sample FHMB01 6-8 (maximum value) appears to be an outlier within the median value MPA of 0.673 kg H₂SO₄/tonne. The ANC of samples varied from 2.5 to 120 kg H₂SO₄/tonne. The median value of ANC was 55 kg H₂SO₄/tonne.

1.4 Classification based on net acid generation pH vs net acid producing potential

A comparison between NAG pH and NAPP (Figure 3) suggests that all the samples (27 of 27; 100%) are NAF.

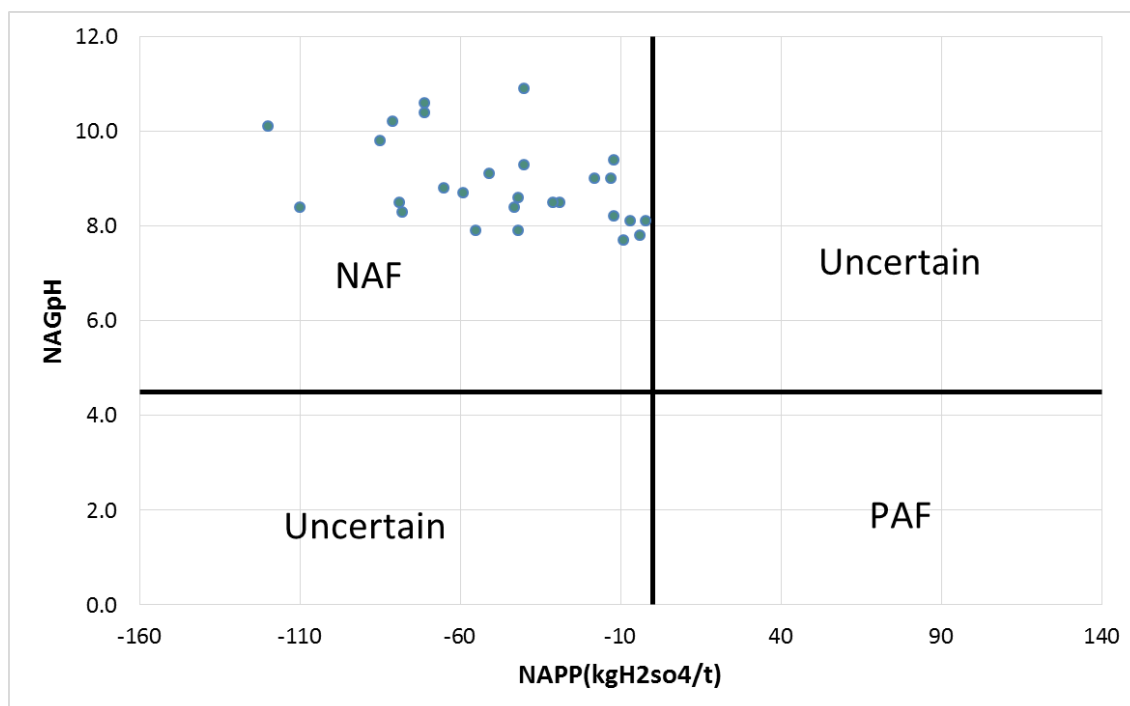


Figure 3: Classification of the FHCP samples based on NAG pH and NAPP

1.5 Discussion

The results indicate that all samples assessed (27) were classified as NAF. While the balance of acid-producing and acid-neutralising minerals influence mine waste drainage quality, there are several subtle mineralogical factors that are also influential. Individual minerals may be entirely liberated from the rock matrix and occur interstitial to other minerals (partially liberated) or as inclusions within other minerals. The extent of liberation affects availability for reaction.

Oxidation of sulfide minerals and dissolution of carbonate minerals are both surface reactions. Therefore, the rates of these reactions are dependent on the surface area of the minerals. Mineral surface area is further dependent on the extent to which the mineral is liberated from the rock matrix, mineral grain size and the surface roughness of the mineral.

Metalliferous and Saline Drainage Potential

1. Metalliferous drainage

The mobilisation of metals from overburden samples in drainage is called metalliferous drainage. Typically, pH controls the mobility of metals in aqueous systems (Smith, 1999) and the potential for metalliferous drainage is greatly reduced in non-acidic conditions. However, the mobility of metals also depends on geochemical changes and on the characteristics of the metals themselves. Therefore, determining the abundances of specific metals via the GAI is a good indicator of the metalliferous drainage potential.

1.1 Geochemical abundance index

The GAI results for the 27 overburden samples from FHCP are presented in Table 6. All samples (except 'FHMB05:7-14 composite' and 'FHMB02:4-7') reported GAI values of 0 for all elements, which means the abundance of elements in these overburden samples are similar to the median soil content.

Two samples ('FHMB05:7-14 composite' and 'FHMB02:4-7') reported GAI value of 1 for arsenic, indicating slight enrichment compared to median soil content.

All the overburden samples are classified as NAF; therefore, the probability of metalliferous run-off is low and unlikely to occur.

Table 6: GAI results for the 27 overburden samples from FHCP

SAMPLE	As	Ba	Be	Cd	Co	Cr	Cu	Mn	Ni	Pb	V	Zn	Hg
FHMB05: 0-6	0	0	0	0	0	0	0	0	0	0	0	0	0
FHMB05: 7-14 composite	1	0	0	0	0	0	0	0	0	0	0	0	0
FHMB05: 9-10+13	0	0	0	0	0	0	0	0	0	0	0	0	0
FHMB05:17-23	0	0	0	0	0	0	0	0	0	0	0	0	0
FHMB07: 32-35	0	0	0	0	0	0	0	0	0	0	0	0	0
FHMB06: 1-6	0	0	0	0	0	0	0	0	0	0	0	0	0
FHMB06: 7-9	0	0	0	0	0	0	0	0	0	0	0	0	0
FHMB06: 10-22	0	0	0	0	0	0	0	0	0	0	0	0	0
FHMB06: 23-33	0	0	0	0	0	0	0	0	0	0	0	0	0
FHMB06: 33-41	0	0	0	0	0	0	0	0	0	0	0	0	0
FHMB02: 0-3	0	0	0	0	0	0	0	0	0	0	0	0	0
FHMB02: 4-7	1	0	0	0	0	0	0	0	0	0	0	0	0
FHMB02: 8-12	0	0	0	0	0	0	0	0	0	0	0	0	0
FHMB02: 9-12	0	0	0	0	0	0	0	0	0	0	0	0	0
FHMB02: 13-18.5	0	0	0	0	0	0	0	0	0	0	0	0	0
FHMB04: 0-1	0	0	0	0	0	0	0	0	0	0	0	0	0
FHMB04: 2-5	0	0	0	0	0	0	0	0	0	0	0	0	0
FHMB04: 6-19	0	0	0	0	0	0	0	0	0	0	0	0	0

SAMPLE	As	Ba	Be	Cd	Co	Cr	Cu	Mn	Ni	Pb	V	Zn	Hg
FHMB04: 19-29.5	0	0	0	0	0	0	0	0	0	0	0	0	0
FHMB03: 2-7	0	0	0	0	0	0	0	0	0	0	0	0	0
FHMB03: 10-15	0	0	0	0	0	0	0	0	0	0	0	0	0
FHMB03: 15-20	0	0	0	0	0	0	0	0	0	0	0	0	0
FHMB01: 5-6	0	0	0	0	0	0	0	0	0	0	0	0	0
FHMB01: 6-8	0	0	0	0	0	0	0	0	0	0	0	0	0
FHMB01: 8-11	0	0	0	0	0	0	0	0	0	0	0	0	0
FHMB01: 11-13	0	0	0	0	0	0	0	0	0	0	0	0	0
FHMB01: 13-20	0	0	0	0	0	0	0	0	0	0	0	0	0

2. Saline drainage

2.1 Electrical conductivity

EC measures the capacity of a solution to conduct electricity. It is often used as a proxy for salinity and is expressed as $\mu\text{S}/\text{cm}$. All 27 samples had ASLP extracts measured for EC (Table 7).

Table 7: EC values for ASLP extract performed on FHCP samples, based on DERM (1995) criteria

	VERY LOW	LOW	MODERATE	HIGH
	<150 $\mu\text{S}/\text{cm}$	150–450 $\mu\text{S}/\text{cm}$	450–900 $\mu\text{S}/\text{cm}$	>900 $\mu\text{S}/\text{cm}$
Number of samples	5	18	4	0

Leachate results for the 27 samples were assessed and can be categorised into the following groups:

- The largest group with 18 samples (67%) produced leachate with an EC between 150 and 450 $\mu\text{S}/\text{cm}$ (average=305 $\mu\text{S}/\text{cm}$).
- The second largest group consisted of five samples (18%) and produced a leachate with an EC that was less than 150 $\mu\text{S}/\text{cm}$ (average=122 $\mu\text{S}/\text{cm}$).
- The final group consisted of four samples (15%) and produced a leachate with an EC between 450 and 900 $\mu\text{S}/\text{cm}$ (670 $\mu\text{S}/\text{cm}$).
- No samples recorded an EC that was higher than 900 $\mu\text{S}/\text{cm}$.

The leachate test values reflect low EC potential. Therefore, saline drainage is unlikely to occur.

Soil Physical Characteristics and Trace Metal Chemistry

1. Soil physical characteristics

1.1 Exchangeable sodium percentage

ESP can be used to determine the sodicity of the soil. The implication of high sodic soils is the decreased structural integrity due to the swelling and dispersal of clay (Department of Primary Industries, 2018).

The ESP of overburden samples varied from 5% to 59% with a median value of 30%. According to the classification scheme mentioned by the University of New South Wales (2017), 19 overburden samples (~70%) fall within the 'highly sodic' category and 6 samples fall within the 'slightly-moderately sodic' category. Sample distribution based on the ESP values reported is presented in Table 8.

Table 8: Sample distribution based on ESP values

RATING	NON-SODIC	SLIGHTLY-MODERATELY SODIC	MODERATELY SODIC	HIGHLY SODIC
ESP	<6	6–10	10–15	>15
Number of samples	1	6	1	19

2. Trace metal chemistry

Trace metals have the potential to cause a range of adverse health effects in both humans and animals (Benson *et al.*, 2016; He *et al.*, 2005). Trace metal analyses (Table 9) were compared to the National Environment protection Measure (NEPM) Health Investigation Levels (HILs) for urban/industrial areas (NEPC, 1999). Barium and vanadium do not have an assigned HIL. Although HILs are used for land contamination, it is a useful tool for understanding potential risks associated with the overburden waste trace metal compositions.

All the recorded trace metal values reported by the overburden samples at FHCP were below the HIL values.

Table 9: Maximum, minimum and median metal concentrations of overburden samples collected, and the HIL values.

METAL (mg/L)	HIL	MAX	MIN	MEDIAN
As	3000	28	1.4	5.9
Ba	-	1300	38	160
Be	500	1.3	0.4	0.9
Cd	900	0.2	0.05	0.1
Co	4000	20	3.3	9.9
Cr	3600	38	0.5	4.8
Cu	240000	59	8.5	24
Pb	8900	22	7.7	13
Mn	60000	2000	56	670
Ni	6000	31	1.6	7.4
V	-	120	5.5	31
Zn	400000	95	25	67

Conclusion

The geochemical classification of overburden samples at FHCP classified all 27 samples in the NAF category. Thus, acid generation probability is extremely low and unlikely to occur. GAI assessment of overburden samples suggested that all samples (except 'FHMB05:7-14 composite' and 'FHMB02:4-7') reported similar concentrations of all elements to those found in the soil median content. Sample 'FHMB05:7-14 composite' and 'FHMB02:4-7' reported slight enrichment of arsenic than that in the median soil content. None of the overburden samples reported high EC, thereby reducing the likelihood of saline drainage.

Soil characteristic assessment by ESP suggested that out of the 27 overburden samples assessed, 19 samples were categorised as 'highly sodic' and 6 samples were categorised as 'slightly to moderately sodic'. This further suggests that these materials are potentially highly dispersive and extremely susceptible to erosion.

Based on the above-mentioned assessments, it is very unlikely that there will be any runoff or seepage that will adversely impact the surrounding receiving environment. During the next stages of development and mining, further investigations should take place. A groundwater and surface water sampling regime will compliment any further investigations to ensure the ongoing accuracy of the findings of this and any future reports. Ongoing monitoring of water in mine affected water storages is recommended at least once a quarter. If the pH of the mine affected water decreases below 6.0, an operational waste rock or overburden classification methodology will need to be developed based on the ARD test handbook (AMIRA, 2002).

References

- AMIRA. (2002). ARD test handbook - project P387A, Prediction & kinetic control of acid mine drainage.
- ANZECC & ARMCANZ. (2000). An introduction to the Australian and New Zealand guidelines for fresh and marine water quality.
- Benson, N. U., Enyong, P. A., & Fred-Ahmadu, O. H. (2016). Trace metal contamination characteristics and health risks assessment of *Commelina africana* L. and psammitic sandflats in the Niger Delta, Nigeria. *Applied and Environmental Soil Science*, 14 pages.
- Berkman, D. A., & Ryall, W. R. (1976). *Field geologists' manual*. The Australian Institute of Mining and Metallurgy.
- Bowen, H. J. M. (1979). *Environmental chemistry of the elements*. Academic Press.
- Dickens, J., & Malone, E. J. (1973). Geology of the Bowen Basin, Queensland. Department of Minerals and Energy Bureau of Mineral Resources Geology and Geophysics, Bulletin 130.
- Department of Primary Industries, New South Wales (2018). Sodic soil management. Retrieved from https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0009/127278/Sodic-soil-management.pdf
- Environmental and Earth Sciences. (2012). Soil and land capability assessment: Wilton coal project, Report to Northern Resource Consultants March 2012, Version 1.
- Fairhill Coking Coal Pty Ltd, (2013). Minescape Model report and 2012 JORC Resource Statement, prepared by ROM Resources in November 2013.
- Ferguson, K. D., & Erickson, P. M. (1988). Pre-mine prediction of acid mine drainage. *Environmental Management of Solid Waste-Dredged Material and Mine Tailings*, 24-43.
- Förstner, U., Ahlf, W., & Calmano, W., 1993, "Sediment Quality Objectives and Criteria Development in Germany", *Water Science & Technology*, 28:307-316.
- Galloway, R. W. (1967). Chapter 2: Summary description of the Isaac-Comet area. Lands of the Isaac-Comet Area, Queensland Land Research Series No.19.
- He, Z.L., Yang, X.E., & Stoffella, P.J. (2005). Trace elements in agroecosystems and impacts on the environment. *Journal of Trace Elements in Medicine and Biology*, 19(2-3), 125-140.
- Jensen, A.R. (1975), Permo Triassic Stratigraphy and sedimentation in the Bowen Basin, Queensland. BMR Bulletin 154, AGPS Canberra.
- Joint Ore Reserves Committee., (2012). The Australasian Code for the reporting of Exploration Results, Mineral Resources and Reserves, The 2012 Code, The Joint Ore Reserves Committee, Sydney, Dec 2012, 92pp
- National Environmental Protection Council (NEPC), 1999. National Environmental Protection (Assessment of Site Contamination) Measure (NEPM) 1999. Schedule B7. Guideline on the

- Investigation Levels for Soil and Groundwater. National Environmental Protection Council, Australia. Retrieved from <http://www.nepc.gov.au/system/files/resources/93ae0e77-e697-e494-656f-afaaf9fb4277/files/schedule-b7-guideline-health-based-investigation-levels-updated-oct10.pdf>
- Northern Resource Consultants Pty Ltd (NRC). (2017). Waste rock characterisation of the Wilton coal project. Prepared by Northern Resource Consultants, Townsville (Unpublished).
- Prouza, V. (1977), Coal Exploration, South Central Bowen Basin, Mt. Stuart-Comet Area, Geological Survey Queensland, Record 1977/27.
- RGS Environmental Pty Ltd. (2010). *Washpool coal project geochemical assessment of overburden and potential coal reject materials*. Appendix F of the Washpool EIS.
- Scott, S., Beeston, J., & Carr, A. (1995). Galilee Basin. *Geology of Australian Coal Basins*. Geological Society of Australia-Coal Geology Group, Brisbane, 341-352.
- Smith, K. S. (1999). Metal sorption on mineral surfaces: An overview with examples relating to mineral deposits. *Reviews in Economic Geology*, 6A and 6B, 161-182.
- University of New South Wales (2017). Exchangeable Sodium Percentage (ESP). Retrieved from http://www.terragis.bees.unsw.edu.au/terraGIS_soil/sp_exchangeable_sodium_percentage.html
- URS Australia Pty Ltd (URS). (2006). *Geochemical characterisation and Assessment of overburden and potential coal reject material at the Ensham central project*. Appendix A of the Ensham EIS 2006.
- Xstrata Coal Queensland Pty Ltd. & Ors v. Friends of the Earth—Brisbane Co-op Ltd. & Ors & Dep't of Env't & Res. Mgmt. (2012) 33 QLCR 79 (Austl.), at 511 et seq.

Appendix summary

Appendix A	Maps
Appendix B	Laboratory Results

Appendix A

Maps

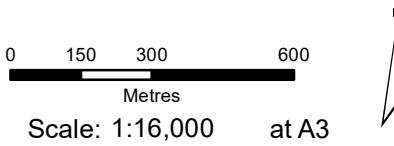
FAIRHILL PROPOSED INFRASTRUCTURE

Legend

-  Fairhill Infrastructure
 Watercourse / Drainage
 Exploration permit for coal

redits:
PC Boundaries, ML Boundaries amd MDL Boundaries and
Watercourse Drainage, Cadastral
State of Queensland (Department of Natural
Resources and Mines) 2016.

Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator
Datum: GDA 1994
Date: 22-Nov-18



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

FAIRHILL
COKING COAL
PTY LTD

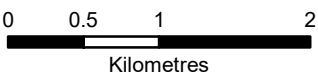
FAIRHILL
REGIONAL
GEOLOGY

Legend

- Watercourse / Drainage
- Exploration Permits for Coal
- Fairhill Infrastructure

Credits:
Geodata - Queensland geological mapping (polygonised vector) data
November 2012
EPC Boundaries, ML Boundaries and MDL Boundaries and Watercourse Drainage
© State of Queensland (Department of Natural

Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator
Datum: GDA 1994
Date: 23-Nov-18



Scale: 1:50,000 at A3



GEOLOGICAL BOUNDARIES

- Geological Boundary (Conformable) Approximate
- Geological Boundary (Conformable) Inferred
- Geological Boundary (Disconformable) Approximate
- Geological Boundary (Stratigraphic) Approximate
- Geological Boundary (Unconformable) Approximate

FOLDS

- Anticline Approximate

TRENDS AND DIPS

- Trend Line
- 5YearMineLife_FairhillInfrastructure_20181121
- 5YearMineLife_FairhillInfrastructure_20181121

QUATERNARY

Qa-QLD

EARLY TERTIARY

Te - Emerald Formation

TERTIARY

Td-QLD

LATE PERMIAN

- Pwg - Burngrove Formation
- Pwt - Fair Hill Formation
- German Creek Formation
- Pbn - MacMillan Formation

Source: DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User



FAIRHILL COKING COAL PTY LTD FAIRHILL GEOLOGY

Legend

- Watercourse / Drainage
- Fairhill Infrastructure
- Exploration Permits for Coal

QUATERNARY

- Qa-QLD

TERTIARY

- Td-QLD

LATE PERMIAN

- Burngrove Formation
- Pwt - Fair Hill Formation
- Pbn - MacMillan Formation

GEOLOGICAL BOUNDARIES

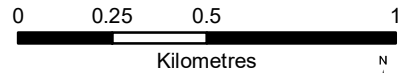
- Geological Boundary (Conformable) Approximate
- Geological Boundary (Conformable) Inferred
- Geological Boundary (Unconformable) Approximate

TRENDS AND DIPS

- Trend Line

Credits:
Geodata - Queensland geological mapping (polygonised vector) data
November 2012
EPC Boundaries, ML Boundaries and MDL Boundaries and Watercourse Drainage
© State of Queensland (Department of Natural

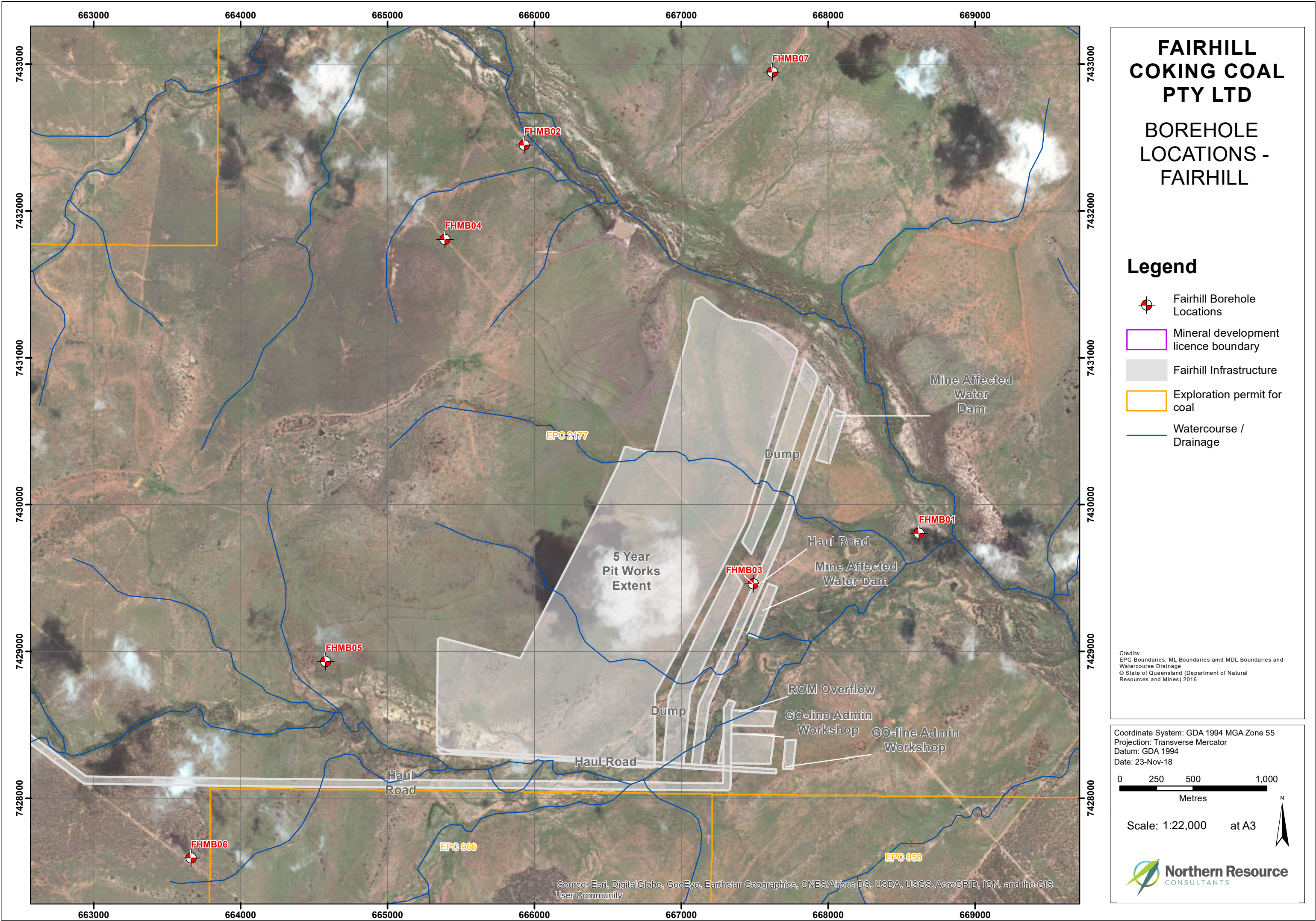
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Projection: Transverse Mercator
Datum: GDA 1994
Date: 23-Nov-18



Scale: 1:20,000 at A3



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Appendix B

Laboratory Results

CLIENT DETAILS

Contact Cameron de Jong
Client NORTHERN RESOURCE CONSULTANTS PTY LTD
Address 12 CANNAN STREET
SOUTH TOWNSVILLE QLD 4810

Telephone 61 7 4772 6500
Facsimile 61 7 4772 2441
Email labresults@northres.com.au

Project **Futura Resources- Fairhill Soil May/June**
Order Number (Not specified)
Samples 27

LABORATORY DETAILS

Manager Jon Dicker
Laboratory SGS Cairns Environmental
Address Unit 2, 58 Comport St
Portsmith QLD 4870

Telephone +61 07 4035 5111
Facsimile +61 07 4035 5122
Email AU.Environmental.Cairns@sgs.com

SGS Reference **CE134786 R0**
Date Received 24 Jul 2018
Date Reported 21 Aug 2018

COMMENTS

Accredited for compliance with ISO/IEC 17025 - Testing. NATA accredited laboratory 2562(3146).

Forms of Carbon LECO subcontracted to SGS Townsville, 50-52 Leyland St Garbutt QLD 4814, Not Accredited, TV097523.

SIGNATORIES



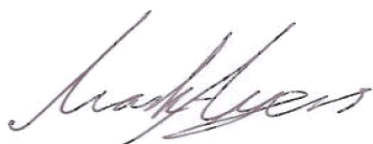
Anthony Nilsson
Operations Manager



Jon Dicker
Manager Northern QLD



Maristela Ganzan
Metals Team Leader



Mark Ayers
Team Leader - Agri Plant/Soil

Parameter	Units	LOR	Sample Number	CE134786.001	CE134786.002	CE134786.003	CE134786.004
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	02 Jun 2018	30 May 2018	30 May 2018	30 May 2018
			Sample Name	FHMB07: 32-35	FHMB05:17-23	FHMB05: 9-10+13	FHMB05: 7-14 composite

Moisture Content Method: AN002 Tested: 24/7/2018

% Moisture	%w/w	0.5	3.1	25	9.1	11
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pH in soil (1:2) Method: AN101 Tested: 31/7/2018

pH (1:2) aged	pH Units	-	9.8	8.2	8.6	7.6
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Conductivity (1:2) in soil Method: AN106 Tested: 31/7/2018

Conductivity (1:2) aged @ 25C	µS/cm	1	930	1600	1400	2300
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Total Sulfur Method: AN012/AN320 Tested: 9/8/2018

Total Sulfur	%w/w	0.005	0.022	0.094	0.47	0.25
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HCl Extractable S, Ca and Mg in Soil ICP OES Method: AN014 Tested: 9/8/2018

Acid Soluble Sulfur (SHCl)	%w/w	0.005	<0.005	0.011	0.032	0.023
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Acid Neutralising Capacity or Neutralisation Potential(ANC/NP) Method: AN212 Tested: 3/8/2018

ANC as % CaCO ₃	% CaCO ₃	0.1	11	8.4	5.8	6.4
Acid Neutralisation Capacity/Neutralisation Potential	kg CaCO ₃ /t	1	110	84	58	64
Acid Neutralisation Capacity/Neutralisation Potential kg H ₂ SO ₄ /t	kg H ₂ SO ₄ /t	1	110	82	56	62

Parameter	Units	LOR	Sample Number	CE134786.001	CE134786.002	CE134786.003	CE134786.004
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	02 Jun 2018	30 May 2018	30 May 2018	30 May 2018
			Sample Name	FHMB07: 32-35	FHMB05:17-23	FHMB05: 9-10+13	FHMB05: 7-14 composite

Net Acid Generation Potential (NAGP) Method: AN215 Tested: 10/8/2018

Net Acid Production Potential (Tot S and ANC only)	kg H ₂ SO ₄ /T	-400	-110	-79	-42	-55
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Single Addition Net Acid Generation (NAG) Method: AN216 Tested: 3/8/2018

ECox (NAG Conductivity)	µS/cm	1	170	190	400	450
pHox (NAG pH)	No unit	-	8.4	8.5	7.9	7.9
NAG as kg H ₂ SO ₄ /tonne to pH 4.5	kg H ₂ SO ₄ /T	0.5	<0.5	<0.5	<0.5	<0.5
NAG as kg H ₂ SO ₄ /tonne to pH 7	kg H ₂ SO ₄ /T	0.5	<0.5	<0.5	<0.5	<0.5
NAG as kg CaCO ₃ /tonne to pH 4.5	kg CaCO ₃ /T	1	<1.0	<1.0	<1.0	<1.0
NAG as kg CaCO ₃ /tonne to pH 7	kg CaCO ₃ /T	1	<1.0	<1.0	<1.0	<1.0

Chromium Reducible Sulphur (CRS) Method: AN217 Tested: 2/8/2018

Chromium Reducible Sulphur (Scr)	%	0.005	0.016	0.050	0.43	0.17
Chromium Reducible Sulphur (Scr)	moles H+/T	5	10	31	270	110

pH in soil (1:5) Method: AN101 Tested: 27/7/2018

pH	pH Units	0.1	10.2	9.8	9.2	8.1
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Conductivity and TDS by Calculation - Soil Method: AN106 Tested: 27/7/2018

Conductivity of Extract (1:5 dry sample basis)	µS/cm	1	690	870	740	1300
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Exchangeable Cations and Cation Exchange Capacity (CEC/ESP/SAR) Method: AN122 Tested: 30/7/2018

Exchangeable Magnesium, Mg	mg/kg	2	180	540	1100	390
Exchangeable Sodium, Na	mg/kg	2	2700	2300	1900	930
Exchangeable Potassium, K	mg/kg	2	550	450	360	89
Exchangeable Calcium, Ca	mg/kg	2	3400	2800	1300	2500
Exchangeable Sodium, Na	meq/100g	0.01	12	9.8	8.3	4.0
Exchangeable Potassium, K	meq/100g	0.01	1.4	1.1	0.91	0.23
Exchangeable Calcium, Ca	meq/100g	0.01	17	14	6.4	12
Exchangeable Magnesium, Mg	meq/100g	0.02	1.5	4.4	9.2	3.2
Exchangeable Sodium Percentage*	%	0.1	36.8	33.2	33.5	20.4
Exchangeable Potassium Percentage*	%	0.1	4.4	3.9	3.7	1.1
Exchangeable Calcium Percentage*	%	0.1	54.1	48.0	25.8	62.2
Exchangeable Magnesium Percentage*	%	0.1	4.7	14.9	37.0	16.2
Exchangeable Calcium/Exchangeable Magnesium Ratio*	No unit	0.1	11.5	3.2	0.7	3.8
Cation Exchange Capacity	meq/100g	0.02	31	30	25	20

Parameter	Units	LOR	Sample Number	CE134786.001	CE134786.002	CE134786.003	CE134786.004
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	02 Jun 2018	30 May 2018	30 May 2018	30 May 2018
			Sample Name	FHMB07: 32-35	FHMB05:17-23	FHMB05: 9-10+13	FHMB05: 7-14 composite

Soil - Aluminium (KCL Extraction) Method: AN046 Tested: 30/7/2018

Exchangeable Aluminium*	mg/kg	1	<1.0	<1.0	<1.0	<1.0
Exchangeable Aluminium*	cmol (+)/kg	0.01	<0.01	<0.01	<0.01	<0.01

Total Recoverable Elements in Soil/Waste Solids/Materials by ICPOES Method: AN040/AN320 Tested: 26/7/2018

Arsenic, As	mg/kg	0.5	5.0	13	17	18
Barium, Ba	mg/kg	0.5	160	120	180	140
Beryllium, Be	mg/kg	0.05	0.95	1.0	0.77	0.73
Cadmium, Cd	mg/kg	0.1	0.1	0.2	0.2	0.2
Cobalt, Co	mg/kg	0.5	3.3	9.8	4.8	4.4
Chromium, Cr	mg/kg	0.5	1.3	4.6	0.5	0.7
Copper, Cu	mg/kg	0.5	15	41	15	21
Manganese, Mn	mg/kg	2	1300	1000	680	300
Nickel, Ni	mg/kg	0.5	2.1	18	1.6	1.9
Lead, Pb	mg/kg	0.5	22	19	21	12
Vanadium, V	mg/kg	0.5	6.8	20	9.6	9.7
Zinc, Zn	mg/kg	0.5	79	77	85	57

Mercury in Soil Method: AN312 Tested: 26/7/2018

Mercury	mg/kg	0.01	0.02	0.05	0.06	0.05
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ASLP (Australian Standard Leaching Procedure) DI Water Method: AN007 Tested: 27/7/2018

Mass of liquid expelled	g	-	-	-	-	-
pH of liquid expelled	pH Units	-	-	-	-	-
Percentage Solids*	%	-	-	-	-	-
Mass of test sample for extraction	g	-	20	20	20	20
Mass of leaching solution used	g	-	400	400	400	400
Leaching solution used*	No unit	-	DIH2O	DIH2O	DIH2O	DIH2O
pH of solids leachate	pH Units	-	10	9.9	9.4	8.7
Conductivity @25C	µS/cm	1	380	370	290	500

Alkalinity in ASLP DI Water Extract Method: AN135 Tested: 27/7/2018

Bicarbonate Alkalinity as HCO3	mg/L	5	110	86	71	160
Carbonate Alkalinity as CO3	mg/L	5	69	28	<5	<5
Hydroxide Alkalinity as OH	mg/L	5	<5	<5	<5	<5
Total Alkalinity as CaCO3	mg/L	5	180	110	71	160

Chloride by Discrete Analyser in ASLP DI Water Extract Method: AN274 Tested: 27/7/2018

Chloride	mg/L	1	2	36	19	47
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Parameter	Units	LOR	Sample Number	CE134786.001	CE134786.002	CE134786.003	CE134786.004
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	02 Jun 2018	30 May 2018	30 May 2018	30 May 2018
			Sample Name	FHMB07: 32-35	FHMB05:17-23	FHMB05: 9-10+13	FHMB05: 7-14 composite

Metals in ASLP DI Extract by ICPOES Method: AN320/AN321 Tested: 31/7/2018

Aluminium, Al	mg/L	0.005	4.5	3.0	2.5	1.3
Barium, Ba	mg/L	0.005	0.85	1.0	0.47	0.069
Calcium, Ca	mg/L	0.2	11	15	7.6	7.3
Iron, Fe	mg/L	0.005	3.4	4.0	1.1	0.59
Magnesium, Mg	mg/L	0.1	4.8	6.9	5.2	4.2
Manganese, Mn	mg/L	0.005	0.25	0.32	0.20	0.087
Potassium, K	mg/L	0.1	8.2	8.5	4.6	2.8
Sodium, Na	mg/L	0.5	74	75	58	98
Sulfur as Sulfate, SO ₄	mg/L	0.3	19	34	61	19
Sulfur, S	mg/L	0.1	6.3	11	20	6.4
Vanadium, V	mg/L	0.005	0.010	0.013	0.005	<0.005
Zinc, Zn	mg/L	0.005	0.036	0.056	0.047	0.014

Metals in ASLP DI Water Extract by ICPOES-USN Method: AN320/AN322 Tested: 31/7/2018

Arsenic, As	mg/L	0.003	0.024	0.028	0.007	0.004
Beryllium, Be	mg/L	0.0001	0.0029	0.0040	0.0012	0.0004
Cadmium, Cd	mg/L	0.0001	0.0002	0.0002	0.0002	<0.0001
Copper, Cu	mg/L	0.001	0.035	0.050	0.011	0.005
Chromium, Cr	mg/L	0.001	0.002	0.001	<0.001	<0.001
Cobalt, Co	mg/L	0.001	0.016	0.020	0.004	0.002
Lead, Pb	mg/L	0.001	0.024	0.030	0.014	0.007
Nickel, Ni	mg/L	0.001	0.021	0.030	<0.001	0.001

Mercury in ASLP DI Water Extract Method: AN311(Perth) /AN312 Tested: 1/8/2018

Mercury	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001
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Total Carbon/Sulphur in soil by LECO Method: CSA06V Tested: 21/8/2018

Carbon*	%	0.01	2.5	2.5	4.1	19
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Total Organic Carbon (TOC) in soil by LECO and Inorganic Carbon Calc Method: CSA03V Tested: 21/8/2018

TOC*	%	0.05	0.42	0.86	3.1	17
Total Inorganic Carbon*	%	0.01	2.0	1.7	1.0	2.3

Parameter	Units	LOR	Sample Number	CE134786.005	CE134786.006	CE134786.007	CE134786.008
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	30 May 2018	29 May 2018	29 May 2018	29 May 2018
			Sample Name	FHMB05: 0-6	FHMB06: 7-9	FHMB06: 10-22	FHMB06: 23-33

Moisture Content Method: AN002 Tested: 24/7/2018

% Moisture	%w/w	0.5	13	2.3	1.6	15
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pH in soil (1:2) Method: AN101 Tested: 31/7/2018

pH (1:2) aged	pH Units	-	8.3	9.6	9.6	9.7
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Conductivity (1:2) in soil Method: AN106 Tested: 31/7/2018

Conductivity (1:2) aged @ 25C	µS/cm	1	3700	820	630	1100
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Total Sulfur Method: AN012/AN320 Tested: 9/8/2018

Total Sulfur	%w/w	0.005	0.025	0.009	0.014	0.057
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HCl Extractable S, Ca and Mg in Soil ICP OES Method: AN014 Tested: 9/8/2018

Acid Soluble Sulfur (SHCl)	%w/w	0.005	0.023	<0.005	<0.005	0.015
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Acid Neutralising Capacity or Neutralisation Potential(ANC/NP) Method: AN212 Tested: 3/8/2018

ANC as % CaCO ₃	% CaCO ₃	0.1	3.0	8.0	4.1	8.9
Acid Neutralisation Capacity/Neutralisation Potential	kg CaCO ₃ /T	1	30	80	41	89
Acid Neutralisation Capacity/Neutralisation Potential kg H ₂ SO ₄ /t	kg H ₂ SO ₄ /T	1	29	78	40	87

Parameter	Units	LOR	Sample Number	CE134786.005	CE134786.006	CE134786.007	CE134786.008
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	30 May 2018	29 May 2018	29 May 2018	29 May 2018
			Sample Name	FHMB05: 0-6	FHMB06: 7-9	FHMB06: 10-22	FHMB06: 23-33

Net Acid Generation Potential (NAGP) Method: AN215 Tested: 10/8/2018

Net Acid Production Potential (Tot S and ANC only)	kg H ₂ SO ₄ /T	-400	-29	-78	-40	-85
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Single Addition Net Acid Generation (NAG) Method: AN216 Tested: 3/8/2018

ECox (NAG Conductivity)	µS/cm	1	270	150	180	150
pHox (NAG pH)	No unit	-	8.5	8.3	10.9	9.8
NAG as kg H ₂ SO ₄ /tonne to pH 4.5	kg H ₂ SO ₄ /T	0.5	<0.5	<0.5	<0.5	<0.5
NAG as kg H ₂ SO ₄ /tonne to pH 7	kg H ₂ SO ₄ /T	0.5	<0.5	<0.5	<0.5	<0.5
NAG as kg CaCO ₃ /tonne to pH 4.5	kg CaCO ₃ /T	1	<1.0	<1.0	<1.0	<1.0
NAG as kg CaCO ₃ /tonne to pH 7	kg CaCO ₃ /T	1	<1.0	<1.0	<1.0	<1.0

Chromium Reducible Sulphur (CRS) Method: AN217 Tested: 2/8/2018

Chromium Reducible Sulphur (Scr)	%	0.005	<0.005	<0.005	<0.005	0.026
Chromium Reducible Sulphur (Scr)	moles H+/T	5	<5	<5	<5	16

pH in soil (1:5) Method: AN101 Tested: 27/7/2018

pH	pH Units	0.1	8.7	9.8	9.8	10.0
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Conductivity and TDS by Calculation - Soil Method: AN106 Tested: 27/7/2018

Conductivity of Extract (1:5 dry sample basis)	µS/cm	1	2000	490	350	690
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Exchangeable Cations and Cation Exchange Capacity (CEC/ESP/SAR) Method: AN122 Tested: 30/7/2018

Exchangeable Magnesium, Mg	mg/kg	2	1800	290	170	280
Exchangeable Sodium, Na	mg/kg	2	4700	910	500	2200
Exchangeable Potassium, K	mg/kg	2	390	370	250	450
Exchangeable Calcium, Ca	mg/kg	2	2900	3600	3400	2900
Exchangeable Sodium, Na	meq/100g	0.01	20	4.0	2.2	9.7
Exchangeable Potassium, K	meq/100g	0.01	0.99	0.94	0.63	1.2
Exchangeable Calcium, Ca	meq/100g	0.01	15	18	17	14
Exchangeable Magnesium, Mg	meq/100g	0.02	15	2.4	1.4	2.3
Exchangeable Sodium Percentage*	%	0.1	40.0	15.5	10.3	35.2
Exchangeable Potassium Percentage*	%	0.1	2.0	3.7	3.0	4.2
Exchangeable Calcium Percentage*	%	0.1	29.0	71.5	80.2	52.1
Exchangeable Magnesium Percentage*	%	0.1	29.0	9.3	6.6	8.4
Exchangeable Calcium/Exchangeable Magnesium Ratio*	No unit	0.1	1.0	7.7	12.2	6.2
Cation Exchange Capacity	meq/100g	0.02	51	26	21	28

Parameter	Units	LOR	Sample Number Sample Matrix Sample Date Sample Name	CE134786.005 Soil 30 May 2018 FHMB05: 0-6	CE134786.006 Soil 29 May 2018 FHMB06: 7-9	CE134786.007 Soil 29 May 2018 FHMB06: 10-22	CE134786.008 Soil 29 May 2018 FHMB06: 23-33
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Soil - Aluminium (KCL Extraction) Method: AN046 Tested: 30/7/2018

Exchangeable Aluminium*	mg/kg	1	<1.0	<1.0	<1.0	<1.0
Exchangeable Aluminium*	cmol (+)/kg	0.01	<0.01	<0.01	<0.01	<0.01

Total Recoverable Elements in Soil/Waste Solids/Materials by ICPOES Method: AN040/AN320 Tested: 26/7/2018

Arsenic, As	mg/kg	0.5	5.9	1.4	1.5	7.2
Barium, Ba	mg/kg	0.5	160	82	62	430
Beryllium, Be	mg/kg	0.05	1.2	1.1	0.40	0.88
Cadmium, Cd	mg/kg	0.1	0.1	0.1	0.1	0.1
Cobalt, Co	mg/kg	0.5	8.0	6.4	3.8	9.9
Chromium, Cr	mg/kg	0.5	2.3	5.8	2.6	3.8
Copper, Cu	mg/kg	0.5	27	15	8.5	40
Manganese, Mn	mg/kg	2	1100	770	340	950
Nickel, Ni	mg/kg	0.5	4.8	7.4	3.7	16
Lead, Pb	mg/kg	0.5	14	14	9.1	16
Vanadium, V	mg/kg	0.5	31	29	5.5	24
Zinc, Zn	mg/kg	0.5	67	59	25	76

Mercury in Soil Method: AN312 Tested: 26/7/2018

Mercury	mg/kg	0.01	0.05	<0.01	<0.01	0.03
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ASLP (Australian Standard Leaching Procedure) DI Water Method: AN007 Tested: 27/7/2018

Mass of liquid expelled	g	-	-	-	-	-
pH of liquid expelled	pH Units	-	-	-	-	-
Percentage Solids*	%	-	-	-	-	-
Mass of test sample for extraction	g	-	20	20	20	20
Mass of leaching solution used	g	-	400	400	400	400
Leaching solution used*	No unit	-	DIH2O	DIH2O	DIH2O	DIH2O
pH of solids leachate	pH Units	-	9.4	9.7	9.7	10
Conductivity @25C	µS/cm	1	670	200	140	340

Alkalinity in ASLP DI Water Extract Method: AN135 Tested: 27/7/2018

Bicarbonate Alkalinity as HCO3	mg/L	5	100	74	54	100
Carbonate Alkalinity as CO3	mg/L	5	8	10	<5	25
Hydroxide Alkalinity as OH	mg/L	5	<5	<5	<5	<5
Total Alkalinity as CaCO3	mg/L	5	110	84	57	120

Chloride by Discrete Analyser in ASLP DI Water Extract Method: AN274 Tested: 27/7/2018

Chloride	mg/L	1	130	14	9	11
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Parameter	Units	LOR	Sample Number Sample Matrix Sample Date Sample Name	CE134786.005 Soil 30 May 2018 FHMB05: 0-6	CE134786.006 Soil 29 May 2018 FHMB06: 7-9	CE134786.007 Soil 29 May 2018 FHMB06: 10-22	CE134786.008 Soil 29 May 2018 FHMB06: 23-33
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Metals in ASLP DI Extract by ICPOES Method: AN320/AN321 Tested: 31/7/2018

Aluminium, Al	mg/L	0.005	3.8	3.2	3.1	4.3
Barium, Ba	mg/L	0.005	0.41	0.12	0.21	1.8
Calcium, Ca	mg/L	0.2	25	9.4	8.2	8.7
Iron, Fe	mg/L	0.005	0.61	1.6	1.4	2.8
Magnesium, Mg	mg/L	0.1	18	3.0	2.2	2.5
Manganese, Mn	mg/L	0.005	0.55	0.61	0.091	0.13
Potassium, K	mg/L	0.1	5.6	8.2	7.1	6.7
Sodium, Na	mg/L	0.5	130	35	22	70
Sulfur as Sulfate, SO ₄	mg/L	0.3	23	1.0	6.1	25
Sulfur, S	mg/L	0.1	7.7	0.3	2.0	8.3
Vanadium, V	mg/L	0.005	0.009	0.007	0.005	0.027
Zinc, Zn	mg/L	0.005	0.028	0.044	0.032	0.072

Metals in ASLP DI Water Extract by ICPOES-USN Method: AN320/AN322 Tested: 31/7/2018

Arsenic, As	mg/L	0.003	0.004	<0.003	0.007	0.037
Beryllium, Be	mg/L	0.0001	0.0021	0.0014	0.0008	0.0019
Cadmium, Cd	mg/L	0.0001	0.0003	0.0003	0.0006	0.0002
Copper, Cu	mg/L	0.001	0.033	0.014	0.021	0.026
Chromium, Cr	mg/L	0.001	<0.001	0.002	0.001	0.002
Cobalt, Co	mg/L	0.001	0.006	0.009	0.008	0.020
Lead, Pb	mg/L	0.001	0.015	0.014	0.019	0.021
Nickel, Ni	mg/L	0.001	0.003	0.005	0.005	0.021

Mercury in ASLP DI Water Extract Method: AN311(Perth) /AN312 Tested: 1/8/2018

Mercury	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001
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Total Carbon/Sulphur in soil by LECO Method: CSA06V Tested: 21/8/2018

Carbon*	%	0.01	1.7	2.2	1.0	3.5
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Total Organic Carbon (TOC) in soil by LECO and Inorganic Carbon Calc Method: CSA03V Tested: 21/8/2018

TOC*	%	0.05	1.4	1.0	0.29	2.4
Total Inorganic Carbon*	%	0.01	0.31	1.2	0.75	1.1

Sample Number	CE134786.009	CE134786.010	CE134786.011	CE134786.012
Sample Matrix	Soil	Soil	Soil	Soil
Sample Date	29 May 2018	29 May 2018	01 Jun 2018	01 Jun 2018
Sample Name	FHMB06: 33-41	FHMB06: 1-6	FHMB02: 13-18.5	FHMB02: 8-12

Parameter	Units	LOR
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Moisture Content Method: AN002 Tested: 24/7/2018

% Moisture	%w/w	0.5	20	3.3	16	12
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pH in soil (1:2) Method: AN101 Tested: 31/7/2018

pH (1:2) aged	pH Units	-	9.2	9.4	8.9	8.6
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Conductivity (1:2) in soil Method: AN106 Tested: 31/7/2018

Conductivity (1:2) aged @ 25C	µS/cm	1	1600	1200	1900	1900
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Total Sulfur Method: AN012/AN320 Tested: 9/8/2018

Total Sulfur	%w/w	0.005	0.29	<0.005	0.12	0.20
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HCl Extractable S, Ca and Mg in Soil ICP OES Method: AN014 Tested: 9/8/2018

Acid Soluble Sulfur (SHCl)	%w/w	0.005	0.012	<0.005	0.017	0.020
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Acid Neutralising Capacity or Neutralisation Potential(ANC/NP) Method: AN212 Tested: 3/8/2018

ANC as % CaCO ₃	% CaCO ₃	0.1	7.5	3.1	5.6	6.6
Acid Neutralisation Capacity/Neutralisation Potential	kg CaCO ₃ /t	1	75	31	56	66
Acid Neutralisation Capacity/Neutralisation Potential kg H ₂ SO ₄ /t	kg H ₂ SO ₄ /t	1	74	31	55	65

Parameter	Units	LOR	Sample Number	CE134786.009	CE134786.010	CE134786.011	CE134786.012
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	29 May 2018	29 May 2018	01 Jun 2018	01 Jun 2018
			Sample Name	FHMB06: 33-41	FHMB06: 1-6	FHMB02: 13-18.5	FHMB02: 8-12

Net Acid Generation Potential (NAGP) Method: AN215 Tested: 10/8/2018

Net Acid Production Potential (Tot S and ANC only)	kg H ₂ SO ₄ /T	-400	-65	-31	-51	-59
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Single Addition Net Acid Generation (NAG) Method: AN216 Tested: 3/8/2018

ECox (NAG Conductivity)	µS/cm	1	300	200	230	290
pHox (NAG pH)	No unit	-	8.8	8.5	9.1	8.7
NAG as kg H ₂ SO ₄ /tonne to pH 4.5	kg H ₂ SO ₄ /T	0.5	<0.5	<0.5	<0.5	<0.5
NAG as kg H ₂ SO ₄ /tonne to pH 7	kg H ₂ SO ₄ /T	0.5	<0.5	<0.5	<0.5	<0.5
NAG as kg CaCO ₃ /tonne to pH 4.5	kg CaCO ₃ /T	1	<1.0	<1.0	<1.0	<1.0
NAG as kg CaCO ₃ /tonne to pH 7	kg CaCO ₃ /T	1	<1.0	<1.0	<1.0	<1.0

Chromium Reducible Sulphur (CRS) Method: AN217 Tested: 2/8/2018

Chromium Reducible Sulphur (Scr)	%	0.005	0.18	<0.005	0.074	0.13
Chromium Reducible Sulphur (Scr)	moles H+/T	5	110	<5	46	82

pH in soil (1:5) Method: AN101 Tested: 27/7/2018

pH	pH Units	0.1	9.7	9.7	9.3	9.1
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Conductivity and TDS by Calculation - Soil Method: AN106 Tested: 27/7/2018

Conductivity of Extract (1:5 dry sample basis)	µS/cm	1	920	620	1000	1000
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Exchangeable Cations and Cation Exchange Capacity (CEC/ESP/SAR) Method: AN122 Tested: 30/7/2018

Exchangeable Magnesium, Mg	mg/kg	2	610	430	780	1200
Exchangeable Sodium, Na	mg/kg	2	2700	1200	2200	2300
Exchangeable Potassium, K	mg/kg	2	370	300	370	300
Exchangeable Calcium, Ca	mg/kg	2	2300	3300	3000	3200
Exchangeable Sodium, Na	meq/100g	0.01	12	5.2	9.5	9.9
Exchangeable Potassium, K	meq/100g	0.01	0.95	0.76	0.96	0.76
Exchangeable Calcium, Ca	meq/100g	0.01	11	16	15	16
Exchangeable Magnesium, Mg	meq/100g	0.02	5.0	3.5	6.4	9.9
Exchangeable Sodium Percentage*	%	0.1	40.0	20.0	29.9	26.9
Exchangeable Potassium Percentage*	%	0.1	3.3	2.9	3.0	2.1
Exchangeable Calcium Percentage*	%	0.1	39.5	63.6	46.8	44.1
Exchangeable Magnesium Percentage*	%	0.1	17.2	13.5	20.3	27.0
Exchangeable Calcium/Exchangeable Magnesium Ratio*	No unit	0.1	2.3	4.7	2.3	1.6
Cation Exchange Capacity	meq/100g	0.02	29	26	32	37

Parameter	Units	LOR	Sample Number	CE134786.009	CE134786.010	CE134786.011	CE134786.012
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	29 May 2018	29 May 2018	01 Jun 2018	01 Jun 2018
			Sample Name	FHMB06: 33-41	FHMB06: 1-6	FHMB02: 13-18.5	FHMB02: 8-12

Soil - Aluminium (KCL Extraction) Method: AN046 Tested: 30/7/2018

Exchangeable Aluminium*	mg/kg	1	<1.0	<1.0	<1.0	<1.0
Exchangeable Aluminium*	cmol (+)/kg	0.01	<0.01	<0.01	<0.01	<0.01

Total Recoverable Elements in Soil/Waste Solids/Materials by ICPOES Method: AN040/AN320 Tested: 26/7/2018

Arsenic, As	mg/kg	0.5	6.5	1.4	4.9	11
Barium, Ba	mg/kg	0.5	110	140	120	150
Beryllium, Be	mg/kg	0.05	0.81	0.77	0.96	0.97
Cadmium, Cd	mg/kg	0.1	0.1	0.1	0.1	0.1
Cobalt, Co	mg/kg	0.5	6.5	8.1	8.1	9.1
Chromium, Cr	mg/kg	0.5	0.5	3.7	1.6	4.8
Copper, Cu	mg/kg	0.5	59	10	36	51
Manganese, Mn	mg/kg	2	670	430	600	1300
Nickel, Ni	mg/kg	0.5	1.9	6.6	5.4	6.9
Lead, Pb	mg/kg	0.5	12	13	18	15
Vanadium, V	mg/kg	0.5	17	8.2	17	35
Zinc, Zn	mg/kg	0.5	67	40	65	68

Mercury in Soil Method: AN312 Tested: 26/7/2018

Mercury	mg/kg	0.01	0.06	<0.01	0.06	0.06
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ASLP (Australian Standard Leaching Procedure) DI Water Method: AN007 Tested: 27/7/2018

Mass of liquid expelled	g	-	-	-	-	-
pH of liquid expelled	pH Units	-	-	-	-	-
Percentage Solids*	%	-	-	-	-	-
Mass of test sample for extraction	g	-	20	20	20	20
Mass of leaching solution used	g	-	400	400	400	400
Leaching solution used*	No unit	-	DIH2O	DIH2O	DIH2O	DIH2O
pH of solids leachate	pH Units	-	9.9	9.8	9.6	9.5
Conductivity @25C	µS/cm	1	390	240	380	370

Alkalinity in ASLP DI Water Extract Method: AN135 Tested: 27/7/2018

Bicarbonate Alkalinity as HCO3	mg/L	5	91	66	68	87
Carbonate Alkalinity as CO3	mg/L	5	7	<5	<5	<5
Hydroxide Alkalinity as OH	mg/L	5	<5	<5	<5	<5
Total Alkalinity as CaCO3	mg/L	5	98	66	68	87

Chloride by Discrete Analyser in ASLP DI Water Extract Method: AN274 Tested: 27/7/2018

Chloride	mg/L	1	40	29	59	53
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Parameter	Units	LOR	Sample Number	CE134786.009	CE134786.010	CE134786.011	CE134786.012
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	29 May 2018	29 May 2018	01 Jun 2018	01 Jun 2018
			Sample Name	FHMB06: 33-41	FHMB06: 1-6	FHMB02: 13-18.5	FHMB02: 8-12

Metals in ASLP DI Extract by ICPOES Method: AN320/AN321 Tested: 31/7/2018

Aluminium, Al	mg/L	0.005	2.8	4.3	2.5	2.0
Barium, Ba	mg/L	0.005	0.16	0.34	0.15	0.17
Calcium, Ca	mg/L	0.2	8.0	7.7	6.9	9.5
Iron, Fe	mg/L	0.005	1.6	1.4	0.90	1.2
Magnesium, Mg	mg/L	0.1	3.2	4.8	2.5	4.9
Manganese, Mn	mg/L	0.005	0.064	0.22	0.077	0.48
Potassium, K	mg/L	0.1	4.1	6.0	4.1	3.4
Sodium, Na	mg/L	0.5	77	44	69	70
Sulfur as Sulfate, SO ₄	mg/L	0.3	48	0.3	36	24
Sulfur, S	mg/L	0.1	16	0.1	12	8.0
Vanadium, V	mg/L	0.005	0.019	0.012	0.011	0.014
Zinc, Zn	mg/L	0.005	0.028	0.030	0.012	0.028

Metals in ASLP DI Water Extract by ICPOES-USN Method: AN320/AN322 Tested: 31/7/2018

Arsenic, As	mg/L	0.003	0.006	<0.003	0.007	0.005
Beryllium, Be	mg/L	0.0001	0.0015	0.0012	0.0005	0.0005
Cadmium, Cd	mg/L	0.0001	<0.0001	0.0004	0.0001	<0.0001
Copper, Cu	mg/L	0.001	0.027	0.014	0.009	0.022
Chromium, Cr	mg/L	0.001	<0.001	0.003	<0.001	<0.001
Cobalt, Co	mg/L	0.001	0.007	0.007	0.005	0.006
Lead, Pb	mg/L	0.001	0.011	0.013	0.015	0.011
Nickel, Ni	mg/L	0.001	0.002	0.004	0.002	0.002

Mercury in ASLP DI Water Extract Method: AN311(Perth) /AN312 Tested: 1/8/2018

Mercury	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001
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Total Carbon/Sulphur in soil by LECO Method: CSA06V Tested: 21/8/2018

Carbon*	%	0.01	18	0.55	12	13
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Total Organic Carbon (TOC) in soil by LECO and Inorganic Carbon Calc Method: CSA03V Tested: 21/8/2018

TOC*	%	0.05	15	<0.05	10	11
Total Inorganic Carbon*	%	0.01	2.6	0.52	1.5	1.8

Parameter	Units	LOR	Sample Number	CE134786.013	CE134786.014	CE134786.015	CE134786.016
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	01 Jun 2018	01 Jun 2018	01 Jun 2018	31 May 2018
			Sample Name	FHMB02: 0-3	FHMB02: 4-7	FHMB02: 9-12	FHMB04: 2-5

Moisture Content Method: AN002 Tested: 24/7/2018

% Moisture	%w/w	0.5	5.2	4.9	12	8.0
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pH in soil (1:2) Method: AN101 Tested: 31/7/2018

pH (1:2) aged	pH Units	-	8.6	8.6	8.6	7.8
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Conductivity (1:2) in soil Method: AN106 Tested: 31/7/2018

Conductivity (1:2) aged @ 25C	µS/cm	1	1600	740	2000	1600
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Total Sulfur Method: AN012/AN320 Tested: 9/8/2018

Total Sulfur	%w/w	0.005	0.022	0.008	0.41	0.016
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HCl Extractable S, Ca and Mg in Soil ICP OES Method: AN014 Tested: 9/8/2018

Acid Soluble Sulfur (SHCl)	%w/w	0.005	0.022	0.008	0.033	0.014
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Acid Neutralising Capacity or Neutralisation Potential(ANC/NP) Method: AN212 Tested: 3/8/2018

ANC as % CaCO ₃	% CaCO ₃	0.1	1.3	4.1	5.6	1.4
Acid Neutralisation Capacity/Neutralisation Potential	kg CaCO ₃ /T	1	13	41	56	14
Acid Neutralisation Capacity/Neutralisation Potential kg H ₂ SO ₄ /t	kg H ₂ SO ₄ /T	1	12	40	55	13

Parameter	Units	LOR	Sample Number	CE134786.013	CE134786.014	CE134786.015	CE134786.016
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	01 Jun 2018	01 Jun 2018	01 Jun 2018	31 May 2018
			Sample Name	FHMB02: 0-3	FHMB02: 4-7	FHMB02: 9-12	FHMB04: 2-5

Net Acid Generation Potential (NAGP) Method: AN215 Tested: 10/8/2018

Net Acid Production Potential (Tot S and ANC only)	kg H ₂ SO ₄ /T	-400	-12	-40	-43	-13
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Single Addition Net Acid Generation (NAG) Method: AN216 Tested: 3/8/2018

ECox (NAG Conductivity)	µS/cm	1	140	140	390	130
pHox (NAG pH)	No unit	-	9.4	9.3	8.4	9.0
NAG as kg H ₂ SO ₄ /tonne to pH 4.5	kg H ₂ SO ₄ /T	0.5	<0.5	<0.5	<0.5	<0.5
NAG as kg H ₂ SO ₄ /tonne to pH 7	kg H ₂ SO ₄ /T	0.5	<0.5	<0.5	<0.5	<0.5
NAG as kg CaCO ₃ /tonne to pH 4.5	kg CaCO ₃ /T	1	<1.0	<1.0	<1.0	<1.0
NAG as kg CaCO ₃ /tonne to pH 7	kg CaCO ₃ /T	1	<1.0	<1.0	<1.0	<1.0

Chromium Reducible Sulphur (CRS) Method: AN217 Tested: 2/8/2018

Chromium Reducible Sulphur (Scr)	%	0.005	<0.005	<0.005	0.27	<0.005
Chromium Reducible Sulphur (Scr)	moles H+/T	5	<5	<5	170	<5

pH in soil (1:5) Method: AN101 Tested: 27/7/2018

pH	pH Units	0.1	9.0	8.8	9.1	8.0
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Conductivity and TDS by Calculation - Soil Method: AN106 Tested: 27/7/2018

Conductivity of Extract (1:5 dry sample basis)	µS/cm	1	840	390	1100	780
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Exchangeable Cations and Cation Exchange Capacity (CEC/ESP/SAR) Method: AN122 Tested: 30/7/2018

Exchangeable Magnesium, Mg	mg/kg	2	940	850	980	1100
Exchangeable Sodium, Na	mg/kg	2	1800	490	2200	1500
Exchangeable Potassium, K	mg/kg	2	220	140	280	360
Exchangeable Calcium, Ca	mg/kg	2	2200	2900	2700	650
Exchangeable Sodium, Na	meq/100g	0.01	7.0	2.1	9.6	6.6
Exchangeable Potassium, K	meq/100g	0.01	0.55	0.36	0.73	0.91
Exchangeable Calcium, Ca	meq/100g	0.01	11	15	14	3.2
Exchangeable Magnesium, Mg	meq/100g	0.02	7.7	7.0	8.0	9.0
Exchangeable Sodium Percentage*	%	0.1	26.4	8.8	30.1	33.4
Exchangeable Potassium Percentage*	%	0.1	2.1	1.5	2.3	4.6
Exchangeable Calcium Percentage*	%	0.1	42.2	60.7	42.6	16.3
Exchangeable Magnesium Percentage*	%	0.1	29.4	29.0	25.1	45.7
Exchangeable Calcium/Exchangeable Magnesium Ratio*	No unit	0.1	1.4	2.1	1.7	0.4
Cation Exchange Capacity	meq/100g	0.02	26	24	32	20

Parameter	Units	LOR	Sample Number	CE134786.013	CE134786.014	CE134786.015	CE134786.016
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	01 Jun 2018	01 Jun 2018	01 Jun 2018	31 May 2018
			Sample Name	FHMB02: 0-3	FHMB02: 4-7	FHMB02: 9-12	FHMB04: 2-5

Soil - Aluminium (KCL Extraction) Method: AN046 Tested: 30/7/2018

Exchangeable Aluminium*	mg/kg	1	<1.0	<1.0	<1.0	<1.0
Exchangeable Aluminium*	cmol (+)/kg	0.01	<0.01	<0.01	<0.01	<0.01

Total Recoverable Elements in Soil/Waste Solids/Materials by ICPOES Method: AN040/AN320 Tested: 26/7/2018

Arsenic, As	mg/kg	0.5	3.2	28	13	3.3
Barium, Ba	mg/kg	0.5	220	490	66	560
Beryllium, Be	mg/kg	0.05	0.65	1.2	0.82	1.2
Cadmium, Cd	mg/kg	0.1	<0.1	0.2	0.2	<0.1
Cobalt, Co	mg/kg	0.5	9.3	17	6.9	13
Chromium, Cr	mg/kg	0.5	10	18	1.1	1.3
Copper, Cu	mg/kg	0.5	8.7	19	57	37
Manganese, Mn	mg/kg	2	240	2000	880	150
Nickel, Ni	mg/kg	0.5	6.8	21	2.4	6.8
Lead, Pb	mg/kg	0.5	8.4	21	13	7.7
Vanadium, V	mg/kg	0.5	32	75	14	17
Zinc, Zn	mg/kg	0.5	47	95	79	67

Mercury in Soil Method: AN312 Tested: 26/7/2018

Mercury	mg/kg	0.01	<0.01	<0.01	0.08	<0.01
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ASLP (Australian Standard Leaching Procedure) DI Water Method: AN007 Tested: 27/7/2018

Mass of liquid expelled	g	-	-	-	-	-
pH of liquid expelled	pH Units	-	-	-	-	-
Percentage Solids*	%	-	-	-	-	-
Mass of test sample for extraction	g	-	20	20	20	20
Mass of leaching solution used	g	-	400	400	400	400
Leaching solution used*	No unit	-	DIH2O	DIH2O	DIH2O	DIH2O
pH of solids leachate	pH Units	-	9.4	9.2	9.5	8.9
Conductivity @25C	µS/cm	1	310	160	400	280

Alkalinity in ASLP DI Water Extract Method: AN135 Tested: 27/7/2018

Bicarbonate Alkalinity as HCO3	mg/L	5	63	42	65	64
Carbonate Alkalinity as CO3	mg/L	5	<5	<5	<5	<5
Hydroxide Alkalinity as OH	mg/L	5	<5	<5	<5	<5
Total Alkalinity as CaCO3	mg/L	5	63	42	65	64

Chloride by Discrete Analyser in ASLP DI Water Extract Method: AN274 Tested: 27/7/2018

Chloride	mg/L	1	36	19	58	46
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Parameter	Units	LOR	Sample Number	CE134786.013	CE134786.014	CE134786.015	CE134786.016
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	01 Jun 2018	01 Jun 2018	01 Jun 2018	31 May 2018
			Sample Name	FHMB02: 0-3	FHMB02: 4-7	FHMB02: 9-12	FHMB04: 2-5

Metals in ASLP DI Extract by ICPOES Method: AN320/AN321 Tested: 31/7/2018

Aluminium, Al	mg/L	0.005	3.0	0.12	1.5	2.5
Barium, Ba	mg/L	0.005	0.39	0.068	0.057	2.4
Calcium, Ca	mg/L	0.2	7.8	5.1	7.3	10
Iron, Fe	mg/L	0.005	1.5	0.12	0.89	0.83
Magnesium, Mg	mg/L	0.1	5.5	3.9	3.7	16
Manganese, Mn	mg/L	0.005	0.078	<0.005	0.13	0.15
Potassium, K	mg/L	0.1	2.1	1.6	3.2	7.4
Sodium, Na	mg/L	0.5	56	19	73	55
Sulfur as Sulfate, SO4	mg/L	0.3	26	5.3	51	7.8
Sulfur, S	mg/L	0.1	8.7	1.8	17	2.6
Vanadium, V	mg/L	0.005	0.044	<0.005	0.008	0.005
Zinc, Zn	mg/L	0.005	0.064	<0.005	0.023	0.044

Metals in ASLP DI Water Extract by ICPOES-USN Method: AN320/AN322 Tested: 31/7/2018

Arsenic, As	mg/L	0.003	0.006	0.004	0.005	<0.003
Beryllium, Be	mg/L	0.0001	0.0007	<0.0001	0.0005	0.0024
Cadmium, Cd	mg/L	0.0001	<0.0001	<0.0001	0.0001	0.0002
Copper, Cu	mg/L	0.001	0.006	<0.001	0.023	0.021
Chromium, Cr	mg/L	0.001	0.002	<0.001	<0.001	<0.001
Cobalt, Co	mg/L	0.001	0.004	<0.001	0.005	0.008
Lead, Pb	mg/L	0.001	0.006	<0.001	0.007	0.006
Nickel, Ni	mg/L	0.001	0.002	<0.001	0.001	0.003

Mercury in ASLP DI Water Extract Method: AN311(Perth) /AN312 Tested: 1/8/2018

Mercury	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001
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Total Carbon/Sulphur in soil by LECO Method: CSA06V Tested: 21/8/2018

Carbon*	%	0.01	0.29	0.73	21	0.27
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Total Organic Carbon (TOC) in soil by LECO and Inorganic Carbon Calc Method: CSA03V Tested: 21/8/2018

TOC*	%	0.05	0.12	0.10	18	<0.05
Total Inorganic Carbon*	%	0.01	0.17	0.62	2.7	0.22

Parameter	Units	LOR	Sample Number	CE134786.017	CE134786.018	CE134786.019	CE134786.020
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	31 May 2018	31 May 2018	31 May 2018	14 Jun 2018
			Sample Name	FHMB04: 0-1	FHMB04: 19-29.5	FHMB04: 6-19	FHMB03: 2-7

Moisture Content Method: AN002 Tested: 24/7/2018

% Moisture	%w/w	0.5	6.3	3.4	2.2	4.0
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pH in soil (1:2) Method: AN101 Tested: 31/7/2018

pH (1:2) aged	pH Units	-	8.3	8.9	9.4	8.8
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Conductivity (1:2) in soil Method: AN106 Tested: 31/7/2018

Conductivity (1:2) aged @ 25C	µS/cm	1	580	780	770	340
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Total Sulfur Method: AN012/AN320 Tested: 9/8/2018

Total Sulfur	%w/w	0.005	0.011	0.042	0.047	0.029
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HCl Extractable S, Ca and Mg in Soil ICP OES Method: AN014 Tested: 9/8/2018

Acid Soluble Sulfur (SHCl)	%w/w	0.005	0.011	0.007	0.012	<0.005
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Acid Neutralising Capacity or Neutralisation Potential(ANC/NP) Method: AN212 Tested: 3/8/2018

ANC as % CaCO ₃	% CaCO ₃	0.1	1.0	12	8.4	4.4
Acid Neutralisation Capacity/Neutralisation Potential	kg CaCO ₃ /t	1	10	120	84	44
Acid Neutralisation Capacity/Neutralisation Potential kg H ₂ SO ₄ /t	kg H ₂ SO ₄ /t	1	9.8	120	82	43

Parameter	Units	LOR	Sample Number	CE134786.017	CE134786.018	CE134786.019	CE134786.020
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	31 May 2018	31 May 2018	31 May 2018	14 Jun 2018
			Sample Name	FHMB04: 0-1	FHMB04: 19-29.5	FHMB04: 6-19	FHMB03: 2-7

Net Acid Generation Potential (NAGP) Method: AN215 Tested: 10/8/2018

Net Acid Production Potential (Tot S and ANC only)	kg H ₂ SO ₄ /T	-400	-9	-120	-81	-42
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Single Addition Net Acid Generation (NAG) Method: AN216 Tested: 3/8/2018

ECox (NAG Conductivity)	µS/cm	1	120	130	130	120
pHox (NAG pH)	No unit	-	7.7	10.1	10.2	8.6
NAG as kg H ₂ SO ₄ /tonne to pH 4.5	kg H ₂ SO ₄ /T	0.5	<0.5	<0.5	<0.5	<0.5
NAG as kg H ₂ SO ₄ /tonne to pH 7	kg H ₂ SO ₄ /T	0.5	<0.5	<0.5	<0.5	<0.5
NAG as kg CaCO ₃ /tonne to pH 4.5	kg CaCO ₃ /T	1	<1.0	<1.0	<1.0	<1.0
NAG as kg CaCO ₃ /tonne to pH 7	kg CaCO ₃ /T	1	<1.0	<1.0	<1.0	<1.0

Chromium Reducible Sulphur (CRS) Method: AN217 Tested: 2/8/2018

Chromium Reducible Sulphur (Scr)	%	0.005	<0.005	0.018	0.020	<0.005
Chromium Reducible Sulphur (Scr)	moles H+/T	5	<5	11	12	<5

pH in soil (1:5) Method: AN101 Tested: 27/7/2018

pH	pH Units	0.1	8.5	9.3	9.7	9.0
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Conductivity and TDS by Calculation - Soil Method: AN106 Tested: 27/7/2018

Conductivity of Extract (1:5 dry sample basis)	µS/cm	1	320	430	420	200
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Exchangeable Cations and Cation Exchange Capacity (CEC/ESP/SAR) Method: AN122 Tested: 30/7/2018

Exchangeable Magnesium, Mg	mg/kg	2	870	290	530	650
Exchangeable Sodium, Na	mg/kg	2	450	550	700	370
Exchangeable Potassium, K	mg/kg	2	380	180	290	140
Exchangeable Calcium, Ca	mg/kg	2	2800	4200	2900	4500
Exchangeable Sodium, Na	meq/100g	0.01	2.0	2.4	3.1	1.6
Exchangeable Potassium, K	meq/100g	0.01	0.96	0.47	0.74	0.35
Exchangeable Calcium, Ca	meq/100g	0.01	14	21	15	23
Exchangeable Magnesium, Mg	meq/100g	0.02	7.1	2.3	4.4	5.4
Exchangeable Sodium Percentage*	%	0.1	8.1	9.2	13.4	5.4
Exchangeable Potassium Percentage*	%	0.1	4.0	1.8	3.2	1.2
Exchangeable Calcium Percentage*	%	0.1	58.4	80.0	64.2	75.5
Exchangeable Magnesium Percentage*	%	0.1	29.5	9.0	19.2	17.9
Exchangeable Calcium/Exchangeable Magnesium Ratio*	No unit	0.1	2.0	8.9	3.3	4.2
Cation Exchange Capacity	meq/100g	0.02	24	26	23	30

Parameter	Units	LOR	Sample Number	CE134786.017	CE134786.018	CE134786.019	CE134786.020
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	31 May 2018	31 May 2018	31 May 2018	14 Jun 2018
			Sample Name	FHMB04: 0-1	FHMB04: 19-29.5	FHMB04: 6-19	FHMB03: 2-7

Soil - Aluminium (KCL Extraction) Method: AN046 Tested: 30/7/2018

Exchangeable Aluminium*	mg/kg	1	<1.0	<1.0	<1.0	<1.0
Exchangeable Aluminium*	cmol (+)/kg	0.01	<0.01	<0.01	<0.01	<0.01

Total Recoverable Elements in Soil/Waste Solids/Materials by ICPOES Method: AN040/AN320 Tested: 26/7/2018

Arsenic, As	mg/kg	0.5	3.8	4.6	6.8	3.8
Barium, Ba	mg/kg	0.5	350	100	210	310
Beryllium, Be	mg/kg	0.05	1.1	0.70	0.69	0.67
Cadmium, Cd	mg/kg	0.1	<0.1	<0.1	0.1	0.1
Cobalt, Co	mg/kg	0.5	10	18	15	12
Chromium, Cr	mg/kg	0.5	6.5	7.2	4.4	26
Copper, Cu	mg/kg	0.5	12	24	37	24
Manganese, Mn	mg/kg	2	56	1900	680	530
Nickel, Ni	mg/kg	0.5	5.2	16	12	30
Lead, Pb	mg/kg	0.5	11	9.6	13	11
Vanadium, V	mg/kg	0.5	31	120	60	51
Zinc, Zn	mg/kg	0.5	34	60	81	69

Mercury in Soil Method: AN312 Tested: 26/7/2018

Mercury	mg/kg	0.01	0.02	0.01	0.03	0.02
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ASLP (Australian Standard Leaching Procedure) DI Water Method: AN007 Tested: 27/7/2018

Mass of liquid expelled	g	-	-	-	-	-
pH of liquid expelled	pH Units	-	-	-	-	-
Percentage Solids*	%	-	-	-	-	-
Mass of test sample for extraction	g	-	20	20	20	20
Mass of leaching solution used	g	-	400	400	400	400
Leaching solution used*	No unit	-	DIH2O	DIH2O	DIH2O	DIH2O
pH of solids leachate	pH Units	-	9.0	9.3	9.6	9.1
Conductivity @25C	µS/cm	1	140	170	180	100

Alkalinity in ASLP DI Water Extract Method: AN135 Tested: 27/7/2018

Bicarbonate Alkalinity as HCO3	mg/L	5	67	53	64	48
Carbonate Alkalinity as CO3	mg/L	5	<5	<5	<5	<5
Hydroxide Alkalinity as OH	mg/L	5	<5	<5	<5	<5
Total Alkalinity as CaCO3	mg/L	5	67	53	66	48

Chloride by Discrete Analyser in ASLP DI Water Extract Method: AN274 Tested: 27/7/2018

Chloride	mg/L	1	7	16	8	2
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Parameter	Units	LOR	Sample Number Sample Matrix Sample Date Sample Name	CE134786.017 Soil 31 May 2018 FHMB04: 0-1	CE134786.018 Soil 31 May 2018 FHMB04: 19-29.5	CE134786.019 Soil 31 May 2018 FHMB04: 6-19	CE134786.020 Soil 14 Jun 2018 FHMB03: 2-7
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Metals in ASLP DI Extract by ICPOES Method: AN320/AN321 Tested: 31/7/2018

Aluminium, Al	mg/L	0.005	3.9	2.7	2.8	0.79
Barium, Ba	mg/L	0.005	1.4	0.11	0.49	0.047
Calcium, Ca	mg/L	0.2	21	39	15	6.1
Iron, Fe	mg/L	0.005	1.2	6.8	3.0	0.47
Magnesium, Mg	mg/L	0.1	12	4.4	6.6	2.1
Manganese, Mn	mg/L	0.005	0.087	0.53	0.22	0.008
Potassium, K	mg/L	0.1	7.1	4.5	6.4	1.4
Sodium, Na	mg/L	0.5	19	23	29	14
Sulfur as Sulfate, SO ₄	mg/L	0.3	4.7	8.6	19	2.2
Sulfur, S	mg/L	0.1	1.6	2.9	6.2	0.7
Vanadium, V	mg/L	0.005	0.024	0.020	0.026	<0.005
Zinc, Zn	mg/L	0.005	0.20	0.017	0.038	<0.005

Metals in ASLP DI Water Extract by ICPOES-USN Method: AN320/AN322 Tested: 31/7/2018

Arsenic, As	mg/L	0.003	0.003	0.005	0.013	<0.003
Beryllium, Be	mg/L	0.0001	0.0036	0.0003	0.0012	<0.0001
Cadmium, Cd	mg/L	0.0001	<0.0001	0.0001	0.0004	<0.0001
Copper, Cu	mg/L	0.001	0.037	0.004	0.027	<0.001
Chromium, Cr	mg/L	0.001	0.001	0.001	0.002	0.001
Cobalt, Co	mg/L	0.001	0.017	0.008	0.035	<0.001
Lead, Pb	mg/L	0.001	0.025	0.006	0.019	<0.001
Nickel, Ni	mg/L	0.001	0.006	0.005	0.018	<0.001

Mercury in ASLP DI Water Extract Method: AN311(Perth) /AN312 Tested: 1/8/2018

Mercury	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001
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Total Carbon/Sulphur in soil by LECO Method: CSA06V Tested: 21/8/2018

Carbon*	%	0.01	0.40	4.1	2.1	0.68
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Total Organic Carbon (TOC) in soil by LECO and Inorganic Carbon Calc Method: CSA03V Tested: 21/8/2018

TOC*	%	0.05	0.16	0.15	<0.05	0.11
Total Inorganic Carbon*	%	0.01	0.24	4.0	2.1	0.57

Parameter	Units	LOR
Sample Number	CE134786.021	CE134786.022
Sample Matrix	Soil	Soil
Sample Date	14 Jun 2018	14 Jun 2018
Sample Name	FHMB03: 10-15	FHMB03: 15-20
		FHMB01: 13-20
		FHMB01: 8-11

Moisture Content Method: AN002 Tested: 24/7/2018

% Moisture	%w/w	0.5	3.0	2.9	23	14
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pH in soil (1:2) Method: AN101 Tested: 31/7/2018

pH (1:2) aged	pH Units	-	9.0	9.2	8.0	8.0
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Conductivity (1:2) in soil Method: AN106 Tested: 31/7/2018

Conductivity (1:2) aged @ 25C	µS/cm	1	390	440	2300	4800
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Total Sulfur Method: AN012/AN320 Tested: 9/8/2018

Total Sulfur	%w/w	0.005	0.034	0.016	0.038	0.029
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HCl Extractable S, Ca and Mg in Soil ICP OES Method: AN014 Tested: 9/8/2018

Acid Soluble Sulfur (SHCl)	%w/w	0.005	0.007	0.007	0.016	0.031
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Acid Neutralising Capacity or Neutralisation Potential(ANC/NP) Method: AN212 Tested: 3/8/2018

ANC as % CaCO ₃	% CaCO ₃	0.1	7.4	7.3	1.4	0.3
Acid Neutralisation Capacity/Neutralisation Potential	kg CaCO ₃ /t	1	74	73	14	2.5
Acid Neutralisation Capacity/Neutralisation Potential kg H ₂ SO ₄ /t	kg H ₂ SO ₄ /t	1	72	71	13	2.5

Parameter	Units	LOR	Sample Number	CE134786.021	CE134786.022	CE134786.023	CE134786.024
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	14 Jun 2018	14 Jun 2018	15 Jun 2018	15 Jun 2018
			Sample Name	FHMB03: 10-15	FHMB03: 15-20	FHMB01: 13-20	FHMB01: 8-11

Net Acid Generation Potential (NAGP) Method: AN215 Tested: 10/8/2018

Net Acid Production Potential (Tot S and ANC only)	kg H ₂ SO ₄ /T	-400	-71	-71	-12	-2
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Single Addition Net Acid Generation (NAG) Method: AN216 Tested: 3/8/2018

ECox (NAG Conductivity)	µS/cm	1	120	130	140	210
pHox (NAG pH)	No unit	-	10.6	10.4	8.2	8.1
NAG as kg H ₂ SO ₄ /tonne to pH 4.5	kg H ₂ SO ₄ /T	0.5	<0.5	<0.5	<0.5	<0.5
NAG as kg H ₂ SO ₄ /tonne to pH 7	kg H ₂ SO ₄ /T	0.5	<0.5	<0.5	<0.5	<0.5
NAG as kg CaCO ₃ /tonne to pH 4.5	kg CaCO ₃ /T	1	<1.0	<1.0	<1.0	<1.0
NAG as kg CaCO ₃ /tonne to pH 7	kg CaCO ₃ /T	1	<1.0	<1.0	<1.0	<1.0

Chromium Reducible Sulphur (CRS) Method: AN217 Tested: 2/8/2018

Chromium Reducible Sulphur (Scr)	%	0.005	0.012	0.016	<0.005	<0.005
Chromium Reducible Sulphur (Scr)	moles H ⁺ /T	5	7	10	<5	<5

pH in soil (1:5) Method: AN101 Tested: 27/7/2018

pH	pH Units	0.1	9.3	9.5	8.3	8.4
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Conductivity and TDS by Calculation - Soil Method: AN106 Tested: 27/7/2018

Conductivity of Extract (1:5 dry sample basis)	µS/cm	1	230	260	1200	2400
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Exchangeable Cations and Cation Exchange Capacity (CEC/ESP/SAR) Method: AN122 Tested: 30/7/2018

Exchangeable Magnesium, Mg	mg/kg	2	520	460	900	650
Exchangeable Sodium, Na	mg/kg	2	350	450	2300	3300
Exchangeable Potassium, K	mg/kg	2	200	230	290	180
Exchangeable Calcium, Ca	mg/kg	2	3500	3100	930	800
Exchangeable Sodium, Na	meq/100g	0.01	1.5	2.0	10	14
Exchangeable Potassium, K	meq/100g	0.01	0.52	0.59	0.75	0.46
Exchangeable Calcium, Ca	meq/100g	0.01	18	15	4.6	4.0
Exchangeable Magnesium, Mg	meq/100g	0.02	4.3	3.8	7.4	5.3
Exchangeable Sodium Percentage*	%	0.1	6.3	9.1	44.4	59.4
Exchangeable Potassium Percentage*	%	0.1	2.2	2.7	3.3	1.9
Exchangeable Calcium Percentage*	%	0.1	73.7	70.8	20.2	16.6
Exchangeable Magnesium Percentage*	%	0.1	17.8	17.4	32.1	22.1
Exchangeable Calcium/Exchangeable Magnesium Ratio*	No unit	0.1	4.2	4.1	0.6	0.8
Cation Exchange Capacity	meq/100g	0.02	24	22	23	24

Parameter	Units	LOR	Sample Number	CE134786.021	CE134786.022	CE134786.023	CE134786.024
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	14 Jun 2018	14 Jun 2018	15 Jun 2018	15 Jun 2018
			Sample Name	FHMB03: 10-15	FHMB03: 15-20	FHMB01: 13-20	FHMB01: 8-11

Soil - Aluminium (KCL Extraction) Method: AN046 Tested: 30/7/2018

Exchangeable Aluminium*	mg/kg	1	<1.0	<1.0	<1.0	<1.0
Exchangeable Aluminium*	cmol (+)/kg	0.01	<0.01	<0.01	<0.01	<0.01

Total Recoverable Elements in Soil/Waste Solids/Materials by ICPOES Method: AN040/AN320 Tested: 26/7/2018

Arsenic, As	mg/kg	0.5	8.5	5.0	2.5	7.0
Barium, Ba	mg/kg	0.5	38	64	340	1300
Beryllium, Be	mg/kg	0.05	0.68	0.76	0.89	1.3
Cadmium, Cd	mg/kg	0.1	0.2	<0.1	<0.1	<0.1
Cobalt, Co	mg/kg	0.5	13	14	12	16
Chromium, Cr	mg/kg	0.5	21	21	14	38
Copper, Cu	mg/kg	0.5	24	34	35	25
Manganese, Mn	mg/kg	2	660	530	570	1600
Nickel, Ni	mg/kg	0.5	23	31	21	21
Lead, Pb	mg/kg	0.5	12	13	15	21
Vanadium, V	mg/kg	0.5	50	48	37	81
Zinc, Zn	mg/kg	0.5	66	70	56	69

Mercury in Soil Method: AN312 Tested: 26/7/2018

Mercury	mg/kg	0.01	0.02	0.02	0.05	0.05
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ASLP (Australian Standard Leaching Procedure) DI Water Method: AN007 Tested: 27/7/2018

Mass of liquid expelled	g	-	-	-	-	-
pH of liquid expelled	pH Units	-	-	-	-	-
Percentage Solids*	%	-	-	-	-	-
Mass of test sample for extraction	g	-	20	20	20	20
Mass of leaching solution used	g	-	400	400	400	400
Leaching solution used*	No unit	-	DIH2O	DIH2O	DIH2O	DIH2O
pH of solids leachate	pH Units	-	9.2	9.4	8.7	8.8
Conductivity @25C	µS/cm	1	110	120	350	730

Alkalinity in ASLP DI Water Extract Method: AN135 Tested: 27/7/2018

Bicarbonate Alkalinity as HCO3	mg/L	5	55	54	11	25
Carbonate Alkalinity as CO3	mg/L	5	<5	<5	<5	<5
Hydroxide Alkalinity as OH	mg/L	5	<5	<5	<5	<5
Total Alkalinity as CaCO3	mg/L	5	55	54	11	25

Chloride by Discrete Analyser in ASLP DI Water Extract Method: AN274 Tested: 27/7/2018

Chloride	mg/L	1	1	<1	78	180
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Parameter	Units	LOR	Sample Number	CE134786.021	CE134786.022	CE134786.023	CE134786.024
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	14 Jun 2018	14 Jun 2018	15 Jun 2018	15 Jun 2018
			Sample Name	FHMB03: 10-15	FHMB03: 15-20	FHMB01: 13-20	FHMB01: 8-11

Metals in ASLP DI Extract by ICPOES Method: AN320/AN321 Tested: 31/7/2018

Aluminium, Al	mg/L	0.005	4.1	1.4	2.6	0.16
Barium, Ba	mg/L	0.005	0.11	0.016	1.1	0.14
Calcium, Ca	mg/L	0.2	19	3.5	10	4.8
Iron, Fe	mg/L	0.005	4.9	0.50	2.1	0.12
Magnesium, Mg	mg/L	0.1	6.1	1.7	11	4.6
Manganese, Mn	mg/L	0.005	0.28	<0.005	0.48	0.009
Potassium, K	mg/L	0.1	4.7	3.8	5.2	2.4
Sodium, Na	mg/L	0.5	15	18	71	110
Sulfur as Sulfate, SO ₄	mg/L	0.3	5.6	7.7	20	30
Sulfur, S	mg/L	0.1	1.9	2.6	6.8	10
Vanadium, V	mg/L	0.005	0.018	0.009	0.034	<0.005
Zinc, Zn	mg/L	0.005	0.027	<0.005	0.011	<0.005

Metals in ASLP DI Water Extract by ICPOES-USN Method: AN320/AN322 Tested: 31/7/2018

Arsenic, As	mg/L	0.003	0.032	0.010	<0.003	<0.003
Beryllium, Be	mg/L	0.0001	0.0011	<0.0001	0.0022	<0.0001
Cadmium, Cd	mg/L	0.0001	0.0001	<0.0001	<0.0001	<0.0001
Copper, Cu	mg/L	0.001	0.013	<0.001	0.12	<0.001
Chromium, Cr	mg/L	0.001	0.003	0.002	0.001	<0.001
Cobalt, Co	mg/L	0.001	0.014	<0.001	0.004	<0.001
Lead, Pb	mg/L	0.001	0.030	<0.001	0.025	<0.001
Nickel, Ni	mg/L	0.001	0.011	<0.001	0.003	<0.001

Mercury in ASLP DI Water Extract Method: AN311(Perth) /AN312 Tested: 1/8/2018

Mercury	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001
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Total Carbon/Sulphur in soil by LECO Method: CSA06V Tested: 21/8/2018

Carbon*	%	0.01	1.4	1.6	0.95	0.20
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Total Organic Carbon (TOC) in soil by LECO and Inorganic Carbon Calc Method: CSA03V Tested: 21/8/2018

TOC*	%	0.05	0.40	0.66	0.54	0.10
Total Inorganic Carbon*	%	0.01	0.98	0.98	0.41	0.09

		Sample Number	CE134786.025	CE134786.026	CE134786.027
		Sample Matrix	Soil	Soil	Soil
		Sample Date	15 Jun 2018	15 Jun 2018	15 Jun 2018
		Sample Name	FHMB01: 11-13	FHMB01: 5-6	FHMB01: 6-8
Parameter		Units	LOR		

Moisture Content Method: AN002 Tested: 24/7/2018

% Moisture	%w/w	0.5	15	4.5	13
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pH in soil (1:2) Method: AN101 Tested: 31/7/2018

pH (1:2) aged	pH Units	-	8.3	7.9	8.3
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Conductivity (1:2) in soil Method: AN106 Tested: 31/7/2018

Conductivity (1:2) aged @ 25C	µS/cm	1	2500	2200	4700
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Total Sulfur Method: AN012/AN320 Tested: 9/8/2018

Total Sulfur	%w/w	0.005	0.015	0.025	0.48
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HCl Extractable S, Ca and Mg in Soil ICP OES Method: AN014 Tested: 9/8/2018

Acid Soluble Sulfur (SHCl)	%w/w	0.005	0.026	0.015	0.027
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Acid Neutralising Capacity or Neutralisation Potential(ANC/NP) Method: AN212 Tested: 3/8/2018

ANC as % CaCO ₃	% CaCO ₃	0.1	0.8	0.5	3.4
Acid Neutralisation Capacity/Neutralisation Potential	kg CaCO ₃ /t	1	7.5	5.0	34
Acid Neutralisation Capacity/Neutralisation Potential kg H ₂ SO ₄ /t	kg H ₂ SO ₄ /t	1	7.4	4.9	33

Parameter	Units	LOR
Sample Number CE134786.025 Sample Matrix Soil Sample Date 15 Jun 2018 Sample Name FHMB01: 11-13		
Sample Number CE134786.026 Sample Matrix Soil Sample Date 15 Jun 2018 Sample Name FHMB01: 5-6		
Sample Number CE134786.027 Sample Matrix Soil Sample Date 15 Jun 2018 Sample Name FHMB01: 6-8		

Net Acid Generation Potential (NAGP) Method: AN215 Tested: 10/8/2018

Net Acid Production Potential (Tot S and ANC only)	kg H ₂ SO ₄ /T	-400	-7	-4	-18
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Single Addition Net Acid Generation (NAG) Method: AN216 Tested: 3/8/2018

ECox (NAG Conductivity)	µS/cm	1	150	110	290
pHox (NAG pH)	No unit	-	8.1	7.8	9.0
NAG as kg H ₂ SO ₄ /tonne to pH 4.5	kg H ₂ SO ₄ /T	0.5	<0.5	<0.5	<0.5
NAG as kg H ₂ SO ₄ /tonne to pH 7	kg H ₂ SO ₄ /T	0.5	<0.5	<0.5	<0.5
NAG as kg CaCO ₃ /tonne to pH 4.5	kg CaCO ₃ /T	1	<1.0	<1.0	<1.0
NAG as kg CaCO ₃ /tonne to pH 7	kg CaCO ₃ /T	1	<1.0	<1.0	<1.0

Chromium Reducible Sulphur (CRS) Method: AN217 Tested: 2/8/2018

Chromium Reducible Sulphur (Scr)	%	0.005	<0.005	<0.005	<0.005
Chromium Reducible Sulphur (Scr)	moles H+/T	5	<5	<5	<5

pH in soil (1:5) Method: AN101 Tested: 27/7/2018

pH	pH Units	0.1	8.8	8.1	8.8
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Conductivity and TDS by Calculation - Soil Method: AN106 Tested: 27/7/2018

Conductivity of Extract (1:5 dry sample basis)	µS/cm	1	1300	990	2400
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Exchangeable Cations and Cation Exchange Capacity (CEC/ESP/SAR) Method: AN122 Tested: 30/7/2018

Exchangeable Magnesium, Mg	mg/kg	2	670	410	1400
Exchangeable Sodium, Na	mg/kg	2	1900	1500	4900
Exchangeable Potassium, K	mg/kg	2	130	150	600
Exchangeable Calcium, Ca	mg/kg	2	1400	360	4200
Exchangeable Sodium, Na	meq/100g	0.01	8.3	6.5	22
Exchangeable Potassium, K	meq/100g	0.01	0.33	0.39	1.5
Exchangeable Calcium, Ca	meq/100g	0.01	7.1	1.8	21
Exchangeable Magnesium, Mg	meq/100g	0.02	5.5	3.3	11
Exchangeable Sodium Percentage*	%	0.1	39.2	54.1	39.0
Exchangeable Potassium Percentage*	%	0.1	1.5	3.2	2.8
Exchangeable Calcium Percentage*	%	0.1	33.4	14.9	37.9
Exchangeable Magnesium Percentage*	%	0.1	25.8	27.8	20.3
Exchangeable Calcium/Exchangeable Magnesium Ratio*	No unit	0.1	1.3	0.5	1.9
Cation Exchange Capacity	meq/100g	0.02	21	12	55

Parameter	Units	LOR	Sample Number	CE134786.025	CE134786.026	CE134786.027
			Sample Matrix	Soil	Soil	Soil
			Sample Date	15 Jun 2018	15 Jun 2018	15 Jun 2018
			Sample Name	FHMB01: 11-13	FHMB01: 5-6	FHMB01: 6-8

Soil - Aluminium (KCL Extraction) Method: AN046 Tested: 30/7/2018

Exchangeable Aluminium*	mg/kg	1	<1.0	<1.0	<1.0
Exchangeable Aluminium*	cmol (+)/kg	0.01	<0.01	<0.01	<0.01

Total Recoverable Elements in Soil/Waste Solids/Materials by ICPOES Method: AN040/AN320 Tested: 26/7/2018

Arsenic, As	mg/kg	0.5	6.4	8.4	5.6
Barium, Ba	mg/kg	0.5	640	470	160
Beryllium, Be	mg/kg	0.05	0.64	0.88	0.96
Cadmium, Cd	mg/kg	0.1	0.1	0.2	<0.1
Cobalt, Co	mg/kg	0.5	10	20	11
Chromium, Cr	mg/kg	0.5	9.1	19	10
Copper, Cu	mg/kg	0.5	23	17	26
Manganese, Mn	mg/kg	2	270	1800	460
Nickel, Ni	mg/kg	0.5	19	17	13
Lead, Pb	mg/kg	0.5	9.3	22	15
Vanadium, V	mg/kg	0.5	23	60	32
Zinc, Zn	mg/kg	0.5	51	34	89

Mercury in Soil Method: AN312 Tested: 26/7/2018

Mercury	mg/kg	0.01	0.04	<0.01	0.02
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ASLP (Australian Standard Leaching Procedure) DI Water Method: AN007 Tested: 27/7/2018

Mass of liquid expelled	g	-	-	-	-
pH of liquid expelled	pH Units	-	-	-	-
Percentage Solids*	%	-	-	-	-
Mass of test sample for extraction	g	-	20	20	20
Mass of leaching solution used	g	-	400	400	400
Leaching solution used*	No unit	-	DIH2O	DIH2O	DIH2O
pH of solids leachate	pH Units	-	9.4	8.5	9.4
Conductivity @25C	µS/cm	1	390	290	780

Alkalinity in ASLP DI Water Extract Method: AN135 Tested: 27/7/2018

Bicarbonate Alkalinity as HCO3	mg/L	5	44	6	70
Carbonate Alkalinity as CO3	mg/L	5	<5	<5	<5
Hydroxide Alkalinity as OH	mg/L	5	<5	<5	<5
Total Alkalinity as CaCO3	mg/L	5	44	6	70

Chloride by Discrete Analyser in ASLP DI Water Extract Method: AN274 Tested: 27/7/2018

Chloride	mg/L	1	74	65	170
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Parameter	Units	LOR	Sample Number	CE134786.025	CE134786.026	CE134786.027
			Sample Matrix	Soil	Soil	Soil
			Sample Date	15 Jun 2018	15 Jun 2018	15 Jun 2018
			Sample Name	FHMB01: 11-13	FHMB01: 5-6	FHMB01: 6-8

Metals in ASLP DI Extract by ICPOES Method: AN320/AN321 Tested: 31/7/2018

Aluminium, Al	mg/L	0.005	1.4	3.1	2.0
Barium, Ba	mg/L	0.005	0.24	1.5	0.029
Calcium, Ca	mg/L	0.2	4.4	6.6	3.2
Iron, Fe	mg/L	0.005	0.30	1.4	1.3
Magnesium, Mg	mg/L	0.1	2.9	8.4	2.4
Manganese, Mn	mg/L	0.005	0.024	0.41	0.020
Potassium, K	mg/L	0.1	2.1	3.1	4.0
Sodium, Na	mg/L	0.5	66	57	140
Sulfur as Sulfate, SO ₄	mg/L	0.3	21	19	35
Sulfur, S	mg/L	0.1	7.2	6.2	12
Vanadium, V	mg/L	0.005	<0.005	0.025	0.016
Zinc, Zn	mg/L	0.005	<0.005	0.015	<0.005

Metals in ASLP DI Water Extract by ICPOES-USN Method: AN320/AN322 Tested: 31/7/2018

Arsenic, As	mg/L	0.003	<0.003	0.005	0.005
Beryllium, Be	mg/L	0.0001	0.0001	0.0012	<0.0001
Cadmium, Cd	mg/L	0.0001	0.0001	0.0002	<0.0001
Copper, Cu	mg/L	0.001	0.003	0.012	<0.001
Chromium, Cr	mg/L	0.001	0.001	0.001	0.001
Cobalt, Co	mg/L	0.001	<0.001	0.005	<0.001
Lead, Pb	mg/L	0.001	0.005	0.010	0.002
Nickel, Ni	mg/L	0.001	0.001	0.003	<0.001

Mercury in ASLP DI Water Extract Method: AN311(Perth) /AN312 Tested: 1/8/2018

Mercury	mg/L	0.0001	<0.0001	<0.0001	<0.0001
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Total Carbon/Sulphur in soil by LECO Method: CSA06V Tested: 21/8/2018

Carbon*	%	0.01	0.73	0.06	0.71
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Total Organic Carbon (TOC) in soil by LECO and Inorganic Carbon Calc Method: CSA03V Tested: 21/8/2018

TOC*	%	0.05	0.61	<0.05	0.26
Total Inorganic Carbon*	%	0.01	0.11	0.05	0.43

MB blank results are compared to the Limit of Reporting

LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.

DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage*. Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

Acid Neutralising Capacity or Neutralisation Potential(ANC/NP) Method: ME-(AU)-[ENV]AN212

Parameter	QC Reference	Units	LOR	DUP %RPD	LCS %Recovery
Acid Neutralisation Capacity/Neutralisation Potential	LB058829	kg CaCO ₃ /T	1	0 - 2%	NA
Acid Neutralisation Capacity/Neutralisation Potential kg H ₂ SO ₄ /t	LB058829	kg H ₂ SO ₄ /T	1	0 - 2%	NA

Alkalinity in ASLP DI Water Extract Method: ME-(AU)-[ENV]AN135

Parameter	QC Reference	Units	LOR	DUP %RPD
Total Alkalinity as CaCO ₃	LB058631	mg/L	5	4 - 9%

Chromium Reducible Sulphur (CRS) Method: ME-(AU)-[ENV]AN217

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Chromium Reducible Sulphur (Scr)	LB058793	%	0.005	<0.005	0 - 1%	95%
Chromium Reducible Sulphur (Scr)	LB058793	moles H ⁺ /T	5	<5		

Conductivity (1:2) in soil Method: ME-(AU)-[ENV]AN106

Parameter	QC Reference	Units	LOR	DUP %RPD
Conductivity (1:2) aged @ 25C	LB058739	µS/cm	1	1 - 11%

Conductivity and TDS by Calculation - Soil Method: ME-(AU)-[ENV]AN106

Parameter	QC Reference	Units	LOR	DUP %RPD	LCS %Recovery
Conductivity of Extract (1:5 dry sample basis)	LB058632	µS/cm	1	0 - 2%	104%

Exchangeable Cations and Cation Exchange Capacity (CEC/ESP/SAR) Method: ME-(AU)-[ENV]AN122

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Exchangeable Magnesium, Mg	LB058672	mg/kg	2		0 - 2%	99 - 103%
Exchangeable Sodium, Na	LB058672	mg/kg	2		0 - 2%	97 - 100%
Exchangeable Potassium, K	LB058672	mg/kg	2		0 - 2%	107 - 113%
Exchangeable Calcium, Ca	LB058672	mg/kg	2		0 - 1%	99 - 100%
Exchangeable Sodium, Na	LB058672	meq/100g	0.01	<0.01		
Exchangeable Potassium, K	LB058672	meq/100g	0.01	<0.01		
Exchangeable Calcium, Ca	LB058672	meq/100g	0.01	<0.01		
Exchangeable Magnesium, Mg	LB058672	meq/100g	0.02	<0.02		
Exchangeable Sodium Percentage*	LB058672	%	0.1	47.9 - 53.4		
Exchangeable Potassium Percentage*	LB058672	%	0.1	9.3 - 10.4		
Exchangeable Calcium Percentage*	LB058672	%	0.1	27.5 - 35.5		
Exchangeable Magnesium Percentage*	LB058672	%	0.1	7.4 - 9.8		
Exchangeable Calcium/Exchangeable Magnesium Ratio*	LB058672	No unit	0.1	3.1 - 4.8		
Cation Exchange Capacity	LB058672	meq/100g	0.02	<0.02		

MB blank results are compared to the Limit of Reporting

LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.

DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage*. Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

Mercury in ASLP DI Water Extract Method: ME-(AU)-[ENV]AN311(Perth) /AN312

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Mercury	LB058768	mg/L	0.0001	<0.0001	0%	NA

Mercury in Soil Method: ME-(AU)-[ENV]AN312

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Mercury	LB058605	mg/kg	0.01	<0.01	0 - 3%	104 - 105%

Metals in ASLP DI Extract by ICPOES Method: ME-(AU)-[ENV]AN320/AN321

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Aluminium, Al	LB058709	mg/L	0.005	<0.005	0 - 8%	NA	NA
Barium, Ba	LB058709	mg/L	0.005	<0.005	0 - 6%	NA	NA
Calcium, Ca	LB058709	mg/L	0.2	<0.2	1 - 5%	NA	NA
Iron, Fe	LB058709	mg/L	0.005	<0.005	0 - 6%	NA	NA
Magnesium, Mg	LB058709	mg/L	0.1	<0.1	1 - 6%	NA	NA
Manganese, Mn	LB058709	mg/L	0.005	<0.005	0 - 8%	NA	NA
Potassium, K	LB058709	mg/L	0.1	<0.1	1 - 7%	NA	NA
Sodium, Na	LB058709	mg/L	0.5	<0.5	1 - 2%	NA	NA
Sulfur as Sulfate, SO4	LB058709	mg/L	0.3	<0.3	0 - 9%	NA	NA
Sulfur, S	LB058709	mg/L	0.1	<0.1	0 - 9%	NA	NA
Vanadium, V	LB058709	mg/L	0.005	<0.005	0 - 6%	NA	NA
Zinc, Zn	LB058709	mg/L	0.005	<0.005	0 - 6%	NA	NA

Metals in ASLP DI Water Extract by ICPOES-USN Method: ME-(AU)-[ENV]AN320/AN322

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Arsenic, As	LB058711	mg/L	0.003	<0.003	0 - 3%	NA
Beryllium, Be	LB058711	mg/L	0.0001	<0.0001	0 - 19%	NA
Cadmium, Cd	LB058711	mg/L	0.0001	<0.0001	0 - 3%	NA
Copper, Cu	LB058711	mg/L	0.001	<0.001	0 - 6%	NA
Chromium, Cr	LB058711	mg/L	0.001	<0.001	0 - 6%	NA
Cobalt, Co	LB058711	mg/L	0.001	<0.001	0 - 7%	NA
Lead, Pb	LB058711	mg/L	0.001	<0.001	0 - 5%	NA
Nickel, Ni	LB058711	mg/L	0.001	<0.001	0 - 1%	NA

MB blank results are compared to the Limit of Reporting

LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.

DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage*. Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

pH in soil (1:2) Method: ME-(AU)-[ENV]AN101

Parameter	QC Reference	Units	LOR	DUP %RPD
pH (1:2) aged	LB058739	pH Units	-	0%

pH in soil (1:5) Method: ME-(AU)-[ENV]AN101

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
pH	LB058632	pH Units	0.1	5.8	0 - 1%	101%

Single Addition Net Acid Generation (NAG) Method: ME-(AU)-[ENV]AN216

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
ECox (NAG Conductivity)	LB058830	µS/cm	1	40	5 - 7%	102%
pHox (NAG pH)	LB058830	No unit	-	4.0	0 - 4%	96%
NAG as kg H ₂ SO ₄ /tonne to pH 4.5	LB058830	kg H ₂ SO ₄ /T	0.5		0%	
NAG as kg H ₂ SO ₄ /tonne to pH 7	LB058830	kg H ₂ SO ₄ /T	0.5		0%	
NAG as kg CaCO ₃ /tonne to pH 4.5	LB058830	kg CaCO ₃ /T	1		0%	
NAG as kg CaCO ₃ /tonne to pH 7	LB058830	kg CaCO ₃ /T	1		0%	

Soil - Aluminium (KCL Extraction) Method: AN046

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Exchangeable Aluminium*	LB058669	mg/kg	1	<1.0	0%	NA
Exchangeable Aluminium*	LB058669	cmol (+)/kg	0.01	<0.01	0%	NA

Total Recoverable Elements in Soil/Waste Solids/Materials by ICPOES Method: ME-(AU)-[ENV]AN040/AN320

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Arsenic, As	LB058603	mg/kg	0.5	<0.5	0 - 7%	98 - 99%
Barium, Ba	LB058603	mg/kg	0.5	<0.5	1 - 3%	96%
Beryllium, Be	LB058603	mg/kg	0.05	<0.05	0 - 2%	101 - 102%
Cadmium, Cd	LB058603	mg/kg	0.1	<0.1	0%	95%
Cobalt, Co	LB058603	mg/kg	0.5	<0.5	1 - 3%	95%
Chromium, Cr	LB058603	mg/kg	0.5	<0.5	3 - 17%	101 - 103%
Copper, Cu	LB058603	mg/kg	0.5	<0.5	2 - 5%	101 - 102%
Manganese, Mn	LB058603	mg/kg	2	<2	0 - 3%	95 - 96%
Nickel, Ni	LB058603	mg/kg	0.5	<0.5	3 - 4%	96 - 97%
Lead, Pb	LB058603	mg/kg	0.5	<0.5	3 - 7%	98 - 99%
Vanadium, V	LB058603	mg/kg	0.5	<0.5	1 - 4%	97%
Zinc, Zn	LB058603	mg/kg	0.5	<0.5	0 - 3%	93 - 94%

METHOD

METHODOLOGY SUMMARY

AN002	The test is carried out by drying (at either 40°C or 105°C) a known mass of sample in a weighed evaporating basin. After fully dry the sample is re-weighed. Samples such as sludge and sediment having high percentages of moisture will take some time in a drying oven for complete removal of water.						
AN007	Contaminants of interest in a waste material are leached out of the waste with a selected leaching solution under controlled conditions. The ratio of sample to extraction fluid is 100 g to 2 L (1 to 20 by mass). The concentration of each contaminant of interest is determined in the leachate by appropriate methods after separation from the sample by filtering. Based on AS4439.3.						
AN012/AN320	Dried prepared soil is digested by oxidation with nitric acid and bromine followed by analysis of the digest by ICP OES.						
AN014	This method is for the determination of soluble sulfate (SO ₄ -S) by extraction with hydrochloric acid. Sulphides should not react and would normally be expelled. Sulfur is determined by ICP.						
AN040/AN320	A portion of sample is digested with nitric acid to decompose organic matter and hydrochloric acid to complete the digestion of metals. The digest is then analysed by ICP OES with metals results reported on the dried sample basis. Based on USEPA method 200.8 and 6010C.						
AN101	pH in Soil Sludge Sediment and Water: pH is measured electrometrically using a combination electrode and is calibrated against 3 buffers purchased commercially. For soils, sediments and sludges, an extract with water (or 0.01M CaCl ₂) is made at a ratio of 1:5 and the pH determined and reported on the extract. Reference APHA 4500-H+.						
AN106	Conductivity and TDS by Calculation: Conductivity is measured by meter with temperature compensation and is calibrated against a standard solution of potassium chloride. Conductivity is generally reported as µmhos/cm or µS/cm @ 25°C. For soils, an extract with water is made at a ratio of 1:5 and the EC determined and reported on the extract, or calculated back to the as-received sample. Salinity can be estimated from conductivity using a conversion factor, which for natural waters, is in the range 0.55 to 0.75. Reference APHA 2510 B.						
AN106	Resistivity of the extract is reported on the extract basis and is the reciprocal of conductivity. Salinity and TDS can be calculated from the extract conductivity and is reported back to the soil basis.						
AN122	Exchangeable Cations, CEC and ESP: Soil sample is extracted in 1M Ammonium Acetate at pH=7 (or 1M Ammonium Chloride at pH=7) with cations (Na, K, Ca & Mg) then determined by ICP OES/ICP MS and reported as Exchangeable Cations. For saline soils, these results can be corrected for water soluble cations and reported as Exchangeable cations in meq/100g or soil can be pre-treated (aqueous ethanol/aqueous glycerol) prior to extraction. Cation Exchange Capacity (CEC) is the sum of the exchangeable cations in meq/100g.						
AN122	The Exchangeable Sodium Percentage (ESP) is calculated as the exchangeable sodium divided by the CEC (all in meq/100g) times 100. ESP can be used to categorise the sodicity of the soil as below : <table> <tr> <td>ESP < 6%</td><td>non-sodic</td></tr> <tr> <td>ESP 6-15%</td><td>sodic</td></tr> <tr> <td>ESP >15%</td><td>strongly sodic</td></tr> </table> Method is referenced to Rayment and Lyons, 2011, sections 15D3 and 15N1.-	ESP < 6%	non-sodic	ESP 6-15%	sodic	ESP >15%	strongly sodic
ESP < 6%	non-sodic						
ESP 6-15%	sodic						
ESP >15%	strongly sodic						
AN135	Alkalinity (and forms of) by Titration: The sample Extract is titrated with standard acid to pH 8.3 (P titre) and pH 4.5 (T titre) and permanent and/or total alkalinity calculated. The results are expressed as equivalents of calcium carbonate or recalculated as bicarbonate, carbonate and hydroxide. Reference APHA 2320. Internal Reference AN135						
AN212	Samples are initially evaluated to determine the strength of reagents needed using a 'fizz' test. Samples are then subjected to an excess of hydrochloric acid followed by alkaline back titration to pH 7. Results are expressed in kg H ₂ SO ₄ /tonne or Kg CaCO ₃ /tonne after correction for moisture content if applicable.						

METHOD

METHODOLOGY SUMMARY

AN215	This is purely a calculation based on results obtained from Total Sulphur , Sulfate Method, and Acid Neutralisation Capacity Method (ME-AU-ENV-AN212). The negative value included as the LOR allows negative NAPP data to be reported in the LIMS, it is not the numerical LOR which would theoretically be 1kg H2SO4/tonne. The range of results is theoretically -980 to 1640kg H2SO4/Tonne.
AN216	Pulverised sub-sample of a waste rock or an as received sample of filter cake, soil or sludge is subjected to an oxidising digest with 15% hydrogen peroxide adjusted to pH 4.5. The pH and EC of the NAG suspension is recorded at various stages in the digest. The acid produced (if any) is titrated using standardised NaOH to pH 7.0. NAG results are reported to 0.5 kg H2SO4/tonne.
AN217	Dried pulped sample is mixed with acid and chromium metal in a rapid distillation unit to produce hydrogen sulfide (H2S) which is collected and titrated with iodine (I2(aq)) to measure SCR.
AN274	Chloride by Aquakem DA following ASLP DI extraction: Chloride reacts with mercuric thiocyanate forming a mercuric chloride complex. In the presence of ferric iron, highly coloured ferric thiocyanate is formed which is proportional to the chloride concentration. Reference APHA 4500Cl-
AN311(Perth) /AN312	Mercury by Cold Vapour AAS in Waters: Mercury ions are reduced by stannous chloride reagent in acidic solution to elemental mercury. This mercury vapour is purged by nitrogen into a cold cell in an atomic absorption spectrometer or mercury analyser. Quantification is made by comparing absorbances to those of the calibration standards. Reference APHA 3112/3500.
AN312	Mercury by Cold Vapour AAS in Soils: After digestion with nitric acid, hydrogen peroxide and hydrochloric acid, mercury ions are reduced by stannous chloride reagent in acidic solution to elemental mercury. This mercury vapour is purged by nitrogen into a cold cell in an atomic absorption spectrometer or mercury analyser. Quantification is made by comparing absorbances to those of the calibration standards. Reference APHA 3112/3500
AN320	ICP-OES (Ultrasonic Nebuliser): After preservation with 10% nitric acid, a wide range of metals and some non-metals in solution can be measured by ICP- Ultrasonic nebulisation. Solutions are aspirated using an ultrasonic nebuliser into an argon plasma at 8000-10000K and emit characteristic energy or light as a result of electron transitions through unique energy levels. The emitted light is focused onto a diffraction grating where it is separated into components.
AN320/322	Photomultipliers or CCDs are used to measure the light intensity at specific wavelengths. This intensity is directly proportional to concentration. Corrections are required to compensate for spectral overlap between elements. Reference APHA 3120 B
AN320/AN321	Metals by ICP-OES: Samples are preserved with 10% nitric acid for a wide range of metals and some non-metals. This solution is measured by Inductively Coupled Plasma. Solutions are aspirated into an argon plasma at 8000-10000K and emit characteristic energy or light as a result of electron transitions through unique energy levels. The emitted light is focused onto a diffraction grating where it is separated into components .
AN320/AN321	Photomultipliers or CCDs are used to measure the light intensity at specific wavelengths. This intensity is directly proportional to concentration. Corrections are required to compensate for spectral overlap between elements. Reference APHA 3120 B.
CSA03V	This method involves the determination of total carbon which includes both organic and inorganic carbon. Carbon is determined via infra red absorption of the evolved CO2 gases after heating the sample in a carrier gas of oxygen. The IR cal output is calibrated against the value of the known standards to provide the total carbon value of the unknown sample.
CSA06V	The sulfur is oxidised to sulfur trioxide gas in a tube furnace using oxygen to aid the oxidation process. The evolved sulfur trioxide is measured by an infra red cell. The infra red cell output is calibrated against the value of a known standard sample to provide the total sulfur value of the unknown sample.

METHOD

METHODOLOGY SUMMARY

SOL061

Soil sample is extracted 1:10 in 1MKCl with aluminium determined by ICP OES.

FOOTNOTES

IS	Insufficient sample for analysis.	LOR	Limit of Reporting
LNR	Sample listed, but not received.	↑↓	Raised or Lowered Limit of Reporting
*	NATA accreditation does not cover the performance of this service.	QFH	QC result is above the upper tolerance
**	Indicative data, theoretical holding time exceeded.	QFL	QC result is below the lower tolerance
		-	The sample was not analysed for this analyte
		NVL	Not Validated

Samples analysed as received.

Solid samples expressed on a dry weight basis.

Where "Total" analyte groups are reported (for example, Total PAHs, Total OC Pesticides) the total will be calculated as the sum of the individual analytes, with those analytes that are reported as <LOR being assumed to be zero. The summed (Total) limit of reporting is calculated by summing the individual analyte LORs and dividing by two. For example, where 16 individual analytes are being summed and each has an LOR of 0.1 mg/kg, the "Totals" LOR will be 1.6 / 2 (0.8 mg/kg). Where only 2 analytes are being summed, the "Total" LOR will be the sum of those two LORs.

Some totals may not appear to add up because the total is rounded after adding up the raw values.

If reported, measurement uncertainty follow the ± sign after the analytical result and is expressed as the expanded uncertainty calculated using a coverage factor of 2, providing a level of confidence of approximately 95%, unless stated otherwise in the comments section of this report.

Results reported for samples tested under test methods with codes starting with ARS-SOP, radionuclide or gross radioactivity concentrations are expressed in becquerel (Bq) per unit of mass or volume or per wipe as stated on the report. Becquerel is the SI unit for activity and equals one nuclear transformation per second.

Note that in terms of units of radioactivity:

- 1 Bq is equivalent to 27 pCi
- 37 MBq is equivalent to 1 mCi

For results reported for samples tested under test methods with codes starting with ARS-SOP, less than (<) values indicate the detection limit for each radionuclide or parameter for the measurement system used. The respective detection limits have been calculated in accordance with ISO 11929.

The QC criteria are subject to internal review according to the SGS QAQC plan and may be provided on request or alternatively can be found here : <http://www.sgs.com.au/~media/Local/Australia/Documents/Technical%20Documents/MP-AU-ENV-QU-022%20QA%20QC%20Plan.pdf>

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Fairhill Coal Project

**Progressive Rehabilitation and Closure Plan (PRCP)
Community Consultation Plan**

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1 Introduction

Community consultation undertaken during the development of the PRC Plan is detailed in the PRC Plan and the Community and Consultation Register (Appendix A).

Progressive Rehabilitation and Closure Planning requires a Community Consultation Plan (CCP) to be developed to ensure that relevant stakeholders i.e. anyone impacted by **rehabilitation and closure activities** are kept informed and given an opportunity to comment on the rehabilitation and closure of the site. This CCP details ongoing consultation in relation to the rehabilitation and closure of the site and ensures compliance with section 126C(1)(c)(iii) and (iv) of the EP Act.

1.1 Purpose and Scope

The purpose of the CCP is to:

- Identify the land where the activity will occur, and adjacent land.
- Identify stakeholders that are likely to have a genuine interest in the land or will be impacted either directly or indirectly by rehabilitation activities and the closure plan.
- Detail the engagement approach.
- Details the process of recording, and managing stakeholder comments/concerns.

1.2 Objectives

The CCP aims to provide FHCP with a practical and ongoing management tool for effective stakeholder engagement specifically relating to rehabilitation activities and the closure plan. This will ensure that anyone impacted by rehabilitation and closure activities will be kept informed, provided with opportunities to communicate and provide feedback.

The objectives of the CCP include:

- Identifying the activity, the land on which it occurs and adjacent land;
- Identifying the activity components that have not yet been consulted and require ongoing consultation;
- Identifying and recording key stakeholders;
- Identifying the level, style and frequency of engagement required;
- Determining the information and appropriate method of communication;
- Providing opportunities for communication or avenues to receive feedback;
- Describing the procedure for recording and responding to complaints; and
- Incorporating feedback into mine rehabilitation and closure plans.

2 The Activity

The Fairhill Coal Project operates on mining lease (ML) 700043 under Environmental Authority (EA) BRID0071. The ML is held by Fairhill Coking Coal Pty Ltd (FHCP), a wholly owned subsidiary of Futura Resources Ltd. Project details are available in the PRC Plan.

Activities considered in relation to stakeholder consultation for PRC Plan & PRC Plan Schedule components are as follows.

2.1 Land disturbances that will facilitate the project

- Open pit;
- Overburden dumps;
- Administration office blocks for personnel.
- Ablution facilities.
- Surface water and mine-affected water (MAW) management structures (dams);
- Maintenance workshop and laydown area;
- Warehouse facilities for mining and haulage contractors;
- Power generators for workshop, and administration facilities;
- Haul road network, and site access road network; and
- ROM coal stockpile area.

These are not outcomes but rather disturbance activities that are approved under the granted Mining Leases and Environmental Authority. These are therefore not considered to be outcomes requiring a demonstration of consultation as a key component of the PRC Plan. These impacts have been addressed through legislated public notice requirements as part of the approvals process.

2.2 Proposed final post mining land use (PMLU) final landform design and retained infrastructure:

The PMLU proposed for all land associated with the Project aims to re-instate the pre-mining land use of low-intensity grazing at the completion of PRC Plan rehabilitation activities.

At the cessation of depression will remain as a feature of the post-mining landform, as proposed and approved under the ML and EA for the Project.

Infrastructure that is proposed to be retained in the post-mining landscape is limited to items considered advantageous to on-going land management activities associated with the PMLU of low-intensity cattle grazing. Retention of specific project infrastructure has not yet been agreed or planned for at this stage, however the possibility of infrastructure retention will be assessed and agreed closer to the end of the active life of mine. Water storages comprise Infrastructure likely to be considered for retention is described in the PRCP Plan.

The PMLU of grazing and the depression are consistent with the existing land use and already has prior approval through the Project EA. These are PRC Plan components that are transitioned from the EA to the PRC Plan and are therefore not considered to be outcomes requiring a demonstration of consultation as a key component of the PRC Plan. However, as noted in the Community Consultation Register, consultation on these outcomes has been undertaken as part of the ML and EA permitting and approvals process.

Any requests to retain infrastructure consistent with the final PMLU will be negotiated with landholder.

2.3 Rehabilitation Outcomes (Objectives, Indicators and Completion Criteria)

The General Rehabilitation Goal is to rehabilitate the land to a stable condition:

- (a) the land is safe and structurally stable;
- (b) there is no environmental harm being caused by anything on or in the land; and
- (c) the land can sustain a post-mining land use.

To achieve rehabilitation objectives, separate domains are defined:

- Domain 1 - Open Cut Depression
- Domain 2 - Overburden Spoil Dump
- Domain 3 - Access Tracks and Haul Roads
- Domain 4 - Water Storage Infrastructure – to be retained.
- Domain 5 - Mine Infrastructure (Site office, ROM pad, and Workshop buildings), and Water storage Infrastructure – to be decommissioned.

Rehabilitation objectives, indicators and completion criteria are outlined in Table 11 of the PRC Plan and are included in the Project's EA. These are land outcomes that are already pre-approved and which are being transitioned into the PRC Plan.

A progressive rehabilitation requirement representing the area of disturbance as a percentage that must achieve the completion criteria and associated timeframe is provided in Table 21 of the PRC Plan. This is being transitioned into the PRC Plan and aligns with the proposed PRCP Schedule.

Sections 2.1, 2.2 and 2.3 above, are all outcomes which have been addressed through consultation to date. These comprise all of the land outcomes, rehabilitation completion criteria and the area of disturbance achieving completion criteria on a timeframe basis, and which are pre-approved and are being transitioned into the *rehabilitation planning part* of the proposed PRC Plan.

2.4 Rehabilitation and Management Methodology

Throughout the approvals process the Fairhill Coal Project has outlined its rehabilitation strategy ensuring that the methodologies proposed will meet the Department of Environment Science and Innovation's (DESI) requirements for achieving a stable condition (see the Fairhill Coal Project – Mine Closure Plan). The rehabilitation methodologies that are proposed have formed part of the project approvals and have been carried through to the PRC Plan. Components of rehabilitation methodology that are not fully refined will be further refined over the initial stages on mine life and will be consulted accordingly. eg. establishing Landscape Function Analysis (LFA) reference sites and better topsoil inventory estimates. This information is key to measuring success against rehabilitation milestone criteria.

2.5 Rehabilitation Schedule

In the PRC Plan Schedule, the domains described in the PRC Plan are further detailed as 'Rehabilitation Areas' with 'Rehabilitation Milestones' and 'Rehabilitation Milestone Criteria' applicable to each. Completion dates for each milestone are identified and these are targets that will be used to demonstrate that progressive rehabilitation is occurring and that milestone criteria are being achieved.

Rehabilitation Milestone Monitoring will be the measure of how rehabilitation is tracking towards achieving Milestone criteria and final rehabilitation of the site.

The PRC Plan Schedule and Rehabilitation Milestone Monitoring is the primary consideration for ongoing community consultation and this Community Consultation Plan.

2.6 Land tenure and Landholders

The project Mining Lease (ML), ML700043 is held by Fairhill Coking Coal Pty Ltd (FHCP), a wholly owned subsidiary of Futura Resources Ltd, and are situated over one underlying tenure (Table 2-1). Adjacent Landholders are listed below (Table 2-2).

Table 2-1 Underlying Landholder

Lot/Plan	Council	Tenure	Usage	Owner
2/TT241	Isaac Regional	Freehold	Grazing	Peter and Denise Comiskey
M/TT397	Isaac Regional	Easement	No Longer Used	N/A

Table 2-2 Adjacent Landholder

Lot/Plan	Council	Tenure	Property Name	Owner
2/SP254309	Isaac Regional	Freehold	Red Rock	R & R Simmons
1/SP165518	Isaac Regional	Freehold	Red Rock	D & M Haigh

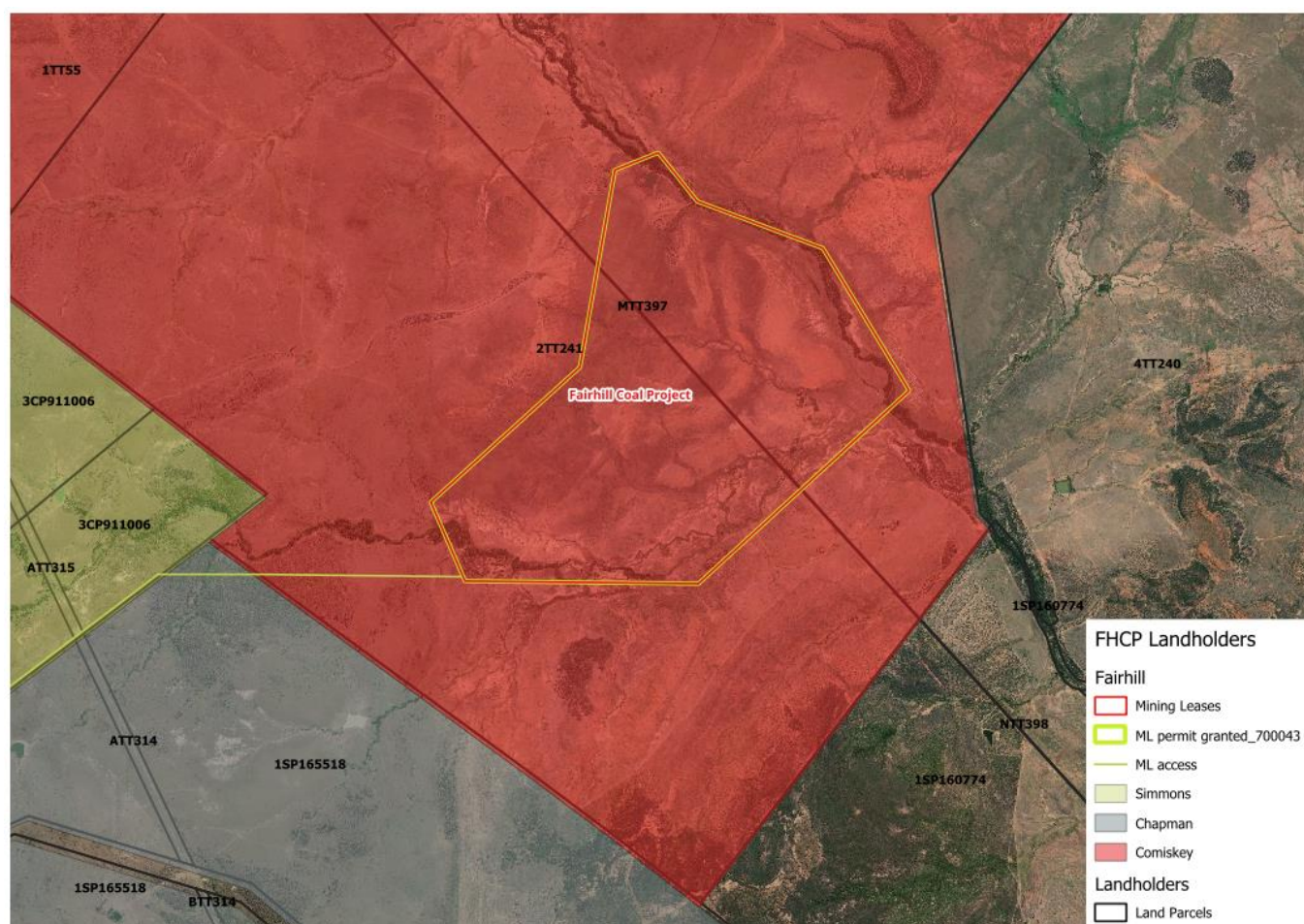


Figure 2-1. Underlying and Adjacent Landholders

3 Community Engagement

Key stakeholders are identified in accordance with the Information Sheet – Community Consultation for PRCP (ESR/2019/51012), as those who in the broader community are directly impacted by the rehabilitation process or final land outcomes. They should have a genuine interest in

- the land on which the activity is occurring;
- adjacent land; and
- surroundings that are likely to be impacted

The interest should be genuine, but the ‘area of interest’ may differ for each interested party identified.

3.1 Relevant Community Members

Table 3-1, below lists potential interested stakeholders according to the Information Sheet – Community Consultation for PRCP (ESR/2019/51012). The table also lists the areas of potential interest in relation to progressive rehabilitation and post-mining land outcomes. Areas of interest take cognisance of consultation undertaken to date and conduct and compensation/ settlement agreements.

Table 3-1 Stakeholder by category and potential area of interest

Interested Stakeholders	Area of Interest
Underlying Landholders:	
Peter and Denise Comiskey (Lyra Park)	• Direct impact; • Land Use (weed control, access, grazing, management of surface and groundwater); • Infrastructure to be retained.
Adjacent Landholders:	
Richard and Robyn Simmons (Simmons Cattle Company)	• Indirect impact • Land Use (eg. weed control, access, grazing, management of surface and groundwater); • Health • Amenity
Keith and Carolyn Chapman & Debora & Murray Haigh (Redrock)	
Clint Chalmers (Simmons Cattle Company)	
Traditional Owners	
Western Kangoulu	• Cultural • Heritage
Local Council	
Isaac Regional Council	• Land Use • Environmental • Health • Planning and Infrastructure • Economic • Social

Neighbouring Mining Operations

Other Operators in the area

- Kestrel (18km), Crinum and Gregory (25km) Mines to the northwest;
- Oaky Creek, 28km to the north; and
- Curragh Mine 37km to the east.
- Ensham Coal Project to the South

- Land Use
- Environmental
- Health

State Regulators

Queensland Department of Environment, Science and Innovation (DESI)

- Land Use
- Environmental
- Health
- Economic
- Social

Queensland Department of Resources (DoR)

- Land Use
- Safety
- Planning and Infrastructure
- Economic
- Social

Queensland Department of Transport and Main Roads (DTMR)

- Planning and Infrastructure

3.2 Consultation

The FHCP is a small-scale, short-term coal project located within a well-established coal mining region of Queensland. Based on this and limited social impacts determined to be associated with the Project, the need for broad community engagement has been determined to be limited. Representative bodies for the community (IRC, government agencies) will and have been consulted and the general public has had the opportunity to comment on the EA application and PRCP as part of the EA application assessment process. General awareness of the project and interested parties have been well established.

3.2.1 Levels of Community Engagement

Three tiers of engagement are identified. The intensity of engagement scales from 'Level 1' which is targeted and more appropriate for directly impacted landholders through to broader scale interest driven engagement for potentially interested members of the community that are less likely to be interested in rehabilitation progress or specific closure criteria achievement.

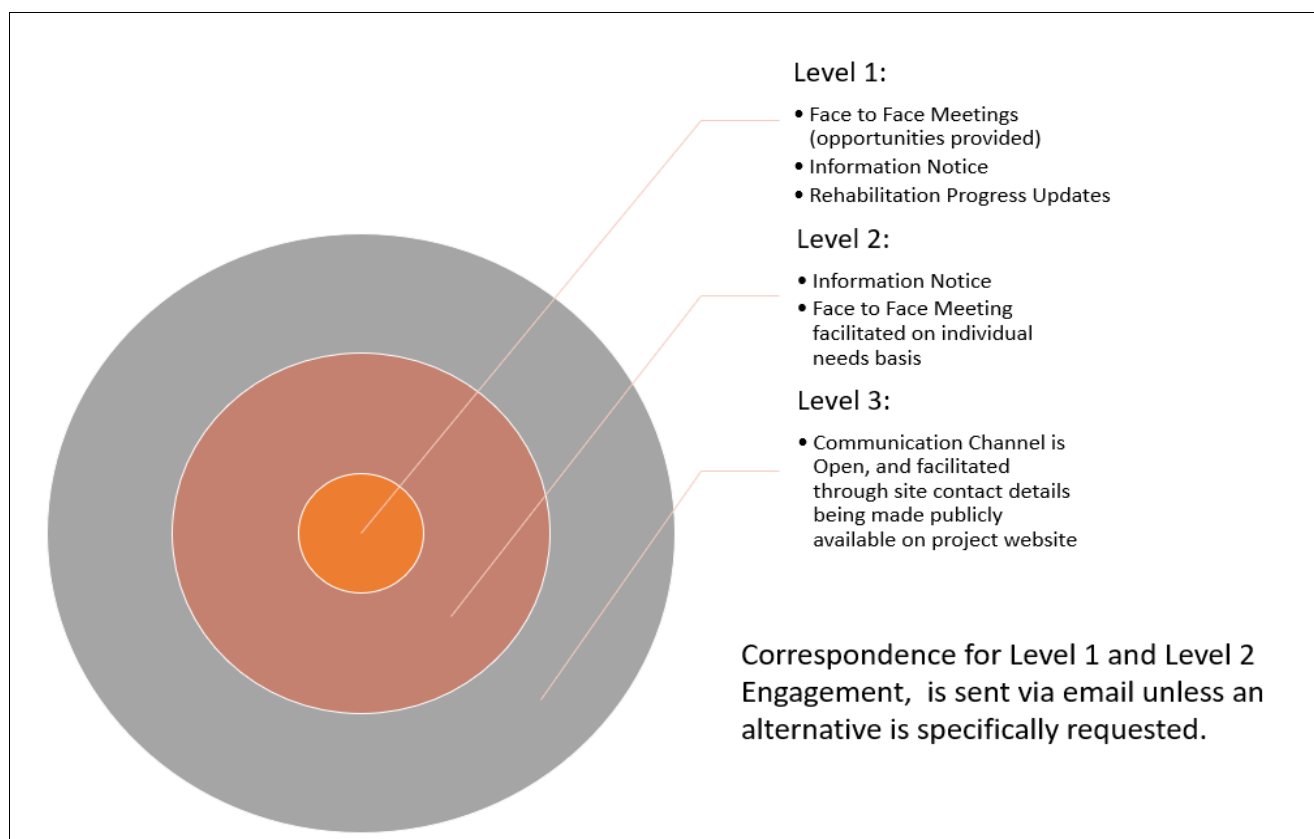


Figure 3-1 Level of Community Engagement

Table 2, below shows the Interested stakeholder, level of engagement and frequency of engagement associated with each level.

Table 3-2 Levels and Frequency of Engagement

Interested Stakeholder	Level of Engagement	Frequency
Underlying Landholders	1	Annually, to occur within 2 months of 10 December commencing 2026 i.e. the first year that an Rehabilitation Area becomes available for rehabilitation (as per proposed PRCP Schedule) and to align with milestone completion reporting and annual returns.
Adjacent Landholders	2	Annually as above.
Traditional Owners	2	Annually as above
Local Council	2	Annually as above
Mining Operations	3	Ongoing
State Regulators	3	Ongoing

3.3 Content of Consultation

3.3.1 Face to Face

Content of 'Face to Face' meetings will hinge off the Information Notice Content and is subject to any query or information being sought.

3.3.2 Information Notice

Level 1 – will provide the Final Land Use, Rehabilitation Areas and all Rehabilitation Milestones. It will provide the progress (area in hectares) for each Rehabilitation Milestone for that year.

It is not considered necessary to address infrastructure to be retained or complaints submissions. This is because the current conduct and compensation agreement contains a Complaints Regime, which is confidential but fully addresses an existing complaints procedure. Similarly infrastructure to be retained, including the 'residual void' are addressed in the current agreement and provision is made for negotiating the retention of additional infrastructure.

Level 2 – will provide the Final Land Use, Rehabilitation Areas and corresponding completion dates for the Final Rehabilitation Milestone for each area for the year of liability, as well as a statement of how Rehabilitation is tracking towards the Final Milestone Criteria for that year if applicable.

Similarly in relation to complaints, Level 2 does not address a complaints submission as these are comprehensively addressed in specific landholder agreements (these are confidential).

Level 1 and Level 2 Notices will include information relevant to any planned significant amendments to the PRC Plan Schedule.

3.3.3 Communication Channels

All Information Notices will provide:

- Futura Resources Ltd. Weblink (Site environmental contacts will be made available via the website)
- Site Contact details (email and telephone number) of the Environment, Community and Approvals Co-ordinator.
- Feedback on information provided will be encouraged indicating the channels available for feedback or complaints to be received.

4 Record Keeping, Review and Response

A record of all community engagement will be maintained. The current Community Consultation Register in Appendix A, will be updated with the ongoing Consultation. As per the register in appendix A. The following information will be recorded.

- Consultation date and Level of Consultation;
- Community Member;
- Content/Information Shared;
- Issues raised;
- How issues have been considered;
- Decisions or Outcomes from engagement; and
- Commitments made in relation to feedback/ issues raised.

Appendix A Community Consultation Register

Consultation date	Consultation type	Stakeholder	Location	Attendees	Information Provided	Topics of discussion	Outcomes/ ongoing commitments
ML and EA Approval Process July 2017 to November 2022							
July-2017 to November 2022	Face to Face Meetings Teleconference Written (email and mail)	P & D Comiskey	Various	Peter Comiskey Denise Comiskey Geoff Comiskey Ben Dunlop (FUT) *Marty Costello (NRC) *Pat Stewart (SJZ) *Narelle Allen (Comiskey) *Occasional attendees	- Mining Lease Application - Environmental Authority Application - All supporting documentation to above Applications - Mine design plans. - Rehabilitation designs and outcomes. - Infrastructure requirements, development and uses.	- Overarching operational plans and impacts to land and community proposed for the Fairhill Coal Project, as per the ML and EA Applications. - Location of new fencing, laneways, water infrastructure. - Compensation arrangements for access to the land. - Plans and outcomes for the rehabilitation of the land and its eventual return to the landholder, including landholder feedback on desired outcomes (grades, grass type, etc).	- Comiskey's and Fairhill entered into a Compensation Agreement allowing Fairhill to access the land to carry out the proposed activities. - Ongoing commitment for meetings and information sharing as required between the parties. - Commitment to meet once the mine infrastructure has been installed to discuss and agree what items the landholder would like to retain post mining.
July-2017 to November 2022	Face to Face Meetings Teleconference Written (email and mail)	R & R Simmons	Various	Richard Simmons Robyn Simmons Ben Dunlop (FUT) *Marty Costello (NRC) *Pat Stewart (SJZ) *Occasional attendees	- Mining Lease Application - Environmental Authority Application - All supporting documentation to above Applications	- Overarching operational plans and impacts to land and community proposed for the Fairhill Coal Project, as per the ML and EA Applications. - Location of new fencing, laneways, water infrastructure. - Compensation arrangements for access to the land.	- Simmons and Fairhill entered into a Compensation Agreement allowing Fairhill to access the land to carry out the proposed activities. - Ongoing commitment for meetings and information sharing as required between the parties.

Consultation date	Consultation type	Stakeholder	Location	Attendees	Information Provided	Topics of discussion	Outcomes/ ongoing commitments
					- Mine design plans. - Rehabilitation designs and outcomes. - Infrastructure requirements, development and uses.	- Plans and outcomes for the rehabilitation of the land and its eventual return to the landholder, including landholder feedback on desired outcomes (grades, grass type, etc).	- Commitment to meet once the mine infrastructure has been installed to discuss and agree what items the landholder would like to retain post mining.
July-2017 to November 2022	Face to Face Meetings Written (email and mail)	P MacKenzie	Various	Paul MacKenzie Ben Dunlop (FUT)	- Mining Lease Application - Environmental Authority Application - All supporting documentation to above Applications - Infrastructure requirements, development and uses.	- No overlap with mining lease and landholders property, adjoining only. - Overarching operational plans and impacts to the affected land and community proposed for the Fairhill Coal Project, as per the ML and EA Applications.	- Party did not object and comfortable for the project to progress. - Did not require ongoing communications given distance from actual Project area.
July-2017 to November 2022	Face to Face Meetings Written (email and mail)	J & J Randal	Various	James Randell Jason Randell Ben Dunlop (FUT)	- Mining Lease Application - Environmental Authority Application - All supporting documentation to above Applications - Infrastructure requirements, development and uses.	- No overlap with mining lease and landholders property, adjoining only. - Overarching operational plans and impacts to the affected land and community proposed for the Fairhill Coal Project, as per the ML and EA Applications.	- Party did not object and comfortable for the project to progress. - Did not require ongoing communications given distance from actual Project area.

Consultation date	Consultation type	Stakeholder	Location	Attendees	Information Provided	Topics of discussion	Outcomes/ ongoing commitments
July-2017 to November 2022	Face to Face Meetings Teleconference Written (email and mail)	D & M Haigh	Various	Deborah Haigh Murray Haigh Ben Dunlop (FUT) *Marty Costello (NRC) *Pat Stewart (SJZ) *Occasional attendees	- Mining Lease Application - Environmental Authority Application - All supporting documentation to above Applications	- Overarching operational plans and impacts to land and community proposed for the Fairhill Coal Project, as per the ML and EA Applications. - Location of new fencing, laneways, water infrastructure. - Compensation arrangements for access to the land. - Plans and outcomes for the rehabilitation of the land and its eventual return to the landholder, including landholder feedback on desired outcomes (grades, grass type, etc).	- Simmons and Fairhill entered into a Compensation Agreement allowing Fairhill to access the land to carry out the proposed activities. - Ongoing commitment for meetings and information sharing as required between the parties. - Commitment to meet once the mine infrastructure has been installed to discuss and agree what items the landholder would like to retain post mining.
July-2017 to November 2022	Teleconference Written (email and mail)	D Stumer	Various	Desmond Stumer Ben Dunlop (FUT)	- Mining Lease Application - Environmental Authority Application - All supporting documentation to above Applications	- No overlap with mining lease and landholders property, adjoining only. - Overarching operational plans and impacts to the affected land and community proposed for the Fairhill Coal Project, as per the ML and EA Applications.	- Party did not object and comfortable for the project to progress. - Did not require ongoing communications given distance from actual Project area.
July-2017 to November 2022	Face to Face Meetings Teleconference Written (email and mail)	Isaac Regional Council	Various	Sean Robinson Cate Beresowskyj Ben Dunlop (FUT) *Marty Costello (NRC) *Pat Stewart (SJZ) *Occasional attendees	- Mining Lease Application - Environmental Authority Application - All supporting documentation to above Applications - Infrastructure requirements,	- Overarching operational plans and impacts to land and community proposed for the Fairhill Coal Project, as per the ML and EA Applications. - Compensation applicable for potential impact to council infrastructure.	- Ongoing commitment for meetings and information sharing as required between the parties.

Consultation date	Consultation type	Stakeholder	Location	Attendees	Information Provided	Topics of discussion	Outcomes/ ongoing commitments
					development and uses.		
July-2017 to November 2022	Face to Face Meetings Teleconference Written (email and mail)	Central Highlands Regional Council	Various	Gerhard Joubert Kym Downey *Jason Hoolihan *Councillors Ben Dunlop (FUT) *Marty Costello (NRC) *Pat Stewart (SJZ) *Occasional attendees	- Mining Lease Application - Environmental Authority Application - All supporting documentation to above Applications - Infrastructure requirements, development and uses.	- Overarching operational plans and impacts to land and community proposed for the Fairhill Coal Project, as per the ML and EA Applications. - Compensation applicable for potential impact to council infrastructure.	- Ongoing commitment for meetings and information sharing as required between the parties.
Register from October 2022							
October-2022	Teleconference	- P & D Comiskey - R & R Simmons - D & M Haigh - IRC - CHRC	Telephone	- Various Stakeholder Representatives - Ben Dunlop (FUT)	Impending grant of Mining Leases	Companies progress with funding activities and impending grant of Mining Leases	- Commitment to advise parties once ML had been granted.
November-2022 to December-2022	Teleconference	- P & D Comiskey - R & R Simmons - D & M Haigh - IRC - CHRC	Telephone	- Various Stakeholder Representatives - Ben Dunlop (FUT)	ML's granted	ML's granted and progression to operations.	- Commitment to keep parties informed of operational outcomes and any items which may impact stakeholders.

Consultation date	Consultation type	Stakeholder	Location	Attendees	Information Provided	Topics of discussion	Outcomes/ ongoing commitments
October-2023	Teleconference	R & R Simmons	Telephone	- Robyn Simmons - Ben Dunlop (FUT) - Peter O'Donnell (FUT)	Start up of activities.	- Start up of activities. - Desire to arrange a meeting.	- Meeting date set.
7-Nov-2023	Face to Face Meeting	R & R Simmons	Yan Yan Homestead	- Richard Simmons - Robyn Simmons - Clint Chalmers - Ben Dunlop (FUT) - Peter O'Donnell (FUT)	Start up of activities.	- Start up of activities. - Impacts on cattle usage of affected paddocks. - Ability to fence operational areas to return land for grazing. - Infrastructure landholder may wish to retain post mining. - Rehabilitation process and alignment with outcomes identified in ML and EA application process. - Seeding of rehabilitated areas and desire for landholder to select preferred seed type.	- Commitment to keep parties informed of operational outcomes and any items which may impact stakeholders. - Ongoing engagement with property manager (Clint) on operational interaction between mining and farming activities.
22-Nov-2023 & 28-Nov-2024	Email (attempted phone call)	P & D Comiskey	Email	- Denise Comiskey - Narelle Allen - Ben Dunlop (FUT)	ML grant and activities planned.	- ML Grant dates. - Desire to arrange a meeting.	

Consultation date	Consultation type	Stakeholder	Location	Attendees	Information Provided	Topics of discussion	Outcomes/ ongoing commitments
Jan-2024	Email (attempted phone call)	P & D Comiskey	Email	- Denise Comiskey - Geoff Comiskey - Narelle Allen - Ben Dunlop (FUT)	Compensation updates	- Compensation timing and invoices. - Desire to arrange a meeting.	
Jan-2024	Teleconference	D & M Haigh	Telephone	- Deborah Haigh - Ben Dunlop (FUT)	Update on activities.	- Update on activities. - Desire to arrange a meeting.	- Email to set a meeting date.
9-Feb-2024	Face to Face Meeting	D & M Haigh	Haigh's Homestead	- Deborah Haigh - Murray Haigh - Ben Dunlop (FUT) - Peter O'Donnell (FUT) - Barbara van der Pol (FUT)	Update on activities.	- Update on activities. - Impacts on Red Rock / Fairhill Road. - Timing of Fairhill operation start-up.	- Commitment to keep parties informed of operational outcomes and any items which may impact stakeholders.
Feb-2024 to May-2024	Email Teleconference	D & M Haigh	Email Telephone	- Deborah Haigh - Barbara van der Pol (FUT)	Location of air monitors	- Location and placement of air monitors	- Location agreed and process set for installation.
9-April - 2024	Face to Face Meeting	D & M Haigh	Redrock	-Deborah Haigh -Murray Haigh -Barbara van der Pol	Locate air monitors	- Location and placement of air monitors	

Consultation date	Consultation type	Stakeholder	Location	Attendees	Information Provided	Topics of discussion	Outcomes/ ongoing commitments
Feb-2024 to Apr-2024	Email	P & D Comiskey	Email	- Nicholas Taylor - Ben Dunlop (FUT) *Various other lawyers	Discussions on compensation	- Timing and process around final compensation.	- Ongoing discussions.
16-Apr-2024	Meeting	P & D Comiskey	Emenate Legal Offices	- Peter Comiskey - Denise Comiskey - Peter (Jr) Comiskey - Ben Dunlop (FUT) Mediator Futura Lawyers Comiskey Lawyers	Nil	- Ongoing interaction with Comiskey lawyers. - Additional compensation offer.	- Nil
21-May-2024	Meeting	P & D Comiskey	Lyra Park	- Peter Comiskey - Denise Comiskey - Geoff Comiskey - Peter (Jr) Comiskey - Ben Dunlop (FUT)	Planning maps	- Timing of access to property. - Location of fencing and paddocks. - Impacts to and mitigation measures for water infrastructure. - Ongoing interaction with Comiskey lawyers. - Additional compensation offer.	- Time to be set for access to property in June. - Peter and Barabara to be introduced. - Mining activities to commence in July.



Northern Resource
CONSULTANTS

Fairhill Coal Project

Soils and Land Suitability Assessment

August 2018

prepared for

Fairhill Coking Coal Pty Ltd

Contact Information	Details
Organisation	Northern Resource Consultants Pty Limited
Contact Person	Marty Costello
Phone	07 4772 6500
Email	marty@northres.com.au
Mail	12 Cannan Street, South Townsville QLD, 4810
ABN	55 126 894 693

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Client: Fairhill Coking Coal Pty Ltd

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Executive Summary

The Fairhill Coal Project is a proposed coal mining project in central Queensland located approximately 45km northeast of Emerald on EPC2177.

Fairhill Coking Coal Pty Ltd commissioned a soils and land suitability assessment as part of baseline environmental studies to support environmental approvals for development of the Fairhill Coal Project. The study area for this report is located in the eastern section of EPC2177 and encompasses an area of approximately 885ha. The study area incorporates the proposed disturbance area for the project and includes a targeted on-ground assessment.

The survey of soils and landscapes was consistent with a 1:25,000 study and was compared to land suitability assessment and good quality agricultural land (GQAL) requirements. Twelve full profiles were described and analysed within the study area and 26 observations undertaken. Detailed profile descriptions and observations met minimum requirements for land suitability assessments and requirements for GQAL. Three dominant soils were classified within the study area:

- grey dermosol
- brown dermosol
- red dermosol.

The Fairhill Coal Project study area was identified as Class 5 under the Land Suitability Framework and no further consideration has been given in this regard as it is considered to be not suitable.

Pastoral management associated with the study area indicates that for the majority of the study area (e.g. Site 2, brown dermosols), the land is Class C3 QGAL with limited suitability for pasture improvement. For the remaining sites (Sites 1 and 3), the GQAL framework identifies the sites as Class D and not suitable for pastoral activities.

No strategic cropping land trigger mapping was identified within the study area and no strategic cropping land was assessed.

Due to the erosive nature of the majority of soils identified within the study area, soil will require careful management to ensure that the maximum volume is retained for rehabilitation activities. Careful management during stripping and storage is an important factor given the potentially long-term storage requirements for the Fairhill project and a number of recommendations have been provided to manage available resources.

Introduction

1. Background

The Fairhill Coal Project is a proposed coal mining project in central Queensland located approximately 45km northeast of Emerald on EPC2177. The total area of EPC2177 is approximately 6,297ha.

Fairhill Coking Coal Pty Ltd commissioned a soils and land suitability assessment as part of baseline environmental studies to support environmental approvals for development of the Fairhill Coal Project.

The study area for this report is located in the eastern section of EPC2177 and encompasses an area of approximately 868ha. The study area incorporates the proposed disturbance area for the project and includes a targeted on-ground assessment and maps provided in Appendix A of this report.



Figure 1: Fairhill Coal Project study area, September 2017

2. Purpose

This report details the following aspects of a soils and land suitability assessment conducted by Northern Resource Consultants Pty Ltd (NRC) within the study area:

- methodologies employed for assessing the soils and land suitability within the study area
- findings relating to mapped soils and land suitability within the study area
- potential impacts of the project and recommendations for mitigating impacts, with a focus on impact to land suitability and management of soil resources (e.g. topsoil volume).

Background Environment

1. Climate

The Fairhill Coal Project is located within the subtropics with warm, wet summers and cool, dry winters. The nearest Bureau of Meteorology (BOM) weather station is located at the Emerald Airport (Station ID: 035264), approximately 46km south-west of the Fairhill Coal Project. The mean maximum temperature for summer months is 34.1°C with a mean rainfall total of 259mm. The mean minimum temperature for summer months is 20.1°C. The mean maximum temperature for winter months is 23.9°C with a mean rainfall total of 72.4mm. The mean minimum temperature for winter months is 9.8°C (BOM, 2017).

2. Hydrology and topography

The proposed Fairhill Coal Project is located within the Mackenzie River sub-basin of the Fitzroy Basin, a major Queensland catchment that occupies approximately 9.1% of the state (Department of Environment and Heritage Protection, 2018). Several drainage features are located within the proposed Fairhill Coal Project area and typically drain southerly to Sandy Creek, a minor watercourse, or easterly to Cooroora Creek, a major watercourse.

It is noted that all drainage features within the proposed Fairhill Coal Project area are tributaries of Cooroora Creek. During the undertaken field study, it was observed that a weir had been installed historically, presumably for the purpose of water supply.

The topography of the proposed Fairhill Coal Project study area is generally 150m to 170m Australian Height Datum (AHD) and includes undulating plains and lowlands. Tablelands are identified within the north-east corner of the study area with an elevation up to 240m AHD.

3. Surface geology and soil land systems

3.1 Surface geology

Geological units were derived from web-based mapping (Queensland Globe, 2017) and include:

- Quaternary alluvium (**Qa**) comprising clay, silt, sand, gravel and flood plain alluvium.
- Fairhill Formation (**Pwt**) comprising late Permian aged suite of sediments described as:
 - Lithic and feldspathic labile sandstone, quartzose sublabile sandstone, siltstone, mudstone, calcareous and tuffaceous sandstone, volcanic conglomerate, carbonaceous mudstone and coal.

3.2 Fairhill Formation

NRC (2018) described the Fairhill Formation that hosts the targeted coal seams for the Fairhill Coal Project. Jensen (1975) described the Fairhill Formation in its type section north of Cooroora homestead as coarse-grained, micaceous, calcareous sandstone, conglomeratic in places and interbedded with very minor brown calcareous mudstone. Fossil logs are common, generally replaced with siderite or limonite (Jensen, 1975). Prouza (1977) reported that thick banded coal seams with mudstone and tuffaceous mudstone interbeds occur in 'cyclothems' within the predominantly arenaceous formation. The seams were named, based on correlations in government boreholes, in descending order as Phoenix, Pegasus, Hercules, Canis, Lepus and Fairhill. All these coal seams are interbedded with various amounts of layered sediments of non-coal material, generally siltstone and carbonaceous mudstone. The significant sequence of the Fairhill Formation coal seams is found in a stratigraphic interval approximately 130m thick.

3.3 Soil land systems

Humboldt

The Humboldt land system comprises Blackbutt (*Eucalyptus pilularis*) and Brigalow (*Acacia harpophylla*) weathered clay plains, occurring in most parts of the land system, texture contrast and cracking clay soils (Story et al., 1967).

The Humboldt land system is dominated by plains and lowlands with slopes less than 2% and is dominated by Tertiary clay and older rocks with quartz and billy gravel common. Soils include texture contrast soils with thin sandy or loamy surface soils and strongly alkaline subsoils (Story et al., 1967) such as the Taurus (Dd1.13, Db1.23 and Dy2.43) and Retro soils (Dd1.13).

Girrah

The Girrah land system comprises lowlands with downs and Brigalow and cracking clay soils on unweathered Permian shale and lithic sandstone (Story et al., 1967).

The Girrah land system is dominated by lowlands and plains on shales and detrital clay with slopes up to 5%. Soils are generally cracking clays and commonly with linear gilgai such as the Teviot soil (Ug5.15) and brown and grey soils such as the Cheshire soil (Gn3.93). Texture contrast soils have also been observed with thin sandy surface horizons and strongly alkaline sub-soils such as the Taurus soil (Dr2.13 and Dd1.23) and minor Wyseby soils (Dr2.22).

4. Current land use

The current land use of the Fairhill Coal Project area and immediate surrounds is primarily grazing on cleared lands and coal mining.

Soil Survey

1. Methodology

The distribution of dominant soils was determined for the Fairhill Coal Project based on the *Guidelines for Surveying Soils and Land Resources* (National Committee on Soil and Terrain (NCST), 2008). Methods for surveying the study area are provided below.

1.1 Desktop review

A desktop review of the Fairhill Coal Project study area was undertaken and included a review of regional land resource assessment and soil type mapping by Storey *et al.* (1967). Additional information reviewed included:

- Aerial imagery and topographical mapping to analyse and interpret landscape and map features to predict soil type and features prior to field investigations.
- Surface geology mapping to provide additional information of soil formation processes and anticipated properties.
- Vegetation surveys of the Fairhill Coal Project to understand any potential soil-plant interactions and further indicate soil and land unit boundaries.

The follow reference materials were utilised to cross reference on-ground findings:

- Visible Atmospherically Resistant Index obtained for the study area.
- *Lands of the Isaac and Comet Area, Queensland* (Storey *et al.*, 1967).
- Queensland Globe spatial data portal (Queensland Globe, 2017).

1.2 Field survey

The *Guidelines for Surveying Soils and Land Resources* (NCST, 2009) prescribe a free survey as a qualitative, conventional form of survey that is suited to detailed scale surveys and has been the method for mapping in most developed countries. The free survey is useful when determining soil variation between units that may be abrupt or gradual and evaluating associated topographic sequences within the broader landscape unit, as it allows for the surveyor to focus on key features within the study area.

Soil survey and observations

Map scale, survey intensity and assessment details are outlined in Table 1 and have been compared to land suitability assessment and good quality agricultural land (GQAL) requirements. Twelve full profiles were described and analysed within the study area and 26 observations undertaken. Detailed profile descriptions and observations met minimum requirements for land suitability assessments and GQAL requirements. Therefore, the field

survey design is considered to be sufficiently detailed to assess soil properties and their distribution across the proposed Fairhill Coal Project.

Table 1: Field survey observations compared to land suitability assessment and GQAL requirements

CLASS	OBSERVATIONS	LAND SUITABILITY	GQAL	ACTUAL FOR STUDY
	Minimum map scale	1:25000	1:10000	1:25000
	Observation density	Between 1 site/5ha and 1 site/25ha	Between 1 site/6.25ha and 1 site/25ha	1 site/20ha
I	Detailed profile descriptions	6–44	6–35	12
III	Laboratory analysed profiles	4–17	4–14	6
IV	Mapping observations	25–116	25–92	26
	Total observations	35–177	35–141	44

Field descriptions and parameters

Soil physical descriptions were collected during the field survey in accordance with the *Australian Soil and Land Survey Field Handbook* (NCST, 2008). Field descriptions have been collected to classify soil types encountered within the Fairhill Coal Project study area in accordance with the *Australian Soil Classification* (Isbell, 2016). The following soil descriptions were collected during the field survey:

- field texture grade
- boundary distinctiveness
- boundary shape
- pedality grade
- pedality size
- pedality shape
- consistence force
- fragments and segregations (percentage, type and size)
- field pH
- field colour (based on the Munsell colour chart)
- mottles (percentage, colour and contrast)
- field moisture and drainage.

Results

1. Overview

Table 2 provides an overview of survey effort and associated observations made for each map unit during the field investigation. Representative soil profiles are detailed within this section of the report with Certificates of Analysis for all sites provided in Appendix B.

Table 2: Overview of survey effort and observations made for each map unit within the study area

MAP UNIT	ASC CLASS	AREA (ha)	ASSOCIATED SITES	
			Sites	Observations
1	Grey dermosol	214	S6, S25, S26, S29	O45, O53, O71, O73, O74
2	Brown dermosol	585	S5, S9, S19, S20, S22, S23, S24	O10, O17, O33, O34, O35, O38, O39, O40, O41, O42, O52, O54, O65, O66
3	Red dermosol	69	S3	O12, O14, O46, O49, O50, O51

2. Grey dermosol

GREY DERMOSOL – TEVIOT (GREY VARIANT) – SITE 25



Concept	Grey soil profile with moderate depth and structured B2 horizon but lacking strong texture contrast.
Australian Soil Classification	Melanic, Eutrophic, Grey Dermosol; Moderate
Geology	Fairhill Formation (Pwt), Late Permian lithic and feldspathic labile sandstone, quartzose sublabile sandstone, siltstone, mudstone, calcareous and tuffaceous sandstone, volcanic conglomerate, carbonaceous mudstone, coal.
Landscape	Lowlands and plains
Microrelief	Nil
Runoff	Minor
Drainage	Poor
Surface features	Firm with minor sheet erosion.
Ground cover	50% Buffel Grass.
Profile description	
A Horizon 0.00m to 0.25m	Dark brown (7.5YR 3/2), light clay with weak sub-angular blocky structure (5mm to 10mm size) and moderate consistence. Slightly alkaline field pH (7.5). Few roots (approx. 1mm to 2mm), nil fragments and poor drainage. Gradual transition to B21 horizon.

GREY DERMOSOL – TEVIOT (GREY VARIANT) – SITE 25

B21 Horizon 0.25m to 0.50m	Dark grey (7.5YR 4/1), medium heavy clay with moderate sub-angular blocky structure (5mm to 20mm size) and moderate consistence. Slightly alkaline field pH (8.0). Nil roots or fragments and poor drainage. Gradual transition to B/C horizon.
B/C Horizon 0.50m to 0.70m	Grey (7.5YR 5/1) medium heavy clay with weak sub-angular blocky structure (5mm to 10mm size) and moderate consistence. Moderately alkaline field pH (8.5). Gypsum fragments up to 2mm size and 2% abundance, nil roots and poor drainage. Abrupt change to R horizon.

Soil chemical analysis

Depth (m)	pH (lab) (1:5)	Electrical conductivity (EC) (µS/cm)	Chloride (mg/kg)	CEC (meq/100g)	ESP (%)	Ca:Mg ratio
0.00 to 0.25	7.9	250	180	-	-	-
0.25 to 0.50	8.6	900	1100	53	17.2	1.9
0.50 to 0.70	8.6	980	1200	56	13.4	2.6

Soil nutrient analysis

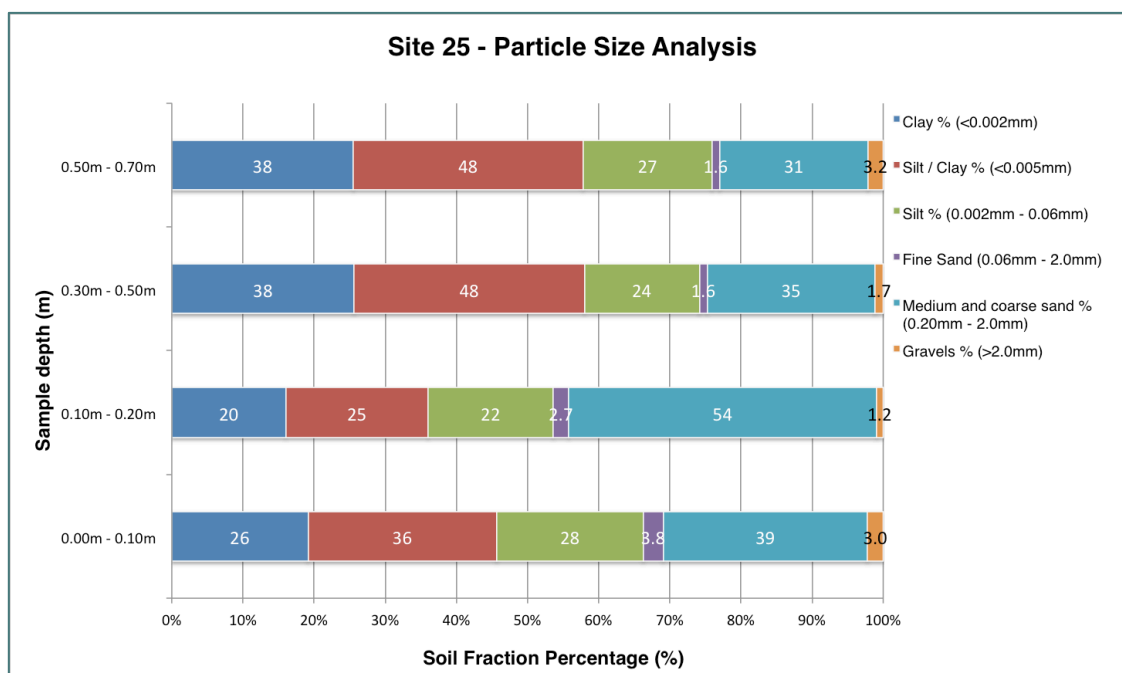
Depth (m)	Total organic carbon (%w/w)	Total phosphorous (mg/kg)	Nitrate/Nitrite as NOx as N (mg/kg)	Total Kjeldahl nitrogen (mg/kg)	Total nitrogen (mg/kg)
0.00 to 0.25	1.8	7	20	1300	1400
0.25 to 0.50	1.5	3	-	-	-
0.50 to 0.70	1.2	3	-	-	-

Micronutrients

Depth (m)	Boron (mg/kg)	Copper (mg/kg)	Iron (mg/kg)	Manganese (mg/kg)	Molybdenum (mg/kg)	Sulfur (mg/kg)	Zinc (mg/kg)
0.00 to 0.25	1.2	1.6	20	19	<0.10	7	0.43

GREY DERMOSOL – TEVIOT (GREY VARIANT) – SITE 25

Particle size analysis



Soil dispersion

Depth (m)	EAT	Description
0.00 to 0.25	3	Dispersion.
0.25 to 0.50	5	Dispersion.
0.50 to 0.70	5	Dispersion.

3. Brown dermosol

BROWN DERMOSOL – TEVIOT (BROWN VARIANT) – SITE 23



Concept	Moderate brown soil profile with structured B2 horizon and lacking strong texture contrast.
Australian Soil Classification	Haplic, Eutrophic, Brown Dermosol; Moderate
Geology	Fairhill Formation (Pwt), Late Permian lithic and feldspathic labile sandstone, quartzose sublabile sandstone, siltstone, mudstone, calcareous and tuffaceous sandstone, volcanic conglomerate, carbonaceous mudstone, coal.
Landscape	Plains and lowland slopes
Microrelief	Nil
Runoff	Minor
Drainage	Poor
Surface features	Firm with minor sheet erosion.
Ground cover	50% Buffel Grass.
Profile description	
A Horizon 0.00m to 0.20m	Dark greyish brown (10YR 4/2), medium clay with weak sub-angular blocky structure (5mm to 10mm size) and moderate consistence. Few roots up to 1mm, 5mm – 10mm ironstone fragments of 5% abundance. Slightly alkaline field pH (7.0) and dry with poor drainage. Gradual transition to B21 horizon.

BROWN DERMOSOL – TEVIOT (BROWN VARIANT) – SITE 23

B21 Horizon
0.20m to 0.50m
Greyish brown (10YR 5/2) light clay with moderate sub-angular blocky structure (10mm to 25mm size) and moderate consistence. Moderately alkaline field pH (8.5), moist with poor drainage, 5mm – 10mm ironstone fragments of 5% abundance and nil roots.

B22 Horizon
0.50m to 0.70m
Brown (10YR 5/3) sandy clay with moderate sub-angular structure (15mm to 40mm size) and moderate consistence. Moderately alkaline field pH (8.5), moist with poor drainage, 5mm – 10mm ironstone fragments of 5% abundance and 1mm to 2mm gypsum segregations of 2% abundance and nil roots.

Soil chemical analysis

Depth (m)	pH (lab) (1:5)	EC (µS/cm)	Chloride (mg/kg)	CEC (meq/100g)	ESP (%)	Ca:Mg ratio
0.00 to 0.20	8.3	270	39	-	-	-
0.20 to 0.50	8.9	380	160	-	-	-
0.50 to 0.70	7.1	49	8	17	1.0	4.7

Soil nutrient analysis

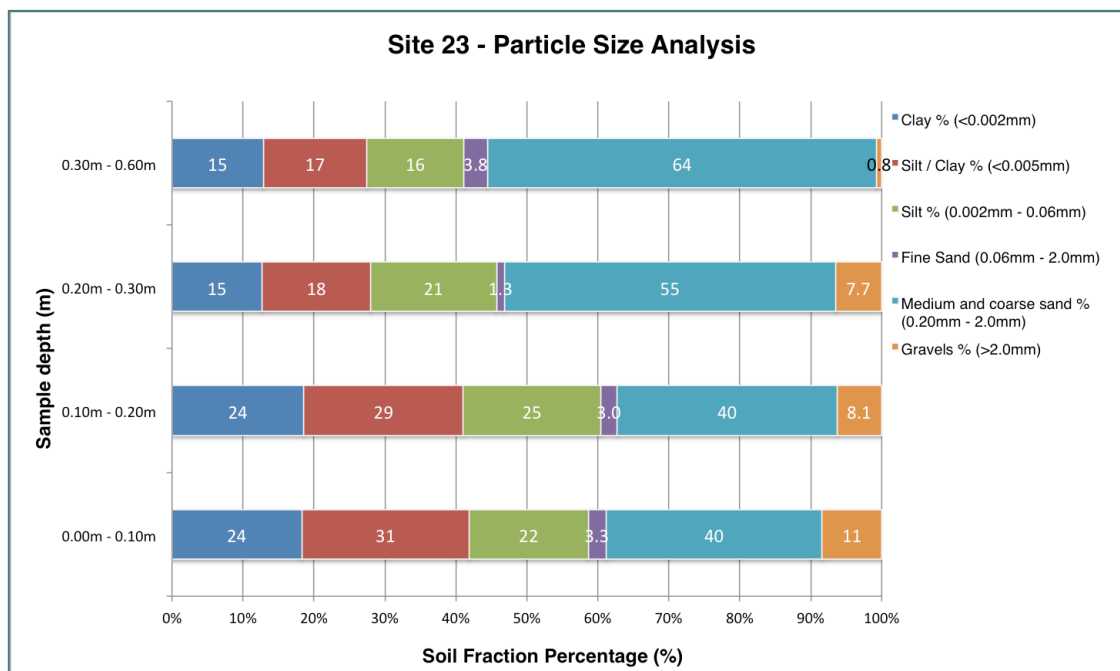
Depth (m)	Total organic carbon (%w/w)	Total phosphorous (mg/kg)	Nitrate/Nitrite as NO _x as N (mg/kg)	Total Kjeldahl nitrogen (mg/kg)	Total nitrogen (mg/kg)
0.00 to 0.20	1.3	5	0.9	960	960
0.20 to 0.50	1.0	3	0.9	790	800
0.50 to 0.70	0.85	15	-	-	-

Micronutrients

Depth (m)	Boron (mg/kg)	Copper (mg/kg)	Iron (mg/kg)	Manganese (mg/kg)	Molybdenum (mg/kg)	Sulfur (mg/kg)	Zinc (mg/kg)
0.00 to 0.20	0.92	2.1	15	10	<0.10	7	0.26
0.20 to 0.50	-	-	-	-	-	4	-

BROWN DERMOSOL – TEVIOT (BROWN VARIANT) – SITE 23

Particle size analysis



Soil dispersion

Depth (m)	EAT	Description
0.00 to 0.20	3	Dispersion.
0.20 to 0.50	5	Dispersion.
0.50 to 0.70	5	Dispersion.

4. Red dermosol

RED DERMOSOL – WYSEBY – SITE 3



Concept	Shallow red soil profile with structured B2 horizon and lacking strong texture contrast.
Australian Soil Classification	Haplic, Eutrophic, Red Dermosol; Shallow
Geology	Fairhill Formation (Pwt), Late Permian lithic and feldspathic labile sandstone, quartzose sublabile sandstone, siltstone, mudstone, calcareous and tuffaceous sandstone, volcanic conglomerate, carbonaceous mudstone, coal.
Landscape	Lowlands and plains
Microrelief	Nil
Runoff	Minor
Drainage	Poor
Surface features	Loose with minor sheet erosion.
Ground cover	50% Buffel grass.
Profile description	
A Horizon 0.00m to 0.10m	Dark reddish brown (2.5YR 3/3), sandy loam with weak sub-angular blocky structure (5mm size) and weak consistence. Few roots (approx. 1mm to 2mm), 10% ironstone fragments up to 5mm. Slightly alkaline field pH (7.0) and dry with moderate drainage. Diffuse transition to B2 horizon.

RED DERMOSOL – WYSEBY – SITE 3

B2 Horizon0.10m to
0.40m

Red (2.5YR 5/8), light clay loam with moderate sub-angular blocky structure (5mm to 20mm size) and moderate consistence. Nil fragments, slightly alkaline field pH (7.5) and dry with moderate drainage. Clear transition to C horizon.

Soil chemical analysis

Depth (m)	pH (1:5)	EC (μ S/cm)	Chloride (mg/kg)	CEC (meq/100g)	ESP (%)	Ca:Mg ratio
0.00 to 0.10	6.9	46	7	-	-	-
0.10 to 0.40	7.6	160	11	26	1.0	6.3

Soil nutrient analysis

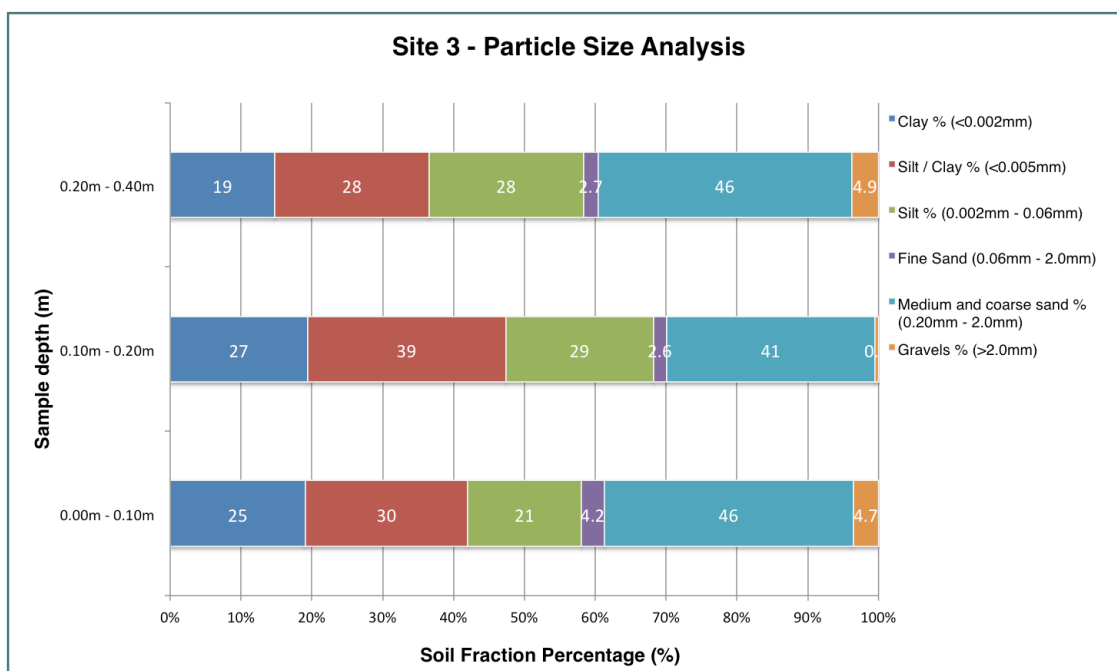
Depth (m)	Total organic carbon (%w/w)	Total phosphorous (mg/kg)	Nitrate/Nitrite as NO _x as N (mg/kg)	Total Kjeldahl nitrogen (mg/kg)	Total nitrogen (mg/kg)
0.00 to 0.10	0.82	8	1.1	740	750
0.10 to 0.40	0.76	4	-	-	-

Micronutrients

Depth (m)	Boron (mg/kg)	Copper (mg/kg)	Iron (mg/kg)	Manganese (mg/kg)	Molybdenum (mg/kg)	Sulfur (mg/kg)	Zinc (mg/kg)
0.00 to 0.10	0.76	0.57	8.5	23	<0.10	8	0.23

RED DERMOSOL – WYSEBY – SITE 3

Particle size analysis



Soil dispersion

Depth (m)	EAT	Description
0.00 to 0.10	5	Dispersion.
0.10 to 0.40	5	Dispersion.

Land Suitability Assessment

1. Overview

The Department of Mines and Energy (DME, 1995) guideline *Land Suitability Assessment Techniques* provides guidance on the assessment of land suitability pre-mining land and establishment of post-mining land use potential. The Fairhill Coal Project has been assessed against these *Land Suitability Assessment Techniques* (DME, 1995) to determine pre-mining land suitability.

Class definitions for land suitability are provided in the *Land Suitability Assessment Techniques* (DME, 1995) and have been generally standardised into five classes. The five classes are summarised in Table 3.

Table 3: Land suitability classes

CLASS	DEFINITION
Class 1	Suitable land with negligible limitations that is highly productive and requires only simple management to maintain economic production.
Class 2	Suitable land with minor limitations that either reduce production or require more than the simple management practices of Class 1 to maintain economic production.
Class 3	Suitable land with moderate limitations that either further lower production or require more than those management practices of Class 2 to maintain economic production.
Class 4	Marginal land with severe limitations that make it doubtful whether benefits of the activity will outweigh the input/costs required to achieve and maintain production in the long term.
Class 5	Unsuitable land with extreme limitations that preclude its use.

2. Methods

Assessment of soil profile characteristics was conducted against *Land Suitability Assessment Techniques* (DME, 1995) guidelines and provides an assessment of the climate, soils, geology, topography, soil erosion and land use. Outputs of the assessment may not necessarily reflect the current land use and are an indicator of the suitability of land to a particular agricultural use. Assessment of suitability to rainfed broadacre cropping (Table 2.1 in DME, 1995) and beef

cattle grazing (Table 2.2 in DME, 1995) was undertaken with consideration to the following potential limitations:

- ESP (beef cattle grazing category only)
- flooding
- microrelief
- nutrient deficiency
- pH (beef cattle grazing category only)
- rockiness
- soil physical factors (S)
- soil workability
- salinity (EC)
- topography
- water availability (also referred to as plant available water capacity or PAWC)
- water erosion
- wetness
- vegetation regrowth (management limitation for beef cattle grazing only).

Each potential limitation was ranked according to the land suitability classes described in Table 3. The overall land suitability class for each soil type was determined by the most severe limitation determined.

Water availability is an estimation of water stored within the soil profile that is available to a plant for use. The PAWC of a soil profile is dependent on the effective rooting depth for each soil profile assessed. This assessment is detailed in the sections below.

2.1 Plant available water capacity

For the purpose of this assessment, the effective rooting depth (and, subsequently, PAWC) for each soil profile described has been calculated using methodologies detailed in *RPI Act Statutory Guideline 08/14 – How to demonstrate that land in the strategic cropping area does not meet the criteria for strategic cropping land* (Department of Infrastructure, Local Government and Planning (DILGP), 2014). Criteria for effective rooting depth as described in this report (DILGP, 2014) are as follows:

- elevated soil salinity levels (i.e. greater than 0.56dS/cm or greater than 800mg/kg chloride)
- extremes of soil pH (i.e. $pH_{1:5}$ equal to or less than 5 and, except in non-rigid soils, $pH_{1:5}$ equal to or greater than 9)
- strongly sodic conditions (i.e. ESP greater than 15%) and gross imbalances between exchangeable calcium and magnesium (i.e. Ca: Mg equal to or less than 0.1) in rigid soils other than those having:
 - sandy loam or lighter textures
 - overall CECs less than 3 cmol+/kg.

3. Assessment

3.1 Plant available water capacity

The PAWC and effective rooting depths for each soil profile are detailed in Table 4.

Table 4: PAWC and effective rooting depth for soil profiles of the Fairhill Coal Project

SITE	ASC CLASS	EFFECTIVE ROOTING DEPTH (m)	LIMITATION	PAWC (mm)
1	Grey dermosol	0.25	EC	41
2	Brown dermosol	0.70	Nil	66
3	Red dermosol	0.40	Nil	42

3.2 Land suitability classes

Soil type characteristics for soils assessed at the Fairhill Coal Project have been cross referenced against both rainfed cropping and beef cattle grazing land suitability classes and are presented in Table 5.

Table 5: Rainfed cropping and beef cattle grazing land suitability classes for the Fairhill Coal Project

SOIL TYPE	RAINFED BROADACRE CROPPING		LIMITATION	BEEF CATTLE GRAZING	LIMITATION
Site	ASC class	Class		Class	
1	Grey dermosol	Class 5	PAWC ₅ , P ₃ , N ₃ , S ₃ , F ₄	Class 5	PAWC ₅ , ESP ₃
2	Brown dermosol	Class 5	PAWC ₅ , P ₃ , N ₄ , S ₃ , F ₃ , EC ₃	Class 4	PAWC ₄ , EC ₃
3	Red dermosol	Class 5	PAWC ₅ , P ₃ , N ₃	Class 5	PAWC ₅

SOIL TYPE	RAINFED BROADACRE CROPPING	LIMITATION	BEEF CATTLE GRAZING	LIMITATION
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PAWC – Plant available water capacity

P – Soil physical factors

N – Nutrients

S – Slope

F – Flooding

ESP – Exchangeable sodium percentage.

4. Findings

Overall, there were moderate limitations on all soils for Rainfed Broadacre Cropping, but less limitations for Beef Cattle Grazing. Limitations to soil types identified within the Fairhill Coal Project study area were due to PAWC (as a result of effective rooting depth) and soil physical factors at all sites. Additional limiting factors included salinity and erodibility (ESP). Therefore, it is considered that soils within the study area are Class 5 land for Rainfed Broadacre Cropping and Beef Cattle Grazing, with the exception to Beef Cattle Grazing on Site 2, which was noted to be Class 4.

Good Quality Agricultural Land

1. Overview

The system of assessing GQAL as presented in *Planning Guidelines: The identification of good quality agricultural land* (QDPI, 1993) evaluates land suitability for specific types of agricultural production. The system consists of four classes, which have been designed to assess land based on the suitability and potential for agricultural production (Table 6).

2. Methods

2.1 Agricultural land classes

Table 6: GQAL classes

CLASS	DESCRIPTION
A	Crop land – Land that is suitable for current and potential crops with limitations to production that range from none to moderate.
B	Limited crop land – Land that is marginal for current and potential crops due to severe limitations, and suitable for pastures. Engineering and/or agronomic improvements may be required before the land is considered to be suitable for cropping.
C	Pasture land – Land that is suitable only for improved or native pastures due to limitations, which preclude continuous cultivation for crop production; however, some areas may tolerate a short period of ground disturbance for pasture establishment.
D	Non-agricultural land – Land not suitable for agricultural uses due to extreme limitations. This may be undisturbed land with significant habitat, conservation and/or catchment values or land that may be unsuitable because of very steep slopes, shallow soils, rock outcrop or poor drainage.

Correlation for the assessment of GQAL with land suitability classes is provided in Table 7.

Table 7: Correlation of land suitability and GQAL classes

LAND SUITABILITY	LAND SUITABILITY DESCRIPTION (DME, 1995)	GQAL	PASTORAL MANAGEMENT	COMMON VEGETATION ASSOCIATION
1	High quality land with few or minor limitations.	C1	Good quality grazing and/or highly suitable for pasture improvement.	Brigalow vegetation; appropriate for fattening beef cattle; good grazing on sown pastures and can withstand ground disturbance.
2	Land with minor limitations.	C1		Brigalow vegetation and/or transitional vegetation to poplar box vegetation communities.
3	Moderate limitations to sustaining its use.	C2	Moderate quality grazing and/or moderately suitable for pasture improvement.	Eucalypt woodland, poplar box, narrow-leaved Eucalyptus, gum-top woodlands; low-moderate PAWC and low-moderate fertility; good grazing on native pastures without ground disturbance; appropriate for beef cattle breeders.
4	Marginal land requiring major inputs to sustain the use.	C3	Low quality grazing, grazing of native pastures with limited suitability for pasture improvement.	Tea-tree vegetation; usually characterised by steep country or mangrove flats.
5	Unsuitable due to extreme limitations.	D	Not suitable.	Unsuitable due to extreme limitations.

3. Findings

As the Fairhill Coal Project study area has been noted as Class 5 under the Land Suitability Framework, no further consideration has been given in this regard as it is considered to be not suitable. Pastoral management associated with the study area indicates that for the majority of the study area (e.g. Site 2, brown dermosols), the land is Class C3 GQAL with limited suitability for pasture improvement. Additional supporting evidence of this was the extensive land clearing/pasture improvement activities noted to have occurred on the study area during field activities (Figure 2). For the remaining sites (Sites 1 and 3), the GQAL framework identifies the sites as Class D and not suitable for pastoral activities.



Figure 2: Example of extensive pasture improvement activities (November, 2017)

Strategic Cropping Land

1. Overview

The *Regional Planning Interests Act 2014* (RPI Act) identifies and protects areas of Queensland that are of regional interest. The intent of the RPI Act is to manage the impact and support the coexistence of resource activities and other regulated activities in areas of regional interest. The RPI Act is supported by the Regional Planning Interests Regulation 2014 (RPI Regulation) and seeks to establish an appropriate balance between protecting priority land uses and delivering economic projects for Queensland regions and protects:

- living areas in regional communities
- high-quality agricultural areas from dislocation
- strategic cropping land
- regionally important environmental areas.

Protections are provided to areas of regional interest as defined under the RPI Act for the following areas:

- a priority agricultural area
- a priority living area
- the strategic cropping area
- a strategic environmental area.

The RPI Act restricts the carrying out of resource or regulated activities where the activity is not exempt from the provisions of the RPI Act or a regional interests development approval has not been granted.

Assessment of strategic cropping land (SCL) is required to demonstrate impacts (if any) to SCL.

2. Strategic cropping land assessment

Methodology for the assessment of SCL commenced as a desktop review of available SCL trigger mapping provided by Department of Natural Resources and Mines (DNRM). The Fairhill Coal Project study area falls within the western cropping zone and no mapped potential SCL was identified to fall within the management zone of SCL.

3. Findings

As no mapped potential SCL has been identified within the Fairhill Coal Project study area, no further assessment has been considered.

Disturbance Management

1. Topdressing material assessment

Topdressing material is an important resource for the restoration of disturbed landscapes. The assessment of topdressing material availability has been undertaken with guidance adapted from the study by Charman and Murphy (2010). The following considerations were given when determining estimated topdressing material availability as outlined in Table 8:

- soil structure
- coherence
- mottling
- texture
- soil pH
- salinity.

Topdressing volume estimates do not consider condition restraints such as clearing restrictions, disturbance areas, protected areas, and so on.

Table 8: Estimated topdressing material availability

SOIL TYPE		AREA (ha)	DEPTH (m)	VOLUME (m ³)
Site	ASC Class			
1	Grey dermosol	214	0.25	535,000
2	Brown dermosol	585	0.20	1,170,000
3	Red dermosol	69	0.10	69,000

2. Soil erosion hazard and risk assessment

2.1 Methodology

The International Erosion Control Association (IECA, 2008) details methodology for assessing erosion hazard and soil loss using the revised universal soil loss equation (RUSLE), which predicts the *average* soil loss rates resulting from sheet and rill flows.

As detailed in IECA (2008), soil losses calculated by the RUSLE are considered best estimates based on long-term average rainfall records. Soil losses predicted are not absolute values or estimates of soil losses in a given year or time period.

The RUSLE is presented below:

$$A = R \cdot K \cdot LS \cdot C \cdot P$$

where,

A = annual soil loss due to erosion (t/ha/yr)

R = rainfall erosivity factor

K = soil erodibility factor

LS = topographic cover derived from slope length and slope gradient

C = cover and management factor

P = erosion control practice factor

The RUSLE is primarily used as an indicator of potential soil loss for the purpose of sediment control standards. Table 4.5.1 in the IECA (2008) document provides a summary of sediment control standard requirements based on soil loss rate and is summarised in Table 9.

Table 9: Sediment control standard (default) based on soil loss rate (Table 4.5.1 in IECA, 2008)

AREA LIMIT (m ²)	SOIL LOSS RATE LIMIT (t/ha/yr)			SOIL LOSS RATE (t/ha/month)		
	Type 1	Type 2	Type 3	Type 1	Type 2	Type 3
250	N/A	N/A	All cases	N/A	N/A	All cases
1000	N/A	N/A	All cases	N/A	N/A	All cases
2500	N/A	>75	75	N/A	>6.25	6.25
>2500	>150	150	75	>12.5	>12.5	6.25

Erosion risk is based on monthly rainfall erosivity factors and is categorised based on Table 4.4.3 of IECA (2008) and is summarised in Table 10.

Table 10: Erosion risk rating based on estimated soil loss rate (Table 4.4.3 in IECA, 2008)

EROSION RISK RATING	SOIL LOSS (t/ha/yr)
Very low	0 to 150
Low	150+ to 225
Moderate	225+ to 500
High	500+ to 1500
Extreme	>1500

2.2 Rainfall erosivity, slope, soil type and groundcover

Rainfall erosivity

Rainfall erosivity (R-Factor) is a measure of the ability of rainfall to generate erosion (IECA, 2008). The R-Factor is comprised of two components, total energy (E) and maximum 30-minute intensity for each storm.

IECA (2008) provides R-Factors for pre-determined locations; however, due to the location of the Fairhill project, the interpolated factors are inappropriate. As such, a site-specific R-Factor was determined using the following equation:

$$R = 164.74 * (1.1177)^S * S^{0.6444}$$

where,

R = rainfall erosivity factor

S = 2-year annual recurrence interval (ARI), 6-hour rainfall event (mm)

S is determined using the Intensity, Frequency, Duration (IFD) for the Fairhill project location from the BOM (2018). The IFD curve and table outputs are detailed in Figure 3 and Figure 4, respectively.

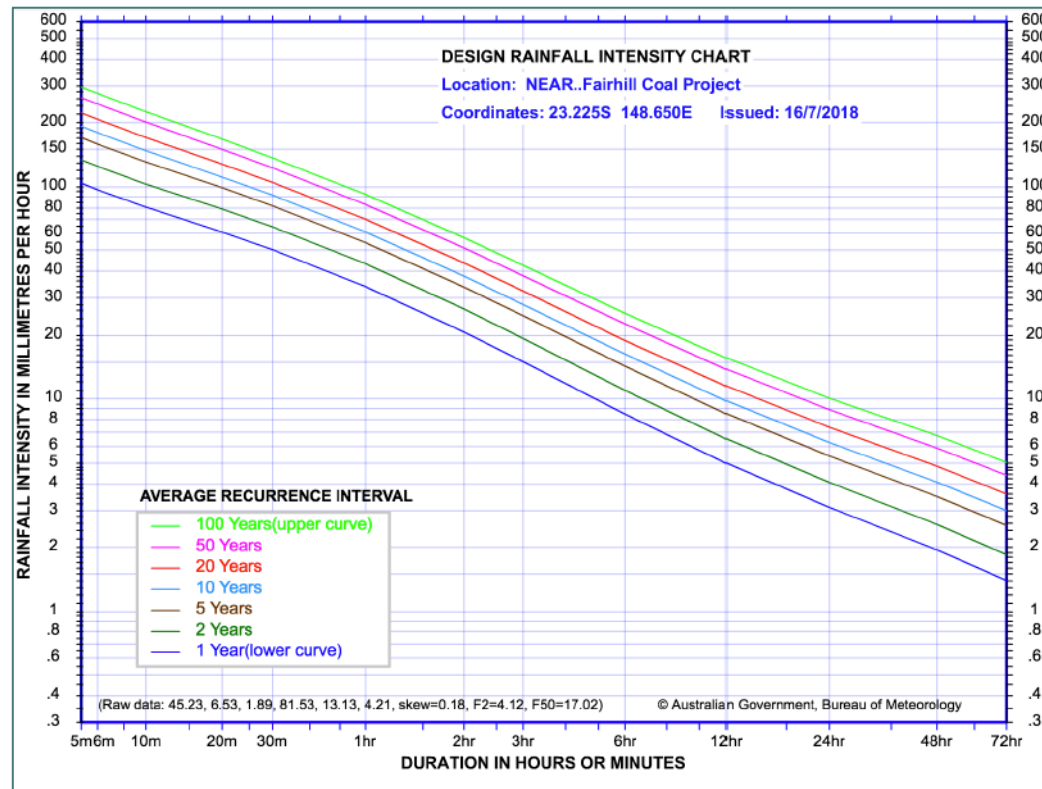


Figure 3: IFD curves for the Fairhill project (BOM, 2018)

Intensity-Frequency-Duration Table							
Location: 23.225S 148.650E NEAR.. Fairhill Coal Project Issued: 16/7/2018							
Rainfall intensity in mm/h for various durations and Average Recurrence Interval							
Average Recurrence Interval							
Duration	1 YEAR	2 YEARS	5 YEARS	10 YEARS	20 YEARS	50 YEARS	100 YEARS
5Mins	104	134	171	193	223	263	295
6Mins	96.9	125	159	180	208	246	276
10Mins	80.3	103	131	148	171	202	226
20Mins	61.2	78.5	99.0	111	128	150	168
30Mins	50.6	64.8	81.5	91.5	105	123	137
1Hr	33.9	43.5	54.7	61.4	70.5	82.7	92.2
2Hrs	20.7	26.6	33.7	38.0	43.8	51.6	57.6
3Hrs	15.0	19.3	24.7	27.9	32.3	38.1	42.7
6Hrs	8.51	11.0	14.3	16.3	18.9	22.6	25.4
12Hrs	4.98	6.49	8.52	9.79	11.5	13.8	15.6
24Hrs	3.09	4.05	5.40	6.25	7.37	8.92	10.1
48Hrs	1.95	2.57	3.48	4.06	4.83	5.88	6.73
72Hrs	1.40	1.85	2.54	2.99	3.57	4.38	5.04
(Raw data: 45.23, 6.53, 1.89, 81.53, 13.13, 4.21, skew=0.18, F2=4.12, F50=17.02)							
© Australian Government, Bureau of Meteorology							

Figure 4: IFD table for the Fairhill project (BOM, 2018)

As detailed in Figure 4, the 2-year ARI, 6-hour rainfall event is 11.0mm; therefore, based on this information, the annual R-Factor is **2,626**.

Erodibility (K-Factor)

The erodibility (K-Factor) is a numeric representation of the ability of soils to resist the erosive energy of rain (IECA, 2008). Whilst it is recommended that the K-Factor should be determined from laboratory analysis, K-Factors for each major soil type have been determined using field soil texture determined for the study area and conversions provided in Hazelton and Murphy (2016). K-Factors for major soil types at the Fairhill project are provided in Table 11.

Table 11: K-Factors for representative soils within the study area

ASC CLASS	DEPTH (m)	K-FACTOR	RATING
Grey dermosol	0.00 – 0.10	0.04	High
	0.10 – 0.20	0.03	Moderate
	0.30 – 0.50	0.05	High
	0.50 – 0.70	0.06	High
Brown dermosol	0.00 – 0.10	0.04	High

ASC CLASS	DEPTH (m)	K-FACTOR	RATING
	0.10 – 0.20	0.04	High
	0.20 – 0.30	0.03	Moderate
	0.30 – 0.60	0.03	Moderate
Red dermosol	0.00 – 0.10	0.05	High
	0.10 – 0.20	0.05	High
	0.20 – 0.40	0.05	High

Slope (LS-Factor)

The slope (LS-Factor) is a numerical representation of the length and slope combination of the landform. Due to the varying terrain of the Fairhill project, a conservative approach has been applied.

A LS-Factor for flatter areas (e.g. laydown areas, workshops, crests, etc.) has been applied based on a 100m slope length and 1% slope gradient. Based on these conditions and in accordance with Table E3 in IECA (2008), the LS-Factor is **0.20**.

A LS-Factor for steeper areas (e.g. haul roads, ridgelines, etc.) has been applied based on a 100m slope length and 20% slope gradient. Based on these conditions and in accordance with Table E3 in IECA (2008), the LS-Factor is **8.68**.

Ground cover management factor (C-Factor)

The ground cover management factor (C-Factor) is determined based on the combined effect of all the interrelated cover and management variables for a site. It also represents non-structural methods for controlling erosion.

Previous site observations conducted have identified minimal grass cover and are reflective of dominant landform categories 'Upper Slopes, Mesas' and 'Mountain Tops, High Ridges'. Based on this and on the expectation that, during construction, ground cover will be minimal, a conservative C-Factor of **1.00** has been deemed appropriate.

Erosion control practice factor (P-Factor)

The erosion control practice factor (P-Factor) measures the combined effect of all support practices and management variables for a site. It also represents structural methods for controlling erosion (IECA, 2008).

The P-Factor is decreased by practices that reduce both the velocity of runoff and the tendency of runoff to flow directly downhill. At construction sites, it reflects the roughening or smoothing of soil surfaces by machinery (IECA, 2008).

Based on this and with consideration of the surrounding landscape and the expected construction phase condition of the Fairhill project, a P-Factor of **1.3** is considered appropriate.

2.3 Calculated soil loss and erosion risk

Based on the factors determined for each component of the RUSLE, the predicted soil loss rates have been calculated for the dominant soil types across the Fairhill project. An erosion risk rating is also applied to each dominant soil type as detailed in Table 12.

Table 12: Predicted soil loss and erosion risk rating for dominant soils at the Fairhill Coal Project

RUSLE	GREY DERMOSOL								BROWN DERMOSOL								RED DERMOSOL					
Depth (m)	0.00 – 0.10		0.10 – 0.20		0.30 – 0.50		0.50 – 0.70		0.00 – 0.10		0.10 – 0.20		0.20 – 0.30		0.30 – 0.60		0.00 – 0.10		0.10 – 0.20		0.20 – 0.40	
Slope (%)	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20
R-Factor	2626	2626	2626	2626	2626	2626	2626	2626	2626	2626	2626	2626	2626	2626	2626	2626	2626	2626	2626	2626	2626	2626
K-Factor	0.04	0.04	0.03	0.03	0.05	0.05	0.06	0.06	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.05	0.05	0.05	0.05	0.05	0.05
LS-Factor	0.20	8.68	0.20	8.68	0.20	8.68	0.20	8.68	0.20	8.68	0.20	8.68	8.68	0.20	0.20	8.68	0.20	8.68	0.20	8.68	0.20	8.68
C-Factor	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
P-Factor	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Soil loss (t/ha/yr)	27	1185	20	889	34	1481	41	1778	27	1185	27	1185	20	889	20	889	34	1481	34	1481	34	1481
Erosion risk rating	Very low	High	Very low	High	Very low	High	Very low	Extreme	Very low	High	Very low	High	Very low	High	Very low	High	Very low	High	Very low	High	Very low	High

3. Soil management

3.1 Mitigation strategies

Soil resources require careful management to ensure that maximum volume is retained for rehabilitation activities. Careful management during stripping and storage is an important factor given the potentially long-term storage requirements for the Fairhill project.

Soil management activities should be undertaken whilst in a slightly moist condition and, where possible, when not excessively wet or dry. Minimising the requirement for stockpiling and handling may be achieved where the stripped topdressing resource is placed directly onto a progressively rehabilitated area.

3.2 Minimising disturbance

It is recommended that land disturbance be minimised during development of the Fairhill project, limiting clearing of land to the smallest practical areas for development. Additional recommendations include:

- Staging land disturbance activities in such a way that land disturbed is limited to only the areas required to be actively cleared.
- Limiting the duration of exposure for disturbed lands and ensuring that erosion and sediment control (ESC) plans are developed and implemented prior to disturbance.
- Rehabilitating disturbed lands as soon as practical.

ESC plans should be developed in accordance with the *International Erosion Control Association Best Practice Guidelines* and should include guidance on disturbance management (e.g. duration, treatment requirements, etc.).

Clear delineation of disturbed areas should be established with pegs placed at intervals along the edge of disturbance by a suitably qualified operator prior to the commencement of the disturbance. All operations should be planned to ensure that there is no damage outside the delineated edge of disturbance.

3.3 Stockpiling

Where possible, topdressing material should be stripped into windrows using graders or dozers (as opposed to scrapers) to maximise the retention of soil structure and avoid traversing over stripped stockpiles

Where topdressing material is proposed to be stockpiled for longer than 12 months, it is recommended that seeding and fertilising of stockpiles be conducted. Annual crops such as sterile Japanese Millet or Rye Grass provide short-term coverage until natural growth occurs. Topdressing material should be stockpiled to a maximum height of 3m and ideally no more than 2m to prevent 'hotspot' generation and degradation of soil nutrients.

A topdressing resource inventory is recommended to ensure accurate tracking of topdressing material status and availability.

3.4 Topsoil spreading and seedbed preparation

Topdressing materials stripped for use in rehabilitation should be re-spread onto re-shaped areas as soon as practicable. Where topdressing volumes allow, topdressing resources should be spread to a minimum depth of 0.2m across disturbance lands. Compaction of topdressing materials should be avoided to promote vegetation establishment and maximise rainfall infiltration.

Application of fertiliser and seed mix should be made in one consecutive operation following re-spread of topdressing materials to promote vegetative growth and reduce potential for topsoil losses from wind and water erosion.

4. Erosion and sediment control – surface water diversion

To minimise or prevent sheet or rill erosion and the potential for sediment laden run-off, all 'clean water' (e.g. waters running onto site and unaffected by mining activities) should be diverted to clean water drainage lines and off site. Suitably designed diversion infrastructure is required to be designed and implemented for the Fairhill project and an ESC plan is recommended to be developed.

References

- Bureau of Meteorology (BOM) (2017). *Climate statistics for Australian locations – Emerald Airport* (Station ID 035264). Retrieved from http://www.bom.gov.au/climate/averages/tables/cw_035264.shtml.
- BOM (2018). *Intensity frequency duration data system*. Retrieved from <http://www.bom.gov.au/hydro/has/cdirswebx/cdirswebx.shtml>.
- Story et al., (1967). *Lands of the Isaac-Comet Area, Queensland*. Queensland Department of Natural Resources and Mines.
- Charman, Peter E. V. and Murphy, Brian W. (2010). *Soils their properties and management*. Third Edition. Oxford University Press Australia and New Zealand.
- Commonwealth Scientific and Industrial Research Organisation (CSIRO) (2012). Australian Soil Resource Information System (ASRIS). CSIRO Land and Water.
- Department of Environment and Heritage Protection. (2018). *Wetlands info*. Retrieved from <https://wetlandinfo.ehp.qld.gov.au/wetlands/>.
- Department of Infrastructure, Local Government and Planning (DILGP). (2014). *How to demonstrate that land in the Strategic Cropping Area does not meet the criteria for Strategic Cropping Land*.
- Department of Mines and Energy (DME) (1995). *Technical guidelines for the environmental management of exploration and mining in Queensland, Land suitability techniques*.
- Environmental Earth Sciences (EES) (2012). *Soil and land suitability assessment, Wilton Coal Project*, Report Number 611023, Version 2.
- Hazelton, P. & Murphy, B. (2016). *Interpreting soil test results – What do all the numbers mean?* CSIRO Publishing.
- International Erosion Control Association (IECA) (2008). *Best practice erosion and sediment control*. Picton, NSW: International Erosion Control Association (Australasia).
- Isbell, R.F. (2016). *The Australian soil classification* (2nd ed.). CSIRO Publishing.
- Jensen, A.R. (1975). Permo Triassic stratigraphy and sedimentation in the Bowen Basin, Queensland. BMR Bulletin 154, AGP S Canberra.
- National Committee on Soil and Terrain (NCST). (2008). *Australian soil and land survey field handbook* (3rd ed.). CSIRO Publishing.
- NCST. (2009) *Guidelines for surveying soil and land resources* (2nd ed.). CSIRO Publishing.
- Northern Resource Consultants (NRC). (2018). *Fairhill coal project groundwater technical report*.
- Prouza, V. (1977). Coal exploration, South Central Bowen Basin, Mt. Stuart-Comet area, Geological Survey Queensland, Record 1977/27.

Queensland Globe (2017). *Queensland Globe spatial data portal*. Retrieved from <https://qldglobe.information.qld.gov.au/>

Appendix summary

Appendix A Maps

Appendix B Certificates of Analysis

Appendix A

Maps



FAIRHILL COKING COAL PTY LTD

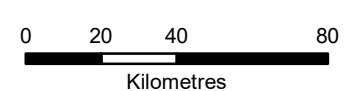
SITE LOCATION FAIRHILL

Legend

- Towns and Cities
- Major Roads
- Highways

Credits:
Roads and Towns
© State of Queensland (Department of Natural
Resources and Mines) 2016.

Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator
Datum: GDA 1994
Date: 23-Nov-18



Scale: 1:2,000,000 at A3



FAIRHILL COKING COAL PTY LTD

FAIRHILL SOILS GROUND TRUTHED LAND SUITABILITY - RAINFED CROPPING

Legend

-  Soil Study Area
-  Fairhill Infrastructure
- Ground trued land suitability - Rainfed cropping**
 -  Rainfed Cropping (Class 5)
 -  Exploration permit for coal

Credits:
EPC Boundaries, ML Boundaries and MDL Boundaries and Watercourse Drainage
© State of Queensland (Department of Natural Resources, Mines and Energy) 2018.

Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator
Datum: GDA 1994
Date: 22-Nov-18

0 165 330 660
Metres

Scale: 1:20,000 at A3



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

FAIRHILL COKING COAL PTY LTD

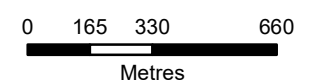
FAIRHILL SOILS GROUNDTRUTHED GOOD QUALITY AGRICULTURAL LAND

Legend

-  Soil Study Area
-  Fairhill Infrastructure
- Ground truthed
Good Quality
Agricultural Land**
 -  GQAL (Class C3)
 -  GQAL (Class D)
 -  Exploration permit for coal

Credits:
EPC Boundaries, ML Boundaries and MDL Boundaries
and Watercourse Drainage
© State of Queensland (Department of Natural
Resources, Mines and Energy) 2018.

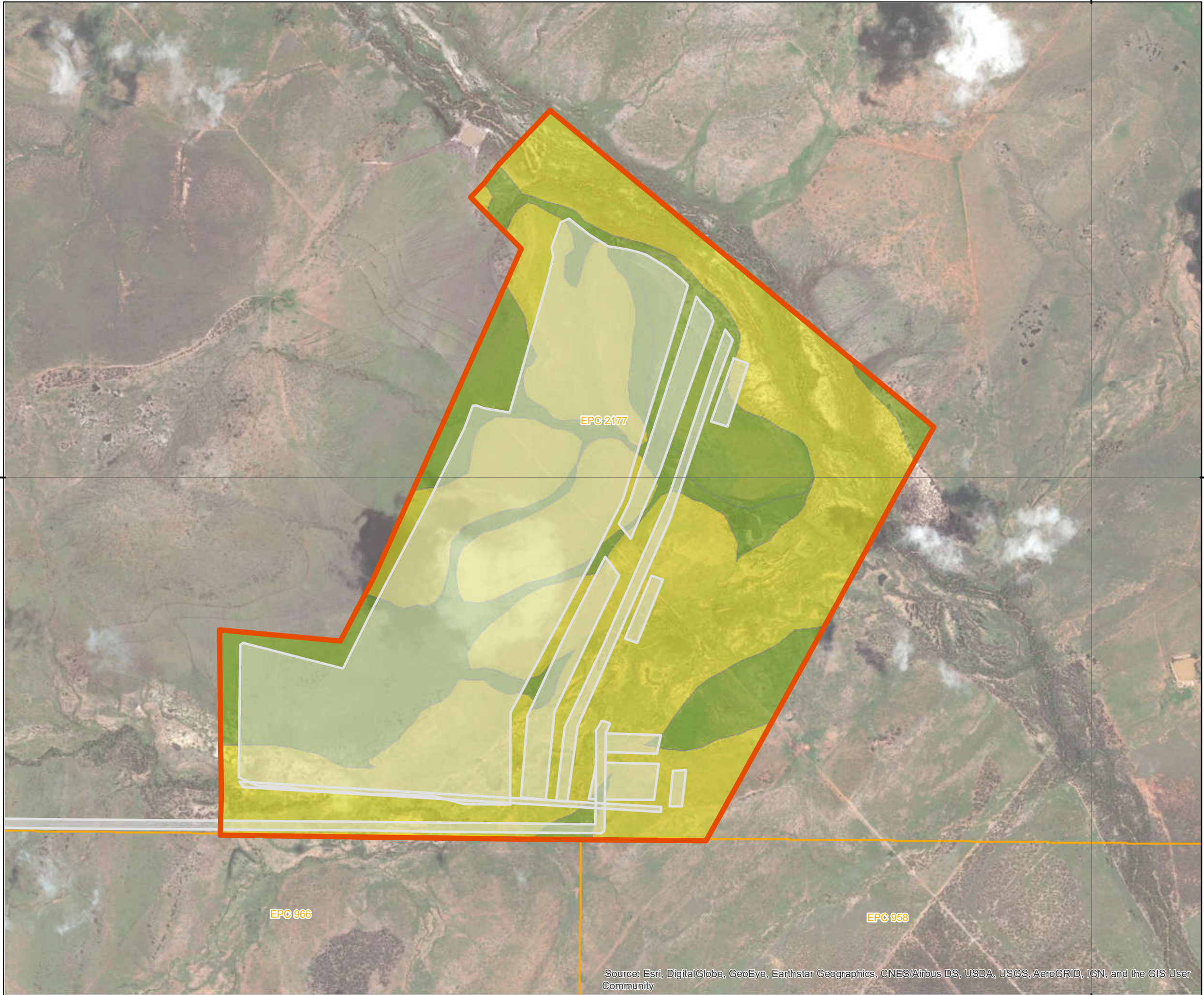
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Date: 22-Nov-18



Scale: 1:20,000 at A3



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



**FAIRHILL
COKING COAL
PTY LTD**

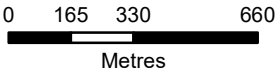
**FAIRHILL
SOILS
GROUND
TRUTHED
LAND
SUITABILITY
- BROAD ACRE
GRAZING**

Legend

-  Soil Study Area
-  Fairhill Infrastructure
-  Beef Cattle Grazing (Class 4)
-  Beef Cattle Grazing (Class 5); Beef Cattle Grazing (Class 5)
-  Exploration permit for coal

Credits:
EPC Boundaries, ML Boundaries and MDL Boundaries
and Watercourse Drainage
© State of Queensland (Department of Natural
Resources, Mines and Energy) 2018.

Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator
Datum: GDA 1994
Date: 22-Nov-18



Scale: 1:20,000 at A3



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

**FAIRHILL
COKING COAL
PTY LTD**

**FAIRHILL
SOIL TYPE**

Legend

-  Soil Study Area
-  Fairhill Infrastructure
-  Watercourse / Drainage
-  Exploration permit for coal

Soil types encountered

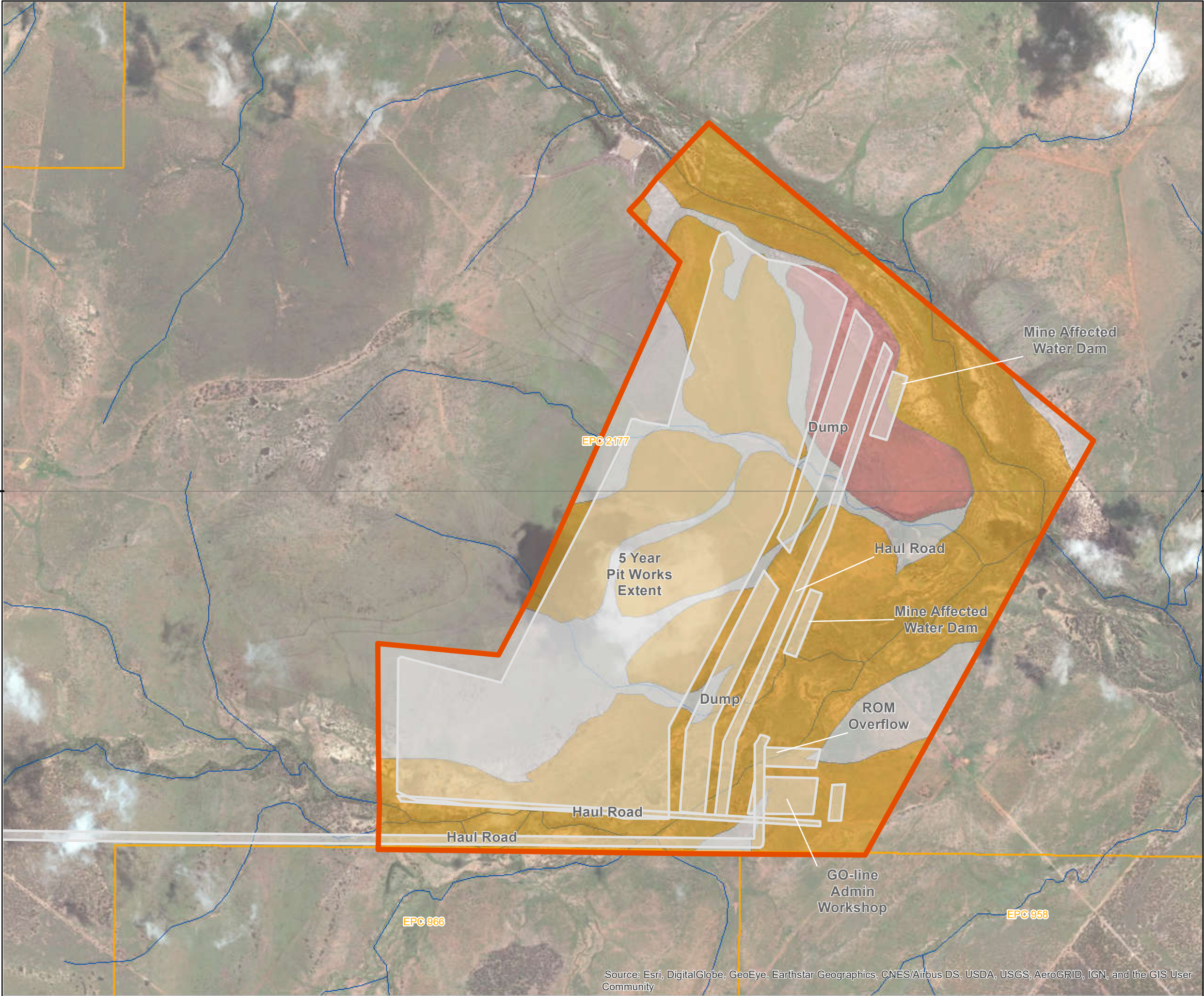
-  Brown Dermosol
-  Grey Dermosol
-  Red Dermosol

Credits:
EPC Boundaries, ML Boundaries and MDL Boundaries and Watercourse Drainage
© State of Queensland (Department of Natural Resources, Mines and Energy) 2018.

Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator
Datum: GDA 1994
Date: 22-Nov-18



Scale: 1:20,000 at A3



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

**FAIRHILL
COKING COAL
PTY LTD**

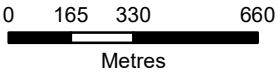
**FAIRHILL
SOIL
STUDY
AREA**

Legend

-  Soil Study Area
-  Fairhill Infrastructure
-  Watercourse / Drainage
-  Exploration permit for coal

Credits:
EPC Boundaries, ML Boundaries and MDL Boundaries
and Watercourse Drainage
© State of Queensland (Department of Natural
Resources, Mines and Energy) 2018.

Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator
Datum: GDA 1994
Date: 22-Nov-18



Scale: 1:20,000 at A3



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

FAIRHILL COKING COAL PTY LTD FAIRHILL GOOD QUALITY AGRICULTURAL LAND

Legend

-  Watercourse / Drainage
-  Fairhill Infrastructure
-  Soil Study
- Agricultural Land Audit - Queensland Agricultural Land Class (A and B)**
-  C1/A: Mix of class C1 and class A land
-  Exploration permit for coal

Credits:
EPC Boundaries, ML Boundaries and MDL Boundaries and
Agricultural Land Audit - Queensland Agricultural Land Class A
and B and Watercourse Drainage
© State of Queensland (Department of Natural
Resources, Mines and Energy) 2018.

Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator
Datum: GDA 1994
Date: 22-Nov-18

0 165 330 660
Metres

Scale: 1:20,000 at A3



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

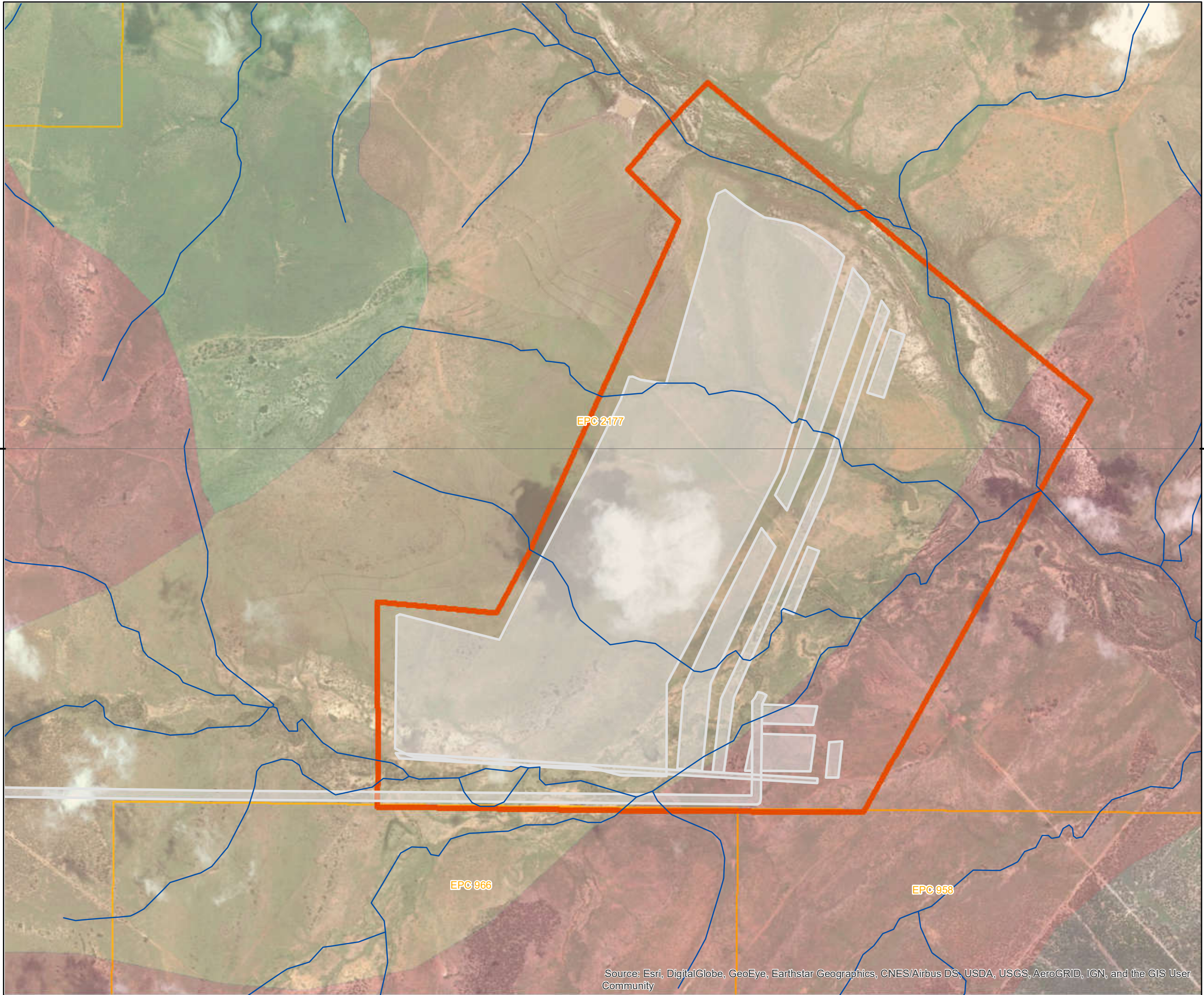
7430000

7430000

EPC 2177

EPC 966

EPC 958



FAIRHILL COKING COAL PTY LTD

FAIRHILL LAND UNITS OF THE ISSAC - COMET AREA

Legend

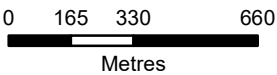
- Watercourse / Drainage
- Fairhill Infrastructure
- Soil Study Area
- Exploration permit for coal

Land units of the Issac and Comet area

- Da, Daunia
- Gi, Girrah
- Hu, Humboldt

Credits:
EPC Boundaries, ML Boundaries and MDL Boundaries and
Land Units of the Issac and Comet Area
and Watercourse Drainage
© State of Queensland (Department of Natural
Resources, Mines and Energy) 2018.

Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator
Datum: GDA 1994
Date: 22-Nov-18



Scale: 1:20,000 at A3



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

FAIRHILL COKING COAL PTY LTD

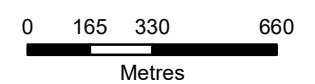
FAIRHILL SOIL SAMPLING LOCATIONS

Legend

-  Soil sample location
-  Watercourse / Drainage
-  Exploration permit for coal
-  Soil Study Area
-  Fairhill Infrastructure

Credits:
EPC Boundaries, ML Boundaries and MDL Boundaries and
Land Units of the Issac and Comet Area
and Watercourse Drainage
© State of Queensland (Department of Natural
Resources, Mines and Energy) 2018.

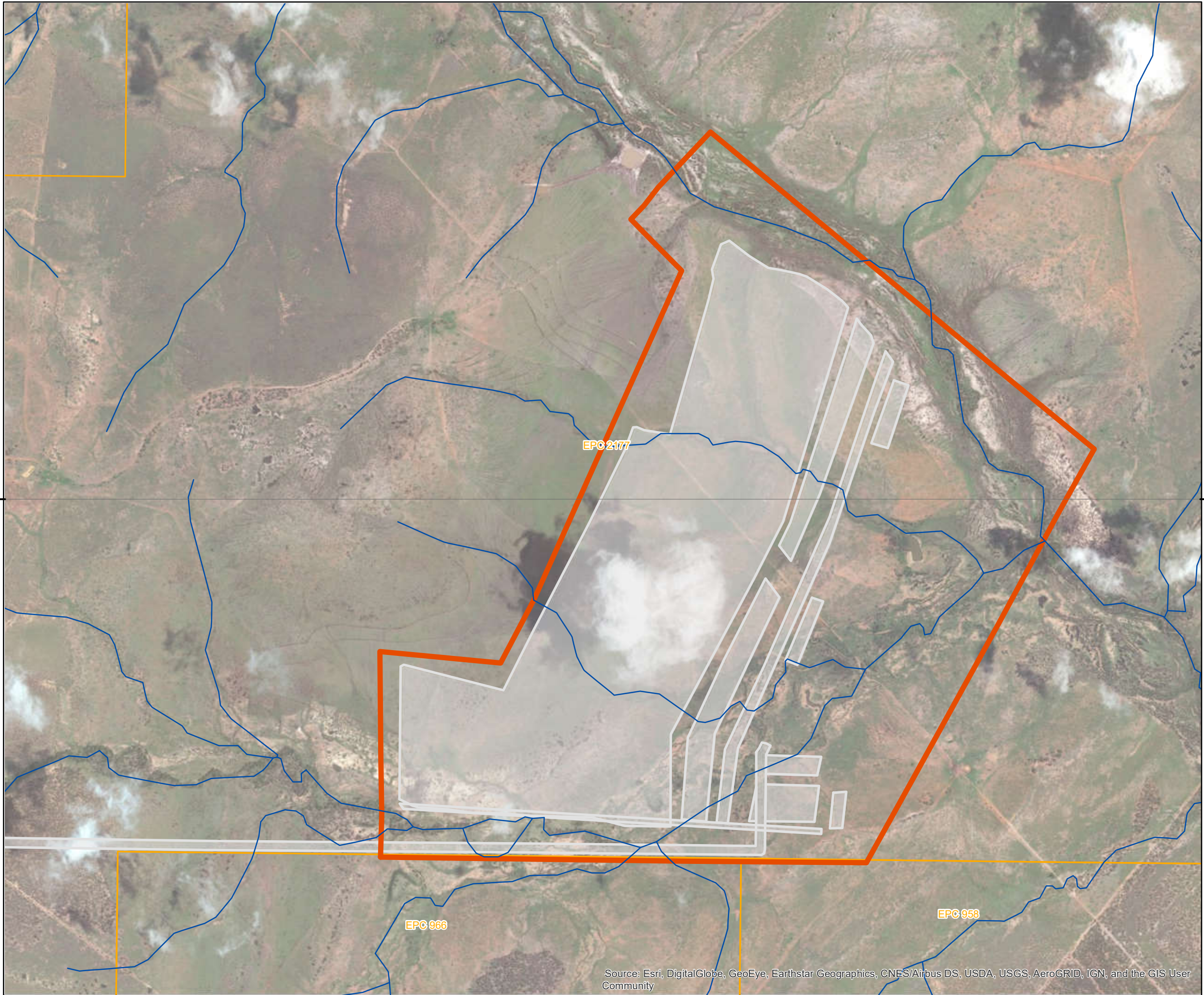
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Date: 22-Nov-18



Scale: 1:20,000 at A3



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



**FAIRHILL
COKING COAL
PTY LTD**

**FAIRHILL
STRATEGIC
CROPPING
LAND**

Legend

- Watercourse / Drainage
- Soil Study
- Strategic cropping land
- Exploration permit for coal
- Fairhill Infrastructure

Credits:
EPC Boundaries, ML Boundaries and MDL Boundaries and Strategic Cropping Land
and Watercourse Drainage
© State of Queensland (Department of Natural Resources, Mines and Energy) 2018.

Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator
Datum: GDA 1994
Date: 22-Nov-18

0 165 330 660
Metres

Scale: 1:20,000 at A3



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Appendix B

Certificates of Analysis



SOIL TEST REPORT

Page 1 of 3

Scone Research Centre

REPORT NO: SCO17/175R1

REPORT TO: Shey Goddard
SGS Australia Pty Ltd
Unit 2, 58 Comport Street
Portsmith QLD 4870

REPORT ON: Thirty Three Soil Samples
Your Reference: CE129907

PRELIMINARY RESULTS

ISSUED: Not Issued

REPORT STATUS: Final

DATE REPORTED: 10 November 2017

METHODS: Information on test procedures can be obtained from Scone
Research Centre

TESTING CARRIED OUT ON SAMPLE AS RECEIVED
THIS DOCUMENT MAY NOT BE REPRODUCED EXCEPT IN FULL

L Dunn
Scone Laboratory

SOIL CONSERVATION SERVICE
Scone Research Centre

Page 2 of 3

Report No: SCO17/175R1
Client Reference: Shey Goddard
SGS Australia Pty Ltd
Unit 2, 58 Comport Street
Portsmith QLD 4870

Lab No	Method	P18A/3 (%)*		
	Sample Id	0.3 bar (Field Capacity)	15 bar (Wilting Point)	Available Water Capacity
1	CE129907.001	10	2	8
2	CE129907.002	15	6	9
3	CE129907.003	39	18	21
4	CE129907.004	38	19	19
5	CE129907.005	45	22	23
6	CE129907.006	40	20	20
7	CE129907.007	24	10	14
8	CE129907.008	28	13	15
9	CE129907.009	34	15	19
10	CE129907.010	36	17	19
11	CE129907.011	37	17	20
12	CE129907.012	10	2	8
13	CE129907.013	27	11	16
14	CE129907.014	27	14	13
15	CE129907.015	27	14	13
16	CE129907.016	30	13	17
17	CE129907.017	26	11	15
18	CE129907.018	24	10	14
19	CE129907.019	37	18	19
20	CE129907.020	38	18	20
21	CE129907.021	25	11	14
22	CE129907.022	27	10	17
23	CE129907.023	28	12	16
24	CE129907.024	35	17	18
25	CE129907.025	38	19	19

*moisture content (%) by weight



SOIL CONSERVATION SERVICE
Scone Research Centre

Page 3 of 3

Report No: SCO17/175R1
Client Reference: Shey Goddard
SGS Australia Pty Ltd
Unit 2, 58 Comport Street
Portsmith QLD 4870

Lab No	Method	P18A/3 (%)*		
	Sample Id	0.3 bar (Field Capacity)	15 bar (Wilting Point)	Available Water Capacity
26	CE129907.026	23	10	13
27	CE129907.027	36	19	17
28	CE129907.028	36	20	16
29	CE129907.029	44	25	19
30	CE129907.030	44	24	20
31	CE129907.031	4	2	2
32	CE129907.032	5	2	3
33	CE129907.033	6	2	4

*moisture content (%) by weight



END OF TEST REPORT

CLIENT DETAILS

Contact Scott Hayes-Stanley
Client NORTHERN RESOURCE CONSULTANTS PTY LTD
Address 12 CANNAN STREET
SOUTH TOWNSVILLE QLD 4810

Telephone 61 7 4772 6500
Facsimile 61 7 4772 2441
Email scotths@northres.com.au

Project Fairhill Soil
Order Number (Not specified)
Samples 33

LABORATORY DETAILS

Manager Jon Dicker
Laboratory SGS Cairns Environmental
Address Unit 2, 58 Comport St
Portsmith QLD 4870

Telephone +61 07 4035 5111
Facsimile +61 07 4035 5122
Email AU.Environmental.Cairns@sgs.com

SGS Reference CE129907 R0
Date Received 16 Oct 2017
Date Reported 10 Nov 2017

COMMENTS

Accredited for compliance with ISO/IEC 17025 - Testing. NATA accredited laboratory 2562(3146).

Particle sizing of soils <75um by Hydrometer not conducted where insufficient sample passes the 75um fraction.

Please see attached report for plant available water subcontracted to Soil Conservation Service, 709 Gundy Road, SCONE NSW 2337, SCO17/175R1.

SIGNATORIES



Anthony Nilsson
Operations Manager



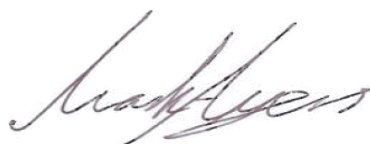
Jon Dicker
Manager Northern QLD



Leanne Orsmond
Quality & Microbiology Coordinator



Maristela Ganzan
Metals Team Leader



Mark Ayers
Team Leader - Agri Plant/Soil

Parameter	Units	LOR	Sample Number	CE129907.001	CE129907.002	CE129907.003	CE129907.004
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	26 Sep 2017	26 Sep 2017	27 Sep 2017	27 Sep 2017
			Sample Name	S1_10_20	S1_20_30	S20_0_10	S20_10_20

Moisture Content Method: AN002 Tested: 16/10/2017

% Moisture	%w/w	0.5	1.1	3.0	7.7	8.2
------------	------	-----	-----	-----	-----	-----

pH in soil (1:5) Method: AN101 Tested: 19/10/2017

pH	pH Units	-	7.2	7.4	8.7	8.8
----	----------	---	-----	-----	-----	-----

Conductivity and TDS by Calculation - Soil Method: AN106 Tested: 19/10/2017

Conductivity of Extract (1:5 dry sample basis)	µS/cm	1	38	56	270	330
Total Dissolved Solids (by calculation)	mg/kg	5	110	170	810	980

Chloride (water extractable) Method: AN274 Tested: 20/10/2017

Chloride (water extractable 1:5)	mg/kg	5	8	23	76	140
----------------------------------	-------	---	---	----	----	-----

Water Soluble Acidity of Soil Method: AN002/AN140 Tested: 19/10/2017

Water Soluble Acidity as CaCO ₃ to pH 8.3*	mg/kg	25	-	-	-	-
---	-------	----	---	---	---	---

Colwell Phosphorus Method: AN015 Tested: 18/10/2017

Colwell Phosphorus	mg/kg	1	11	7	12	11
--------------------	-------	---	----	---	----	----

Parameter	Units	LOR	Sample Number	CE129907.001	CE129907.002	CE129907.003	CE129907.004
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	26 Sep 2017	26 Sep 2017	27 Sep 2017	27 Sep 2017
			Sample Name	S1_10_20	S1_20_30	S20_0_10	S20_10_20

Bicarbonate Extractable (Colwell) Potassium, K Method: AN015/AN320 Tested: 26/10/2017

Bicarbonate Extractable (Colwell) Potassium, K*	mg/kg	10	130	140	370	340
---	-------	----	-----	-----	-----	-----

Nitrate Nitrogen and Nitrite Nitrogen (NOx) by Auto Analyser in Soil Method: AN248 Tested: 20/10/2017

Nitrate/Nitrite Nitrogen, NOx as N	mg/kg	0.1	<0.1	<0.1	3.8	3.2
------------------------------------	-------	-----	------	------	-----	-----

Total Kjeldahl Nitrogen and Total Nitrogen in Soil/Sludges Method: AN281 Tested: 19/10/2017

Total Kjeldahl Nitrogen	mg/kg	5	240	400	1300	1000
Total Nitrogen	mg/kg	10	240	400	1300	1000

Total Organic Carbon by Heanes Oxidation Method: AN273 Tested: 19/10/2017

Total Organic Carbon	%w/w	0.05	0.35	0.34	1.4	1.4
Organic Matter	%w/w	0.1	0.60	0.58	2.4	2.4

Emerson Class Number Method: AN009 Tested: 18/10/2017

Emerson Class Number	No unit	1	1	1	5	5
----------------------	---------	---	---	---	---	---

Exchangeable Cations and Cation Exchange Capacity (CEC/ESP/SAR) Method: AN122 Tested: 20/10/2017

Exchangeable Sodium, Na	mg/kg	2	-	-	-	-
Exchangeable Sodium, Na	meq/100g	0.01	-	-	-	-
Exchangeable Sodium Percentage	%	0.1	-	-	-	-
Exchangeable Potassium, K	mg/kg	2	-	-	-	-
Exchangeable Potassium, K	meq/100g	0.01	-	-	-	-
Exchangeable Potassium Percentage	%	0.1	-	-	-	-
Exchangeable Calcium Percentage	%	0.1	-	-	-	-
Exchangeable Calcium, Ca	mg/kg	2	-	-	-	-
Exchangeable Calcium, Ca	meq/100g	0.01	-	-	-	-
Exchangeable Magnesium, Mg	mg/kg	2	-	-	-	-
Exchangeable Magnesium, Mg	meq/100g	0.02	-	-	-	-
Exchangeable Magnesium Percentage	%	0.1	-	-	-	-
Cation Exchange Capacity	meq/100g	0.02	-	-	-	-
Exchangeable Calcium/Exchangeable Magnesium Ratio	No unit	0.1	-	-	-	-
Monovalent Cations/Divalent Cations Ratio*	No unit	0.1	-	-	-	-
Cation Exchange Capacity (soluble salts removed)	meq/100g	0.02	-	-	-	-
Sodium Adsorption Ratio	No unit	0.1	-	-	-	-
Exchangeable Aluminium, Al	cmol (+)/kg	0.01	-	-	-	-

Parameter	Units	LOR	Sample Number	CE129907.001	CE129907.002	CE129907.003	CE129907.004
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	26 Sep 2017	26 Sep 2017	27 Sep 2017	27 Sep 2017
			Sample Name	S1_10_20	S1_20_30	S20_0_10	S20_10_20

DTPA Extractable Metals in Soil Method: AN025/AN320 Tested: 20/10/2017

Copper, Cu	mg/kg	0.05	0.46	0.73	1.6	1.6
Zinc, Zn	mg/kg	0.05	0.28	0.26	0.45	0.35
Manganese, Mn	mg/kg	0.5	17	15	12	9.6
Iron, Fe	mg/kg	0.5	23	30	17	18

Calcium Chloride Extractable Boron Method: RL 12C2/AN320 Tested: 20/10/2017

CaCl ₂ -extractable Boron, B*	mg/kg	0.05	0.34	0.43	0.95	1.3
--	-------	------	------	------	------	-----

Calcium Chloride Extractable Molybdenum Method: RL 12E1/AN318 Tested: 31/10/2017

CaCl ₂ -extractable Molybdenum, Mo*	mg/kg	0.1	<0.10	<0.10	<0.10	<0.10
--	-------	-----	-------	-------	-------	-------

Potassium Chloride Extractable Sulphur Method: RL 10D1/AN320 Tested: 20/10/2017

KCl-40-extractable Sulphur, S*	mg/kg	1	2	2	9	8
--------------------------------	-------	---	---	---	---	---

Particle sizing of soils by sieving Method: AN005 Tested: 30/10/2017

Passing 2.00mm	%w/w	1	94	97	92	94
Retained 2.00mm	%w/w	1	6	3	8	6
Passing 600µm	%w/w	1	66	69	87	89
Retained 600µm	%w/w	1	28	27	5	5
Passing 300µm	%w/w	1	36	42	84	86
Retained 300µm	%w/w	1	29	28	3	3
Passing 125µm	%w/w	1	22	25	73	76
Retained 125µm	%w/w	1	15	17	11	10
Passing 63µm	%w/w	1	20	23	70	73
Retained 63µm	%w/w	1	2	2	4	3

Particle sizing of soils <75µm by hydrometer Method: AN005 Tested: 28/10/2017

Sedimentation Diameter 1	mm	0.0001	0.0596	0.0592	0.0525	0.0518
Passing Sedimentation Diameter 1	%w/w	1	19	21	67	72
Retained Sedimentation Diameter 1	%w/w	1	1	2	3	1
Sedimentation Diameter 2	mm	0.0001	0.0424	0.0420	0.0377	0.0372
Passing Sedimentation Diameter 2	%w/w	1	16	20	62	67
Retained Sedimentation Diameter 2	%w/w	1	2	1	5	5
Sedimentation Diameter 3	mm	0.0001	0.0301	0.0298	0.0270	0.0264
Passing Sedimentation Diameter 3	%w/w	1	14	19	58	65
Retained Sedimentation Diameter 3	%w/w	1	2	1	5	2
Sedimentation Diameter 4	mm	0.0001	0.0214	0.0212	0.0193	0.0193
Passing Sedimentation Diameter 4	%w/w	1	12	17	53	53
Retained Sedimentation Diameter 4	%w/w	1	2	2	5	12
Sedimentation Diameter 5	mm	0.0001	0.01570	0.0155	0.0142	0.0143
Passing Sedimentation Diameter 5	%w/w	1	12	16	50	48
Retained Sedimentation Diameter 5	%w/w	1	<1	1	2	5
Sedimentation Diameter 6	mm	0.0001	0.0111	0.0110	0.0102	0.0102
Passing Sedimentation Diameter 6	%w/w	1	11	16	46	44
Retained Sedimentation Diameter 6	%w/w	1	1	<1	5	5
Sedimentation Diameter 7	mm	0.0001	0.0079	0.0078	0.0072	0.0073
Passing Sedimentation Diameter 7	%w/w	1	10	13	43	39
Retained Sedimentation Diameter 7	%w/w	1	1	2	2	5
Sedimentation Diameter 8	mm	0.0001	0.0056	0.0055	0.0052	0.0052
Passing Sedimentation Diameter 8	%w/w	1	8	12	41	37
Retained Sedimentation Diameter 8	%w/w	1	2	1	2	2
Sedimentation Diameter 9	mm	0.0001	0.0040	0.0039	0.0037	0.0037
Passing Sedimentation Diameter 9	%w/w	1	8	11	36	32
Retained Sedimentation Diameter 9	%w/w	1	<1	1	5	5
Sedimentation Diameter 10	mm	0.0001	0.0016	0.0016	0.0015	0.0016
Passing Sedimentation Diameter 10	%w/w	1	5	9	32	25

Parameter	Units	LOR	Sample Number	CE129907.001	CE129907.002	CE129907.003	CE129907.004
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	26 Sep 2017	26 Sep 2017	27 Sep 2017	27 Sep 2017
			Sample Name	S1_10_20	S1_20_30	S20_0_10	S20_10_20

Particle sizing of soils <75µm by hydrometer Method: AN005 Tested: 28/10/2017 (continued)

Retained Sedimentation Diameter 10	%w/w	1	2	2	5	7
Sedimentation Diameter 11	mm	0.0001	0.0012	0.0011	0.0011	0.0011
Passing Sedimentation Diameter 11	%w/w	1	3	8	22	22
Retained Sedimentation Diameter 11	%w/w	1	2	1	9	2
Clay (<0.002mm)	%w/w	0.1	5.0	9.0	32	25
Silt and Clay (<0.005mm)*	%w/w	0.1	8.0	12	41	37
Silt (0.002mm to 0.06mm)*	%w/w	0.1	15	14	38	48
Fine Sand (0.06mm to 0.20mm)*	%w/w	0.1	2.0	2.3	3.6	3.0
Medium and Coarse Sand (0.20mm to 2.0mm)*	%w/w	0.1	72	71	19	18
Gravels (>2.0mm)*	%w/w	0.1	6.3	3.4	7.8	6.2

Parameter	Sample Number		CE129907.001	CE129907.002	CE129907.003	CE129907.004
	Sample Matrix		Soil	Soil	Soil	Soil
	Sample Date		26 Sep 2017	26 Sep 2017	27 Sep 2017	27 Sep 2017
	Sample Name		S1_10_20	S1_20_30	S20_0_10	S20_10_20
Units	LOR					

Erodibility Factor of Soil Method: CSIRO Tech Report 13/01 Tested: 26/10/2017

Erodibility Factor (K)*	t.ha.h/ha/MJ/	-	0.02	0.03	0.06	0.07
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Soil Texture (Northcote, 1979) Method: Northcote (1979) Tested: 18/10/2017

Texture Classification*	No unit	1	Sand	Sand	Light Clay	Light Clay
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Sample Subcontracted Method: Tested: 10/11/2017

Sample Subcontracted*	No unit	-	See attached	See attached	See attached	See attached
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Parameter	Units	LOR	Sample Number	CE129907.005	CE129907.006	CE129907.007	CE129907.008
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	27 Sep 2017	27 Sep 2017	28 Sep 2017	28 Sep 2017
			Sample Name	S20_50_70	S20_20_50	S21_0_10	S21_10_20

Moisture Content Method: AN002 Tested: 16/10/2017

% Moisture	%w/w	0.5	14	12	3.8	5.5
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pH in soil (1:5) Method: AN101 Tested: 19/10/2017

pH	pH Units	-	8.4	8.6	7.0	7.2
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Conductivity and TDS by Calculation - Soil Method: AN106 Tested: 19/10/2017

Conductivity of Extract (1:5 dry sample basis)	µS/cm	1	1200	480	41	46
Total Dissolved Solids (by calculation)	mg/kg	5	3500	1400	120	140

Chloride (water extractable) Method: AN274 Tested: 20/10/2017

Chloride (water extractable 1:5)	mg/kg	5	1400	360	15	7
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Water Soluble Acidity of Soil Method: AN002/AN140 Tested: 19/10/2017

Water Soluble Acidity as CaCO ₃ to pH 8.3*	mg/kg	25	<25	<25	-	-
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Colwell Phosphorus Method: AN015 Tested: 18/10/2017

Colwell Phosphorus	mg/kg	1	3	4	8	5
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Parameter	Units	LOR	Sample Number	CE129907.005	CE129907.006	CE129907.007	CE129907.008
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	27 Sep 2017	27 Sep 2017	28 Sep 2017	28 Sep 2017
			Sample Name	S20_50_70	S20_20_50	S21_0_10	S21_10_20

Bicarbonate Extractable (Colwell) Potassium, K Method: AN015/AN320 Tested: 26/10/2017

Bicarbonate Extractable (Colwell) Potassium, K*	mg/kg	10	250	240	160	150
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Nitrate Nitrogen and Nitrite Nitrogen (NOx) by Auto Analyser in Soil Method: AN248 Tested: 20/10/2017

Nitrate/Nitrite Nitrogen, NOx as N	mg/kg	0.1	-	-	0.8	0.6
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Total Kjeldahl Nitrogen and Total Nitrogen in Soil/Sludges Method: AN281 Tested: 17/10/2017

Total Kjeldahl Nitrogen	mg/kg	5	-	-	780	710
Total Nitrogen	mg/kg	10	-	-	780	710

Total Organic Carbon by Heanes Oxidation Method: AN273 Tested: 25/10/2017

Total Organic Carbon	%w/w	0.05	1.0	1.1	0.88	0.87
Organic Matter	%w/w	0.1	1.7	1.9	1.7	1.5

Emerson Class Number Method: AN009 Tested: 18/10/2017

Emerson Class Number	No unit	1	5	5	5	3
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Exchangeable Cations and Cation Exchange Capacity (CEC/ESP/SAR) Method: AN122 Tested: 20/10/2017

Exchangeable Sodium, Na	mg/kg	2	2300	1200	-	-
Exchangeable Sodium, Na	meq/100g	0.01	10	5.0	-	-
Exchangeable Sodium Percentage	%	0.1	17.4	8.7	-	-
Exchangeable Potassium, K	mg/kg	2	420	400	-	-
Exchangeable Potassium, K	meq/100g	0.01	1.1	1.0	-	-
Exchangeable Potassium Percentage	%	0.1	1.9	1.8	-	-
Exchangeable Calcium Percentage	%	0.1	56.0	66.5	-	-
Exchangeable Calcium, Ca	mg/kg	2	6400	7700	-	-
Exchangeable Calcium, Ca	meq/100g	0.01	32	38	-	-
Exchangeable Magnesium, Mg	mg/kg	2	1700	1600	-	-
Exchangeable Magnesium, Mg	meq/100g	0.02	14	13	-	-
Exchangeable Magnesium Percentage	%	0.1	24.7	23.0	-	-
Cation Exchange Capacity	meq/100g	0.02	57	58	-	-
Exchangeable Calcium/Exchangeable Magnesium Ratio	No unit	0.1	2.3	2.9	-	-
Monovalent Cations/Divalent Cations Ratio*	No unit	0.1	0.2	0.1	-	-
Cation Exchange Capacity (soluble salts removed)	meq/100g	0.02	-	-	-	-
Sodium Adsorption Ratio	No unit	0.1	2.1	1.0	-	-
Exchangeable Aluminium, Al	cmol (+)/kg	0.01	-	-	-	-

Parameter	Units	LOR	Sample Number	CE129907.005	CE129907.006	CE129907.007	CE129907.008
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	27 Sep 2017	27 Sep 2017	28 Sep 2017	28 Sep 2017
			Sample Name	S20_50_70	S20_20_50	S21_0_10	S21_10_20

DTPA Extractable Metals in Soil Method: AN025/AN320 Tested: 24/10/2017

Copper, Cu	mg/kg	0.05	-	-	1.2	1.2
Zinc, Zn	mg/kg	0.05	-	-	0.23	0.19
Manganese, Mn	mg/kg	0.5	-	-	25	23
Iron, Fe	mg/kg	0.5	-	-	16	14

Calcium Chloride Extractable Boron Method: RL 12C2/AN320 Tested: 24/10/2017

CaCl ₂ -extractable Boron, B*	mg/kg	0.05	-	-	0.50	0.59
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Calcium Chloride Extractable Molybdenum Method: RL 12E1/AN318 Tested: 31/10/2017

CaCl ₂ -extractable Molybdenum, Mo*	mg/kg	0.1	-	-	<0.10	<0.10
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Potassium Chloride Extractable Sulphur Method: RL 10D1/AN320 Tested: 20/10/2017

KCl-40-extractable Sulphur, S*	mg/kg	1	11	10	4	4
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Particle sizing of soils by sieving Method: AN005 Tested: 30/10/2017

Passing 2.00mm	%w/w	1	96	94	92	91
Retained 2.00mm	%w/w	1	4	6	8	9
Passing 600µm	%w/w	1	92	89	87	86
Retained 600µm	%w/w	1	4	5	5	5
Passing 300µm	%w/w	1	90	87	67	71
Retained 300µm	%w/w	1	2	3	20	14
Passing 125µm	%w/w	1	84	80	43	44
Retained 125µm	%w/w	1	6	7	24	27
Passing 63µm	%w/w	1	82	78	38	40
Retained 63µm	%w/w	1	2	2	5	4

Particle sizing of soils <75µm by hydrometer Method: AN005 Tested: 28/10/2017

Sedimentation Diameter 1	mm	0.0001	0.0511	0.0515	0.0568	0.0568
Passing Sedimentation Diameter 1	%w/w	1	81	77	37	38
Retained Sedimentation Diameter 1	%w/w	1	1	1	1	3
Sedimentation Diameter 2	mm	0.0001	0.0364	0.0368	0.0406	0.0404
Passing Sedimentation Diameter 2	%w/w	1	79	73	33	36
Retained Sedimentation Diameter 2	%w/w	1	3	4	5	2
Sedimentation Diameter 3	mm	0.0001	0.0259	0.0262	0.0288	0.0287
Passing Sedimentation Diameter 3	%w/w	1	76	71	32	33
Retained Sedimentation Diameter 3	%w/w	1	3	2	1	2
Sedimentation Diameter 4	mm	0.0001	0.0185	0.0186	0.0204	0.0203
Passing Sedimentation Diameter 4	%w/w	1	74	68	30	33
Retained Sedimentation Diameter 4	%w/w	1	3	2	1	<1
Sedimentation Diameter 5	mm	0.0001	0.0136	0.0138	0.0149	0.0149
Passing Sedimentation Diameter 5	%w/w	1	71	62	30	31
Retained Sedimentation Diameter 5	%w/w	1	3	6	<1	2
Sedimentation Diameter 6	mm	0.0001	0.0097	0.0098	0.0106	0.0106
Passing Sedimentation Diameter 6	%w/w	1	69	62	28	31
Retained Sedimentation Diameter 6	%w/w	1	3	<1	2	<1
Sedimentation Diameter 7	mm	0.0001	0.0069	0.0070	0.0075	0.0075
Passing Sedimentation Diameter 7	%w/w	1	64	57	28	29
Retained Sedimentation Diameter 7	%w/w	1	5	5	<1	2
Sedimentation Diameter 8	mm	0.0001	0.0049	0.0050	0.0053	0.0053
Passing Sedimentation Diameter 8	%w/w	1	61	52	26	29
Retained Sedimentation Diameter 8	%w/w	1	3	5	2	<1
Sedimentation Diameter 9	mm	0.0001	0.0035	0.0036	0.0038	0.0038
Passing Sedimentation Diameter 9	%w/w	1	56	47	24	26
Retained Sedimentation Diameter 9	%w/w	1	5	5	2	2
Sedimentation Diameter 10	mm	0.0001	0.0015	0.0015	0.0016	0.0015
Passing Sedimentation Diameter 10	%w/w	1	48	40	19	26

Parameter	Units	LOR	Sample Number	CE129907.005	CE129907.006	CE129907.007	CE129907.008
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	27 Sep 2017	27 Sep 2017	28 Sep 2017	28 Sep 2017
			Sample Name	S20_50_70	S20_20_50	S21_0_10	S21_10_20

Particle sizing of soils <75µm by hydrometer Method: AN005 Tested: 28/10/2017 (continued)

Retained Sedimentation Diameter 10	%w/w	1	8	7	5	<1
Sedimentation Diameter 11	mm	0.0001	0.0011	0.0011	0.0011	0.0011
Passing Sedimentation Diameter 11	%w/w	1	43	35	19	24
Retained Sedimentation Diameter 11	%w/w	1	5	5	<1	2
Clay (<0.002mm)	%w/w	0.1	48	40	19	26
Silt and Clay (<0.005mm)*	%w/w	0.1	61	52	26	29
Silt (0.002mm to 0.06mm)*	%w/w	0.1	34	38	19	14
Fine Sand (0.06mm to 0.20mm)*	%w/w	0.1	1.9	2.0	4.6	3.9
Medium and Coarse Sand (0.20mm to 2.0mm)*	%w/w	0.1	12	14	50	47
Gravels (>2.0mm)*	%w/w	0.1	3.9	6.2	7.8	9.2

Parameter	Sample Number		CE129907.005	CE129907.006	CE129907.007	CE129907.008
	Sample Matrix		Soil	Soil	Soil	Soil
	Sample Date		27 Sep 2017	27 Sep 2017	28 Sep 2017	28 Sep 2017
	Sample Name		S20_50_70	S20_20_50	S21_0_10	S21_10_20
Units	LOR					

Erodibility Factor of Soil Method: CSIRO Tech Report 13/01 Tested: 26/10/2017

Erodibility Factor (K)*	t.ha.h/ha/MJ/	-	0.08	0.07	0.04	0.04
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Soil Texture (Northcote, 1979) Method: Northcote (1979) Tested: 18/10/2017

Texture Classification*	No unit	1	Medium Heavy Clay	Medium Clay	Sandy Clay	Medium Clay
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Sample Subcontracted Method: Tested: 10/11/2017

Sample Subcontracted*	No unit	-	See attached	See attached	See attached	See attached
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Parameter	Units	LOR	Sample Number	CE129907.009	CE129907.010	CE129907.011	CE129907.012
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	28 Sep 2017	28 Sep 2017	28 Sep 2017	26 Sep 2017
			Sample Name	S21_30_40	S21_40_60	S21_65_75	S1_0_10

Moisture Content Method: AN002 Tested: 16/10/2017

% Moisture	%w/w	0.5	8.9	11	11	1.0
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pH in soil (1:5) Method: AN101 Tested: 19/10/2017

pH	pH Units	-	7.6	8.5	8.9	7.0
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Conductivity and TDS by Calculation - Soil Method: AN106 Tested: 19/10/2017

Conductivity of Extract (1:5 dry sample basis)	µS/cm	1	53	250	720	30
Total Dissolved Solids (by calculation)	mg/kg	5	160	760	2200	90

Chloride (water extractable) Method: AN274 Tested: 20/10/2017

Chloride (water extractable 1:5)	mg/kg	5	7	130	670	6
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Water Soluble Acidity of Soil Method: AN002/AN140 Tested: 19/10/2017

Water Soluble Acidity as CaCO ₃ to pH 8.3*	mg/kg	25	25	<25	<25	-
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Colwell Phosphorus Method: AN015 Tested: 18/10/2017

Colwell Phosphorus	mg/kg	1	3	2	2	12
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Parameter	Units	LOR	Sample Number	CE129907.009	CE129907.010	CE129907.011	CE129907.012
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	28 Sep 2017	28 Sep 2017	28 Sep 2017	26 Sep 2017
			Sample Name	S21_30_40	S21_40_60	S21_65_75	S1_0_10

Bicarbonate Extractable (Colwell) Potassium, K Method: AN015/AN320 Tested: 26/10/2017

Bicarbonate Extractable (Colwell) Potassium, K*	mg/kg	10	110	74	74	130
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Nitrate Nitrogen and Nitrite Nitrogen (NOx) by Auto Analyser in Soil Method: AN248 Tested: 20/10/2017

Nitrate/Nitrite Nitrogen, NOx as N	mg/kg	0.1	-	-	-	<0.1
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Total Kjeldahl Nitrogen and Total Nitrogen in Soil/Sludges Method: AN281 Tested: 17/10/2017

Total Kjeldahl Nitrogen	mg/kg	5	-	-	-	290
Total Nitrogen	mg/kg	10	-	-	-	290

Total Organic Carbon by Heanes Oxidation Method: AN273 Tested: 25/10/2017

Total Organic Carbon	%w/w	0.05	0.68	0.50	0.37	0.40
Organic Matter	%w/w	0.1	1.2	0.87	0.63	0.69

Emerson Class Number Method: AN009 Tested: 18/10/2017

Emerson Class Number	No unit	1	3	5	5	3
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Exchangeable Cations and Cation Exchange Capacity (CEC/ESP/SAR) Method: AN122 Tested: 20/10/2017

Exchangeable Sodium, Na	mg/kg	2	280	760	1000	-
Exchangeable Sodium, Na	meq/100g	0.01	1.2	3.3	4.5	-
Exchangeable Sodium Percentage	%	0.1	4.9	9.6	8.6	-
Exchangeable Potassium, K	mg/kg	2	160	120	100	-
Exchangeable Potassium, K	meq/100g	0.01	0.41	0.30	0.26	-
Exchangeable Potassium Percentage	%	0.1	1.7	0.9	0.5	-
Exchangeable Calcium Percentage	%	0.1	61.1	54.6	66.9	-
Exchangeable Calcium, Ca	mg/kg	2	3000	3800	6900	-
Exchangeable Calcium, Ca	meq/100g	0.01	15	19	35	-
Exchangeable Magnesium, Mg	mg/kg	2	970	1500	1500	-
Exchangeable Magnesium, Mg	meq/100g	0.02	7.9	12	12	-
Exchangeable Magnesium Percentage	%	0.1	32.3	34.9	23.9	-
Cation Exchange Capacity	meq/100g	0.02	25	34	52	-
Exchangeable Calcium/Exchangeable Magnesium Ratio	No unit	0.1	1.9	1.6	2.8	-
Monovalent Cations/Divalent Cations Ratio*	No unit	0.1	<0.1	0.1	0.1	-
Cation Exchange Capacity (soluble salts removed)	meq/100g	0.02	-	-	-	-
Sodium Adsorption Ratio	No unit	0.1	0.4	0.8	0.9	-
Exchangeable Aluminium, Al	cmol (+)/kg	0.01	-	-	-	-

Parameter	Units	LOR	Sample Number	CE129907.009	CE129907.010	CE129907.011	CE129907.012
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	28 Sep 2017	28 Sep 2017	28 Sep 2017	26 Sep 2017
			Sample Name	S21_30_40	S21_40_60	S21_65_75	S1_0_10

DTPA Extractable Metals in Soil Method: AN025/AN320 Tested: 24/10/2017

Copper, Cu	mg/kg	0.05	-	-	-	0.40
Zinc, Zn	mg/kg	0.05	-	-	-	0.29
Manganese, Mn	mg/kg	0.5	-	-	-	15
Iron, Fe	mg/kg	0.5	-	-	-	18

Calcium Chloride Extractable Boron Method: RL 12C2/AN320 Tested: 24/10/2017

CaCl ₂ -extractable Boron, B*	mg/kg	0.05	-	-	-	0.30
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Calcium Chloride Extractable Molybdenum Method: RL 12E1/AN318 Tested: 31/10/2017

CaCl ₂ -extractable Molybdenum, Mo*	mg/kg	0.1	-	-	-	<0.10
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Potassium Chloride Extractable Sulphur Method: RL 10D1/AN320 Tested: 20/10/2017

KCl-40-extractable Sulphur, S*	mg/kg	1	4	8	73	2
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Particle sizing of soils by sieving Method: AN005 Tested: 30/10/2017

Passing 2.00mm	%w/w	1	91	98	89	94
Retained 2.00mm	%w/w	1	9	2	11	6
Passing 600µm	%w/w	1	85	85	81	73
Retained 600µm	%w/w	1	6	13	8	22
Passing 300µm	%w/w	1	72	73	73	41
Retained 300µm	%w/w	1	13	12	8	31
Passing 125µm	%w/w	1	49	55	60	23
Retained 125µm	%w/w	1	24	18	13	19
Passing 63µm	%w/w	1	45	52	58	20
Retained 63µm	%w/w	1	4	3	2	3

Particle sizing of soils <75µm by hydrometer Method: AN005 Tested: 28/10/2017

Sedimentation Diameter 1	mm	0.0001	0.0561	0.0550	0.0543	0.0596
Passing Sedimentation Diameter 1	%w/w	1	44	52	57	19
Retained Sedimentation Diameter 1	%w/w	1	2	1	2	1
Sedimentation Diameter 2	mm	0.0001	0.0399	0.0391	0.0386	0.0424
Passing Sedimentation Diameter 2	%w/w	1	41	50	54	16
Retained Sedimentation Diameter 2	%w/w	1	2	2	2	2
Sedimentation Diameter 3	mm	0.0001	0.0283	0.0278	0.0275	0.0301
Passing Sedimentation Diameter 3	%w/w	1	40	49	52	14
Retained Sedimentation Diameter 3	%w/w	1	1	1	2	2
Sedimentation Diameter 4	mm	0.0001	0.0201	0.0198	0.0196	0.0214
Passing Sedimentation Diameter 4	%w/w	1	38	46	49	12
Retained Sedimentation Diameter 4	%w/w	1	2	2	2	2
Sedimentation Diameter 5	mm	0.0001	0.0147	0.0144	0.0143	0.0157
Passing Sedimentation Diameter 5	%w/w	1	38	46	49	10
Retained Sedimentation Diameter 5	%w/w	1	<1	<1	<1	2
Sedimentation Diameter 6	mm	0.0001	0.0104	0.0102	0.0102	0.0111
Passing Sedimentation Diameter 6	%w/w	1	37	45	47	10
Retained Sedimentation Diameter 6	%w/w	1	1	1	2	<1
Sedimentation Diameter 7	mm	0.0001	0.0074	0.0073	0.0072	0.0079
Passing Sedimentation Diameter 7	%w/w	1	34	42	44	7
Retained Sedimentation Diameter 7	%w/w	1	2	2	2	2
Sedimentation Diameter 8	mm	0.0001	0.0052	0.0052	0.0052	0.0056
Passing Sedimentation Diameter 8	%w/w	1	34	42	42	5
Retained Sedimentation Diameter 8	%w/w	1	<1	<1	2	2
Sedimentation Diameter 9	mm	0.0001	0.0037	0.0037	0.0037	0.0040
Passing Sedimentation Diameter 9	%w/w	1	32	40	40	3
Retained Sedimentation Diameter 9	%w/w	1	2	2	2	2
Sedimentation Diameter 10	mm	0.0001	0.0015	0.0015	0.0015	0.0016
Passing Sedimentation Diameter 10	%w/w	1	28	36	37	1

Parameter	Units	LOR	Sample Number	CE129907.009	CE129907.010	CE129907.011	CE129907.012
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	28 Sep 2017	28 Sep 2017	28 Sep 2017	26 Sep 2017
			Sample Name	S21_30_40	S21_40_60	S21_65_75	S1_0_10

Particle sizing of soils <75µm by hydrometer Method: AN005 Tested: 28/10/2017 (continued)

Retained Sedimentation Diameter 10	%w/w	1	4	4	2	2
Sedimentation Diameter 11	mm	0.0001	0.0011	0.0011	0.0011	0.0012
Passing Sedimentation Diameter 11	%w/w	1	27	35	35	1
Retained Sedimentation Diameter 11	%w/w	1	1	1	2	<1
Clay (<0.002mm)	%w/w	0.1	28	36	37	1.0
Silt and Clay (<0.005mm)*	%w/w	0.1	34	42	42	5.0
Silt (0.002mm to 0.06mm)*	%w/w	0.1	17	16	21	19
Fine Sand (0.06mm to 0.20mm)*	%w/w	0.1	3.5	2.8	2.3	2.6
Medium and Coarse Sand (0.20mm to 2.0mm)*	%w/w	0.1	43	43	29	72
Gravels (>2.0mm)*	%w/w	0.1	8.7	2.3	11	5.8

Parameter	Sample Number		CE129907.009	CE129907.010	CE129907.011	CE129907.012
	Sample Matrix		Soil	Soil	Soil	Soil
	Sample Date		28 Sep 2017	28 Sep 2017	28 Sep 2017	26 Sep 2017
	Sample Name		S21_30_40	S21_40_60	S21_65_75	S1_0_10
Units		LOR				

Erodibility Factor of Soil Method: CSIRO Tech Report 13/01 Tested: 26/10/2017

Erodibility Factor (K)*	t.ha.h/ha/MJ/	-	0.05	0.06	0.06	0.02
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Soil Texture (Northcote, 1979) Method: Northcote (1979) Tested: 18/10/2017

Texture Classification*	No unit	1	Medium Clay	Medium Clay	Medium Heavy Clay	Sand
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Sample Subcontracted Method: Tested: 10/11/2017

Sample Subcontracted*	No unit	-	See attached	See attached	See attached	See attached
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Parameter	Units	LOR	Sample Number	CE129907.013	CE129907.014	CE129907.015	CE129907.016
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	26 Sep 2017	26 Sep 2017	26 Sep 2017	28 Sep 2017
			Sample Name	S3_0_10	S3_10_20	S3_20_40	S22_0_10

Moisture Content Method: AN002 Tested: 16/10/2017

% Moisture	%w/w	0.5	4.7	8.1	7.7	3.0
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pH in soil (1:5) Method: AN101 Tested: 19/10/2017

pH	pH Units	-	6.9	7.2	7.6	6.8
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Conductivity and TDS by Calculation - Soil Method: AN106 Tested: 19/10/2017

Conductivity of Extract (1:5 dry sample basis)	µS/cm	1	46	60	160	120
Total Dissolved Solids (by calculation)	mg/kg	5	140	180	490	360

Chloride (water extractable) Method: AN274 Tested: 20/10/2017

Chloride (water extractable 1:5)	mg/kg	5	7	11	12	30
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Water Soluble Acidity of Soil Method: AN002/AN140 Tested: 19/10/2017

Water Soluble Acidity as CaCO ₃ to pH 8.3*	mg/kg	25	-	-	25	-
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Colwell Phosphorus Method: AN015 Tested: 18/10/2017

Colwell Phosphorus	mg/kg	1	8	4	4	59
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Parameter	Units	LOR	Sample Number	CE129907.013	CE129907.014	CE129907.015	CE129907.016
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	26 Sep 2017	26 Sep 2017	26 Sep 2017	28 Sep 2017
			Sample Name	S3_0_10	S3_10_20	S3_20_40	S22_0_10

Bicarbonate Extractable (Colwell) Potassium, K Method: AN015/AN320 Tested: 26/10/2017

Bicarbonate Extractable (Colwell) Potassium, K*	mg/kg	10	240	150	140	500
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Nitrate Nitrogen and Nitrite Nitrogen (NOx) by Auto Analyser in Soil Method: AN248 Tested: 20/10/2017

Nitrate/Nitrite Nitrogen, NOx as N	mg/kg	0.1	1.1	0.6	-	6.4
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Total Kjeldahl Nitrogen and Total Nitrogen in Soil/Sludges Method: AN281 Tested: 17/10/2017

Total Kjeldahl Nitrogen	mg/kg	5	740	670	-	1600
Total Nitrogen	mg/kg	10	750	670	-	1600

Total Organic Carbon by Heanes Oxidation Method: AN273 Tested: 19/10/2017

Total Organic Carbon	%w/w	0.05	0.82	0.76	0.81	2.5
Organic Matter	%w/w	0.1	1.4	1.3	1.4	4.3

Emerson Class Number Method: AN009 Tested: 18/10/2017

Emerson Class Number	No unit	1	5	5	5	3
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Exchangeable Cations and Cation Exchange Capacity (CEC/ESP/SAR) Method: AN122 Tested: 20/10/2017

Exchangeable Sodium, Na	mg/kg	2	-	-	57	-
Exchangeable Sodium, Na	meq/100g	0.01	-	-	0.25	-
Exchangeable Sodium Percentage	%	0.1	-	-	1.0	-
Exchangeable Potassium, K	mg/kg	2	-	-	140	-
Exchangeable Potassium, K	meq/100g	0.01	-	-	0.36	-
Exchangeable Potassium Percentage	%	0.1	-	-	1.4	-
Exchangeable Calcium Percentage	%	0.1	-	-	84.3	-
Exchangeable Calcium, Ca	mg/kg	2	-	-	4400	-
Exchangeable Calcium, Ca	meq/100g	0.01	-	-	22	-
Exchangeable Magnesium, Mg	mg/kg	2	-	-	420	-
Exchangeable Magnesium, Mg	meq/100g	0.02	-	-	3.4	-
Exchangeable Magnesium Percentage	%	0.1	-	-	13.3	-
Cation Exchange Capacity	meq/100g	0.02	-	-	26	-
Exchangeable Calcium/Exchangeable Magnesium Ratio	No unit	0.1	-	-	6.3	-
Monovalent Cations/Divalent Cations Ratio*	No unit	0.1	-	-	<0.1	-
Cation Exchange Capacity (soluble salts removed)	meq/100g	0.02	-	-	-	-
Sodium Adsorption Ratio	No unit	0.1	-	-	<0.1	-
Exchangeable Aluminium, Al	cmol (+)/kg	0.01	-	-	-	-

Parameter	Units	LOR	Sample Number	CE129907.013	CE129907.014	CE129907.015	CE129907.016
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	26 Sep 2017	26 Sep 2017	26 Sep 2017	28 Sep 2017
			Sample Name	S3_0_10	S3_10_20	S3_20_40	S22_0_10

DTPA Extractable Metals in Soil Method: AN025/AN320 Tested: 20/10/2017

Copper, Cu	mg/kg	0.05	0.57	0.43	-	1.6
Zinc, Zn	mg/kg	0.05	0.23	0.11	-	1.1
Manganese, Mn	mg/kg	0.5	23	21	-	32
Iron, Fe	mg/kg	0.5	8.5	6.0	-	48

Calcium Chloride Extractable Boron Method: RL 12C2/AN320 Tested: 20/10/2017

CaCl ₂ -extractable Boron, B*	mg/kg	0.05	0.76	0.88	-	1.0
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Calcium Chloride Extractable Molybdenum Method: RL 12E1/AN318 Tested: 31/10/2017

CaCl ₂ -extractable Molybdenum, Mo*	mg/kg	0.1	<0.10	<0.10	-	<0.10
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Potassium Chloride Extractable Sulphur Method: RL 10D1/AN320 Tested: 20/10/2017

KCl-40-extractable Sulphur, S*	mg/kg	1	8	10	6	8
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Particle sizing of soils by sieving Method: AN005 Tested: 30/10/2017

Passing 2.00mm	%w/w	1	95	99	95	99
Retained 2.00mm	%w/w	1	5	<1	5	<1
Passing 600µm	%w/w	1	94	98	89	98
Retained 600µm	%w/w	1	1	1	6	2
Passing 300µm	%w/w	1	87	92	76	94
Retained 300µm	%w/w	1	8	6	13	4
Passing 125µm	%w/w	1	50	58	49	69
Retained 125µm	%w/w	1	37	33	26	24
Passing 63µm	%w/w	1	46	56	47	64
Retained 63µm	%w/w	1	4	3	3	5

Particle sizing of soils <75µm by hydrometer Method: AN005 Tested: 28/10/2017

Sedimentation Diameter 1	mm	0.0001	0.0554	0.0543	0.0561	0.0529
Passing Sedimentation Diameter 1	%w/w	1	45	56	43	62
Retained Sedimentation Diameter 1	%w/w	1	2	1	3	2
Sedimentation Diameter 2	mm	0.0001	0.0394	0.0388	0.0400	0.0377
Passing Sedimentation Diameter 2	%w/w	1	43	52	40	60
Retained Sedimentation Diameter 2	%w/w	1	2	4	4	2
Sedimentation Diameter 3	mm	0.0001	0.0280	0.0274	0.0284	0.0268
Passing Sedimentation Diameter 3	%w/w	1	41	52	39	58
Retained Sedimentation Diameter 3	%w/w	1	2	<1	1	2
Sedimentation Diameter 4	mm	0.0001	0.0200	0.0196	0.0202	0.0191
Passing Sedimentation Diameter 4	%w/w	1	38	47	36	55
Retained Sedimentation Diameter 4	%w/w	1	3	5	2	2
Sedimentation Diameter 5	mm	0.0001	0.0147	0.0144	0.0148	0.0140
Passing Sedimentation Diameter 5	%w/w	1	36	45	34	53
Retained Sedimentation Diameter 5	%w/w	1	1	2	2	2
Sedimentation Diameter 6	mm	0.0001	0.0104	0.0102	0.0106	0.0100
Passing Sedimentation Diameter 6	%w/w	1	34	44	32	51
Retained Sedimentation Diameter 6	%w/w	1	2	1	2	2
Sedimentation Diameter 7	mm	0.0001	0.0074	0.0073	0.0075	0.0071
Passing Sedimentation Diameter 7	%w/w	1	32	41	29	49
Retained Sedimentation Diameter 7	%w/w	1	2	2	2	2
Sedimentation Diameter 8	mm	0.0001	0.0053	0.0052	0.0053	0.0051
Passing Sedimentation Diameter 8	%w/w	1	30	39	28	44
Retained Sedimentation Diameter 8	%w/w	1	2	2	1	5
Sedimentation Diameter 9	mm	0.0001	0.0038	0.0037	0.0038	0.0036
Passing Sedimentation Diameter 9	%w/w	1	28	32	23	39
Retained Sedimentation Diameter 9	%w/w	1	2	7	5	5
Sedimentation Diameter 10	mm	0.0001	0.0015	0.0015	0.0016	0.0015
Passing Sedimentation Diameter 10	%w/w	1	25	27	19	35

Parameter	Units	LOR	Sample Number	CE129907.013	CE129907.014	CE129907.015	CE129907.016
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	26 Sep 2017	26 Sep 2017	26 Sep 2017	28 Sep 2017
			Sample Name	S3_0_10	S3_10_20	S3_20_40	S22_0_10

Particle sizing of soils <75µm by hydrometer Method: AN005 Tested: 28/10/2017 (continued)

Retained Sedimentation Diameter 10	%w/w	1	2	5	5	5
Sedimentation Diameter 11	mm	0.0001	0.0011	0.0011	0.0011	0.0011
Passing Sedimentation Diameter 11	%w/w	1	23	27	17	33
Retained Sedimentation Diameter 11	%w/w	1	2	<1	1	2
Clay (<0.002mm)	%w/w	0.1	25	27	19	35
Silt and Clay (<0.005mm)*	%w/w	0.1	30	39	28	44
Silt (0.002mm to 0.06mm)*	%w/w	0.1	21	29	28	29
Fine Sand (0.06mm to 0.20mm)*	%w/w	0.1	4.2	2.6	2.7	5.1
Medium and Coarse Sand (0.20mm to 2.0mm)*	%w/w	0.1	46	41	46	30
Gravels (>2.0mm)*	%w/w	0.1	4.7	0.7	4.9	0.7

Parameter	Sample Number		CE129907.013	CE129907.014	CE129907.015	CE129907.016
	Sample Matrix		Soil	Soil	Soil	Soil
	Sample Date		26 Sep 2017	26 Sep 2017	26 Sep 2017	28 Sep 2017
	Sample Name		S3_0_10	S3_10_20	S3_20_40	S22_0_10
	Units	LOR				

Erodibility Factor of Soil Method: CSIRO Tech Report 13/01 Tested: 26/10/2017

Erodibility Factor (K)*	t.ha.h/ha/MJ/	-	0.05	0.05	0.05	0.05
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Soil Texture (Northcote, 1979) Method: Northcote (1979) Tested: 18/10/2017

Texture Classification*	No unit	1	Medium Clay	Medium Heavy Clay	Sandy Clay	Medium Clay
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Sample Subcontracted Method: Tested: 10/11/2017

Sample Subcontracted*	No unit	-	See attached	See attached	See attached	See attached
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Parameter	Units	LOR	Sample Number	CE129907.017	CE129907.018	CE129907.019	CE129907.020
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	28 Sep 2017	28 Sep 2017	28 Sep 2017	28 Sep 2017
			Sample Name	S22_10_20	S22_20_30	S22_30_50	S22_50_70

Moisture Content Method: AN002 Tested: 16/10/2017

% Moisture	%w/w	0.5	3.5	3.4	11	11
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pH in soil (1:5) Method: AN101 Tested: 19/10/2017

pH	pH Units	-	7.0	7.0	9.1	9.0
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Conductivity and TDS by Calculation - Soil Method: AN106 Tested: 19/10/2017

Conductivity of Extract (1:5 dry sample basis)	µS/cm	1	90	49	690	1100
Total Dissolved Solids (by calculation)	mg/kg	5	270	150	2100	3400

Chloride (water extractable) Method: AN274 Tested: 20/10/2017

Chloride (water extractable 1:5)	mg/kg	5	27	13	640	1300
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Water Soluble Acidity of Soil Method: AN002/AN140 Tested: 19/10/2017

Water Soluble Acidity as CaCO ₃ to pH 8.3*	mg/kg	25	-	-	<25	<25
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Colwell Phosphorus Method: AN015 Tested: 18/10/2017

Colwell Phosphorus	mg/kg	1	27	13	2	2
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Parameter	Units	LOR	Sample Number	CE129907.017	CE129907.018	CE129907.019	CE129907.020
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	28 Sep 2017	28 Sep 2017	28 Sep 2017	28 Sep 2017
			Sample Name	S22_10_20	S22_20_30	S22_30_50	S22_50_70

Bicarbonate Extractable (Colwell) Potassium, K Method: AN015/AN320 Tested: 26/10/2017

Bicarbonate Extractable (Colwell) Potassium, K*	mg/kg	10	360	270	130	140
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Nitrate Nitrogen and Nitrite Nitrogen (NOx) by Auto Analyser in Soil Method: AN248 Tested: 20/10/2017

Nitrate/Nitrite Nitrogen, NOx as N	mg/kg	0.1	2.8	1.1	-	-
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Total Kjeldahl Nitrogen and Total Nitrogen in Soil/Sludges Method: AN281 Tested: 17/10/2017

Total Kjeldahl Nitrogen	mg/kg	5	1400	900	-	-
Total Nitrogen	mg/kg	10	1400	900	-	-

Total Organic Carbon by Heanes Oxidation Method: AN273 Tested: 19/10/2017

Total Organic Carbon	%w/w	0.05	1.9	1.1	0.95	0.68
Organic Matter	%w/w	0.1	3.3	1.9	1.6	1.2

Emerson Class Number Method: AN009 Tested: 18/10/2017

Emerson Class Number	No unit	1	3	3	5	5
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Exchangeable Cations and Cation Exchange Capacity (CEC/ESP/SAR) Method: AN122 Tested: 20/10/2017

Exchangeable Sodium, Na	mg/kg	2	-	-	1700	2300
Exchangeable Sodium, Na	meq/100g	0.01	-	-	7.5	10
Exchangeable Sodium Percentage	%	0.1	-	-	13.3	17.2
Exchangeable Potassium, K	mg/kg	2	-	-	210	220
Exchangeable Potassium, K	meq/100g	0.01	-	-	0.53	0.57
Exchangeable Potassium Percentage	%	0.1	-	-	0.9	1.0
Exchangeable Calcium Percentage	%	0.1	-	-	63.9	60.7
Exchangeable Calcium, Ca	mg/kg	2	-	-	7200	7100
Exchangeable Calcium, Ca	meq/100g	0.01	-	-	36	35
Exchangeable Magnesium, Mg	mg/kg	2	-	-	1500	1500
Exchangeable Magnesium, Mg	meq/100g	0.02	-	-	12	12
Exchangeable Magnesium Percentage	%	0.1	-	-	21.8	21.1
Cation Exchange Capacity	meq/100g	0.02	-	-	56	58
Exchangeable Calcium/Exchangeable Magnesium Ratio	No unit	0.1	-	-	2.9	2.9
Monovalent Cations/Divalent Cations Ratio*	No unit	0.1	-	-	0.2	0.2
Cation Exchange Capacity (soluble salts removed)	meq/100g	0.02	-	-	-	-
Sodium Adsorption Ratio	No unit	0.1	-	-	1.5	2.1
Exchangeable Aluminium, Al	cmol (+)/kg	0.01	-	-	-	-

Parameter	Units	LOR	Sample Number	CE129907.017	CE129907.018	CE129907.019	CE129907.020
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	28 Sep 2017	28 Sep 2017	28 Sep 2017	28 Sep 2017
			Sample Name	S22_10_20	S22_20_30	S22_30_50	S22_50_70

DTPA Extractable Metals in Soil Method: AN025/AN320 Tested: 20/10/2017

Copper, Cu	mg/kg	0.05	1.4	1.4	-	-
Zinc, Zn	mg/kg	0.05	0.67	0.27	-	-
Manganese, Mn	mg/kg	0.5	22	18	-	-
Iron, Fe	mg/kg	0.5	36	31	-	-

Calcium Chloride Extractable Boron Method: RL 12C2/AN320 Tested: 20/10/2017

CaCl ₂ -extractable Boron, B*	mg/kg	0.05	0.83	0.75	-	-
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Calcium Chloride Extractable Molybdenum Method: RL 12E1/AN318 Tested: 31/10/2017

CaCl ₂ -extractable Molybdenum, Mo*	mg/kg	0.1	<0.10	<0.10	-	-
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Potassium Chloride Extractable Sulphur Method: RL 10D1/AN320 Tested: 20/10/2017

KCl-40-extractable Sulphur, S*	mg/kg	1	7	5	23	86
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Particle sizing of soils by sieving Method: AN005 Tested: 30/10/2017

Passing 2.00mm	%w/w	1	99	100	93	93
Retained 2.00mm	%w/w	1	<1	<1	7	7
Passing 600µm	%w/w	1	98	99	83	78
Retained 600µm	%w/w	1	<1	<1	11	15
Passing 300µm	%w/w	1	83	93	77	73
Retained 300µm	%w/w	1	15	6	6	5
Passing 125µm	%w/w	1	58	63	66	61
Retained 125µm	%w/w	1	26	30	11	12
Passing 63µm	%w/w	1	54	57	63	59
Retained 63µm	%w/w	1	4	6	3	2

Particle sizing of soils <75µm by hydrometer Method: AN005 Tested: 28/10/2017

Sedimentation Diameter 1	mm	0.0001	0.0547	0.0540	0.0536	0.0543
Passing Sedimentation Diameter 1	%w/w	1	51	56	62	57
Retained Sedimentation Diameter 1	%w/w	1	3	2	2	2
Sedimentation Diameter 2	mm	0.0001	0.0389	0.0384	0.0381	0.0389
Passing Sedimentation Diameter 2	%w/w	1	49	53	59	52
Retained Sedimentation Diameter 2	%w/w	1	2	2	2	5
Sedimentation Diameter 3	mm	0.0001	0.0275	0.0273	0.0271	0.0275
Passing Sedimentation Diameter 3	%w/w	1	49	51	58	52
Retained Sedimentation Diameter 3	%w/w	1	<1	2	1	<1
Sedimentation Diameter 4	mm	0.0001	0.0196	0.0194	0.0192	0.0195
Passing Sedimentation Diameter 4	%w/w	1	46	49	57	51
Retained Sedimentation Diameter 4	%w/w	1	2	2	1	1
Sedimentation Diameter 5	mm	0.0001	0.0143	0.0143	0.0141	0.0143
Passing Sedimentation Diameter 5	%w/w	1	46	46	54	48
Retained Sedimentation Diameter 5	%w/w	1	<1	2	2	2
Sedimentation Diameter 6	mm	0.0001	0.0102	0.0102	0.0100	0.0102
Passing Sedimentation Diameter 6	%w/w	1	44	44	52	47
Retained Sedimentation Diameter 6	%w/w	1	2	2	2	1
Sedimentation Diameter 7	mm	0.0001	0.0072	0.0072	0.0071	0.0072
Passing Sedimentation Diameter 7	%w/w	1	42	42	49	45
Retained Sedimentation Diameter 7	%w/w	1	2	2	2	2
Sedimentation Diameter 8	mm	0.0001	0.0052	0.0052	0.0051	0.0052
Passing Sedimentation Diameter 8	%w/w	1	40	38	47	40
Retained Sedimentation Diameter 8	%w/w	1	2	3	2	5
Sedimentation Diameter 9	mm	0.0001	0.0037	0.0037	0.0036	0.0037
Passing Sedimentation Diameter 9	%w/w	1	37	35	42	38
Retained Sedimentation Diameter 9	%w/w	1	2	3	5	2
Sedimentation Diameter 10	mm	0.0001	0.0015	0.0015	0.0015	0.0015
Passing Sedimentation Diameter 10	%w/w	1	33	30	37	34

Parameter	Units	LOR	Sample Number	CE129907.017	CE129907.018	CE129907.019	CE129907.020
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	28 Sep 2017	28 Sep 2017	28 Sep 2017	28 Sep 2017
			Sample Name	S22_10_20	S22_20_30	S22_30_50	S22_50_70

Particle sizing of soils <75µm by hydrometer Method: AN005 Tested: 28/10/2017 (continued)

Retained Sedimentation Diameter 10	%w/w	1	5	5	5	4
Sedimentation Diameter 11	mm	0.0001	0.0011	0.0011	0.0011	0.0011
Passing Sedimentation Diameter 11	%w/w	1	31	30	35	33
Retained Sedimentation Diameter 11	%w/w	1	2	<1	2	1
Clay (<0.002mm)	%w/w	0.1	33	30	37	34
Silt and Clay (<0.005mm)*	%w/w	0.1	40	38	47	40
Silt (0.002mm to 0.06mm)*	%w/w	0.1	21	27	26	25
Fine Sand (0.06mm to 0.20mm)*	%w/w	0.1	3.9	6.1	3.0	2.4
Medium and Coarse Sand (0.20mm to 2.0mm)*	%w/w	0.1	42	36	27	32
Gravels (>2.0mm)*	%w/w	0.1	0.7	0.4	6.9	6.6

Parameter	Units	LOR	Sample Number	CE129907.017	CE129907.018	CE129907.019	CE129907.020
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	28 Sep 2017	28 Sep 2017	28 Sep 2017	28 Sep 2017
			Sample Name	S22_10_20	S22_20_30	S22_30_50	S22_50_70

Erodibility Factor of Soil Method: CSIRO Tech Report 13/01 Tested: 26/10/2017

Erodibility Factor (K)*	t.ha.h/ha/MJ/	-	0.04	0.06	0.06	0.06
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Soil Texture (Northcote, 1979) Method: Northcote (1979) Tested: 18/10/2017

Texture Classification*	No unit	1	Medium Clay	Light Medium Clay	Medium Clay	Medium Clay
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Sample Subcontracted Method: Tested: 10/11/2017

Sample Subcontracted*	No unit	-	See attached	See attached	See attached	See attached
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Parameter	Units	LOR	Sample Number	CE129907.021	CE129907.022	CE129907.023	CE129907.024
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	28 Sep 2017	28 Sep 2017	28 Sep 2017	28 Sep 2017
			Sample Name	S22_70_100	S22_100_130	S23_0_10	S23_10_20

Moisture Content Method: AN002 Tested: 16/10/2017

% Moisture	%w/w	0.5	3.3	3.0	4.6	7.7
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pH in soil (1:5) Method: AN101 Tested: 19/10/2017

pH	pH Units	-	7.3	7.6	7.7	8.3
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Conductivity and TDS by Calculation - Soil Method: AN106 Tested: 19/10/2017

Conductivity of Extract (1:5 dry sample basis)	µS/cm	1	44	53	86	270
Total Dissolved Solids (by calculation)	mg/kg	5	130	160	260	820

Chloride (water extractable) Method: AN274 Tested: 20/10/2017

Chloride (water extractable 1:5)	mg/kg	5	15	10	20	39
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Water Soluble Acidity of Soil Method: AN002/AN140 Tested: 19/10/2017

Water Soluble Acidity as CaCO ₃ to pH 8.3*	mg/kg	25	25	25	-	-
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Colwell Phosphorus Method: AN015 Tested: 18/10/2017

Colwell Phosphorus	mg/kg	1	19	23	6	5
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Parameter	Units	LOR	Sample Number	CE129907.021	CE129907.022	CE129907.023	CE129907.024
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	28 Sep 2017	28 Sep 2017	28 Sep 2017	28 Sep 2017
			Sample Name	S22_70_100	S22_100_130	S23_0_10	S23_10_20

Bicarbonate Extractable (Colwell) Potassium, K Method: AN015/AN320 Tested: 26/10/2017

Bicarbonate Extractable (Colwell) Potassium, K*	mg/kg	10	230	220	250	220
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Nitrate Nitrogen and Nitrite Nitrogen (NOx) by Auto Analyser in Soil Method: AN248 Tested: 20/10/2017

Nitrate/Nitrite Nitrogen, NOx as N	mg/kg	0.1	-	-	2.4	0.9
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Total Kjeldahl Nitrogen and Total Nitrogen in Soil/Sludges Method: AN281 Tested: 17/10/2017

Total Kjeldahl Nitrogen	mg/kg	5	-	-	900	960
Total Nitrogen	mg/kg	10	-	-	900	960

Total Organic Carbon by Heanes Oxidation Method: AN273 Tested: 25/10/2017

Total Organic Carbon	%w/w	0.05	0.59	0.48	1.2	1.3
Organic Matter	%w/w	0.1	1.0	0.83	2.0	2.2

Emerson Class Number Method: AN009 Tested: 18/10/2017

Emerson Class Number	No unit	1	5	5	5	3
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Exchangeable Cations and Cation Exchange Capacity (CEC/ESP/SAR) Method: AN122 Tested: 20/10/2017

Exchangeable Sodium, Na	mg/kg	2	70	78	-	-
Exchangeable Sodium, Na	meq/100g	0.01	0.30	0.34	-	-
Exchangeable Sodium Percentage	%	0.1	1.8	1.9	-	-
Exchangeable Potassium, K	mg/kg	2	230	210	-	-
Exchangeable Potassium, K	meq/100g	0.01	0.59	0.55	-	-
Exchangeable Potassium Percentage	%	0.1	3.5	3.1	-	-
Exchangeable Calcium Percentage	%	0.1	77.1	78.3	-	-
Exchangeable Calcium, Ca	mg/kg	2	2600	2700	-	-
Exchangeable Calcium, Ca	meq/100g	0.01	13	14	-	-
Exchangeable Magnesium, Mg	mg/kg	2	360	350	-	-
Exchangeable Magnesium, Mg	meq/100g	0.02	3.0	2.9	-	-
Exchangeable Magnesium Percentage	%	0.1	17.6	16.6	-	-
Cation Exchange Capacity	meq/100g	0.02	17	17	-	-
Exchangeable Calcium/Exchangeable Magnesium Ratio	No unit	0.1	4.4	4.7	-	-
Monovalent Cations/Divalent Cations Ratio*	No unit	0.1	<0.1	<0.1	-	-
Cation Exchange Capacity (soluble salts removed)	meq/100g	0.02	-	-	-	-
Sodium Adsorption Ratio	No unit	0.1	0.1	0.1	-	-
Exchangeable Aluminium, Al	cmol (+)/kg	0.01	-	-	-	-

Parameter	Units	LOR	Sample Number	CE129907.021	CE129907.022	CE129907.023	CE129907.024
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	28 Sep 2017	28 Sep 2017	28 Sep 2017	28 Sep 2017
			Sample Name	S22_70_100	S22_100_130	S23_0_10	S23_10_20

DTPA Extractable Metals in Soil Method: AN025/AN320 Tested: 24/10/2017

Copper, Cu	mg/kg	0.05	-	-	1.9	2.2
Zinc, Zn	mg/kg	0.05	-	-	0.23	0.22
Manganese, Mn	mg/kg	0.5	-	-	17	17
Iron, Fe	mg/kg	0.5	-	-	17	19

Calcium Chloride Extractable Boron Method: RL 12C2/AN320 Tested: 24/10/2017

CaCl ₂ -extractable Boron, B*	mg/kg	0.05	-	-	0.63	0.62
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Calcium Chloride Extractable Molybdenum Method: RL 12E1/AN318 Tested: 31/10/2017

CaCl ₂ -extractable Molybdenum, Mo*	mg/kg	0.1	-	-	<0.10	<0.10
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Potassium Chloride Extractable Sulphur Method: RL 10D1/AN320 Tested: 20/10/2017

KCl-40-extractable Sulphur, S*	mg/kg	1	4	4	4	5
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Particle sizing of soils by sieving Method: AN005 Tested: 30/10/2017

Passing 2.00mm	%w/w	1	100	100	89	92
Retained 2.00mm	%w/w	1	<1	<1	11	8
Passing 600µm	%w/w	1	91	95	74	73
Retained 600µm	%w/w	1	9	4	15	19
Passing 300µm	%w/w	1	74	77	61	60
Retained 300µm	%w/w	1	17	18	14	12
Passing 125µm	%w/w	1	49	53	49	52
Retained 125µm	%w/w	1	25	24	12	8
Passing 63µm	%w/w	1	44	48	46	49
Retained 63µm	%w/w	1	5	5	3	3

Particle sizing of soils <75µm by hydrometer Method: AN005 Tested: 28/10/2017

Sedimentation Diameter 1	mm	0.0001	0.0561	0.0557	0.0557	0.0544
Passing Sedimentation Diameter 1	%w/w	1	42	44	44	48
Retained Sedimentation Diameter 1	%w/w	1	2	3	2	1
Sedimentation Diameter 2	mm	0.0001	0.0399	0.0401	0.0396	0.0396
Passing Sedimentation Diameter 2	%w/w	1	40	37	42	43
Retained Sedimentation Diameter 2	%w/w	1	2	7	2	5
Sedimentation Diameter 3	mm	0.0001	0.0286	0.0285	0.0282	0.0284
Passing Sedimentation Diameter 3	%w/w	1	35	36	40	39
Retained Sedimentation Diameter 3	%w/w	1	5	1	2	5
Sedimentation Diameter 4	mm	0.0001	0.0202	0.0203	0.0201	0.0201
Passing Sedimentation Diameter 4	%w/w	1	35	33	38	39
Retained Sedimentation Diameter 4	%w/w	1	<1	3	2	<1
Sedimentation Diameter 5	mm	0.0001	0.0148	0.0148	0.0147	0.0147
Passing Sedimentation Diameter 5	%w/w	1	34	33	35	36
Retained Sedimentation Diameter 5	%w/w	1	1	<1	2	2
Sedimentation Diameter 6	mm	0.0001	0.0105	0.0106	0.0105	0.0105
Passing Sedimentation Diameter 6	%w/w	1	33	30	33	34
Retained Sedimentation Diameter 6	%w/w	1	1	2	2	2
Sedimentation Diameter 7	mm	0.0001	0.0075	0.0075	0.0075	0.0074
Passing Sedimentation Diameter 7	%w/w	1	30	28	31	33
Retained Sedimentation Diameter 7	%w/w	1	2	2	2	1
Sedimentation Diameter 8	mm	0.0001	0.0053	0.0053	0.0053	0.0053
Passing Sedimentation Diameter 8	%w/w	1	28	26	31	29
Retained Sedimentation Diameter 8	%w/w	1	2	2	<1	4
Sedimentation Diameter 9	mm	0.0001	0.0038	0.0038	0.0038	0.0038
Passing Sedimentation Diameter 9	%w/w	1	26	24	28	27
Retained Sedimentation Diameter 9	%w/w	1	2	2	2	2
Sedimentation Diameter 10	mm	0.0001	0.0016	0.0016	0.0016	0.0016
Passing Sedimentation Diameter 10	%w/w	1	24	21	24	24

Parameter	Units	LOR	Sample Number	CE129907.021	CE129907.022	CE129907.023	CE129907.024
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	28 Sep 2017	28 Sep 2017	28 Sep 2017	28 Sep 2017
			Sample Name	S22_70_100	S22_100_130	S23_0_10	S23_10_20

Particle sizing of soils <75µm by hydrometer Method: AN005 Tested: 28/10/2017 (continued)

Retained Sedimentation Diameter 10	%w/w	1	2	2	5	2
Sedimentation Diameter 11	mm	0.0001	0.0011	0.0010	0.0011	0.0011
Passing Sedimentation Diameter 11	%w/w	1	21	21	21	22
Retained Sedimentation Diameter 11	%w/w	1	2	<1	2	2
Clay (<0.002mm)	%w/w	0.1	24	21	24	24
Silt and Clay (<0.005mm)*	%w/w	0.1	28	26	31	29
Silt (0.002mm to 0.06mm)*	%w/w	0.1	20	27	22	25
Fine Sand (0.06mm to 0.20mm)*	%w/w	0.1	5.2	5.2	3.3	3.0
Medium and Coarse Sand (0.20mm to 2.0mm)*	%w/w	0.1	51	47	40	40
Gravels (>2.0mm)*	%w/w	0.1	0.4	0.4	11	8.1

Parameter	Sample Number		CE129907.021	CE129907.022	CE129907.023	CE129907.024
	Sample Matrix		Soil	Soil	Soil	Soil
	Sample Date		28 Sep 2017	28 Sep 2017	28 Sep 2017	28 Sep 2017
	Sample Name		S22_70_100	S22_100_130	S23_0_10	S23_10_20
	Units	LOR				

Erodibility Factor of Soil Method: CSIRO Tech Report 13/01 Tested: 26/10/2017

Erodibility Factor (K)*	t.ha.h/ha/MJ/	-	0.05	0.05	0.04	0.04
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Soil Texture (Northcote, 1979) Method: Northcote (1979) Tested: 18/10/2017

Texture Classification*	No unit	1	Light Medium Clay	Sandy Clay	Light Medium Clay	Medium Heavy Clay
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Sample Subcontracted Method: Tested: 10/11/2017

Sample Subcontracted*	No unit	-	See attached	See attached	See attached	See attached
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Parameter	Units	LOR	Sample Number	CE129907.025	CE129907.026	CE129907.027	CE129907.028
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	28 Sep 2017	28 Sep 2017	28 Sep 2017	28 Sep 2017
			Sample Name	S23_20_30	S23_30_60	S25_0_10	S25_10_20

Moisture Content Method: AN002 Tested: 16/10/2017

% Moisture	%w/w	0.5	10	3.8	5.8	8.6
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pH in soil (1:5) Method: AN101 Tested: 19/10/2017

pH	pH Units	-	8.9	7.1	7.4	7.9
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Conductivity and TDS by Calculation - Soil Method: AN106 Tested: 19/10/2017

Conductivity of Extract (1:5 dry sample basis)	µS/cm	1	380	49	180	250
Total Dissolved Solids (by calculation)	mg/kg	5	1100	150	530	740

Chloride (water extractable) Method: AN274 Tested: 20/10/2017

Chloride (water extractable 1:5)	mg/kg	5	160	8	98	180
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Water Soluble Acidity of Soil Method: AN002/AN140 Tested: 19/10/2017

Water Soluble Acidity as CaCO ₃ to pH 8.3*	mg/kg	25	-	25	-	-
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Colwell Phosphorus Method: AN015 Tested: 18/10/2017

Colwell Phosphorus	mg/kg	1	3	15	11	7
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Parameter	Units	LOR	Sample Number	CE129907.025	CE129907.026	CE129907.027	CE129907.028
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	28 Sep 2017	28 Sep 2017	28 Sep 2017	28 Sep 2017
			Sample Name	S23_20_30	S23_30_60	S25_0_10	S25_10_20

Bicarbonate Extractable (Colwell) Potassium, K Method: AN015/AN320 Tested: 26/10/2017

Bicarbonate Extractable (Colwell) Potassium, K*	mg/kg	10	170	230	380	280
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Nitrate Nitrogen and Nitrite Nitrogen (NOx) by Auto Analyser in Soil Method: AN248 Tested: 20/10/2017

Nitrate/Nitrite Nitrogen, NOx as N	mg/kg	0.1	0.9	-	20	22
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Total Kjeldahl Nitrogen and Total Nitrogen in Soil/Sludges Method: AN281 Tested: 17/10/2017

Total Kjeldahl Nitrogen	mg/kg	5	790	-	1300	1300
Total Nitrogen	mg/kg	10	800	-	1300	1400

Total Organic Carbon by Heanes Oxidation Method: AN273 Tested: 19/10/2017

Total Organic Carbon	%w/w	0.05	1.0	0.85	2.1	1.8
Organic Matter	%w/w	0.1	1.8	1.5	3.6	3.0

Emerson Class Number Method: AN009 Tested: 18/10/2017

Emerson Class Number	No unit	1	5	5	3	3
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Exchangeable Cations and Cation Exchange Capacity (CEC/ESP/SAR) Method: AN122 Tested: 20/10/2017

Exchangeable Sodium, Na	mg/kg	2	-	41	-	-
Exchangeable Sodium, Na	meq/100g	0.01	-	0.18	-	-
Exchangeable Sodium Percentage	%	0.1	-	1.0	-	-
Exchangeable Potassium, K	mg/kg	2	-	210	-	-
Exchangeable Potassium, K	meq/100g	0.01	-	0.54	-	-
Exchangeable Potassium Percentage	%	0.1	-	3.1	-	-
Exchangeable Calcium Percentage	%	0.1	-	79.1	-	-
Exchangeable Calcium, Ca	mg/kg	2	-	2800	-	-
Exchangeable Calcium, Ca	meq/100g	0.01	-	14	-	-
Exchangeable Magnesium, Mg	mg/kg	2	-	360	-	-
Exchangeable Magnesium, Mg	meq/100g	0.02	-	2.9	-	-
Exchangeable Magnesium Percentage	%	0.1	-	16.8	-	-
Cation Exchange Capacity	meq/100g	0.02	-	17	-	-
Exchangeable Calcium/Exchangeable Magnesium Ratio	No unit	0.1	-	4.7	-	-
Monovalent Cations/Divalent Cations Ratio*	No unit	0.1	-	<0.1	-	-
Cation Exchange Capacity (soluble salts removed)	meq/100g	0.02	-	-	-	-
Sodium Adsorption Ratio	No unit	0.1	-	<0.1	-	-
Exchangeable Aluminium, Al	cmol (+)/kg	0.01	-	-	-	-

Parameter	Units	LOR	Sample Number	CE129907.025	CE129907.026	CE129907.027	CE129907.028
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	28 Sep 2017	28 Sep 2017	28 Sep 2017	28 Sep 2017
			Sample Name	S23_20_30	S23_30_60	S25_0_10	S25_10_20

DTPA Extractable Metals in Soil Method: AN025/AN320 Tested: 20/10/2017

Copper, Cu	mg/kg	0.05	2.1	-	1.6	1.6
Zinc, Zn	mg/kg	0.05	0.26	-	0.60	0.43
Manganese, Mn	mg/kg	0.5	10	-	35	19
Iron, Fe	mg/kg	0.5	15	-	21	20

Calcium Chloride Extractable Boron Method: RL 12C2/AN320 Tested: 20/10/2017

CaCl ₂ -extractable Boron, B*	mg/kg	0.05	0.92	-	0.82	1.2
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Calcium Chloride Extractable Molybdenum Method: RL 12E1/AN318 Tested: 31/10/2017

CaCl ₂ -extractable Molybdenum, Mo*	mg/kg	0.1	<0.10	-	<0.10	<0.10
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Potassium Chloride Extractable Sulphur Method: RL 10D1/AN320 Tested: 20/10/2017

KCl-40-extractable Sulphur, S*	mg/kg	1	7	4	8	7
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Particle sizing of soils by sieving Method: AN005 Tested: 30/10/2017

Passing 2.00mm	%w/w	1	92	99	97	99
Retained 2.00mm	%w/w	1	8	<1	3	1
Passing 600µm	%w/w	1	67	82	74	68
Retained 600µm	%w/w	1	25	17	23	31
Passing 300µm	%w/w	1	54	53	70	53
Retained 300µm	%w/w	1	13	29	5	15
Passing 125µm	%w/w	1	37	35	58	45
Retained 125µm	%w/w	1	17	18	12	8
Passing 63µm	%w/w	1	36	31	54	42
Retained 63µm	%w/w	1	1	4	4	3

Particle sizing of soils <75µm by hydrometer Method: AN005 Tested: 28/10/2017

Sedimentation Diameter 1	mm	0.0001	0.0575	0.0578	0.0543	0.0568
Passing Sedimentation Diameter 1	%w/w	1	35	31	54	39
Retained Sedimentation Diameter 1	%w/w	1	2	1	<1	3
Sedimentation Diameter 2	mm	0.0001	0.0411	0.0411	0.0389	0.0404
Passing Sedimentation Diameter 2	%w/w	1	30	28	50	37
Retained Sedimentation Diameter 2	%w/w	1	5	2	5	2
Sedimentation Diameter 3	mm	0.0001	0.0293	0.0293	0.0277	0.0287
Passing Sedimentation Diameter 3	%w/w	1	27	26	47	34
Retained Sedimentation Diameter 3	%w/w	1	2	2	2	2
Sedimentation Diameter 4	mm	0.0001	0.0208	0.0208	0.0196	0.0204
Passing Sedimentation Diameter 4	%w/w	1	25	24	47	32
Retained Sedimentation Diameter 4	%w/w	1	2	2	<1	2
Sedimentation Diameter 5	mm	0.0001	0.0153	0.0153	0.0144	0.0149
Passing Sedimentation Diameter 5	%w/w	1	23	21	45	32
Retained Sedimentation Diameter 5	%w/w	1	2	2	2	<1
Sedimentation Diameter 6	mm	0.0001	0.0108	0.0108	0.0102	0.0106
Passing Sedimentation Diameter 6	%w/w	1	23	21	43	30
Retained Sedimentation Diameter 6	%w/w	1	<1	<1	2	2
Sedimentation Diameter 7	mm	0.0001	0.0077	0.0077	0.0073	0.0076
Passing Sedimentation Diameter 7	%w/w	1	20	19	39	27
Retained Sedimentation Diameter 7	%w/w	1	2	2	3	2
Sedimentation Diameter 8	mm	0.0001	0.0055	0.0055	0.0052	0.0054
Passing Sedimentation Diameter 8	%w/w	1	18	17	36	25
Retained Sedimentation Diameter 8	%w/w	1	2	2	3	2
Sedimentation Diameter 9	mm	0.0001	0.0039	0.0039	0.0037	0.0038
Passing Sedimentation Diameter 9	%w/w	1	18	17	31	22
Retained Sedimentation Diameter 9	%w/w	1	<1	<1	5	2
Sedimentation Diameter 10	mm	0.0001	0.0016	0.0016	0.0015	0.0016
Passing Sedimentation Diameter 10	%w/w	1	15	15	26	20

Parameter	Units	LOR	Sample Number	CE129907.025	CE129907.026	CE129907.027	CE129907.028
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	28 Sep 2017	28 Sep 2017	28 Sep 2017	28 Sep 2017
			Sample Name	S23_20_30	S23_30_60	S25_0_10	S25_10_20

Particle sizing of soils <75µm by hydrometer Method: AN005 Tested: 28/10/2017 (continued)

Retained Sedimentation Diameter 10	%w/w	1	2	2	5	2
Sedimentation Diameter 11	mm	0.0001	0.0011	0.0011	0.0011	0.0011
Passing Sedimentation Diameter 11	%w/w	1	15	12	25	18
Retained Sedimentation Diameter 11	%w/w	1	<1	2	1	2
Clay (<0.002mm)	%w/w	0.1	15	15	26	20
Silt and Clay (<0.005mm)*	%w/w	0.1	18	17	36	25
Silt (0.002mm to 0.06mm)*	%w/w	0.1	21	16	28	22
Fine Sand (0.06mm to 0.20mm)*	%w/w	0.1	1.3	3.8	3.8	2.7
Medium and Coarse Sand (0.20mm to 2.0mm)*	%w/w	0.1	55	64	39	54
Gravels (>2.0mm)*	%w/w	0.1	7.7	0.8	3.0	1.2

Parameter	Sample Number	CE129907.025	CE129907.026	CE129907.027	CE129907.028
	Sample Matrix	Soil	Soil	Soil	Soil
	Sample Date	28 Sep 2017	28 Sep 2017	28 Sep 2017	28 Sep 2017
	Sample Name	S23_20_30	S23_30_60	S25_0_10	S25_10_20
Units		LOR			

Erodibility Factor of Soil Method: CSIRO Tech Report 13/01 Tested: 26/10/2017

Erodibility Factor (K)*	t.ha.h/ha/MJ/	-	0.03	0.03	0.04	0.03
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Soil Texture (Northcote, 1979) Method: Northcote (1979) Tested: 18/10/2017

Texture Classification*	No unit	1	Light Clay	Sandy Clay	Light Medium Clay	Light Clay
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Sample Subcontracted Method: Tested: 10/11/2017

Sample Subcontracted*	No unit	-	See attached	See attached	See attached	See attached
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Parameter	Units	LOR	Sample Number	CE129907.029	CE129907.030	CE129907.031	CE129907.032
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	28 Sep 2017	28 Sep 2017	28 Sep 2017	26 Sep 2017
			Sample Name	S25_30_50	S25_50_70	S9_0_10	S9_10_20

Moisture Content Method: AN002 Tested: 16/10/2017

% Moisture	%w/w	0.5	13	13	1.0	1.5
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pH in soil (1:5) Method: AN101 Tested: 19/10/2017

pH	pH Units	-	8.6	8.6	5.8	6.2
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Conductivity and TDS by Calculation - Soil Method: AN106 Tested: 19/10/2017

Conductivity of Extract (1:5 dry sample basis)	µS/cm	1	900	980	36	42
Total Dissolved Solids (by calculation)	mg/kg	5	2700	2900	110	130

Chloride (water extractable) Method: AN274 Tested: 20/10/2017

Chloride (water extractable 1:5)	mg/kg	5	1100	1200	11	21
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Water Soluble Acidity of Soil Method: AN002/AN140 Tested: 19/10/2017

Water Soluble Acidity as CaCO ₃ to pH 8.3*	mg/kg	25	<25	<25	-	-
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Colwell Phosphorus Method: AN015 Tested: 18/10/2017

Colwell Phosphorus	mg/kg	1	3	3	4	3
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Parameter	Units	LOR	Sample Number	CE129907.029	CE129907.030	CE129907.031	CE129907.032
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	28 Sep 2017	28 Sep 2017	28 Sep 2017	26 Sep 2017
			Sample Name	S25_30_50	S25_50_70	S9_0_10	S9_10_20

Bicarbonate Extractable (Colwell) Potassium, K Method: AN015/AN320 Tested: 26/10/2017

Bicarbonate Extractable (Colwell) Potassium, K*	mg/kg	10	180	220	100	110
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Nitrate Nitrogen and Nitrite Nitrogen (NOx) by Auto Analyser in Soil Method: AN248 Tested: 20/10/2017

Nitrate/Nitrite Nitrogen, NOx as N	mg/kg	0.1	-	-	<0.1	<0.1
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Total Kjeldahl Nitrogen and Total Nitrogen in Soil/Sludges Method: AN281 Tested: 17/10/2017

Total Kjeldahl Nitrogen	mg/kg	5	-	-	200	200
Total Nitrogen	mg/kg	10	-	-	200	200

Total Organic Carbon by Heanes Oxidation Method: AN273 Tested: 25/10/2017

Total Organic Carbon	%w/w	0.05	1.5	1.2	0.21	0.21
Organic Matter	%w/w	0.1	2.6	2.0	0.37	0.36

Emerson Class Number Method: AN009 Tested: 18/10/2017

Emerson Class Number	No unit	1	5	5	2	2
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Exchangeable Cations and Cation Exchange Capacity (CEC/ESP/SAR) Method: AN122 Tested: 20/10/2017

Exchangeable Sodium, Na	mg/kg	2	2100	1700	-	-
Exchangeable Sodium, Na	meq/100g	0.01	9.2	7.5	-	-
Exchangeable Sodium Percentage	%	0.1	17.2	13.4	-	-
Exchangeable Potassium, K	mg/kg	2	340	330	-	-
Exchangeable Potassium, K	meq/100g	0.01	0.88	0.85	-	-
Exchangeable Potassium Percentage	%	0.1	1.6	1.5	-	-
Exchangeable Calcium Percentage	%	0.1	52.9	61.4	-	-
Exchangeable Calcium, Ca	mg/kg	2	5600	6900	-	-
Exchangeable Calcium, Ca	meq/100g	0.01	28	34	-	-
Exchangeable Magnesium, Mg	mg/kg	2	1800	1600	-	-
Exchangeable Magnesium, Mg	meq/100g	0.02	15	13	-	-
Exchangeable Magnesium Percentage	%	0.1	28.3	23.7	-	-
Cation Exchange Capacity	meq/100g	0.02	53	56	-	-
Exchangeable Calcium/Exchangeable Magnesium Ratio	No unit	0.1	1.9	2.6	-	-
Monovalent Cations/Divalent Cations Ratio*	No unit	0.1	0.2	0.2	-	-
Cation Exchange Capacity (soluble salts removed)	meq/100g	0.02	-	-	-	-
Sodium Adsorption Ratio	No unit	0.1	2.0	1.5	-	-
Exchangeable Aluminium, Al	cmol (+)/kg	0.01	-	-	-	-

Parameter	Units	LOR	Sample Number	CE129907.029	CE129907.030	CE129907.031	CE129907.032
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	28 Sep 2017	28 Sep 2017	28 Sep 2017	26 Sep 2017
			Sample Name	S25_30_50	S25_50_70	S9_0_10	S9_10_20

DTPA Extractable Metals in Soil Method: AN025/AN320 Tested: 24/10/2017

Copper, Cu	mg/kg	0.05	-	-	0.13	0.13
Zinc, Zn	mg/kg	0.05	-	-	0.18	0.16
Manganese, Mn	mg/kg	0.5	-	-	8.7	6.2
Iron, Fe	mg/kg	0.5	-	-	22	27

Calcium Chloride Extractable Boron Method: RL 12C2/AN320 Tested: 24/10/2017

CaCl ₂ -extractable Boron, B*	mg/kg	0.05	-	-	0.29	0.32
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Calcium Chloride Extractable Molybdenum Method: RL 12E1/AN318 Tested: 31/10/2017

CaCl ₂ -extractable Molybdenum, Mo*	mg/kg	0.1	-	-	<0.10	<0.10
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Potassium Chloride Extractable Sulphur Method: RL 10D1/AN320 Tested: 20/10/2017

KCl-40-extractable Sulphur, S*	mg/kg	1	13	9	4	4
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Particle sizing of soils by sieving Method: AN005 Tested: 30/10/2017

Passing 2.00mm	%w/w	1	98	97	84	85
Retained 2.00mm	%w/w	1	2	3	16	15
Passing 600µm	%w/w	1	80	80	63	67
Retained 600µm	%w/w	1	18	17	21	18
Passing 300µm	%w/w	1	70	73	28	34
Retained 300µm	%w/w	1	11	7	35	34
Passing 125µm	%w/w	1	63	66	12	11
Retained 125µm	%w/w	1	6	7	16	22
Passing 63µm	%w/w	1	62	65	9	9
Retained 63µm	%w/w	1	2	2	3	2

Particle sizing of soils <75µm by hydrometer Method: AN005 Tested: 28/10/2017

Sedimentation Diameter 1	mm	0.0001	0.0540	0.0536	-	-
Passing Sedimentation Diameter 1	%w/w	1	61	63	-	-
Retained Sedimentation Diameter 1	%w/w	1	2	2	-	-
Sedimentation Diameter 2	mm	0.0001	0.0383	0.0381	-	-
Passing Sedimentation Diameter 2	%w/w	1	59	60	-	-
Retained Sedimentation Diameter 2	%w/w	1	1	2	-	-
Sedimentation Diameter 3	mm	0.0001	0.0272	0.0271	-	-
Passing Sedimentation Diameter 3	%w/w	1	58	59	-	-
Retained Sedimentation Diameter 3	%w/w	1	1	1	-	-
Sedimentation Diameter 4	mm	0.0001	0.0193	0.0192	-	-
Passing Sedimentation Diameter 4	%w/w	1	56	58	-	-
Retained Sedimentation Diameter 4	%w/w	1	2	1	-	-
Sedimentation Diameter 5	mm	0.0001	0.0141	0.0141	-	-
Passing Sedimentation Diameter 5	%w/w	1	56	55	-	-
Retained Sedimentation Diameter 5	%w/w	1	<1	2	-	-
Sedimentation Diameter 6	mm	0.0001	0.0100	0.0100	-	-
Passing Sedimentation Diameter 6	%w/w	1	53	53	-	-
Retained Sedimentation Diameter 6	%w/w	1	2	2	-	-
Sedimentation Diameter 7	mm	0.0001	0.0071	0.0071	-	-
Passing Sedimentation Diameter 7	%w/w	1	51	51	-	-
Retained Sedimentation Diameter 7	%w/w	1	2	2	-	-
Sedimentation Diameter 8	mm	0.0001	0.0051	0.0051	-	-
Passing Sedimentation Diameter 8	%w/w	1	48	48	-	-
Retained Sedimentation Diameter 8	%w/w	1	2	2	-	-
Sedimentation Diameter 9	mm	0.0001	0.0036	0.0036	-	-
Passing Sedimentation Diameter 9	%w/w	1	46	46	-	-
Retained Sedimentation Diameter 9	%w/w	1	2	2	-	-
Sedimentation Diameter 10	mm	0.0001	0.0015	0.0015	-	-
Passing Sedimentation Diameter 10	%w/w	1	38	38	-	-

Parameter	Units	LOR	Sample Number	CE129907.029	CE129907.030	CE129907.031	CE129907.032
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	28 Sep 2017	28 Sep 2017	28 Sep 2017	26 Sep 2017
			Sample Name	S25_30_50	S25_50_70	S9_0_10	S9_10_20

Particle sizing of soils <75µm by hydrometer Method: AN005 Tested: 28/10/2017 (continued)

Retained Sedimentation Diameter 10	%w/w	1	7	7	-	-
Sedimentation Diameter 11	mm	0.0001	0.0011	0.0011	-	-
Passing Sedimentation Diameter 11	%w/w	1	34	36	-	-
Retained Sedimentation Diameter 11	%w/w	1	4	2	-	-
Clay (<0.002mm)	%w/w	0.1	38	38	-	-
Silt and Clay (<0.005mm)*	%w/w	0.1	48	48	-	-
Silt (0.002mm to 0.06mm)*	%w/w	0.1	24	27	-	-
Fine Sand (0.06mm to 0.20mm)*	%w/w	0.1	1.6	1.6	-	-
Medium and Coarse Sand (0.20mm to 2.0mm)*	%w/w	0.1	35	31	-	-
Gravels (>2.0mm)*	%w/w	0.1	1.7	3.2	-	-

Parameter	Sample Number		CE129907.029	CE129907.030	CE129907.031	CE129907.032
	Sample Matrix		Soil	Soil	Soil	Soil
	Sample Date		28 Sep 2017	28 Sep 2017	28 Sep 2017	26 Sep 2017
	Sample Name		S25_30_50	S25_50_70	S9_0_10	S9_10_20
Units		LOR				

Erodibility Factor of Soil Method: CSIRO Tech Report 13/01 Tested: 26/10/2017

Erodibility Factor (K)*	t.ha.h/ha/MJ/	-	0.05	0.06	0.00	0.00
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Soil Texture (Northcote, 1979) Method: Northcote (1979) Tested: 18/10/2017

Texture Classification*	No unit	1	Medium Heavy Clay	Medium Heavy Clay	Sand	Sand
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Sample Subcontracted Method: Tested: 10/11/2017

Sample Subcontracted*	No unit	-	See attached	See attached	See attached	See attached
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Sample Number CE129907.033
 Sample Matrix Soil
 Sample Date 26 Sep 2017
 Sample Name S9_20_30

Parameter	Units	LOR
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Moisture Content Method: AN002 Tested: 16/10/2017

% Moisture	%w/w	0.5	1.5
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pH in soil (1:5) Method: AN101 Tested: 19/10/2017

pH	pH Units	-	6.2
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Conductivity and TDS by Calculation - Soil Method: AN106 Tested: 19/10/2017

Conductivity of Extract (1:5 dry sample basis)	µS/cm	1	50
Total Dissolved Solids (by calculation)	mg/kg	5	150

Chloride (water extractable) Method: AN274 Tested: 20/10/2017

Chloride (water extractable 1:5)	mg/kg	5	29
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Water Soluble Acidity of Soil Method: AN002/AN140 Tested: 19/10/2017

Water Soluble Acidity as CaCO ₃ to pH 8.3*	mg/kg	25	-
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Colwell Phosphorus Method: AN015 Tested: 18/10/2017

Colwell Phosphorus	mg/kg	1	3
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Sample Number CE129907.033
Sample Matrix Soil
Sample Date 26 Sep 2017
Sample Name S9_20_30

Parameter	Units	LOR
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Bicarbonate Extractable (Colwell) Potassium, K Method: AN015/AN320 Tested: 26/10/2017

Bicarbonate Extractable (Colwell) Potassium, K*	mg/kg	10	110
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Nitrate Nitrogen and Nitrite Nitrogen (NOx) by Auto Analyser in Soil Method: AN248 Tested: 20/10/2017

Nitrate/Nitrite Nitrogen, NOx as N	mg/kg	0.1	<0.1
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Total Kjeldahl Nitrogen and Total Nitrogen in Soil/Sludges Method: AN281 Tested: 19/10/2017

Total Kjeldahl Nitrogen	mg/kg	5	190
Total Nitrogen	mg/kg	10	190

Total Organic Carbon by Heanes Oxidation Method: AN273 Tested: 19/10/2017

Total Organic Carbon	%w/w	0.05	0.12
Organic Matter	%w/w	0.1	0.21

Emerson Class Number Method: AN009 Tested: 18/10/2017

Emerson Class Number	No unit	1	2
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Exchangeable Cations and Cation Exchange Capacity (CEC/ESP/SAR) Method: AN122 Tested: 20/10/2017

Exchangeable Sodium, Na	mg/kg	2	-
Exchangeable Sodium, Na	meq/100g	0.01	-
Exchangeable Sodium Percentage	%	0.1	-
Exchangeable Potassium, K	mg/kg	2	-
Exchangeable Potassium, K	meq/100g	0.01	-
Exchangeable Potassium Percentage	%	0.1	-
Exchangeable Calcium Percentage	%	0.1	-
Exchangeable Calcium, Ca	mg/kg	2	-
Exchangeable Calcium, Ca	meq/100g	0.01	-
Exchangeable Magnesium, Mg	mg/kg	2	-
Exchangeable Magnesium, Mg	meq/100g	0.02	-
Exchangeable Magnesium Percentage	%	0.1	-
Cation Exchange Capacity	meq/100g	0.02	-
Exchangeable Calcium/Exchangeable Magnesium Ratio	No unit	0.1	-
Monovalent Cations/Divalent Cations Ratio*	No unit	0.1	-
Cation Exchange Capacity (soluble salts removed)	meq/100g	0.02	-
Sodium Adsorption Ratio	No unit	0.1	-
Exchangeable Aluminium, Al	cmol (+)/kg	0.01	-

Sample Number CE129907.033
Sample Matrix Soil
Sample Date 26 Sep 2017
Sample Name S9_20_30

Parameter	Units	LOR
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DTPA Extractable Metals in Soil Method: AN025/AN320 Tested: 20/10/2017

Copper, Cu	mg/kg	0.05	0.14
Zinc, Zn	mg/kg	0.05	0.15
Manganese, Mn	mg/kg	0.5	6.7
Iron, Fe	mg/kg	0.5	28

Calcium Chloride Extractable Boron Method: RL 12C2/AN320 Tested: 20/10/2017

CaCl ₂ -extractable Boron, B*	mg/kg	0.05	0.31
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Calcium Chloride Extractable Molybdenum Method: RL 12E1/AN318 Tested: 31/10/2017

CaCl ₂ -extractable Molybdenum, Mo*	mg/kg	0.1	<0.10
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Potassium Chloride Extractable Sulphur Method: RL 10D1/AN320 Tested: 20/10/2017

KCl-40-extractable Sulphur, S*	mg/kg	1	5
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Particle sizing of soils by sieving Method: AN005 Tested: 30/10/2017

Passing 2.00mm	%w/w	1	80
Retained 2.00mm	%w/w	1	20
Passing 600µm	%w/w	1	66
Retained 600µm	%w/w	1	14
Passing 300µm	%w/w	1	35
Retained 300µm	%w/w	1	30
Passing 125µm	%w/w	1	12
Retained 125µm	%w/w	1	24
Passing 63µm	%w/w	1	9
Retained 63µm	%w/w	1	2

		Sample Number	CE129907.033
		Sample Matrix	Soil
		Sample Date	26 Sep 2017
		Sample Name	S9_20_30
Parameter	Units	LOR	

Particle sizing of soils <75µm by hydrometer Method: AN005 Tested: 28/10/2017

Sedimentation Diameter 1	mm	0.0001	-
Passing Sedimentation Diameter 1	%w/w	1	-
Retained Sedimentation Diameter 1	%w/w	1	-
Sedimentation Diameter 2	mm	0.0001	-
Passing Sedimentation Diameter 2	%w/w	1	-
Retained Sedimentation Diameter 2	%w/w	1	-
Sedimentation Diameter 3	mm	0.0001	-
Passing Sedimentation Diameter 3	%w/w	1	-
Retained Sedimentation Diameter 3	%w/w	1	-
Sedimentation Diameter 4	mm	0.0001	-
Passing Sedimentation Diameter 4	%w/w	1	-
Retained Sedimentation Diameter 4	%w/w	1	-
Sedimentation Diameter 5	mm	0.0001	-
Passing Sedimentation Diameter 5	%w/w	1	-
Retained Sedimentation Diameter 5	%w/w	1	-
Sedimentation Diameter 6	mm	0.0001	-
Passing Sedimentation Diameter 6	%w/w	1	-
Retained Sedimentation Diameter 6	%w/w	1	-
Sedimentation Diameter 7	mm	0.0001	-
Passing Sedimentation Diameter 7	%w/w	1	-
Retained Sedimentation Diameter 7	%w/w	1	-
Sedimentation Diameter 8	mm	0.0001	-
Passing Sedimentation Diameter 8	%w/w	1	-
Retained Sedimentation Diameter 8	%w/w	1	-
Sedimentation Diameter 9	mm	0.0001	-
Passing Sedimentation Diameter 9	%w/w	1	-
Retained Sedimentation Diameter 9	%w/w	1	-
Sedimentation Diameter 10	mm	0.0001	-
Passing Sedimentation Diameter 10	%w/w	1	-
Retained Sedimentation Diameter 10	%w/w	1	-
Sedimentation Diameter 11	mm	0.0001	-
Passing Sedimentation Diameter 11	%w/w	1	-
Retained Sedimentation Diameter 11	%w/w	1	-
Clay (<0.002mm)	%w/w	0.1	-
Silt and Clay (<0.005mm)*	%w/w	0.1	-
Silt (0.002mm to 0.06mm)*	%w/w	0.1	-
Fine Sand (0.06mm to 0.20mm)*	%w/w	0.1	-
Medium and Coarse Sand (0.20mm to 2.0mm)*	%w/w	0.1	-
Gravels (>2.0mm)*	%w/w	0.1	-

Sample Number CE129907.033
 Sample Matrix Soil
 Sample Date 26 Sep 2017
 Sample Name S9_20_30

Parameter Units LOR

Erodibility Factor of Soil Method: CSIRO Tech Report 13/01 Tested: 26/10/2017

Erodibility Factor (K)*	t.ha.h/ha/MJ/	-	0.00
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Soil Texture (Northcote, 1979) Method: Northcote (1979) Tested: 18/10/2017

Texture Classification*	No unit	1	Sand
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Sample Subcontracted Method: Tested: 10/11/2017

Sample Subcontracted*	No unit	-	See attached
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MB blank results are compared to the Limit of Reporting

LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.

DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage*. Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

Bicarbonate Extractable (Colwell) Potassium, K Method: ME-(AU)-[ENV]AN015/AN320

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Bicarbonate Extractable (Colwell) Potassium, K*	LB050497	mg/kg	10	<10	1 - 3%	NA

Calcium Chloride Extractable Boron Method: RL 12C2/AN320

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
CaCl2-extractable Boron, B*	LB050320	mg/kg	0.05	0.19	1 - 6%	NA

Calcium Chloride Extractable Molybdenum Method: RL 12E1/AN318

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
CaCl2-extractable Molybdenum, Mo*	LB050591	mg/kg	0.1	<0.10	0%	NA

Chloride (water extractable) Method: ME-(AU)-[ENV]AN274

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Chloride (water extractable 1:5)	LB050331	mg/kg	5	<5	1 - 3%	104 - 105%

Colwell Phosphorus Method: ME-(AU)-[ENV]AN015

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Colwell Phosphorus	LB050241	mg/kg	1	<1	0 - 3%	88 - 97%

Conductivity and TDS by Calculation - Soil Method: ME-(AU)-[ENV]AN106

Parameter	QC Reference	Units	LOR	MB	LCS %Recovery
Conductivity of Extract (1:5 dry sample basis)	LB050304	µS/cm	1		101%
Total Dissolved Solids (by calculation)	LB050304	mg/kg	5	<5	NA

MB blank results are compared to the Limit of Reporting

LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.

DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage*. Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

DTPA Extractable Metals in Soil Method: ME-(AU)-[ENV]AN025/AN320

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Copper, Cu	LB050316	mg/kg	0.05	<0.05	2 - 12%	NA
Zinc, Zn	LB050316	mg/kg	0.05	<0.05	0 - 12%	NA
Manganese, Mn	LB050316	mg/kg	0.5	<0.5	1 - 4%	NA
Iron, Fe	LB050316	mg/kg	0.5	<0.5	0 - 1%	NA

Exchangeable Cations and Cation Exchange Capacity (CEC/ESP/SAR) Method: ME-(AU)-[ENV]AN122

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Exchangeable Sodium, Na	LB050329	mg/kg	2		2 - 3%	88 - 96%
Exchangeable Sodium, Na	LB050329	meq/100g	0.01	<0.01	2 - 3%	NA
Exchangeable Sodium Percentage	LB050329	%	0.1	<0.1	3%	NA
Exchangeable Potassium, K	LB050329	mg/kg	2		0 - 2%	102 - 104%
Exchangeable Potassium, K	LB050329	meq/100g	0.01	<0.01	0 - 2%	NA
Exchangeable Potassium Percentage	LB050329	%	0.1		1 - 3%	NA
Exchangeable Calcium Percentage	LB050329	%	0.1	<0.1	0 - 1%	NA
Exchangeable Calcium, Ca	LB050329	mg/kg	2		0 - 2%	96 - 102%
Exchangeable Calcium, Ca	LB050329	meq/100g	0.01	<0.01	0 - 2%	NA
Exchangeable Magnesium, Mg	LB050329	mg/kg	2		0%	94 - 98%
Exchangeable Magnesium, Mg	LB050329	meq/100g	0.02	<0.02	0%	NA
Exchangeable Magnesium Percentage	LB050329	%	0.1	<0.1	0 - 1%	NA
Cation Exchange Capacity	LB050329	meq/100g	0.02	<0.02	0 - 1%	NA
Exchangeable Calcium/Exchangeable Magnesium Ratio	LB050329	No unit	0.1		0 - 2%	NA
Monovalent Cations/Divalent Cations Ratio*	LB050329	No unit	0.1		0%	NA
Sodium Adsorption Ratio	LB050329	No unit	0.1		2 - 3%	NA

Nitrate Nitrogen and Nitrite Nitrogen (NOx) by Auto Analyser in Soil Method: ME-(AU)-[ENV]AN248

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Nitrate/Nitrite Nitrogen, NOx as N	LB050326	mg/kg	0.1	<0.1	2%	99 - 101%

pH in soil (1:5) Method: ME-(AU)-[ENV]AN101

Parameter	QC Reference	Units	LOR	MB	LCS %Recovery
pH	LB050304	pH Units	-	5.6	100%

MB blank results are compared to the Limit of Reporting

LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.

DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage*. Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

Potassium Chloride Extractable Sulphur Method: RL 10D1/AN320

Parameter	QC Reference	Units	LOR	DUP %RPD
KCl-40-extractable Sulphur, S*	LB050318	mg/kg	1	2 - 4%

Total Kjeldahl Nitrogen and Total Nitrogen in Soil/Sludges Method: ME-(AU)-[ENV]AN281

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Total Kjeldahl Nitrogen	LB050218	mg/kg	5	<5	0%	99%
	LB050307	mg/kg	5	<5	0 - 1%	99 - 103%

Total Organic Carbon by Heanes Oxidation Method: ME-(AU)-[ENV]AN273

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Total Organic Carbon	LB050306	%w/w	0.05	<0.05	2 - 16%	93 - 94%	109%
	LB050426	%w/w	0.05	<0.05	0 - 4%	95%	101%
Organic Matter	LB050306	%w/w	0.1		2 - 16%		
	LB050426	%w/w	0.1		0 - 4%		

Water Soluble Acidity of Soil Method: ME-(AU)-[ENV]AN002/AN140

Parameter	QC Reference	Units	LOR	MB	LCS %Recovery
Water Soluble Acidity as CaCO3 to pH 8.3*	LB050271	mg/kg	25	<25	NA

METHOD

METHODOLOGY SUMMARY

AN002	The test is carried out by drying (at either 40°C or 105°C) a known mass of sample in a weighed evaporating basin. After fully dry the sample is re-weighed. Samples such as sludge and sediment having high percentages of moisture will take some time in a drying oven for complete removal of water.
AN002/AN140	Acidity by Titration: The water extract is titrated with sodium hydroxide to designated pH end point. In a sample containing only carbon dioxide, bicarbonates and carbonates, titration to pH 8.3 at 25°C corresponds to stoichiometric neutralisation of carbonic acid to bicarbonate. Method reference APHA 2310 B.
AN005	The particle size distribution of a soil is determined by wet sieving, using a maximum of 900 mL of deionised water to sieve all fractions down to 75 µm. Referenced to AS1289.3.6.1 and AS1141.11.
AN009	The method follows AS1289 3.8.1 - 2006. Soils are divided into seven classes on the basis of their coherence in water, with one further class being distinguished by the presence of calcium-rich minerals. Class 1: Air-dried crumbs of soil show a strong dispersion reaction, i.e., a colloidal cloud covers nearly the whole of the bottom of the beaker, usually in a very thin layer. The reaction should be evident within 10min. In extreme cases all the water in the beaker becomes cloudy, leaving only a coarse residue in a cloud of clay.
AN009	Class 2: Air-dried crumbs of soil show a moderate to slight reaction. A moderate reaction consists of an easily recognisable cloud of colloids in suspension, usually spreading in thin streaks on the bottom of the beaker. A slight reaction consists of the bare hint of cloud in water at the surface of the crumbs. Class 3: The soil remoulded at the plastic limit disperses in water. Class 4: The remoulded soil does not disperse in water. Calcium carbonate (calcite) or calcium sulfate (gypsum) is present. Class 5: The remoulded soil does not disperse in water and the 1:5 soil/water suspension remains dispersed after 5 min.
AN009	Class 6: The remoulded soil does not disperse in water and the 1:5 soil/water suspension begins to flocculate within 5 min. Class 7: The air-dried crumbs of soil remain coherent in water and swells. Class 8: The air-dried crumbs of soil remain coherent in water and do not swell.
AN015	Soil sample is extracted in an end over end roller in 0.5 N sodium bicarbonate at pH 8.5 with the supernatant liquor analysed for Phosphorous. Orthophosphate anion (PO ₄ ³⁻) is reacted with ammonium molybdate and potassium antimony tartrate in sulfuric acid solution. The resulting phospho-molybdate complex is reduced, using ascorbic acid, to an intense blue coloured complex Molybdenum Blue. The absorbance of this complex is measured at 880 nm by Discrete Analyser, and compared with calibration standards to obtain the concentration of orthophosphate in the sample. Based on Rayment & Higginson 9B1.
AN015/AN320	Soil sample is extracted in an end over end roller in 0.5 N sodium bicarbonate at pH 8.5 with the supernatant liquor analysed for Potassium by ICP OES. Based on Rayment & Higginson 18A1.
AN025/AN320	A chelating agent is used to complex metal ions in solution. The extracted elements are determined by ICP OES.
AN101	pH in Soil Sludge Sediment and Water: pH is measured electrometrically using a combination electrode and is calibrated against 3 buffers purchased commercially. For soils, sediments and sludges, an extract with water (or 0.01M CaCl ₂) is made at a ratio of 1:5 and the pH determined and reported on the extract. Reference APHA 4500-H ⁺ .
AN106	Conductivity and TDS by Calculation: Conductivity is measured by meter with temperature compensation and is calibrated against a standard solution of potassium chloride. Conductivity is generally reported as µmhos/cm or µS/cm @ 25°C. For soils, an extract with water is made at a ratio of 1:5 and the EC determined and reported on the extract, or calculated back to the as-received sample. Salinity can be estimated from conductivity using a conversion factor, which for natural waters, is in the range 0.55 to 0.75. Reference APHA 2510 B.

METHOD

METHODOLOGY SUMMARY

AN122	Exchangeable Cations, CEC and ESP: Soil sample is extracted in 1M Ammonium Acetate at pH=7 (or 1M Ammonium Chloride at pH=7) with cations (Na, K, Ca & Mg) then determined by ICP OES/ICP MS and reported as Exchangeable Cations. For saline soils, these results can be corrected for water soluble cations and reported as Exchangeable cations in meq/100g or soil can be pre-treated (aqueous ethanol/aqueous glycerol) prior to extraction. Cation Exchange Capacity (CEC) is the sum of the exchangeable cations in meq/100g.						
AN122	The Exchangeable Sodium Percentage (ESP) is calculated as the exchangeable sodium divided by the CEC (all in meq/100g) times 100. ESP can be used to categorise the sodicity of the soil as below: <table> <tr> <td>ESP < 6%</td><td>non-sodic</td></tr> <tr> <td>ESP 6-15%</td><td>sodic</td></tr> <tr> <td>ESP >15%</td><td>strongly sodic</td></tr> </table> Method is referenced to Rayment and Higginson, 1992, sections 15D3 and 15N1.-	ESP < 6%	non-sodic	ESP 6-15%	sodic	ESP >15%	strongly sodic
ESP < 6%	non-sodic						
ESP 6-15%	sodic						
ESP >15%	strongly sodic						
AN248	Nitrate / Nitrite in extract by Auto Analyser: In an acidic medium, nitrate is reduced quantitatively to nitrite by cadmium metal. This nitrite plus any original nitrite is determined as an intense red-pink azo dye at 540 nm following diazotisation with sulphanilamide and subsequent coupling with N-(1-naphthyl) ethylenediamine dihydrochloride. Reference APHA 4500-NO3- F.						
AN273	The sample is digested in Dichromate / Sulfuric Acid to oxidise the organic carbon. The determination is completed colourimetrically by Aquakem Discrete Analyser at 600 nm. Based on Rayment & Higginson 6B1.						
AN274	Chloride by Aquakem DA following 1:5 or 1:2 DI water extraction: Chloride reacts with mercuric thiocyanate forming a mercuric chloride complex. In the presence of ferric iron, highly coloured ferric thiocyanate is formed which is proportional to the chloride concentration. Results reported on dry sample basis. Reference APHA 4500Cl-						
AN281	The sample is heated in the presence of Sulphuric acid, K ₂ SO ₄ and CuSO ₄ for two and half hours using a temperature controlled digestion block. Amino Nitrogen of many organic materials is converted to ammonium ion. Free ammonia also is converted to ammonium. The digest is cooled and placed on the Aquakem 250 discrete analyser for Ammonia determination.						
CSIRO Tech Report 13	The soil erodibility factor (K) calculation uses the percentage of soil particles below 125µm, soil organic carbon content and soil permeability class to provide an estimate of soil erodibility used in the universal soil loss equation (USLE) and its derivatives.						
Northcote (1979)	Texture is a measure of the behaviour of a small handful of soil when moistened, worked into a bolus (ball) and then pressed out between thumb and forefinger. It is used mainly as a rough guide to the proportions of gravel, coarse sand, fine sand, silt and clay in the soil.						
RL 10D1/AN320	Air dried <2mm soil is extracted in 0.25M KCl at 40 deg C followed by analysis of filtrate for S by ICP OES. Referenced to Rayment and Lyons method 10D1.						
RL 12C2/AN320	Air dried <2mm soil is extracted in 0.01M CaCl ₂ by refluxing gently for 10 minutes. Extract is then filtered and analysed by ICP OES. Referenced method Rayment and Lyon, 12C2.						
RL12E1/AN318	Air dried <2mm soil is extracted in 0.01M CaCl ₂ by refluxing gently for 10 minutes. Extract is then filtered and analysed by ICP MS. Referenced method Rayment and Lyon, 12E1.						

FOOTNOTES

IS	Insufficient sample for analysis.	LOR	Limit of Reporting
LNR	Sample listed, but not received.	↑↓	Raised or Lowered Limit of Reporting
*	NATA accreditation does not cover the performance of this service.	QFH	QC result is above the upper tolerance
**	Indicative data, theoretical holding time exceeded.	QFL	QC result is below the lower tolerance
		-	The sample was not analysed for this analyte
		NVL	Not Validated

Samples analysed as received.

Solid samples expressed on a dry weight basis.

Where "Total" analyte groups are reported (for example, Total PAHs, Total OC Pesticides) the total will be calculated as the sum of the individual analytes, with those analytes that are reported as <LOR being assumed to be zero. The summed (Total) limit of reporting is calculated by summing the individual analyte LORs and dividing by two. For example, where 16 individual analytes are being summed and each has an LOR of 0.1 mg/kg, the "Totals" LOR will be 1.6 / 2 (0.8 mg/kg). Where only 2 analytes are being summed, the "Total" LOR will be the sum of those two LORs.

Some totals may not appear to add up because the total is rounded after adding up the raw values.

If reported, measurement uncertainty follow the ± sign after the analytical result and is expressed as the expanded uncertainty calculated using a coverage factor of 2, providing a level of confidence of approximately 95%, unless stated otherwise in the comments section of this report.

Results reported for samples tested under test methods with codes starting with ARS-SOP, radionuclide or gross radioactivity concentrations are expressed in becquerel (Bq) per unit of mass or volume or per wipe as stated on the report. Becquerel is the SI unit for activity and equals one nuclear transformation per second.

Note that in terms of units of radioactivity:

- 1 Bq is equivalent to 27 pCi
- 37 MBq is equivalent to 1 mCi

For results reported for samples tested under test methods with codes starting with ARS-SOP, less than (<) values indicate the detection limit for each radionuclide or parameter for the measurement system used. The respective detection limits have been calculated in accordance with ISO 11929.

The QC criteria are subject to internal review according to the SGS QAQC plan and may be provided on request or alternatively can be found here : <http://www.sgs.com.au/~media/Local/Australia/Documents/Technical%20Documents/MP-AU-ENV-QU-022%20QA%20QC%20Plan.pdf>

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Futura Resources Limited

Landform Design Report

Wilton Fairhill Complex

Version 3

Document History

Revision	Date	Issued to	Author	Reviewed
001	28/03/2024	Draft	Barbara van der Pol	Ben Dunlop
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003	16/01/2024	Revision	Barbara van der Pol	Ben Dunlop

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1 Introduction

This report details the process and methodology undertaken in designing stable landforms for the rehabilitation of the Wilton and Fairhill mines (the '**Mines**').

The mines are located approximately 45 kilometres (km) northeast of Emerald, 50 km northwest of Blackwater and The Project's regional location is presented in Figure 1-1.

The Mines extracts hard coking coal from open cut pits, mining several identified coal seams. The Mines will extract up to 3.35 million tonnes per annum (Mtpa) of run of mine (ROM) coal. Futura hauls the Mines product ROM coal via road transport off-site to an external CHPP and train-loadout facility located off the Project's MLs.

The Wilton Coal Mine operates on ML 700028 and 700029 and Environmental Authority EA0002046 issued under the Environmental Protection Act 1994 (EP Act)

The Fairhill Coal Mine operates on ML 700043 and Environmental Authority BRID0071.

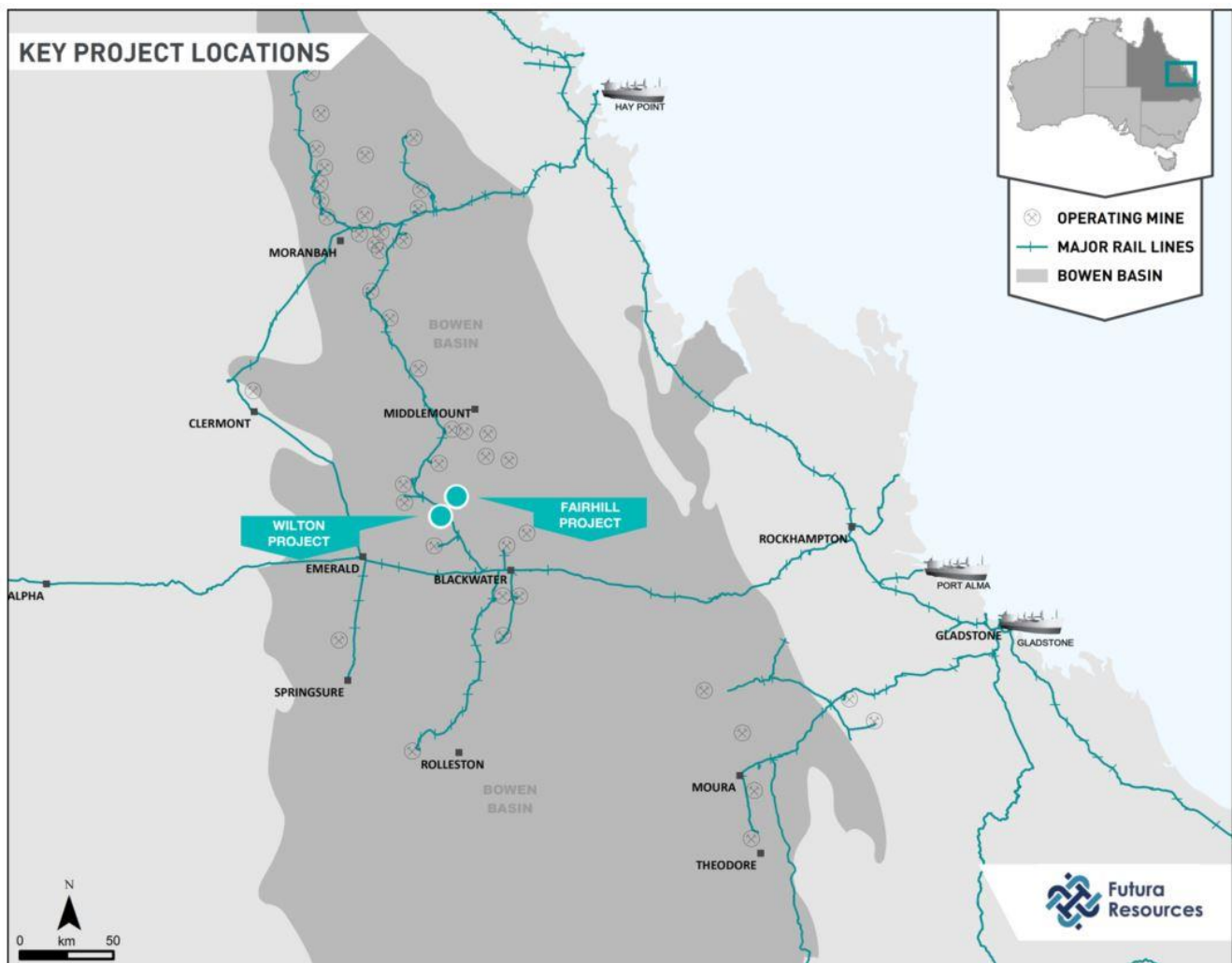


Figure 1. Regional Location

2 Landform Design Methodology

Futura has utilised three key criteria when undertaking landform designs for the Mines, these are:

1. Alignment with the approved EA conditions for the Mines, in particular the Post Mining Land Use (**PMLU**) of low-medium intensity cattle grazing;
2. The creation of safe and stable long-term structures which integrate into the existing landscape; and,
3. Operationally achievable outcomes which can be managed and met in line with progressive rehabilitation requirements and operational outcomes.

Conceptual landform models have been created with these criteria in mind and drawing upon approved design criteria contained in the EA's for the Mines. These conceptual models draw upon the existing topographical features and elevations of the Mines to create landforms which align with the key criteria above.

Modelling utilises constraints based on slope angles of the natural landscape and slope length. This is to ensure compatibility with the natural landscape and overall stability of the final landform.

Landforms are designed to have a Factor of Safety (**FoS**) of greater than 1, taking into consideration the topography, slope geometry, soils and geology, and ground and surface water conditions. Geotechnical Expertise has provided input to achieve the desired FoS. Geotechnical Engineers will analyse the Probability of Failure (**PoF**) for all final landforms and determine a confidence interval for the FoS prior to finalising the landform for rehabilitation. This will be based on geotechnical characterisation of void wall material that will be assessed as the pit excavation progresses.

Examples of existing topographical landform models used at the Wilton Fairhill Complex to inform rehabilitation design criteria and modelling are shown below.

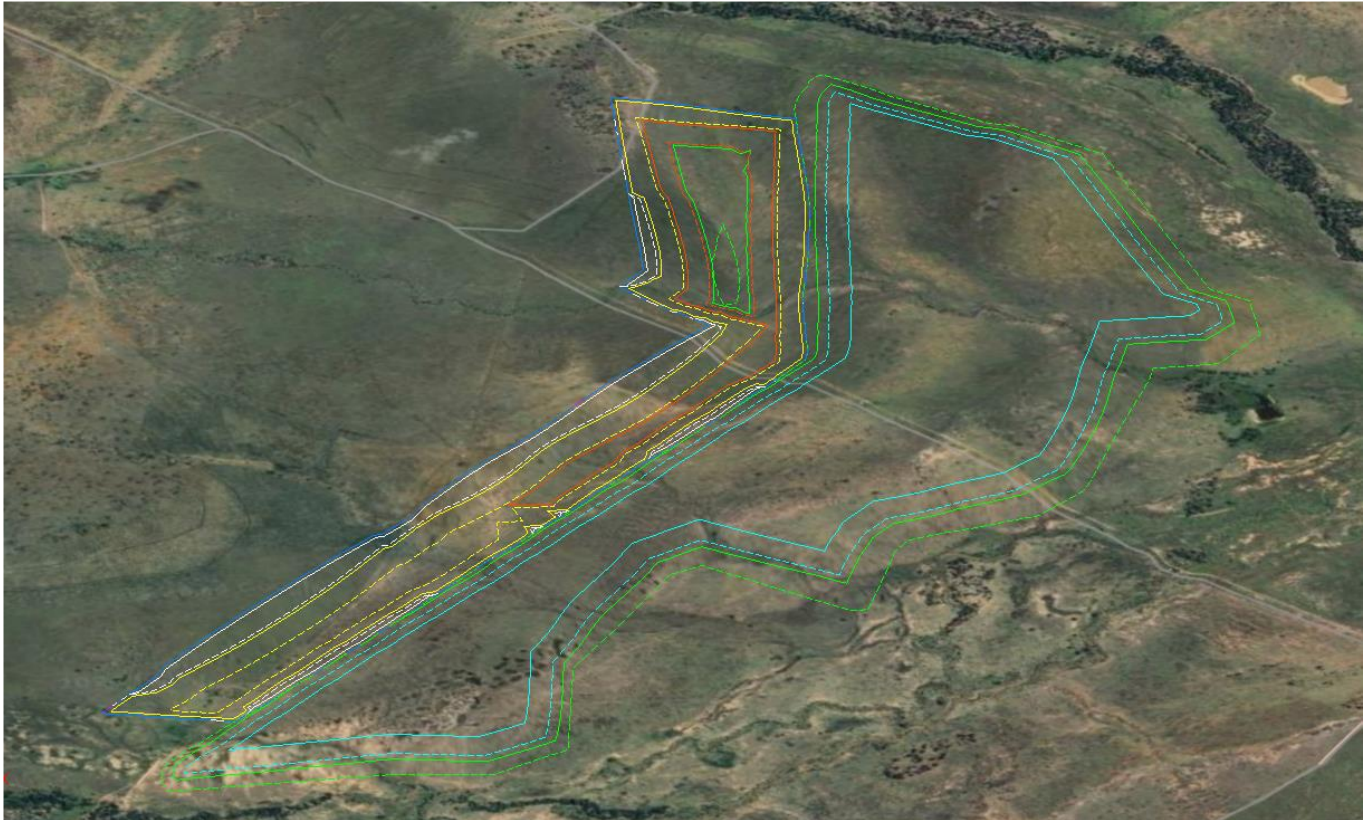


Figure 2. Modelled Landform Elevations at FHCP imposed onto the landscape

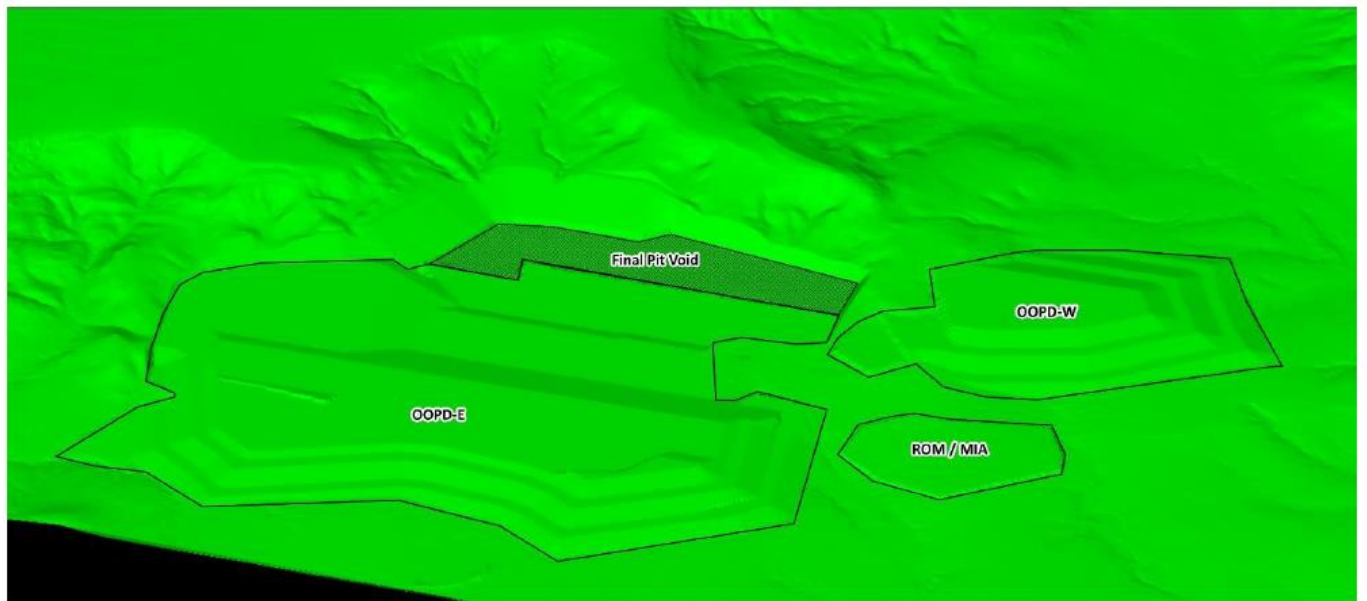


Figure 3. Modelled 3D Landform Elevations at WCP

3 Stability of Landform

At the Wilton Fairhill Complex numerous factors have been considered in ensuring that the planned final landform is safe and structurally stable. The sections that follow highlight work undertaken which informs the practices and methodologies that will be followed operationally and during closure to ensure that the final landform is structurally stable.

It should be noted that the stability of slopes is maintained through the Mines operational lives by ensuring whenever possible during operations geology remains unbroken unless necessary and low walls are deposited at the angle of repose, and for all rehabilitated surfaces, angles are kept to <30%. Geotechnical Inspections are also routinely conducted during operation and will be conducted prior to mine closure on the rehabilitated landform. The integrity of the landform is thus maintained throughout the life of mine.

3.1 Slope & Slope Length Analysis

Cross sections of the proposed final landforms are analysed to demonstrate and ensure that slope angles will not exceed 30%. It is clear that similar slope angles are present in both the conceptual and the natural landforms demonstrating the compatibility of the proposed final landform with the natural landscape.

For the Wilton Coal Mine the final landform slopes will not exceed 30%. The slope analysis for Wilton as depicted below shows that the landscape natural has wide range of variability in slope and is steeply undulating. The final landform for Wilton Coal Mine has been designed to integrate with the final landform so that slope stability is achieved. The final landform slopes are mostly less steep than the slopes to the west and slightly steeper than the land sloping eastwards and will be neatly integrated with the surrounding landscape.



Figure 4. Existing Landform Cross Sections (following edge of disturbance contouring)

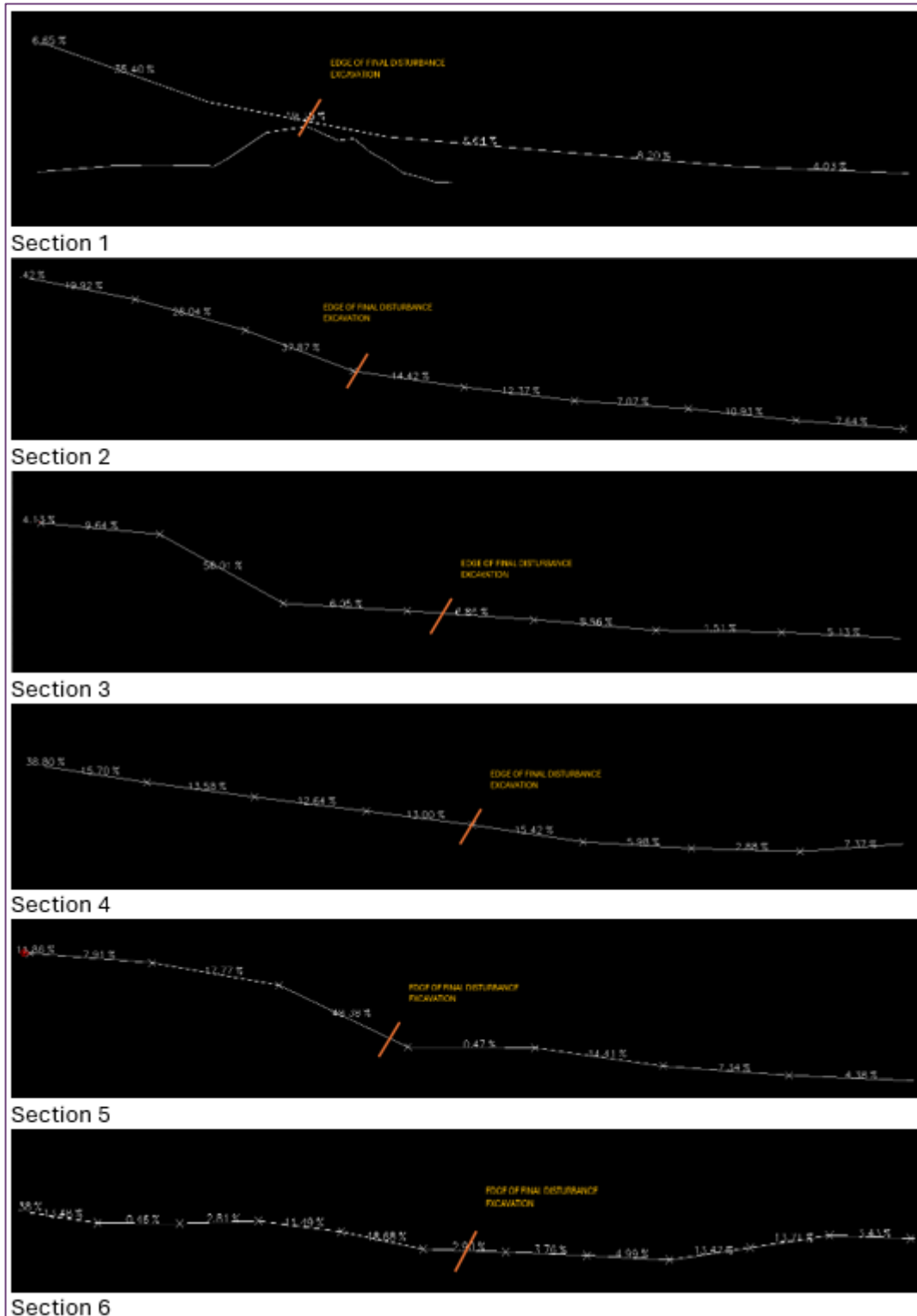


Figure 5. Sections along contour (Figure 3) showing slope angle and length (40m chainage breaks)

For the Fairhill Coal Mine the final landform slopes will not exceed 25%. The slope analysis for Fairhill as depicted below shows that the immediate landscape natural has wide range of variability in slope and is gently undulating. The final landform for Fairhill Coal Mine has been designed to integrate with the final landform so that slope stability is achieved. The final landform slopes in the area of the void are slightly steeper than the naturally occurring slopes in the immediate vicinity. They do however integrate well with the surrounding landscape. Majority of slope angles are modelled to <10% except for battered slope angles which will achieve between 10% and 25%. The overall average slope for total slope length for will approximate <15%.

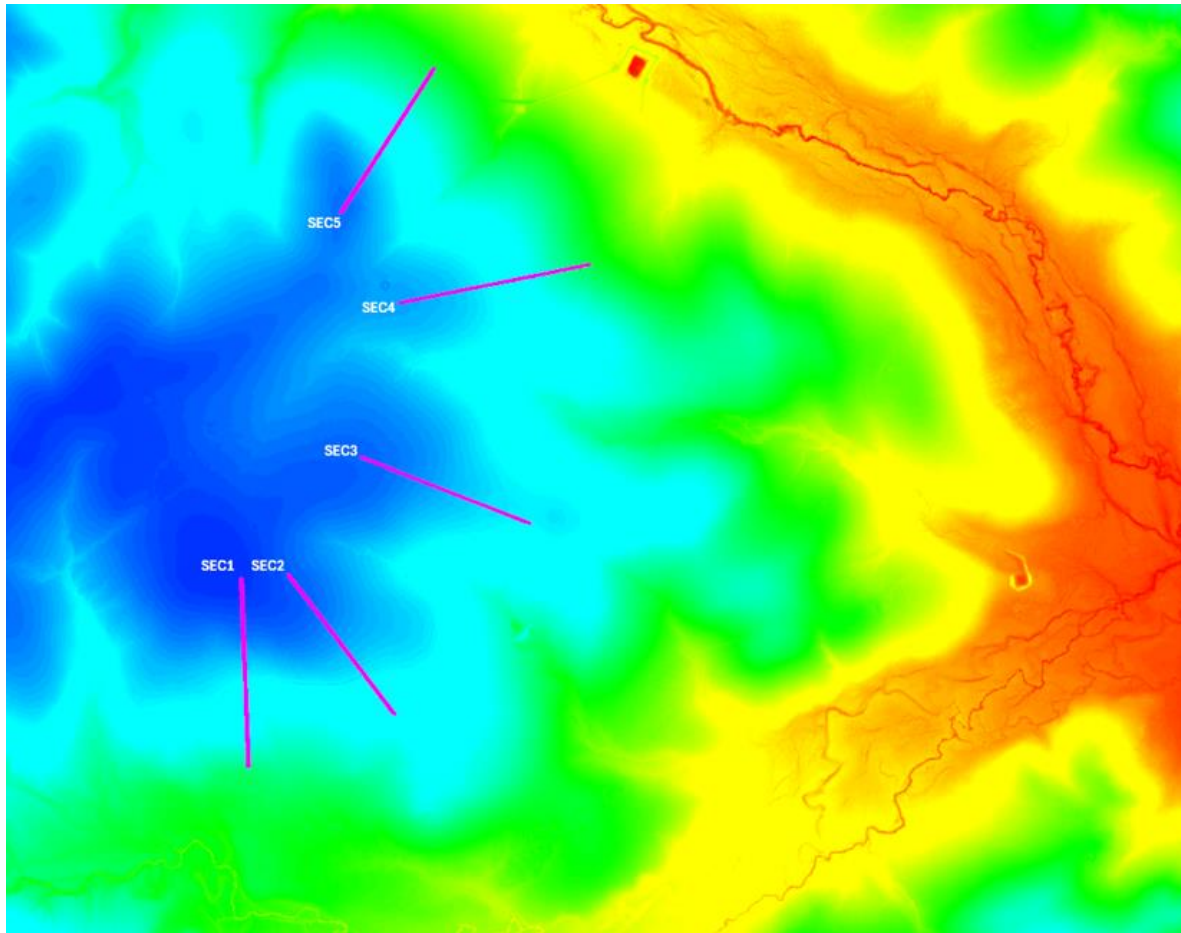


Figure 6. Existing Landform Cross Sections (following edge of disturbance contouring)

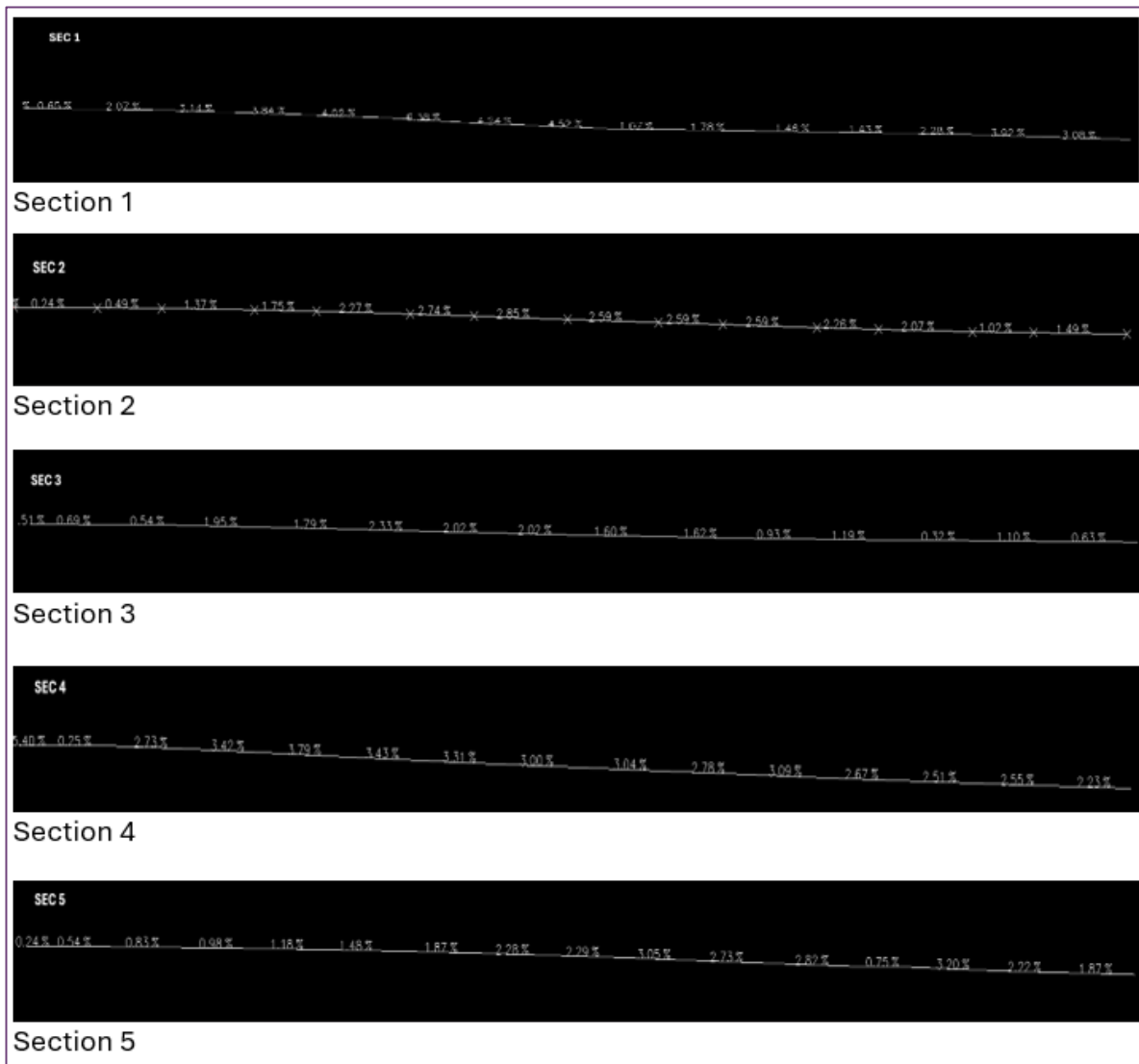


Figure 7. Sections along contour (Figure 3) showing slope angle and length (50m Sections)

Slope Stability on batter slopes is achieved by benching the batter slopes. FoS is improved in benching as it lessens surficial erosion by reducing the run-up distance for flowing water downward over the slope surface and also by trapping the eroded particles at the benches. The correct number of benches (bench height and bench face angle considered) in a given slope has the effect of flattening the slope from a stability perspective. The landform design aims to achieve the highest FoS while at the same time considering the topography, slope geometry, soils and geology, and ground and surface water conditions

3.2 Drainage

Final landform and the associated flood impacts have been modelled for the Mines by ATC Williams, with the data presented as part of the EA applications for the mines. Futura also undertakes internal modelling of flooding impacts around surface designs using HEC RAS software.

The final landform and flood impacts for both projects have been modelled (ATC 2018). Both sites are at the head of a local catchment with watercourses so weakly defined that Queensland's own database has them inaccurately mapped. and as a result, is unlikely ever to accumulate large amounts of surface runoff. Any water received originates from the project site. The drainage lines through the project site are ephemeral with flow occurring only in response to rainfall events and expected to be of short duration.

A 'relevant watercourse' is defined as a stream order 4 or higher under the Strahler stream order classification system.

At Wilton Coal Mine no fourth order streams are present.

At Fairhill Coal Mine Coroora Creek is a fourth order stream and therefore the only 'relevant water course'.

Modelling of rainfall events by ATC for the Wilton Fairhill Complex concluded that flood velocities and depths are minor, and inundation restricted to the local watercourses, the only resulting change resulting due to the final landform being that of reduction of modelled peak velocities at Wilton Coal Mine and a reduction in maximum inundation depths at Fairhill Coal Mine. This means that across the catchment of the final landform there are not expected to be an increase in velocities of flood waters and if cover is maintained. The model included a co-efficient for surface roughness based on cover identified in aerial photography of cover characteristics in the pre-mining landscape.

Groundwater interactions are also expected to be non-existent or minimal. But this interaction with the final landform is described well in the ATC reports (2018 & 2019).

3.3 Erosion and Sediment Control

The catchment modelling undertaken by ATC Williams conclude that across the catchment of the final landform there is not expected to be an increase in the velocities of surface runoff. As such if surface roughness (runoff co-efficient) is maintained erosion is not expected to increase from the pre-mining rates of erosion.

AT WCP minor active sheet erosion and Minor active gulley erosion were noted in the pre-mining landscape (Soils Assessment, SLR 2019). Environmental Earth Sciences (2012) noted a prevalence of Gulley Erosion.

At FHCP minor to moderate sheet Erosion and gully erosion ranging from moderate to deep active gully erosion were observed Soil and Land Suitability Assessment, SLR 2019.

Practices at WCP and FHCP include short duration stock piling of topsoil to retain seedbank and condition and re-spreading over reshaped landform (<6m months) and ongoing monitoring and maintenance of re-establishing vegetation growth. This practice is expected to re-establish plant vigour quickly and reduce erosion risk to negligible levels. The postmining landscape will thus minimise sediment leaving site to maintain erosion rates consistent with the current landform.

Both Carroll et al. (2010) and Waters (2000) found that maintaining ground cover at 40-60% was sufficient in reducing erosion to negligible levels (<0.5 t/ha), regardless of slope.

3.4 Landform Evolution Modelling

Landform Evolution modelling has been considered but determined not to be appropriate for the Wilton Fairhill Complex due to the small overall site and limited disturbance area. Landscape evolution modelling has been demonstrated to be more appropriate for use where the postmining landscape is distinctly different from the surrounding landscape and requires a longer duration of mining for establishment of a long-term field plot for comparative purposes with non-mined areas and model calibration with actual data (NSW Government, 2021).

At WCP the LOM is short the final Landform will integrate with the surrounding landscape, where modelling shows that water loss will be minimised and consequently soil loss will also be minimised. The site is predicted to have a surplus of topsoil which can be ameliorated if necessary to ensure the establishment of sufficient plant vigour to ensure that post-mining soil loss does not exceed pre-mining rates of soil loss.

WCP and FHCP intend to collect data on trial landforms developed throughout the LOM commencing from early on.

4 References

Carroll C., Dougall C., Silburn M., Waters D., Packett B. and Joo M., (2010). Sediment erosion research in the Fitzroy basin central Queensland: an overview. 19th World Congress of Soil Science, Soil Solutions for a Changing World.

NSW Government (2021). Landform Evolution Modelling and Geomorphic Design Principles for Mine Rehabilitation Landforms, Q&A.

Waters, D.K. (2004). Grazing management implications on runoff and erosion processes in semi-arid Central Queensland. In 'Conserving Soil and Water for Society: Sharing Solutions. Proceedings 13th International Soil Conservation Organisation Conference'. Brisbane, 2004. Paper 427. (Eds S.R. Raine, A.J.W. Biggs, N.W. Menzies, D.M. Freebairn, P.E. Tolmie) (ASSSI/IECA: Brisbane, Qld).NRC. (2017b). Wilton Coal Project Waste Rock Characterisation Report.

SLR. (2019). Wilton Coal Project Final Void Modelling.

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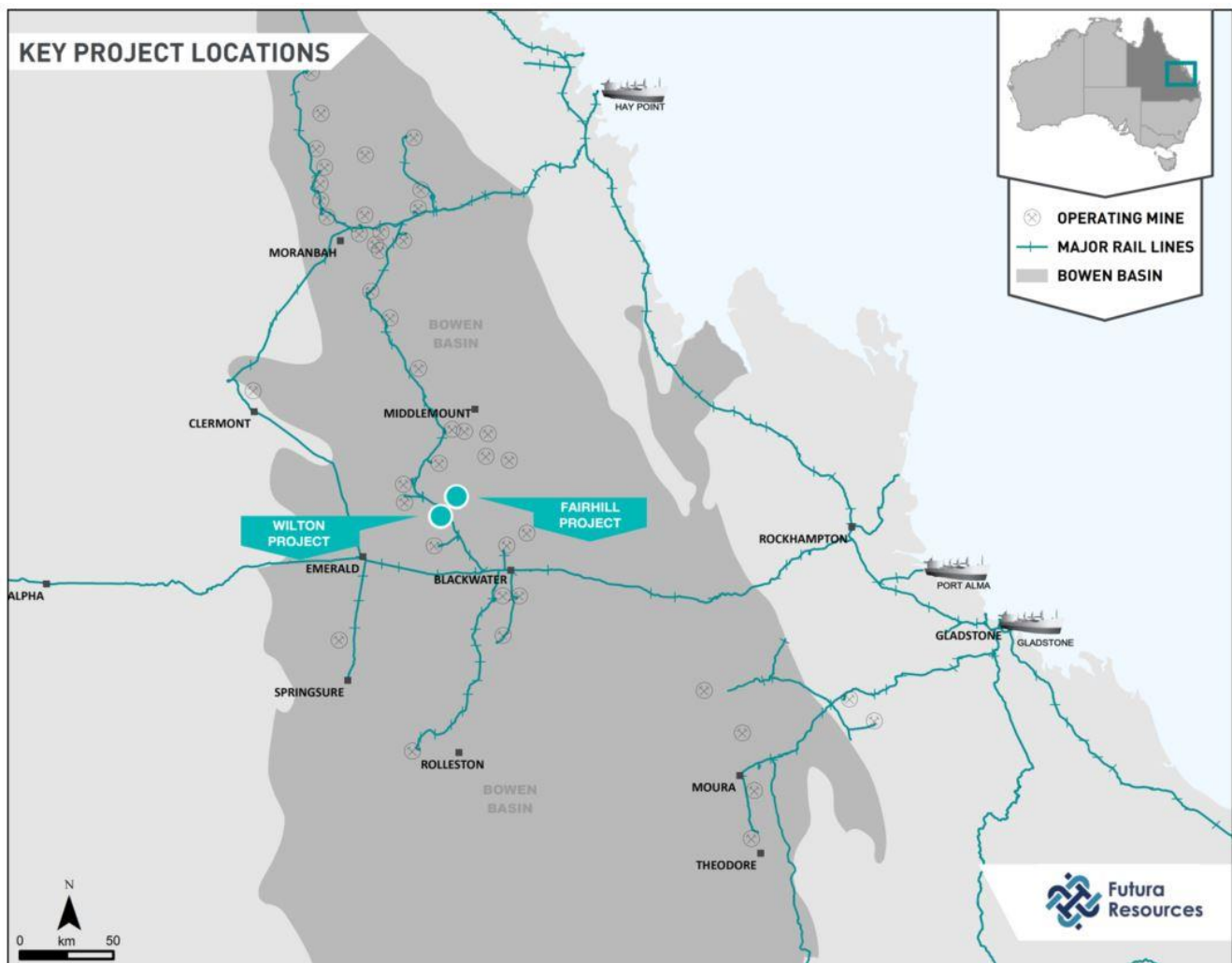


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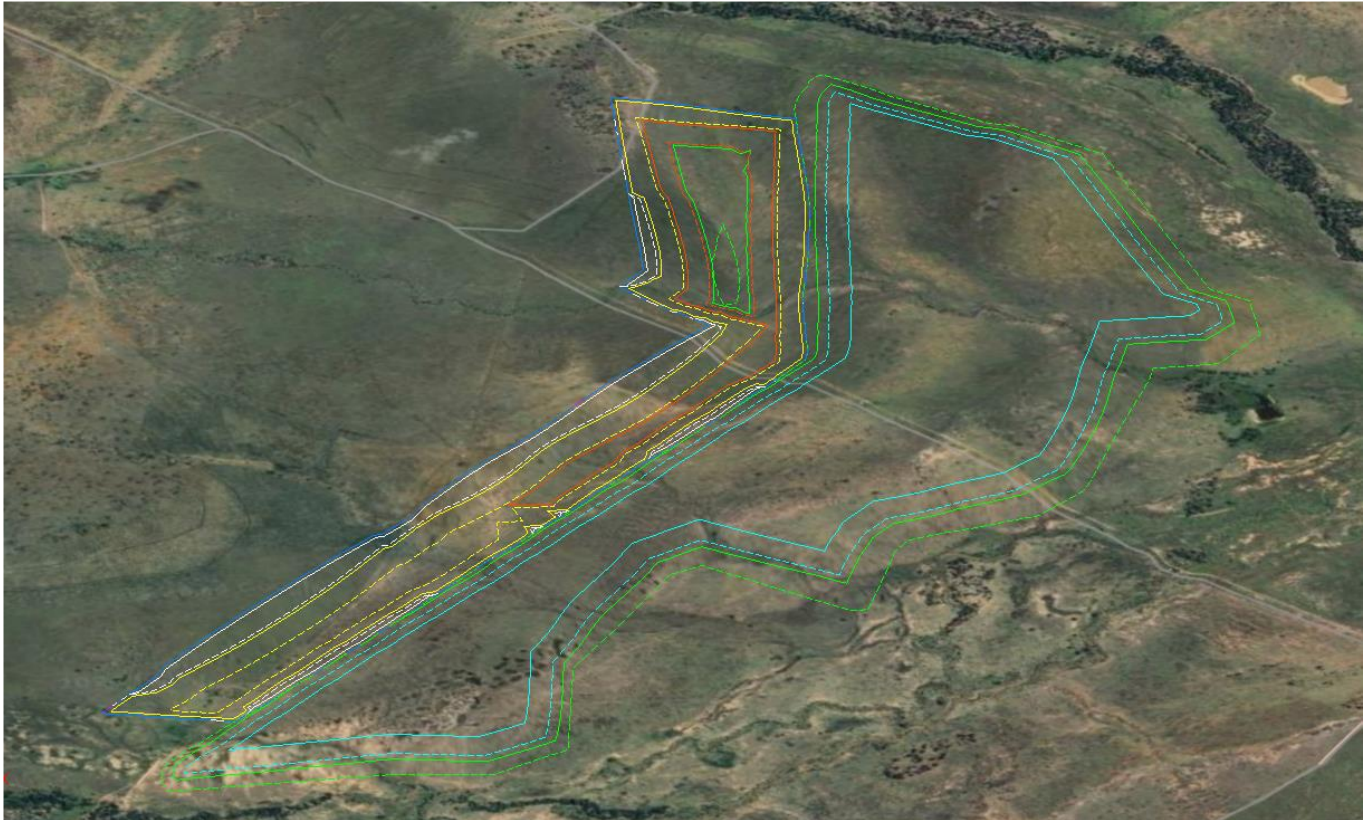


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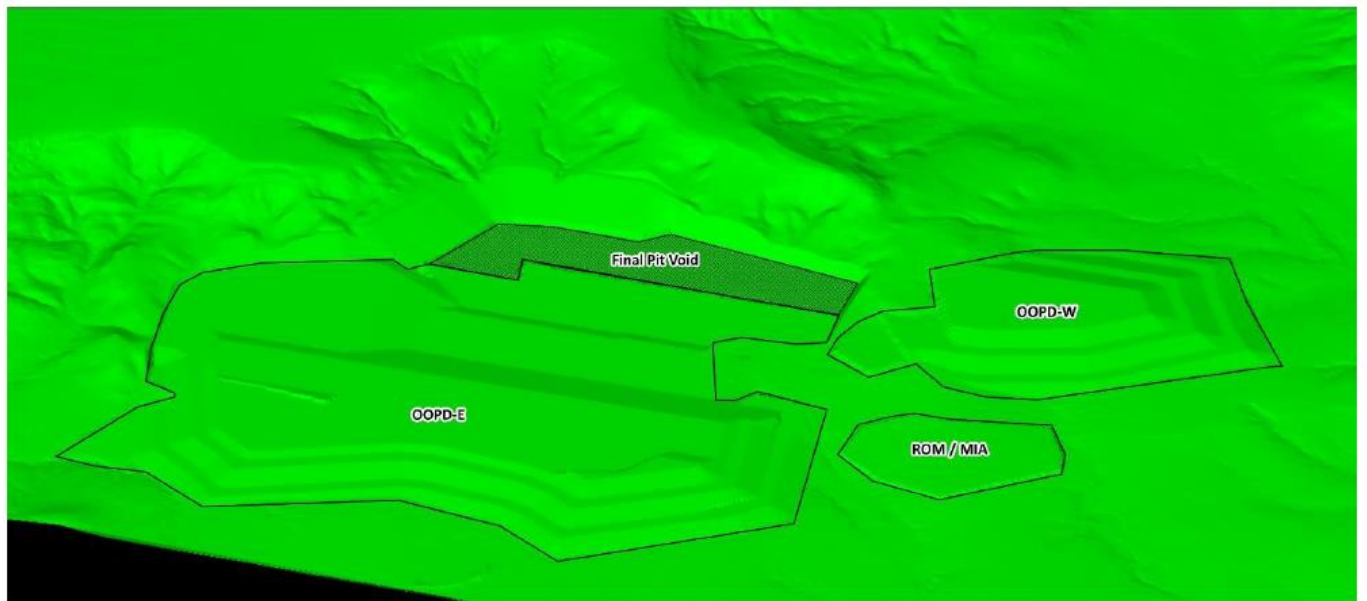


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3 Stability of Landform

At the Wilton Fairhill Complex numerous factors have been considered in ensuring that the planned final landform is safe and structurally stable. The sections that follow highlight work undertaken which informs the practices and methodologies that will be followed operationally and during closure to ensure that the final landform is structurally stable.

It should be noted that the stability of slopes is maintained through the Mines operational lives by ensuring whenever possible during operations geology remains unbroken unless necessary and low walls are deposited at the angle of repose, and for all rehabilitated surfaces, angles are kept to <30%. Geotechnical Inspections are also routinely conducted during operation and will be conducted prior to mine closure on the rehabilitated landform. The integrity of the landform is thus maintained throughout the life of mine.

3.1 Slope & Slope Length Analysis

Cross sections of the proposed final landforms are analysed to demonstrate and ensure that slope angles will not exceed 30%. It is clear that similar slope angles are present in both the conceptual and the natural landforms demonstrating the compatibility of the proposed final landform with the natural landscape.

For the Wilton Coal Mine the final landform slopes will not exceed 30%. The slope analysis for Wilton as depicted below shows that the landscape natural has wide range of variability in slope and is steeply undulating. The final landform for Wilton Coal Mine has been designed to integrate with the final landform so that slope stability is achieved. The final landform slopes are mostly less steep than the slopes to the west and slightly steeper than the land sloping eastwards and will be neatly integrated with the surrounding landscape.



Figure 4. Existing Landform Cross Sections (following edge of disturbance contouring)

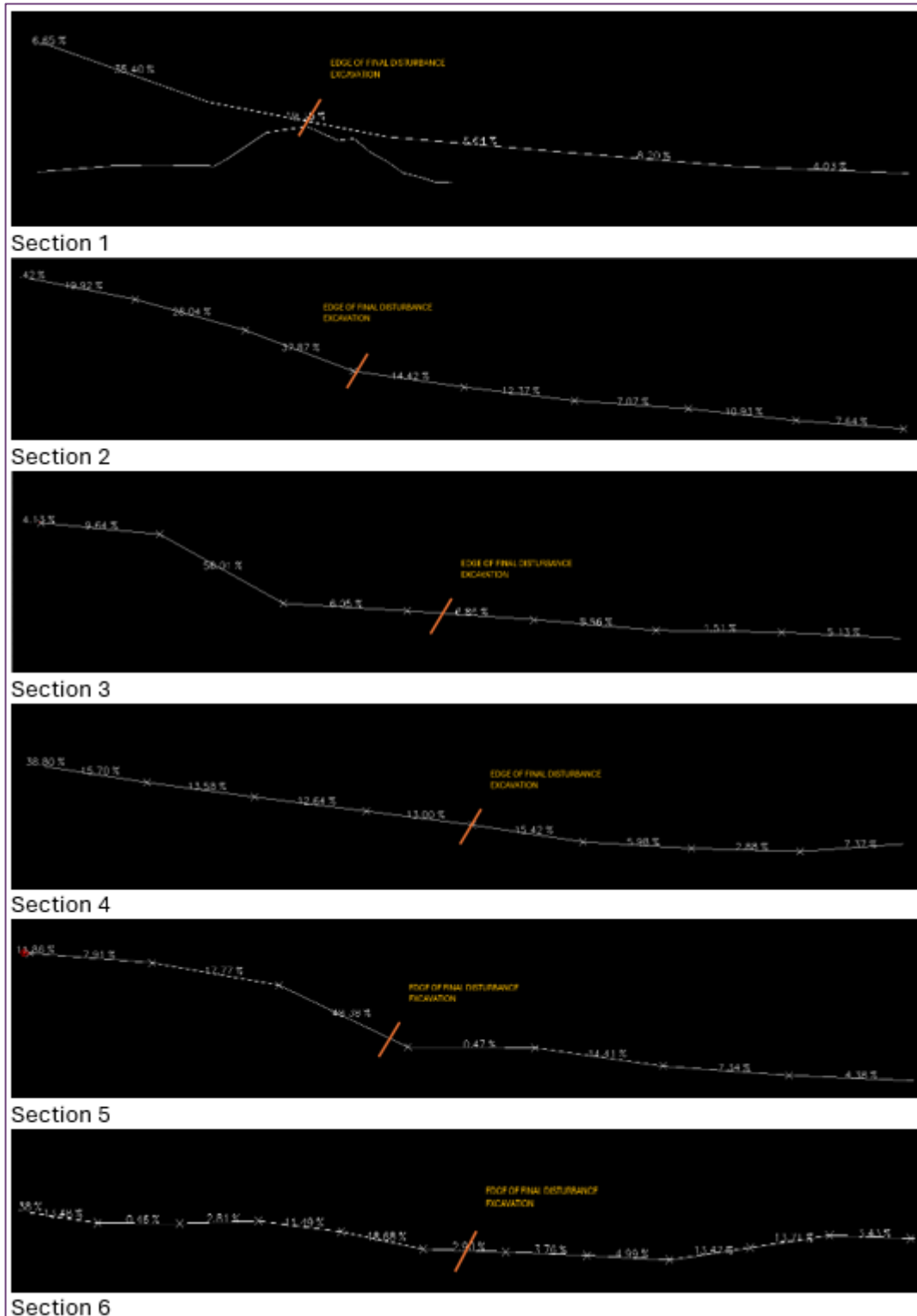


Figure 5. Sections along contour (Figure 3) showing slope angle and length (40m chainage breaks)

For the Fairhill Coal Mine the final landform slopes will not exceed 25%. The slope analysis for Fairhill as depicted below shows that the immediate landscape natural has wide range of variability in slope and is gently undulating. The final landform for Fairhill Coal Mine has been designed to integrate with the final landform so that slope stability is achieved. The final landform slopes in the area of the void are slightly steeper than the naturally occurring slopes in the immediate vicinity. They do however integrate well with the surrounding landscape. Majority of slope angles are modelled to <10% except for battered slope angles which will achieve between 10% and 25%. The overall average slope for total slope length for will approximate <15%.

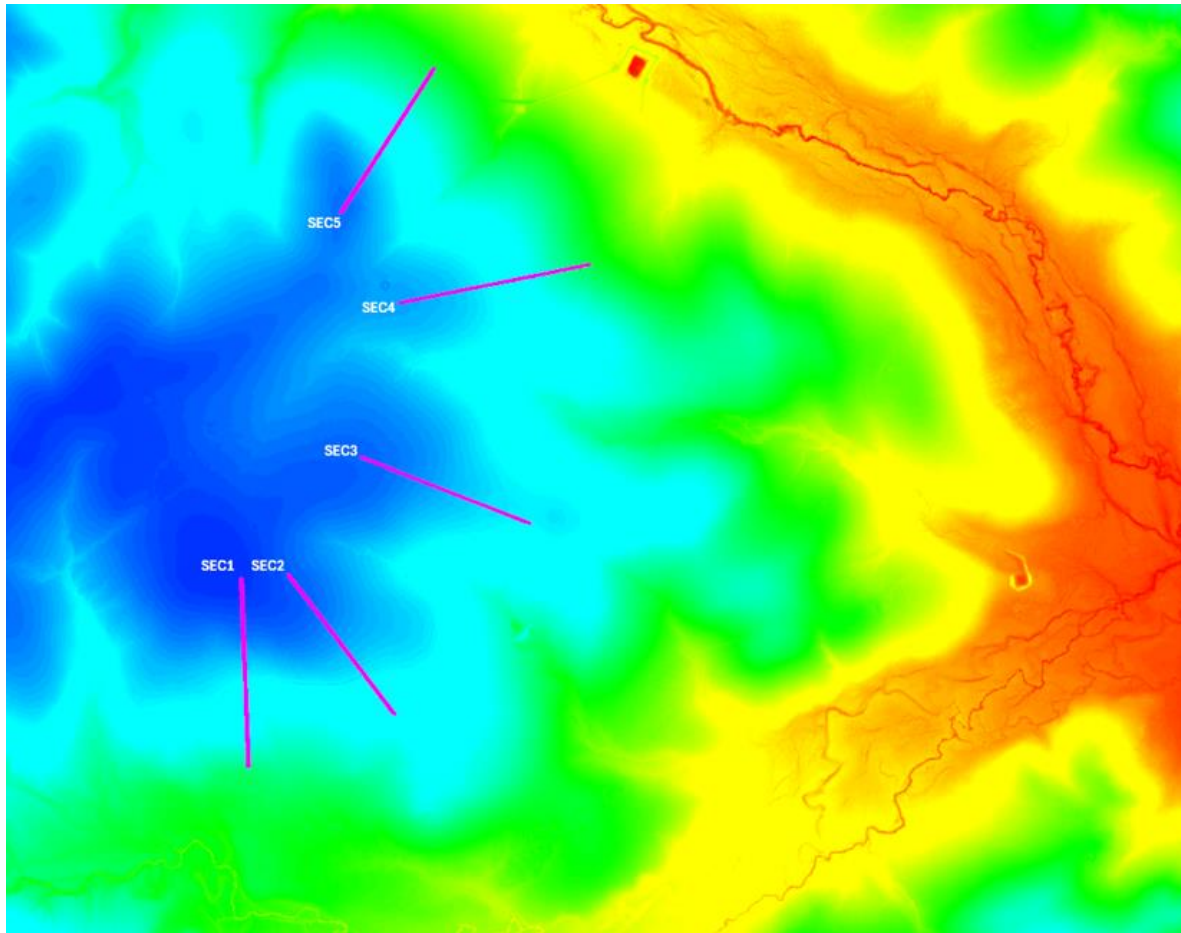


Figure 6. Existing Landform Cross Sections (following edge of disturbance contouring)

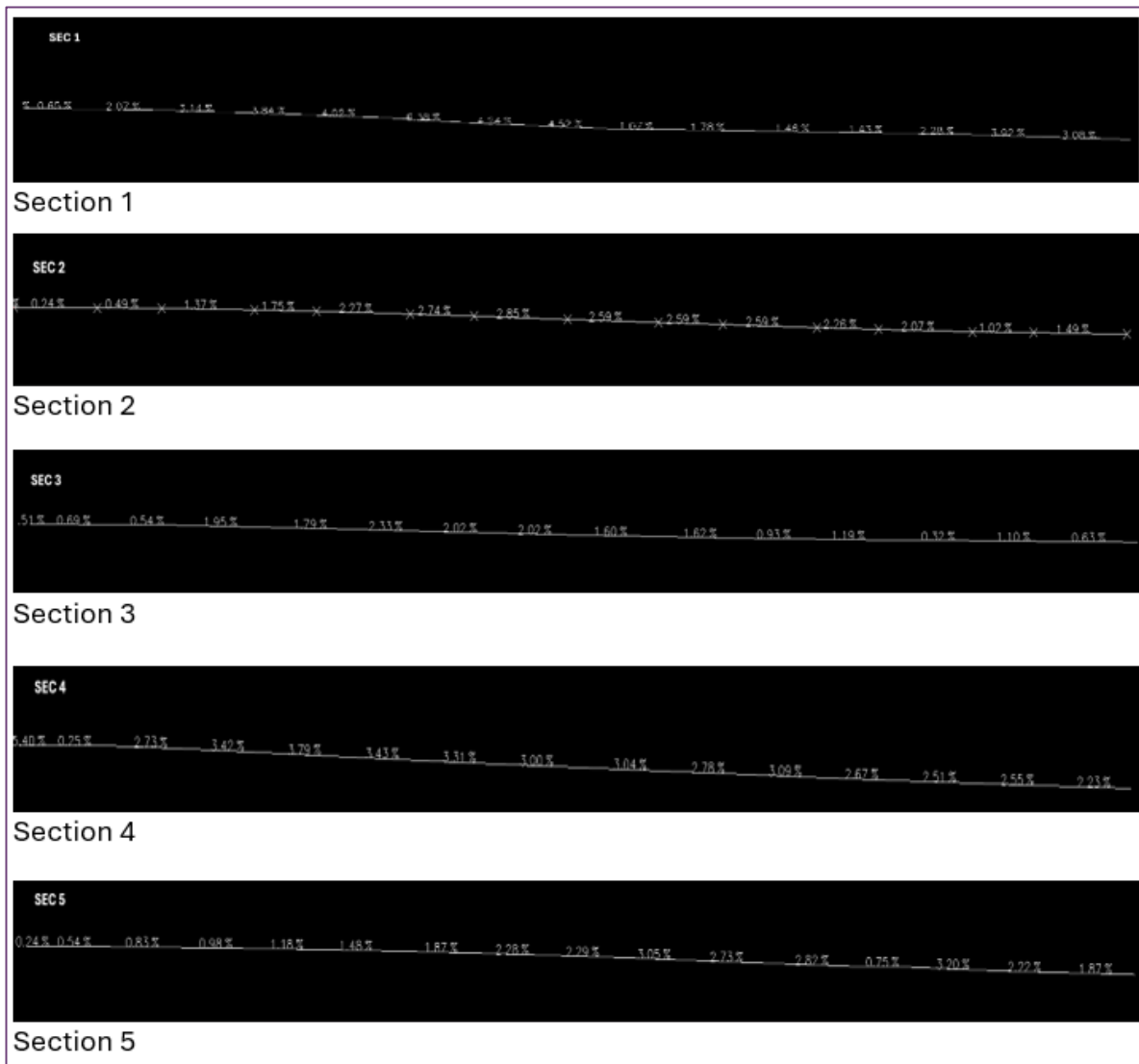


Figure 7. Sections along contour (Figure 3) showing slope angle and length (50m Sections)

Slope Stability on batter slopes is achieved by benching the batter slopes. FoS is improved in benching as it lessens surficial erosion by reducing the run-up distance for flowing water downward over the slope surface and also by trapping the eroded particles at the benches. The correct number of benches (bench height and bench face angle considered) in a given slope has the effect of flattening the slope from a stability perspective. The landform design aims to achieve the highest FoS while at the same time considering the topography, slope geometry, soils and geology, and ground and surface water conditions

3.2 Drainage

Final landform and the associated flood impacts have been modelled for the Mines by ATC Williams, with the data presented as part of the EA applications for the mines. Futura also undertakes internal modelling of flooding impacts around surface designs using HEC RAS software.

The final landform and flood impacts for both projects have been modelled (ATC 2018). Both sites are at the head of a local catchment with watercourses so weakly defined that Queensland's own database has them inaccurately mapped. and as a result, is unlikely ever to accumulate large amounts of surface runoff. Any water received originates from the project site. The drainage lines through the project site are ephemeral with flow occurring only in response to rainfall events and expected to be of short duration.

A 'relevant watercourse' is defined as a stream order 4 or higher under the Strahler stream order classification system.

At Wilton Coal Mine no fourth order streams are present.

At Fairhill Coal Mine Coroora Creek is a fourth order stream and therefore the only 'relevant water course'.

Modelling of rainfall events by ATC for the Wilton Fairhill Complex concluded that flood velocities and depths are minor, and inundation restricted to the local watercourses, the only resulting change resulting due to the final landform being that of reduction of modelled peak velocities at Wilton Coal Mine and a reduction in maximum inundation depths at Fairhill Coal Mine. This means that across the catchment of the final landform there are not expected to be an increase in velocities of flood waters and if cover is maintained. The model included a co-efficient for surface roughness based on cover identified in aerial photography of cover characteristics in the pre-mining landscape.

Groundwater interactions are also expected to be non-existent or minimal. But this interaction with the final landform is described well in the ATC reports (2018 & 2019).

3.3 Erosion and Sediment Control

The catchment modelling undertaken by ATC Williams conclude that across the catchment of the final landform there is not expected to be an increase in the velocities of surface runoff. As such if surface roughness (runoff co-efficient) is maintained erosion is not expected to increase from the pre-mining rates of erosion.

AT WCP minor active sheet erosion and Minor active gulley erosion were noted in the pre-mining landscape (Soils Assessment, SLR 2019). Environmental Earth Sciences (2012) noted a prevalence of Gulley Erosion.

At FHCP minor to moderate sheet Erosion and gully erosion ranging from moderate to deep active gully erosion were observed Soil and Land Suitability Assessment, SLR 2019.

Practices at WCP and FHCP include short duration stock piling of topsoil to retain seedbank and condition and re-spreading over reshaped landform (<6m months) and ongoing monitoring and maintenance of re-establishing vegetation growth. This practice is expected to re-establish plant vigour quickly and reduce erosion risk to negligible levels. The postmining landscape will thus minimise sediment leaving site to maintain erosion rates consistent with the current landform.

Both Carroll et al. (2010) and Waters (2000) found that maintaining ground cover at 40-60% was sufficient in reducing erosion to negligible levels (<0.5 t/ha), regardless of slope.

3.4 Landform Evolution Modelling

Landform Evolution modelling has been considered but determined not to be appropriate for the Wilton Fairhill Complex due to the small overall site and limited disturbance area. Landscape evolution modelling has been demonstrated to be more appropriate for use where the postmining landscape is distinctly different from the surrounding landscape and requires a longer duration of mining for establishment of a long-term field plot for comparative purposes with non-mined areas and model calibration with actual data (NSW Government, 2021).

At WCP the LOM is short the final Landform will integrate with the surrounding landscape, where modelling shows that water loss will be minimised and consequently soil loss will also be minimised. The site is predicted to have a surplus of topsoil which can be ameliorated if necessary to ensure the establishment of sufficient plant vigour to ensure that post-mining soil loss does not exceed pre-mining rates of soil loss.

WCP and FHCP intend to collect data on trial landforms developed throughout the LOM commencing from early on.

4 References

Carroll C., Dougall C., Silburn M., Waters D., Packett B. and Joo M., (2010). Sediment erosion research in the Fitzroy basin central Queensland: an overview. 19th World Congress of Soil Science, Soil Solutions for a Changing World.

NSW Government (2021). Landform Evolution Modelling and Geomorphic Design Principles for Mine Rehabilitation Landforms, Q&A.

Waters, D.K. (2004). Grazing management implications on runoff and erosion processes in semi-arid Central Queensland. In 'Conserving Soil and Water for Society: Sharing Solutions. Proceedings 13th International Soil Conservation Organisation Conference'. Brisbane, 2004. Paper 427. (Eds S.R. Raine, A.J.W. Biggs, N.W. Menzies, D.M. Freebairn, P.E. Tolmie) (ASSSI/IECA: Brisbane, Qld).NRC. (2017b). Wilton Coal Project Waste Rock Characterisation Report.

SLR. (2019). Wilton Coal Project Final Void Modelling.



Northern Resource
CONSULTANTS

Fairhill Coal Project

Guideline Response for Activities with
Impacts to Land

November 2018 (Revised June 2019)

prepared for
Fairhill Coking Coal Pty Ltd

Rev 6

Contact Information	Details
Contact Person	Marty Costello
Phone	07 4772 6500
Email	mcostello@slrconsulting.com
Mail	12 Cannan Street, South Townsville QLD, 4810

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Revision 5	Updated to address DES RFI comments June 2019.

Limitations of this Report

Client: Fairhill Coking Coal Pty Ltd

This disclaimer brings the limitations of the investigations to the attention of the reader.

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The results of work carried out by others may have been used in the preparation of this report. These results have been used in good faith, and we are not responsible for their accuracy.

This report has been formulated in the context of published guidelines, field observations, discussions with site personnel, and results of laboratory analyses.

Opinions in this document are subject to modification if additional information is obtained through further investigation, observations or analysis. They relate solely and exclusively to environmental management matters, and are based on the technical and practical experience of environmental scientists.

They are not presented as legal advice, nor do they represent decisions from the regulatory agencies charged with the administration of the relevant Acts.

Any advice, opinions or recommendations contained in this document should be read and relied upon only in the context of the document as a whole and are considered current as of the date of this document.

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Appendix C2:	Fairhill Coal Project Soils and Land Suitability Assessment (SLR, 2019)
Appendix C3:	Fairhill Coal Project Flora and Fauna Technical Report
Appendix C4:	Fairhill Coal Project Overburden and Potential Coal Reject Characterisation Report
Appendix C5:	Fairhill Coal Project Mine Closure Plan

1. Site Description

1.1 Location and Tenure

The Fairhill coal project (FHCP) tenement is located in the Bowen Basin in Central Queensland, approximately 55 km northeast of Emerald, 47 km northwest of Blackwater and 195 km west of Rockhampton. The project is in close proximity to other coal mines, coal mining infrastructure and coal deposits. Surrounding mines and resources include:

- Ensham's Yongala Mine, 18 km to the southwest
- Kestrel (25 km), Crinum and Gregory (32 km) Mines to the west
- Oaky Creek Mine, 24 km to the northwest
- Mackenzie Coal Project, 33 km to the east.

The FHCP is within Mine Lease (Application) (MLA) 70043 and encompassed by exploration permit for coal EPC2177 as shown in Figure 1. This EPC was originally granted in 2012 and is currently under renewal. The exploration tenement lies within both the Central Highlands Regional Council and Isaac Regional Council local government areas. The FHCP tenement overlies a pastoral property and a registered easement, comprising a third-party infrastructure water pipeline, described in Table 1. The property tenures described in Table 1 lie wholly within the Isaac Regional Council local government area. The Isaac (Nebo Shire) Planning Scheme shows the exploration tenement located on properties zoned as rural.

Table 1: Tenure for the FHCP

LOT	PLAN	AREA WITHIN EPC2177 (HECTARES)	OWNER
2	TT241	420.86	Peter and Denise Comiskey
M	TT397	0.13	Peter and Denise Comiskey

Exploration for the project has been concentrated around the entirety of EPC2177, which encompasses a total exploration area of approximately 6,360 ha.

The core disturbance area associated with the FHCP is proposed to take place on Lot 2 on TT241, owned by the Comiskey family.

1.2 Existing Land Uses

The regional land use in the Emerald area of the Bowen Basin region is generally rural with some coal mining activities. Rural land uses are predominately cattle grazing and irrigated and rainfed broadacre cropping.

A large proportion of the prime agricultural land in the region surrounding the proposed FHCP is situated on the flood plain of the Nogoa River around Emerald and to the east, supplied by Fairbairn Dam. Away from the flood plain, cattle are grazed on native or improved dry land pasture (Environmental Earth Sciences, 2012).

Cattle grazing is the dominant land use in the FHCP area with much of the flatter land across the site being cleared. Tracks, fences, dams and yards are present across the area for the purpose of cattle grazing.

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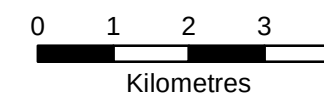
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FIGURE 1
ADJACENT
MINING TENEMENTS

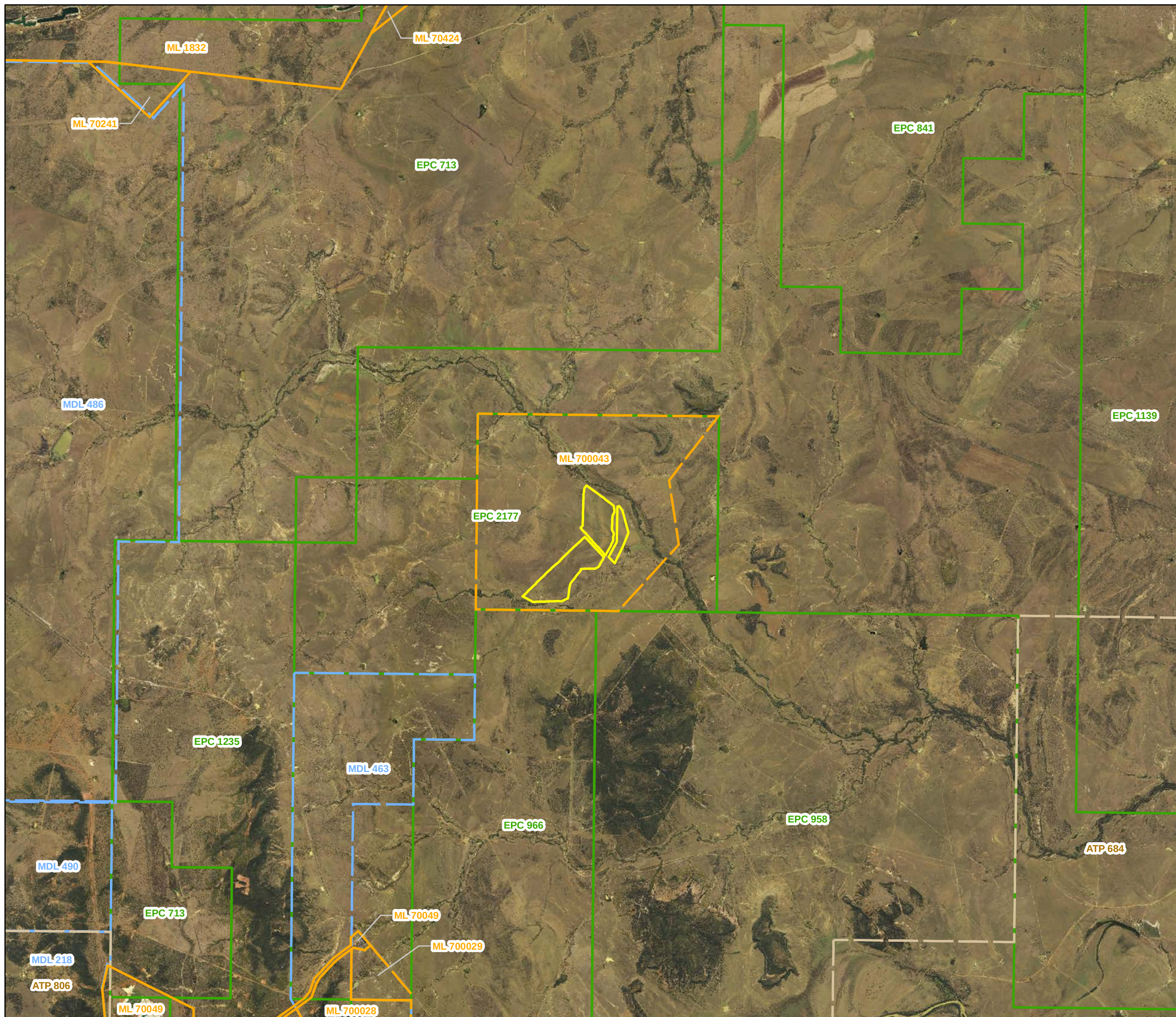
Legend

-  Mining Lease (Application)
-  Mining Lease (Granted)
-  7 Year Pit Shell
-  Proposed Site Infrastructure
-  Exploration Permits for Coal
-  Exploration Permits for Petroleum
-  Mineral Development Permit

Data Sources:
Exploration Permits, Development Permits, and Mining
Lease datasets: © State of Queensland (Department of
Natural Resources, Mines, and Energy) 2019; 7 Year
Pit Shell and Proposed Site Infrastructure datasets:
derived from client data on file (SLR Consulting) 2019.
Imagery Source: 70cm Bowen Basin SISP PeriUrban
2012 Orthophoto Image Service: © State of
Queensland (Department of Natural Resources, Mines,
and Energy) 2019.
Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator
Datum: GDA 1994
Date: 31/05/2019



Scale: 1:100,000 at A3



1.3 Existing Contaminated Land

A desktop assessment and preliminary site investigation were conducted to determine the existence of sites that may be contaminated within the project area. The desktop investigation reviewed each lot within the project area. The investigation included a site inspection and desktop assessment of the following documents to establish the possible location of potentially contaminated areas within the project area:

- Historical and current land titles
- Contaminated Land Register (CLR)
- Environmental Management Register (EMR)
- Historical aerial photographs
- Recent satellite imagery.

1.3.1 Historical and Current Land Use

The project area is contained within a land parcel including a water pipeline infrastructure corridor, watercourse and drainage lines that have been predominantly used for agricultural grazing and pasture improvements. The project area is in close proximity to other coal mines, infrastructure and coal deposits. Surrounding mines and resources include:

- Ensham's Yongala Mine, 18 km to the southwest
- Kestrel (25 km), Crinum and Gregory (32 km) Mines to the west
- Oaky Creek Mine, 24 km to the northwest
- Mackenzie Coal Project, 33 km to the east.

Potential contamination sources from cattle grazing, pasture improvements and mining activities can include:

- Farm chemical storage areas
- Farm fuel storage areas
- Former plunge dips
- Farm landfills
- Exploration drilling activities.

A review of aerial photography of the project area did not reveal any dip sites or fuel and chemical storage sites within the project area or its immediate surrounds. These structures and compounds are most likely to be sited closer to the homesteads and associated farming sheds and stock pens.

As such, investigations within the project area have concluded that the current and past agricultural land use activities, while impacting on the land surface or at shallow depths, showed no evidence of surface or subsurface contamination at the project site.

1.3.2 Third-Party Infrastructure

Lot 2 on TT241 has a water pipeline easement running diagonally from the southeast corner of the exploration tenement to the northwest corner of the EPC tenement as shown in Figure 2 . The water pipeline supplies water from the Bedford Weir to Oaky Creek mine. It is unlikely that the water pipeline corridor would be a significant potential contamination source.

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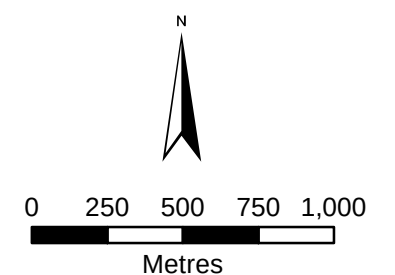
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FIGURE 2
SITE INFRASTRUCTURE

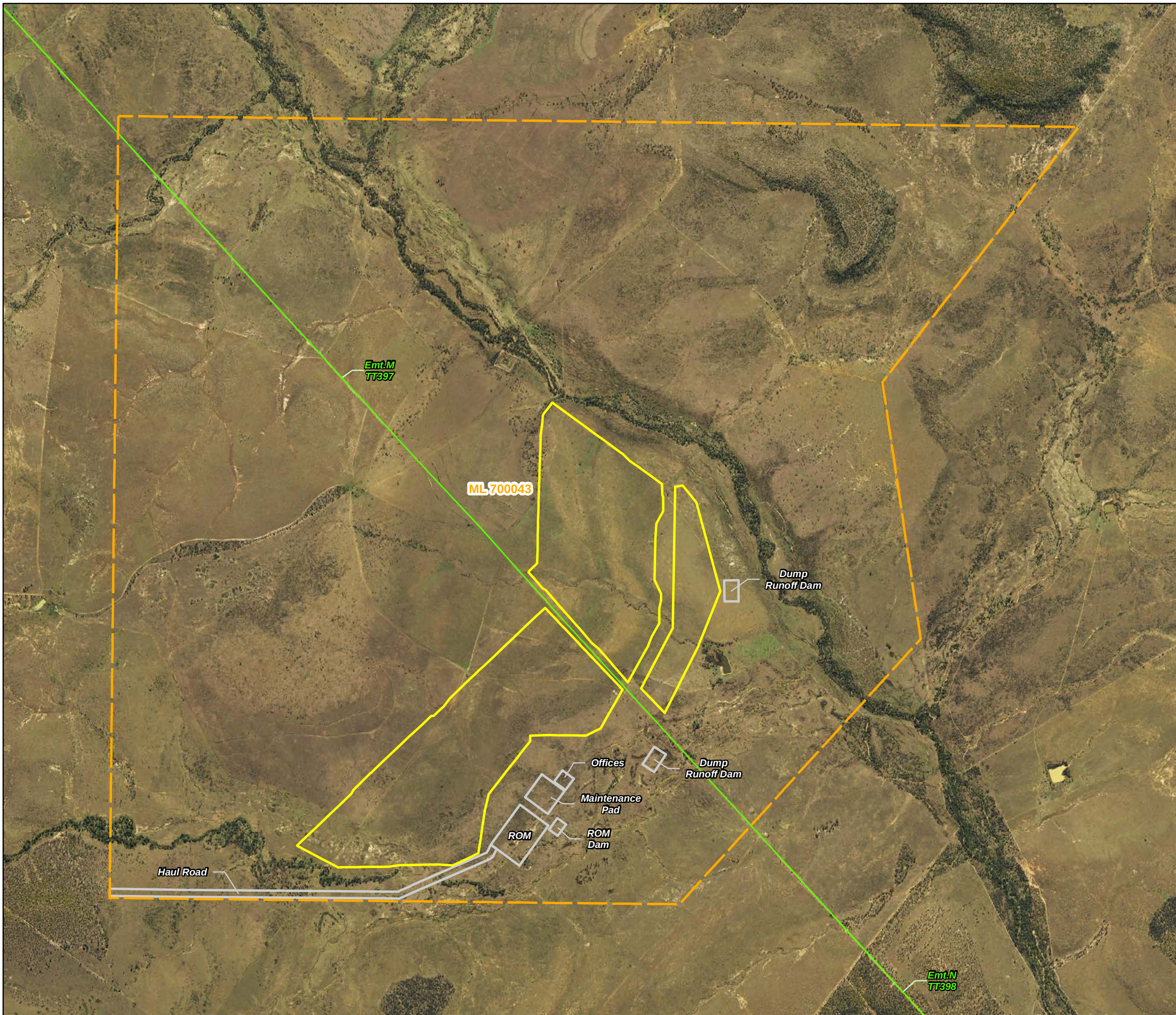
Legend

-  Mining Lease (Application)
-  7 Year Pit Shell
-  Proposed Site Infrastructure
-  Easement

Data Sources:
Mining Lease and Easement (DCDB extracted April 2019) dataset: © State of Queensland (Department of Natural Resources, Mines, and Energy) 2019; 7 Year Pit Shell and Proposed Site Infrastructure datasets: derived from client data on file (SLR Consulting) 2019. Imagery Sources: 70cm Bowen Basin SISP PeriUrban 2012 Orthophoto Image Service: © State of Queensland (Department of Natural Resources, Mines, and Energy) 2019.
Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator
Datum: GDA 1994
Date: 28/05/2019



Scale: 1:25,000 at A3



1.3.3 Nearby Receptors

The project site has a number of homesteads in the vicinity of its boundaries; however, the nearest receptor is located 3.5 km north of the FHCP boundary of the project area and pose no significant risk of contamination to the project area.

Table 2: Sensitive receptors adjacent to the FHCP (Source: SE Group, 2019)

RECEPTOR	DISTANCE (KM)	ANGLE (DEGREES)	COMMENT
Prime (closest) sites			
R01	10	75	On district road
R02	3.5	0	Closest possible dwelling (Old Mt Stuart Homestead)
R03	9.2	320	Situated well away from local roads
R04	8.7	250	(Lat/Lon: 23° 15' 22.8302" S, 148° 31' 48.7815" E) Dwelling north of Ensham mine and 2.7 km from haul route (Fairhill Homestead).
R05	7.2	210	Situated between proposed Fairhill and Wilton projects (Redrock Homestead). 4.5 km from proposed haul route
Secondary (more distant) sites			
R06	15	310	Dwelling closer to Oaky Creek Mine, situated more distant than R03
R07	15	270	Situated more distant than R04 (Beefwood Homestead) 3.6 km from proposed haul route
R08	15	240	Dwelling closer to Ensham Mine, situated more distant than R04 4.7 km from proposed haul route
R09	17	190	Dwelling closer to Ensham Mine, situated more distant than R05
R10	14	140	Dwelling situated close to bitumen road, large distance to mine
R11	14	140	Dwelling situated close to bitumen road, large distance to mine
R12	16	10	Dwelling situated 3 times distance of R02

1.3.4 Contaminated Land and Environmental Management Registers

A review of the Department of Environment and Science CLR and EMR for Lot 2 Plan TT241, described in Table 1, indicates that the lot is not included on either the CLR or EMR.

2. Environmental Values

2.1 Physical Description of the Region

2.1.1 Terrain

Land around the FHCP is relatively low lying and undulating as a result of two transecting creeks: Cooroora Creek, which crosses from the northwest to the southeast and Sandy Creek, which transects the south-eastern section.

There is a ridge along the north-eastern corner boundary of the site that reaches a height of approximately 260 m Australian Height Datum (AHD) and has a slope of approximately 9%–10%; however, the majority of the site lies within 150 m to 175 m AHD and has a slope of between 0% and 4%.

2.1.2 Geology

Regionally, the Bowen Basin is a large synclinorium consisting primarily of Permian and Triassic rocks, and plays host to coal reserves of significant economic importance. The Bowen Basin is overlain by semi-consolidated sediments of Quaternary age (Dickens & Malone, 1973; Galloway, 1967a; Northern Resource Consultants Pty Ltd (NRC), 2017; R. E. Ltd, 2010; U. A. Ltd, 2006).

2.1.2.1 Regional Stratigraphy

PERMIAN

Permian rocks in the region consist of three major units: Lower Bowen Volcanics (LBV), Middle Bowen Beds and Upper Bowen Coal Measures.

LBV are dominated by andesitic flows and pyroclastics. Referred to as the Lizzie Creek Volcanics, LBV are overlain by the Middle Bowen Beds or the Back Creek Group, which consists of marine shales, limestones and sandstones. This unit is superimposed by the Upper Bowen Coal Measures. The Upper Bowen Coal Measures unit comprises terrestrial sandstone, siltstone, shale and coal (Galloway, 1967a).

TRIASSIC

Triassic sediments consist of terrestrial quartz sandstone, shale, siltstone and conglomerates (Galloway, 1967b). Sequences include the Rewan Formation, Clematis Sandstone and the Moolayember Formation.

The Rewan Formation comprises mudstone, siltstone and sandstone. The Clematis Sandstone is a highly resistant quartz sandstone that overlies the Rewan Formation and is itself overlain by the Moolayember Formation.

The Moolayember Formation comprises shale and sandstone beds (Galloway, 1967b).

JURASSIC-CRETACEOUS

To the south, the Bowen Basin is overlain by the Jurassic-Cretaceous sequence of the Great Artesian Basin, and includes Lower Jurassic sandstone and Mesozoic granites.

TERTIARY

Tertiary rocks within the Bowen Basin include basalt, acid igneous intrusions and terrestrial sediments (Galloway, 1967b). Tertiary rocks are widely spread throughout the basin.

QUATERNARY

Deposition of alluvial sediments, comprising sand, clays and gravels occurs throughout the Bowen Basin and are typically overlain by bedrock.

STRUCTURAL GEOLOGY

The Bowen Basin is a large syncline. Folding and faulting runs along a northwest to south-southeast axis and occurred principally during the Mesozoic.

Five major structural zones have been identified in the Bowen Basin (Sliwa *et al.*, 2008):

- Gogango Fold Belt
- Dingo Fold Belt
- Jellinbah Thrust Belt
- Denison Trough
- Springsure Shelf.

2.1.2.2 Geology of the Fairhill Area

The local stratigraphy is composed of the Late Permian Burngrove, Fairhill, MacMillan and German Creek Formations (Figure 3). At the FHCP site, the Burngrove Formation is only present at the surface in the western section of the lease. Tertiary material only covers a small mesa in the north-eastern corner of the tenement. Alluvium is common within the creek beds.

Cainozoic laterite cover is commonly found in the surrounding region capping ridges. Where present, the laterite presents as a hardened siliceous/ferrous cap to higher ground. Distinct laterite layers have not been reported from within the project area.

The strata in the region generally strike north-south and generally dip at angles of approximately three degrees west of the FHCP (ROM Resources, 2013). Dips can vary locally due to the presence of a series of synclines and anticlines. These smaller synclines and anticlines relate directly to the structural deformation, which formed the Comet Ridge and share a north-south axial strike.

Fairhill Formation

The Fairhill Formation hosts the targeted coal seams for the FHCP. Jensen (1975) described the Fairhill Formation in its type section north of Cooroora homestead as coarse-grained, micaceous, calcareous sandstone, conglomeratic in places and interbedded with very minor brown calcareous mudstone. Fossil logs are common, generally replaced with siderite or limonite (Jensen, 1975). Prouza (1977) reported that thick banded coal seams with mudstone and tuffaceous mudstone interbeds occur in 'cyclothems' within the predominantly arenaceous formation. The seams were named, based on correlations in government boreholes, in descending order as Phoenix, Pegasus, Hercules, Canis, Lepus and Fairhill. All these coal seams are interbedded with various amounts of layered sediments of non-coal material, generally siltstone and carbonaceous mudstone. The significant sequence of Fairhill Formation coal seams is found in a stratigraphic interval approximately 130 m thick.

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FIGURE 3
SITE GEOLOGY

Legend

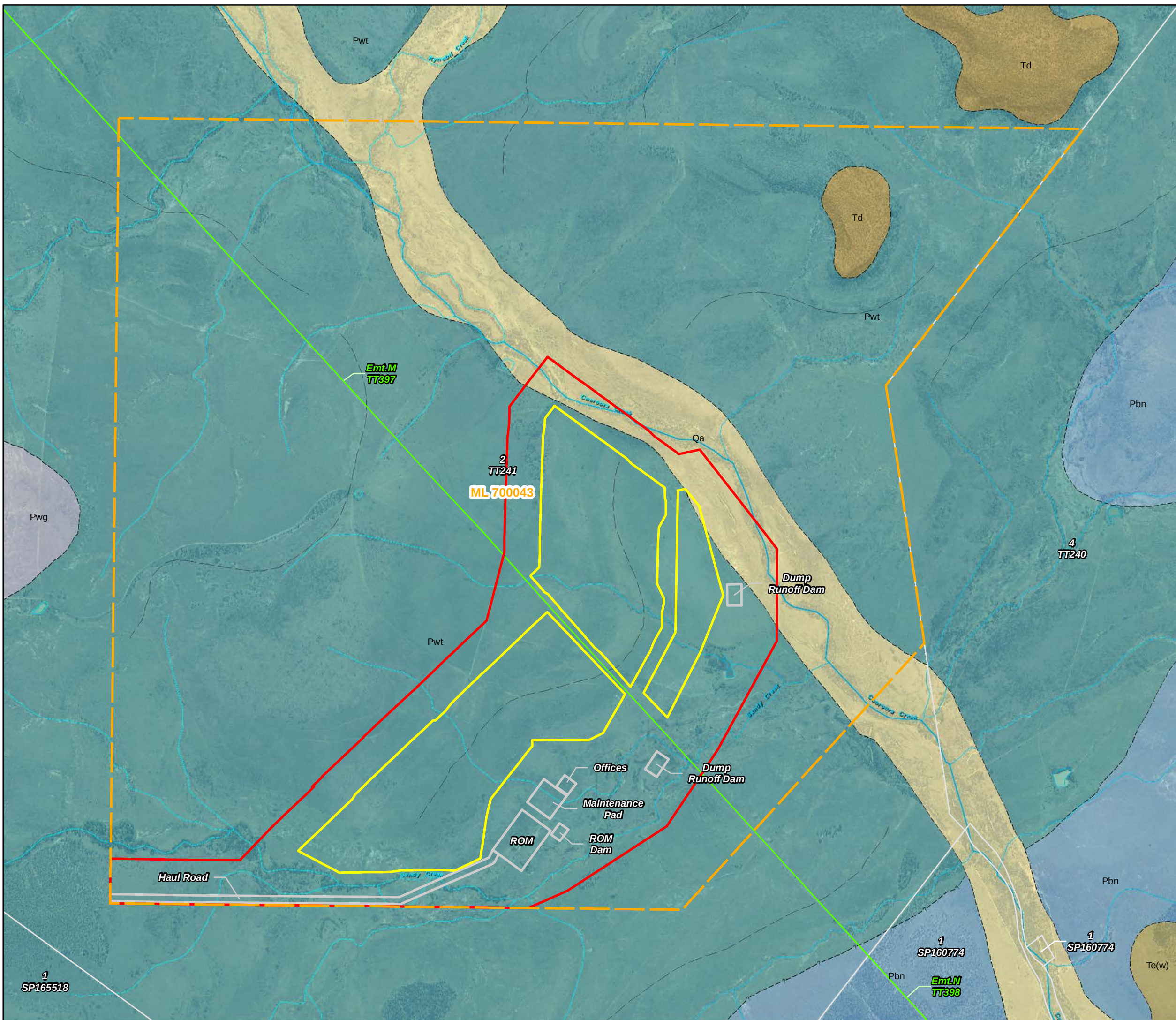
	Watercourse		Easement
	Mining Lease (Application)		Base Cadastre
	7 Year Pit Shell		Investigation Area
	Proposed Site Infrastructure	Geological Structures	
Detailed Surface Geology		 Geological boundary (conformable) approximate	
	Burngrove Formation (Pwg)	 Geological boundary (conformable) inferred	
	Emerald Formation(w) (Te(w))	 Geological boundary (unconformable) approximate	
	Fair Hill Formation (Pwt)	 Trend line	
	MacMillan Formation (Pbn)		
	Qa-QLD (Qa)		
	Td-QLD (Td)		

Data Sources:
Detailed Surface Geology, Detailed Geological Structures, Watercourse, and Mining Lease datasets: © State of Queensland (Department of Natural Resources, Mines, and Energy) 2019; 7 Year Pit Shell, Investigation Area, and Proposed Site Infrastructure datasets: (SLR Consulting) 2019.
Imagery Sources: 70cm Bowen Basin SISF PeriUrban 2012 Orthophoto Image Service: © State of Queensland (Department of Natural Resources, Mines, and Energy) 2019.
Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator
Datum: GDA 1994
Date: 22/06/2019



0 250 500 750 1,000
Metres

Scale: 1:25,000 at A3



2.2 Soils and Land Suitability

2.2.1 Floodplains

The proposed FHCP is located within the Mackenzie River sub-basin of the Fitzroy Basin, a major Queensland catchment. Several drainage features are located within the proposed FHCP area and typically drain southerly to Sandy Creek, a minor watercourse or easterly to Cooroora Creek, a major watercourse.

It is noted that all drainage features within the proposed FHCP area are tributaries of Cooroora Creek. During field studies, it was observed that a weir had been installed historically, presumably for the purpose of stock water supply.

2.2.2 Soils

NRC (2018a) conducted a soil and land suitability assessment for FHCP, which was followed up by an additional assessment by SLR in 2019 due to an amendment to the mine footprint. Summaries of soils described are provided in Table 3 and Figure 4, and further technical detail is available in the SLR assessment report attached in Appendix C2.

Table 3: Soil units mapped within the FHCP study area (SLR 2019)

ASC CLASSIFICATION	SOIL DESCRIPTION	GEOLOGY UNIT
Black, Brown and Grey Vertosols (>90%), possible minor occurrences of Black, Brown and Grey Dermosols (<10%)	Deep (>1.2 m) to moderately deep (>0.6-1.2 m), black, dark brown to brown and grey mostly cracking (possible minor occurrences of non-cracking, especially on gilgai mounds) clays on elevated crests and gently to very gently inclined upper, mid and lower slopes; surfaces mostly gravelly, loose, self-mulching to firm, crusting, sandy light clay to light medium clay grading through mottled, medium clay to light clay down the profile to weathered, metamorphic sandstone and mudstone; formed in situ.	Fair Hill Formation (Pwt)
Brown and Red Dermosols	Moderately deep (>0.6-1.2 m) to shallow (<0.6 m) red, non-cracking clays on very gently inclined mid and lower slopes; surfaces gravelly, firm, crusting, clay loam, sandy, to sandy light clays grading through mottled, sandy light medium to medium clays down the profile to weathered, metamorphic sandstone; formed in situ.	Fair Hill Formation (Pwt)
Black, Brown and Grey Vertosols (>80%), likely minor occurrences of Black, Brown and Grey Dermosols (<20%)	Deep (>1.2 m) to moderately deep (>0.6-1.2 m) to shallow (<0.6 m), black, dark brown to brown and grey mostly cracking (likely minor occurrences of non-cracking) clays on very gently undulating to flat alluvial plains; surfaces loose, self-mulching to firm, crusting, sandy light clay to light medium clay grading through mottled, medium clay to light clay down the profile.	Quaternary alluvium (Qa)
Black, Brown and Grey Dermosols (>80%), likely minor occurrences of Black, Brown and Grey Vertosols (<20%)	Deep (>1.2 m) to moderately deep (>0.6-1.2 m) to shallow (<0.6 m), black, dark brown to brown and grey mostly non-cracking (likely minor occurrences of cracking) clays on very gently undulating to flat alluvial plains; surfaces firm, crusting to hard-setting, clay loam, sandy, to sandy light clays grading through mottled, sandy light medium to medium clays down the profile.	Quaternary alluvium (Qa)

ASC = Australian Soil Classification

The current land use on the Project site and immediate surrounds is primarily grazing on extensively cleared lands and, in wider area, coal mining. Some areas under grazing have also been contoured and may have been sown to improved pasture in the past.

Historical satellite imagery shows fairly extensive vegetation clearing across the project site and surrounds with some areas contoured, ripped or cultivated and sown to improved pasture while other areas appear to be in a more natural state with only clearing being carried out.

The results of the soil assessment identified the majority of the Project site is dominated by Vertosol (cracking clay) soils on both the Fairhill Formation and Quaternary alluvium geological units. Within both of these geological units there were also occurrences of Dermosol (non-cracking) soils.

2.2.3 Land Suitability

NRC (2018a) and SLR (2019) conducted detailed assessment of land suitability class and good quality agricultural land (GQAL). Detail on methodologies to assess land suitability for the FHCP including findings is provided in NRC (2018a). A summary of findings is provided below.

The Department of Mines and Energy (DME, 1995) guideline *Land Suitability Assessment Techniques* provides guidance on the assessment of land suitability pre-mining land and establishment of post-mining land use potential. The FHCP has been assessed against these *Land Suitability Assessment Techniques* (DME, 1995) to determine pre-mining land suitability. The five class definitions for land suitability are summarised in Table 4.

Table 4: Land suitability classes

CLASS	DEFINITION
Class 1	Suitable land with negligible limitations that is highly productive and requires only simple management to maintain economic production.
Class 2	Suitable land with minor limitations which either reduce production or require more than the simple management practices of Class 1 to maintain economic production.
Class 3	Suitable land with moderate limitations which either further lower production or require more than those management practices of Class 2 to maintain economic production.
Class 4	Marginal land with severe limitations which make it doubtful whether benefits of the activity will outweigh the input/costs required to achieve and maintain production in the long term.
Class 5	Unsuitable land with extreme limitations that preclude its use.

Evaluation of the soils within the project footprint against the classes in Table 4 for the different agricultural production systems was made based on interpretation of the physical, chemical and nutritional characteristics of each soil unit and show that the overall suitability rating for FHCP lies between Class 3 to 4 for cropping and 2-3 to 4 for grazing.

The system of assessing GQAL, as presented in the Planning Guidelines: The identification of good quality agricultural land (Department of Primary Industries & Department of Housing, Local Government and Planning, 1993) is a classification system that assesses the land suitability for specific types of agricultural production. The system consists of four classes, which have been designed to assess land based on suitability and potential for agricultural production (see Table 7).

The land use limitations for rainfed broadacre cropping and beef cattle grazing are summarised in Table 5 and Table 6, respectively.

Table 5: Land suitability limitations for rainfed broadacre cropping

SOIL UNIT	WATER AVAILABILITY	NUTRIENTS	PHYSICAL	WORKABILITY	SALINITY	ROCKINESS	MICRO RELIEF	WETNESS	TOPOGRAPHY	WATER EROSION	FLOODING	OVERALL SUITABILITY RATING
Black, Brown and Grey Vertosols on Fair Hill Formation	2-3	2-4	2-4	2-3	1-2	1	1	1	2	3	1	4
Brown and Red Dermosols on Fair Hill Formation	4	3	1	1	1	1-4	1	1	1	3	1	4
Black, Brown and Grey Vertosols on Quaternary alluvium	2	2	2	2	1	1	1	2	2	1	3	3
Black, Brown and Grey Dermosols on Quaternary alluvium	4	2	1	1	1-2	1	1	3	2	2	3	4

Table 6: Land suitability limitations for beef cattle grazing

SOIL UNIT	WATER AVAILABILITY	NUTRIENTS	PHYSICAL	SALINITY	ROCKINESS	MICRO RELIEF	SOIL PH	SOIL ESP	WETNESS	TOPOGRAPHY	WATER EROSION	FLOODING	VEGETATION	OVERALL SUITABILITY RATING
Black, Brown and Grey Vertosols on Fair Hill Formation	1-3	3-4	2-3	1-2	1	1	3-4	1-2	1	1	1	1	1	2-3
Brown and Red Dermosols on Fair Hill Formation	3	4	1	1	1-3	1	2	1	1	1	2	1	1	4
Black, Brown and Grey Vertosols on Quaternary alluvium	1	4	2	1	1	1	2	1	2	1	1	2	1	4
Black, Brown and Grey Dermosols on Quaternary alluvium	3	3	1	1-2	1	1	2-3	1-2	2	1	1	2	1	3

Table 7: GQAL classes

CLASS	DESCRIPTION
A	Crop land – Land that is suitable for current and potential crops with limitations to production that range from none to moderate.
B	Limited crop land – Land that is marginal for current and potential crops due to severe limitations; and suitable for pastures. Engineering and/or agronomic improvements may be required before the land is considered suitable for cropping.
C	Pasture land – Land that is suitable only for improved or native pastures due to limitations which preclude continuous cultivation for crop production; but some areas may tolerate a short period of ground disturbance for pasture establishment.
D	Non-agricultural land – Land not suitable for agricultural uses due to extreme limitations. This may be undisturbed land with significant habitat, conservation and/or catchment values or land that may be unsuitable because of very steep slopes, shallow soils, rock outcrop or poor drainage.

Correlation for assessment of GQAL with land suitability classes are provided in Table 8.

Table 8: Correlation of land suitability classes and GQAL classes

GQAL CLASS	LAND SUITABILITY DESCRIPTION		SOIL MAPPING UNIT	
	CROPPING	GRAZING	CROPPING	GRAZING
A				
A1	1-3	1-3	3. Black, Brown and Grey Vertosols on Quaternary alluvium	
A2	1-3	1-3		
B	4	1-3	1. Black, Brown and Grey Vertosols on Fair Hill Formation 2. Brown and Red Dermosols on Fair Hill Formation 4. Black, Brown and Grey Dermosols on Quaternary alluvium	
C				
C1	5	1-2		1. Black, Brown and Grey Vertosols on Fair Hill Formation
C2	5	3		4. Black, Brown and Grey Dermosols on Quaternary alluvium
C3	5	4		2. Brown and Red Dermosols on Fair Hill Formation 3. Black, Brown and Grey Vertosols on Quaternary alluvium
D	5	5		

Pastoral management associated with the study area indicates that for the majority of the study area the land is Class C3 GQAL with limited suitability for pasture improvement. Additional supporting evidence of this was the extensive land clearing/pasture improvement activities noted to have occurred in the study area during field activities.

2.2.4 Distinct or Unique Features

There are no distinct soil and land suitability features in or around the vicinity of the proposed project disturbance that would be impacted by the FHCP.

FIGURE 4
SOIL UNITS

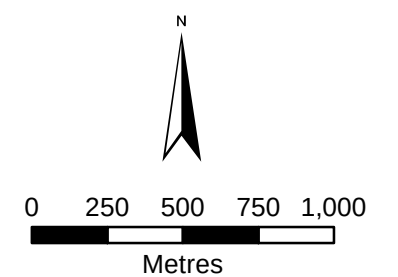
Legend

-  Watercourse
-  Mining Lease (Application)
-  Investigation Area
-  7 Year Pit Shell
-  Proposed Site Infrastructure
-  Easement
-  Base Cadastre

Soil Units

-  Alluvial Dermosol
-  Alluvial Vertosol
-  Fair Hill Dermosol
-  Fair Hill Vertosol

Data Sources:
Mining Lease, Watercourse, and Digital Cadastral
Database (extracted April 2019) datasets: © State of
Queensland (Department of Natural Resources, Mines,
and Energy) 2019; 7 Year Pit Shell, Investigation Area,
Soil Units, and Proposed Site Infrastructure datasets:
(SLR Consulting) 2019.
Imagery Sources: 70cm Bowen Basin SISP PeriUrban
2012 Orthophoto Image Service: © State of
Queensland (Department of Natural Resources, Mines,
and Energy) 2019.
Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator
Datum: GDA 1994
Date: 22/06/2019



Scale: 1:25,000 at A3

SLR 

FAIRHILL COKING COAL PTY LTD

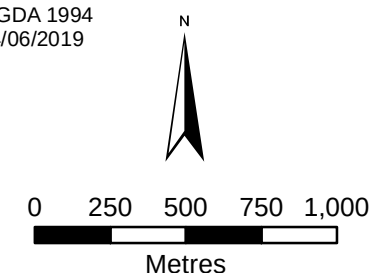
FAIRHILL

FIGURE 5
GOOD QUALITY
AGRICULTURAL LAND

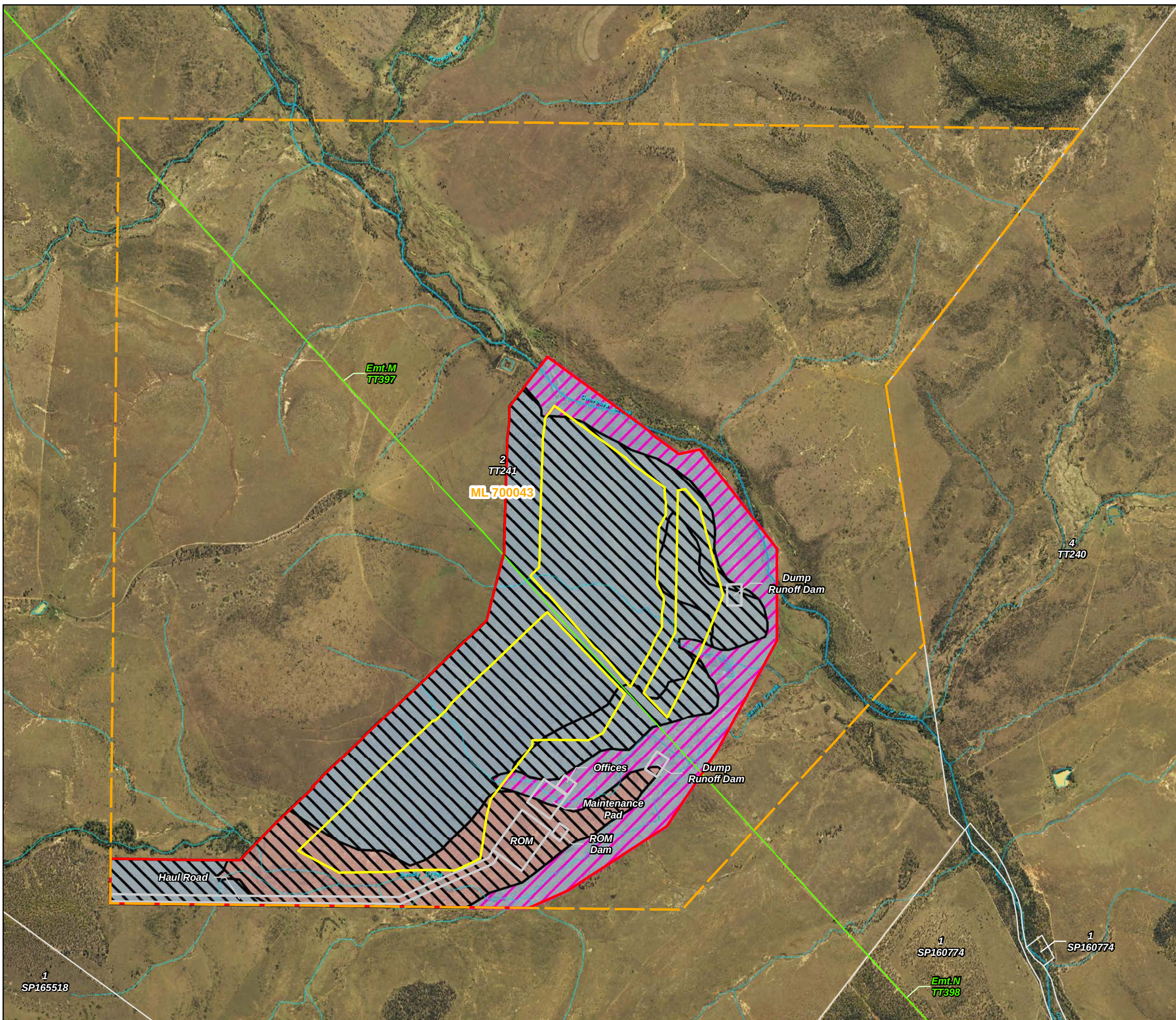
Legend

- Watercourse
- Mining Lease (Application)
- Investigation Area
- 7 Year Pit Shell
- Proposed Site Infrastructure
- Easement
- Base Cadastre
- Land Suitability for Rainfed Broadacre Cropping**
 - Land Suitability Class 3
 - Land Suitability Class 4
- Land Suitability for Beef Cattle Grazing**
 - Land Suitability Class 3
 - Land Suitability Class 4

Data Sources:
Mining Lease, Watercourse, and Digital Cadastral Database (extracted April 2019) datasets: © State of Queensland (Department of Natural Resources, Mines, and Energy) 2019; 7 Year Pit Shell, Investigation Area, Land Suitability, and Proposed Site Infrastructure datasets: (SLR Consulting) 2019.
Imagery Sources: 70cm Bowen Basin SISP PeriUrban 2012 Orthophoto Image Service: © State of Queensland (Department of Natural Resources, Mines, and Energy) 2019.
Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator
Datum: GDA 1994
Date: 24/06/2019



Scale: 1:25,000 at A3



2.3 Bioregions and Regional Ecosystems

The FHCP tenement is located in the Brigalow Belt of Queensland. The land in the area has been largely disturbed by cattle grazing and farming activities. Pasture improvement in the region has led to the clearing and raking of timbered areas, generally in undulating to flat terrain. The majority of the FHCP site is located in such terrain and is characterised by improved pasture with small fragments of remnant vegetation retained along watercourses and drainage features.

2.3.1 Regional Ecosystems

Vegetation community ground-truthing surveys were conducted in September 2017 and May 2018. FHCP has been designed to avoid all areas of remnant regional ecosystems (REs) shown on the Department of Natural Resources, Mines and Energy (DNRME) Vegetation Management Map (Figure 6) as well as those identified through the ground-truthing surveys.

The vegetation community ground-truthing surveys largely supported the DNRME RE mapping and confirmed the presence, extent, status and condition of remnant vegetation within the study area (Figure 7). REs identified in the study area included REs 11.3.25e, 11.9.1, 11.9.2 and 11.10.12. Both REs 11.9.2 and 11.10.12 are of 'least concern' under the *Vegetation Management Act 1999* (VM Act) and have a 'no concern at present' biodiversity status. RE 11.3.25e has a 'least concern' VM Act class and an 'of concern' biodiversity status. RE 11.9.1 has an 'endangered' VM Act class and biodiversity status.

Endangered RE 11.9.1 was confirmed in conjunction with RE 11.3.25e along Cooroora Creek and Sandy Creek. Two small polygons along Sandy Creek were shown on the DNRME RE mapping as mixed polygons of high value regrowth and Category R vegetation (see Maps and further details in the Terrestrial Flora and Fauna Technical Report (Appendix C3)). These mapped regrowth areas were found to support vegetation community heights and covers consistent with remnant vegetation criteria when compared to the respective RE technical descriptions published by DES. These two mixed polygons support a species composition and structure consistent with remnant REs 11.9.1 and 11.3.25e. Similar to the mixed polygon along Cooroora Creek, the small polygons of RE 11.9.1/11.3.25e along Sandy Creek occur with a broad ecotone and accurate differentiation of individual homogenous REs was not possible. RE 11.9.1 is an endangered community and the status, condition and potential for impacts to this community are discussed in the sections below.

Remnant vegetation on the small sandstone outcrop in the northeast section of the study area was shown on the DNRME RE mapping as RE 11.10.11 (*Eucalyptus populnea*, *Eucalyptus melanophloia* +/- *Callitris glaucophylla* woodland); however, ground-truthing identified the vegetation community as RE 11.10.12 (*Eucalyptus populnea* woodland), as *Eucalyptus melanophloia* and *Callitris glaucophylla* were not present.

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FAIRHILL FIGURE 6 STATE-MAPPED REGIONAL ECOSYSTEMS

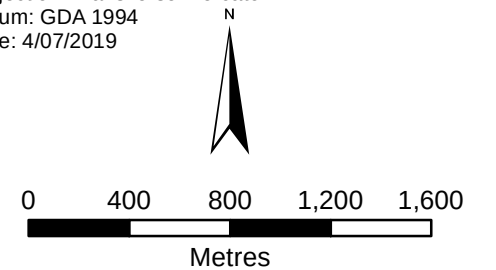
Legend

- Mining Lease (Application)
- VM Watercourse (100/250K)
- Proposed Site Infrastructure
- 7 Year Pit Shell

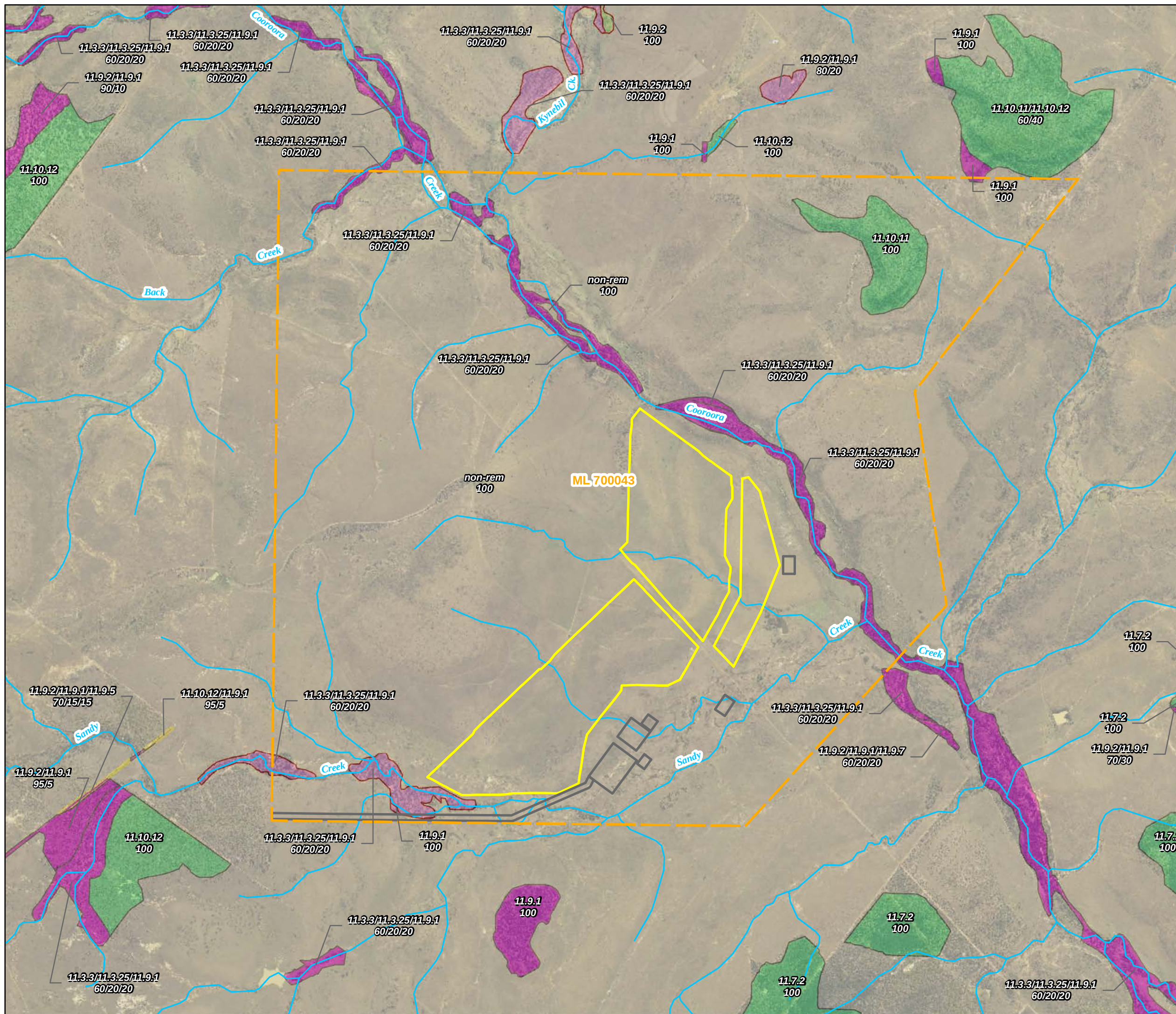
State-Mapped Regional Ecosystems

- Category A or B area containing endangered
- Category A or B area containing endangered and is S20AH
- Category A or B area containing of concern
- Category A or B area that is least concern
- Category C area containing endangered
- Category C area that is of least concern
- Non-remnant

Data Sources:
Mining Lease, Vegetation Management (100/250K)
Watercourse, State-Mapped Regional Ecosystem (v10.1) datasets: the State of Queensland (Department of Natural Resources, Mines, and Energy) 2019; Proposed Site Infrastructure and 7 Year Pit Shell: SLR Consulting 2019.
Imagery Sources: 70cm Bowen Basin SISP PeriUrban 2012 Orthophoto Image Service: © State of Queensland (Department of Natural Resources, Mines, and Energy) 2019.
Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator
Datum: GDA 1994
Date: 4/07/2019



Scale: 1:30,000 at A3



FAIRHILL COKING COAL PTY LTD

FAIRHILL FIGURE 7 GROUND-TRUTHED REGIONAL ECOSYSTEMS

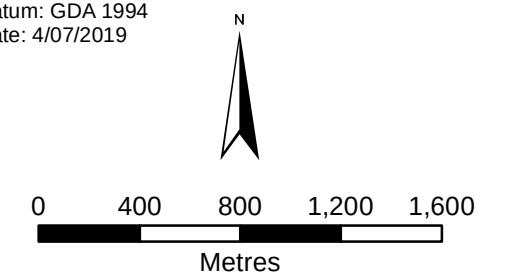
Legend

-  Quaternary Survey
-  Secondary Survey
-  VM Watercourse (100/250K)
-  Study Area
-  Mining Lease Permit (Application)
-  Proposed Site Infrastructure
-  7 Year Pit Shell

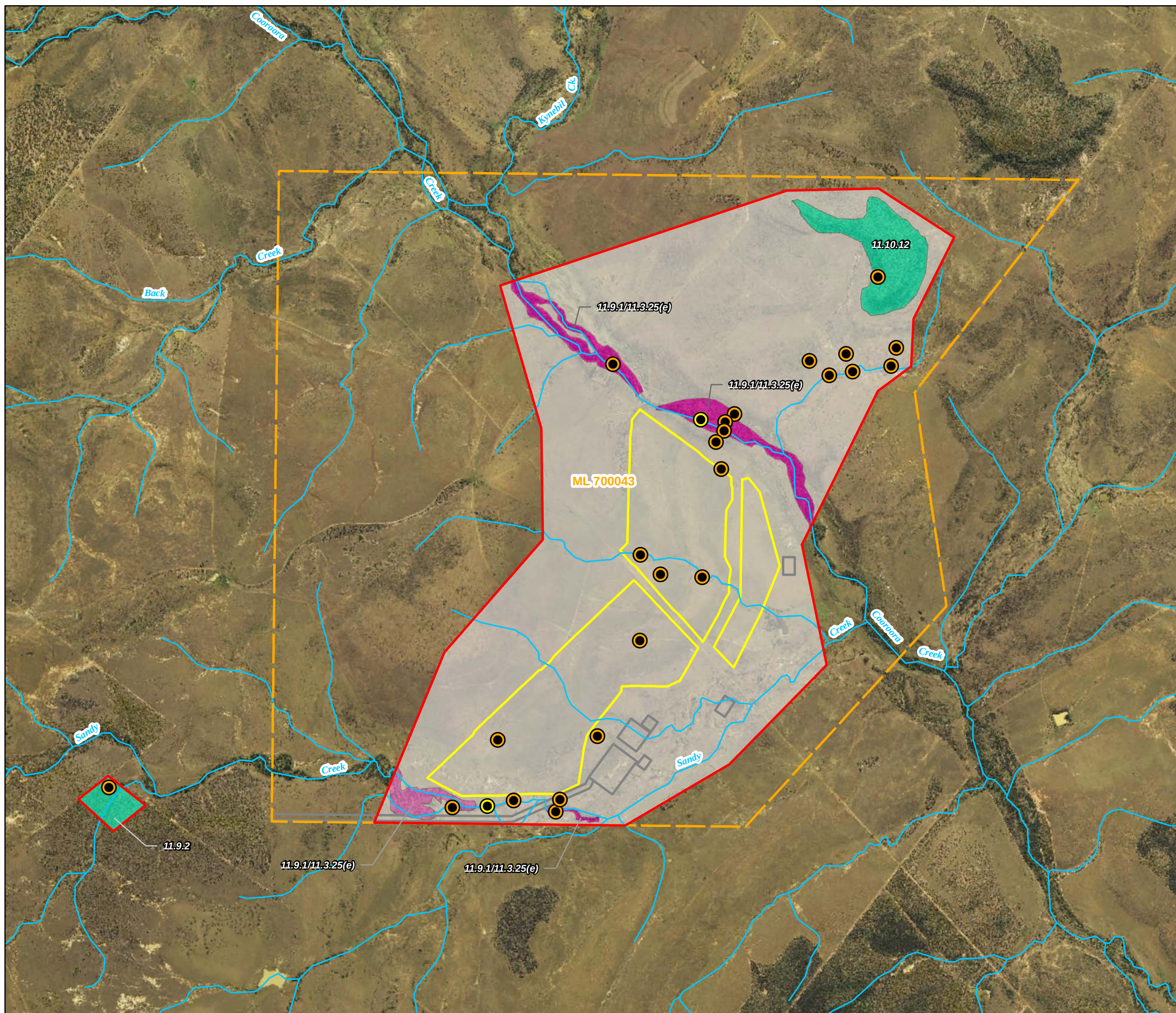
Ground-Truthed Remnant Vegetation

-  Endangered Regional Ecosystem
-  High-Value Regrowth
-  Least Concern Regional Ecosystem
-  Non-remnant

Data Sources:
Mining Lease and Vegetation Management (100/250K)
Watercourse datasets: the State of Queensland
(Department of Natural Resources, Mines, and Energy)
2019; Ground-Truthed Regional Ecosystems, Proposed
Site Infrastructure and 7 Year Pit Shell: SLR Consulting
2019.
Imagery Sources: 70cm Bowen Basin SISPP PeriUrban
2012 Orthophoto Image Service: © State of
Queensland (Department of Natural Resources, Mines,
and Energy) 2019.
Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator
Datum: GDA 1994
Date: 4/07/2019



Scale: 1:30,000 at A3



2.4 Terrestrial Flora

2.4.1 Vegetation Communities

Most areas mapped as non-remnant on the DNRME RE mapping were ground-truthed as accurate representations of land that has been extensively cleared and maintained as improved pasture areas. Exotic pasture grasses, such as Buffel Grass, Sabi Grass and Indian Bluegrass, dominate these areas. Scattered individual trees or stands of Brigalow persist or have regenerated within some non-remnant areas, but due to extremely low cover and generally low height these do not meet the criteria for remnant RE status.

Remnant vegetation communities associated with the project area are restricted to the margins of Cooroora Creek and Sandy Creek. The communities present at these locations are a mix of Brigalow-dominated woodland to open forest and River Red Gum (*Eucalyptus camaldulensis*) woodland. The biodiversity values of these communities are discussed further in the sections below.

2.4.2 Groundwater Dependant Ecosystems

The GDE Atlas (BoM, 2018) identified a moderate potential for aquatic GDEs within the tenement, no aquatic GDEs were located during flora and fauna surveys at Fairhill. A man-made weir located adjacent to the proposed mine pit on Cooroora Creek used for cattle watering is not groundwater dependent. As Cooroora Creek is dry for most of the year with no groundwater expressed at the surface and the alluvia being dry and unsaturated to at least 6 m depth (SLR, 2019), no palustrine or lacustrine aquatic ecosystems exist and the potential for aquatic GDEs is low. Although water pools in Cooroora Creek temporarily during the wet season, the clay rich soil significantly limits the degree of groundwater recharge from surface water (SLR, 2019). A similar band of clay up to two metres thick limits connectivity between the aquifers in the Fairhill formation and those alluvium associated aquifers along Cooroora Creek (SLR, 2019).

The ephemeral nature of the watercourses and gilgai depressions don't allow for water to be retained for long periods of time, and the only permanent water is within artificial stock dams and impoundments. No changes in vegetation type were recorded throughout the watercourses to indicate areas with extended periods of water retention. The only exception is the northern ground-truthed vegetation community within Cooroora Creek. A man-made weir occurs on the southern boundary of this polygon, creating permanent water upstream which is used as a cattle watering point. Although surface water is retained in this area and some aquatic vegetation was noted, it is artificial and only influenced by rainfall in the upstream catchment, not by groundwater expression.

Sandy Creek was ground-truthed as non-remnant vegetation with no significant interaction between groundwater and vegetation. Desktop assessments and ground-truthing surveys indicate that there is very low potential for GDEs to occur within non-remnant areas of Sandy Creek. The only discrepancy were two small areas below the proposed disturbance area within Sandy Creek. One of these areas was shown as high value regrowth of RE 11.9.1/11.3.25/11.3.3 and the other was mapped as non-remnant vegetation on DNRME RE mapping (Figure 8).

Ground-truthed vegetation within the study area along Cooroora Creek was similar to DNRME mapping. Two large polygons were mapped as mixed vegetation community of RE 11.9.1/11.3.25. River Red Gum was recorded as dominant immediately within the bed and bank of Cooroora Creek. It is highly likely that large River Red Gums are using groundwater at least intermittently throughout the year.

Surface water chemistry analysed by NRC (2018/2019) for the Receiving Environment Monitoring Program (REMP) at Fairhill indicated no groundwater is expressed on the surface within Cooroora Creek or Sandy Creek. The chemistry of groundwater within the proposed disturbance area contains high Electrical Conductivity (EC) levels ranging from 15,000 to 44,000 $\mu\text{S}/\text{cm}$ (SLR, 2019), indicative of saline conditions. Coolibah has been recorded utilising groundwater with a salinity of approximately 15-20 g/L^{-1} (22,387 – 29,850 $\mu\text{S}/\text{cm}$) (Gillen, 2017), but with an estimated salinity tolerance of 30 g/L^{-1} (44,775 $\mu\text{S}/\text{cm}$) (Roberts & Marston, 2011).

EC levels recorded within surface water at Fairhill indicate a freshwater system, with low EC levels (140-250 $\mu\text{S}/\text{cm}$). The absence of that highly saline groundwater signature identified in bores shows there is no surface expression of groundwater in Cooroora or Sandy Creek.

Additional information on the GDE's and the interaction with groundwater near the FHCP is provided in Appendix C3 – Flora and Fauna Technical Report.

2.4.3 Endangered, Vulnerable, Rare or Near Threatened Species

A total of 71 flora species from 27 families were recorded within the study area. All flora species observed throughout the study area are common and widespread throughout the region in eucalypt and *Acacia* woodland communities and improved pastures.

No endangered, vulnerable or near threatened (EVNT) flora species (as listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) or *Nature Conservation Act 1992* (NC Act)) were identified during the vegetation surveys, despite targeted surveys in areas of potential habitat. The relevance and likelihood of impacts to EVNT flora species identified in the desktop analysis is addressed within the Terrestrial Flora and Fauna Technical Report (Appendix C3). Overall, the proposed disturbance footprint does not provide suitable habitat for threatened or near threatened flora species.

2.4.4 Pest Species

The number of pest flora species observed within the study area was moderate, comprising around 17% of total flora species identified. Significant weed species recorded include Parthenium (*Parthenium hysterophorus*), Common Pest Pear (*Opuntia stricta*), Prickly Pear (*Opuntia tomentosa*) and Harrisia Cactus (*Harrisia martinii*), which are restricted invasive plants under the Biosecurity Act 2014. Parthenium and Mimosa Bush were recorded throughout the study area on the margins of watercourses and drainage features, often occurring as dense infestations.

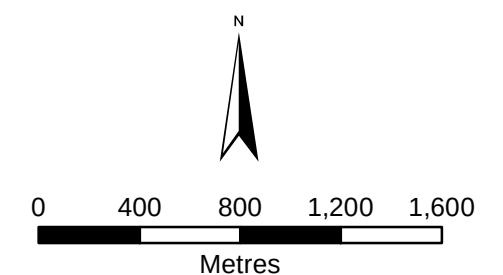
FAIRHILL COKING COAL PTY LTD

FAIRHILL FIGURE 8 GROUND-TRUTHED GROUNDWATER DEPENDENT ECOSYSTEMS

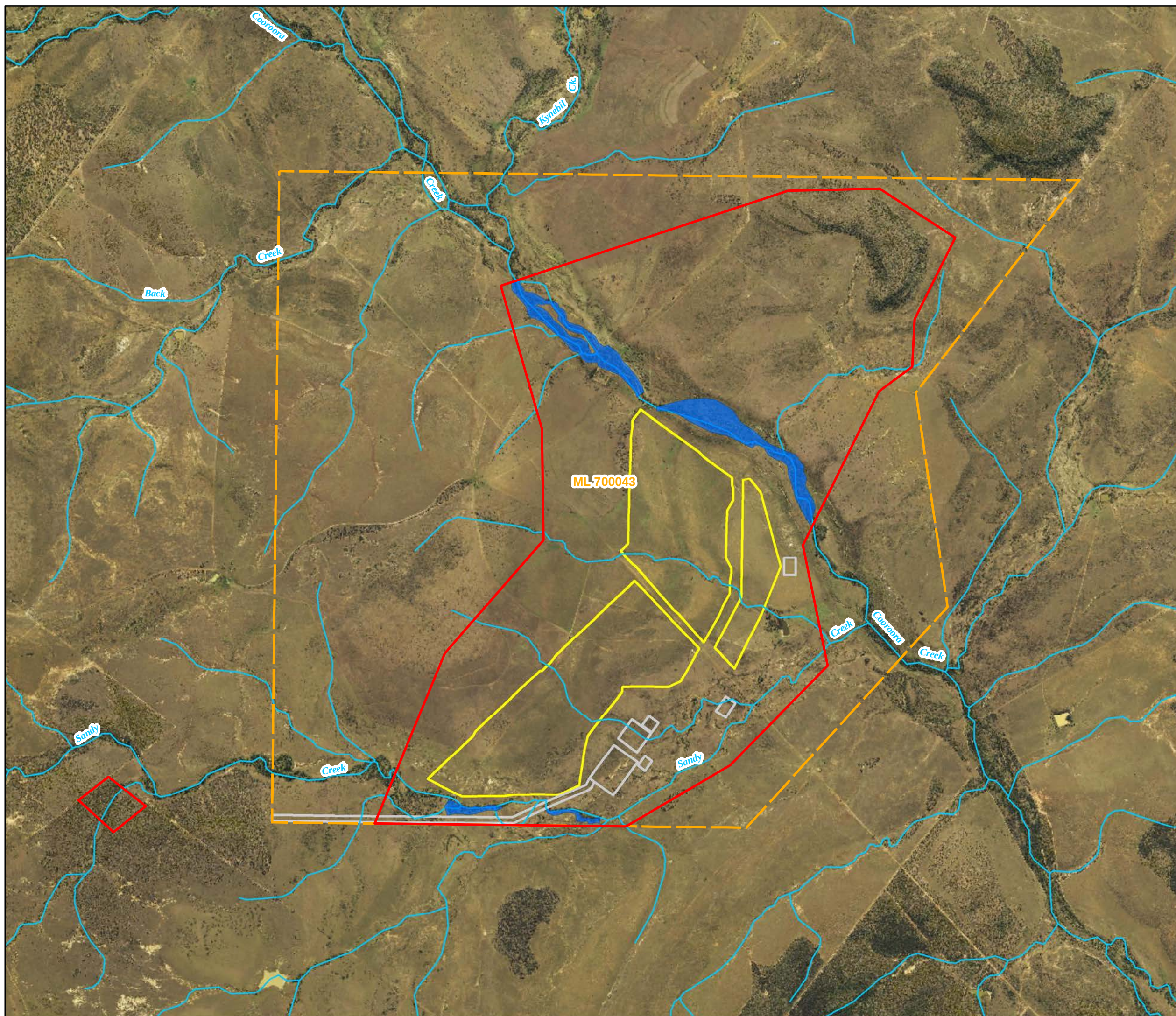
Legend

- VM Watercourse (100/250K)
- Study Area
- Mining Lease Permit (Application)
- Proposed Site Infrastructure
- 7 Year Pit Shell
- Ground-Truthed Terrestrial GDE

Data Sources:
Mining Lease and Vegetation Management (100/250K)
Watercourse datasets: the State of Queensland
(Department of Natural Resources, Mines, and Energy)
2019; Ground-Truthed Groundwater Dependent
Ecosystems (GDE), Proposed Site Infrastructure and 7
Year Pit Shell: SLR Consulting 2019.
Imagery Sources: 70cm Bowen Basin SISP PeriUrban
2012 Orthophoto Image Service: © State of
Queensland (Department of Natural Resources, Mines,
and Energy) 2019.
Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator
Datum: GDA 1994
Date: 4/07/2019



Scale: 1:30,000 at A3



2.5 Terrestrial Fauna

2.5.1 Fauna Habitat and Species

Habitat values for faunal groups were most abundant on the rocky hill slopes, as these areas comprised the highest diversity of flora species and increased topographical complexity compared to flatter areas within the study area. Large, hollow-bearing River Red Gums were present on the larger watercourses within the study area, providing potential shelter habitat for arboreal fauna. Large woody debris was moderately distributed throughout remnant vegetation on hill slopes in the northeast, and smaller vegetative litter and debris was abundant in areas with a denser tree layer such as RE 11.10.12 to the southwest (Figure 9). Disturbance to all of these habitats has been avoided in the design of the proposed FHCP.

Non-remnant pastoral vegetation throughout the study area provided the lowest habitat values for faunal groups within the study area. Open grasslands with a very sparse regrowth tree/shrub layer and little or no large woody debris dominated these areas. Highly eroded ephemeral drainage features were evident throughout this area; however, little to no riparian vegetation was present. Adjacent to Cooroora Creek in areas of non-remnant vegetation were two large areas containing numerous gilgai. These areas contained high-quality habitat features for a variety of fauna including the retention of water for longer duration during the dry season, cracking soil to provide refugia for small fauna and dense tussocks of sedges and grasses occur along the banks of the gilgai that provide shelter for wetland fauna species.

Numerous fauna species were identified within the study area over the two field survey periods using a variety of different observational and trapping techniques. A combined list of all species identified during the survey period is included in the Terrestrial Flora and Fauna Technical Report (Appendix C3). The following is a brief discussion of the species observed for each taxonomic group.

Mammals

A total of 30 species of mammals were recorded within the study area over the survey periods. The assemblage recorded is typical of similar habitat types in the region and the species recorded are generally common. Bats showed the greatest diversity of all mammal groups, with at least 13 and as many as 16 species identified from call data collected. The *Microbat Call Interpretation Reports* from the fauna surveys are included within the Terrestrial Flora and Fauna Technical Report (Appendix C3). While some calls could not be clearly distinguished between several species, most of these calls are not attributable to any species listed as EVNT under the NC Act or EPBC Act. One of the call types is attributed to a *Nyctophilus* species, with two species known from the region – *Nyctophilus geoffroyi* and *Nyctophilus gouldi*. *Nyctophilus corbeni* is vulnerable under the NC Act and EPBC Act but there are no records of this species near the Emerald region. It is considered a low likelihood that the call was from *Nyctophilus corbeni*.

No mammals listed as EVNT were observed within the study area; however, evidence of the Short-beaked Echidna (*Tachyglossus aculeatus aculeatus*, listed as special least concern under the NC Act) was observed in the form of termite mound excavation at fauna trapping site 3, located over 2.5 km from the proposed disturbance footprint.

Reptiles

Nineteen species of reptiles from eight families were observed within the study area. All these species are common and widespread throughout similar habitats within the broader region. No evidence of any reptiles listed as EVNT was observed within the study area.

Amphibians

Eleven amphibian species from three families were recorded within the study area, all of which are common and widespread in the local area. Most native amphibian observations were restricted to areas adjacent to permanent water or within larger watercourses. The introduced Cane Toad (*Rhinella marina*) was encountered near drainage lines and other water sources throughout the study area. No amphibians listed as EVNT were identified during the survey periods.

Birds

A total of 77 species of bird were observed within the study area during the survey periods. This species assemblage included a number of both sedentary and nomadic species. The majority of species observed are common in similar habitats throughout the region. No EVNT bird species were observed during the survey programs. However, some locally occurring threatened bird species have the potential to occur within the study area. The likelihood of impacts to listed threatened species is discussed in the sections below.

2.5.2 Protected Animal Breeding Places

No protected animal breeding places were detected during the field surveys within the proposed disturbance area.

2.5.3 Endangered, Vulnerable, Rare or Near Threatened Species

None of the vegetation communities mapped within the study area are mapped as essential habitat on the DNRME essential habitat map (Figure 10).

No EVNT fauna species were detected within the study area during the survey periods. Two threatened fauna species, the Squatter Pigeon (southern) and the Ornamental Snake, have been recorded in the local area (Saunders Havill Group, 2011) and therefore have a high likelihood of occurrence within the study area. These species are both listed as vulnerable under the EPBC Act and NC Act. High-quality habitat for the Ornamental Snake was mapped in the northern extent of the proposed disturbance area, adjacent to Cooroora Creek. This included two areas of cracking soils associated with gilgai habitat that retain water into the dry season for a longer duration than the surrounding landscape. These gilgai areas may equate to protected wildlife habitat due to the potential suitability for the Ornamental Snake. The potential for significant impacts to this area of habitat has been avoided by design, including through the implementation of buffer zones. Further details about this species, potential habitat areas and the avoidance of significant residual impacts are presented in the attached Terrestrial Flora and Fauna Technical Report (Appendix C3).

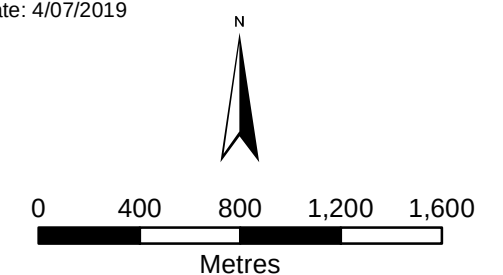
FAIRHILL COKING COAL PTY LTD

FAIRHILL FIGURE 9 FAUNA SURVEY

Legend

- | | |
|------------------------------|--|
| ▼ Bat Detector | Study Area |
| ■ Cage Trap | Proposed Site Infrastructure |
| ▲ IR Camera | 7 Year Pit Shell |
| ● Pigs | Ground-Truthed Remnant Vegetation |
| — Elliot trap line | Endangered Regional Ecosystem |
| — Pitfall trap line | High-Value Regrowth |
| VM | Least Concern Regional Ecosystem |
| — Watercourse (100/250K) | Non-remnant |
| □ Fauna Survey Site | |
| — Mining Lease (Application) | |

Data Sources:
Mining Lease and Vegetation Management (100/250K)
Watercourse datasets: the State of Queensland (Department of Natural Resources, Mines, and Energy) 2019; Fauna Survey, Ground-Truthed Regional Ecosystems, Proposed Site Infrastructure and 7 Year Pit Shell: SLR Consulting 2019.
Imagery Sources: 70cm Bowen Basin SISP PeriUrban 2012 Orthophoto Image Service: © State of Queensland (Department of Natural Resources, Mines, and Energy) 2019.
Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator
Datum: GDA 1994
Date: 4/07/2019



Scale: 1:30,000 at A3

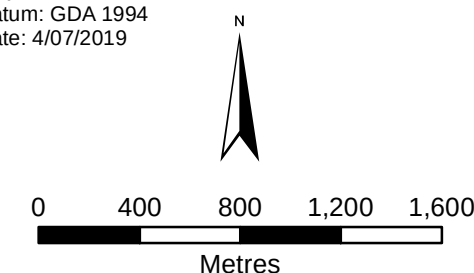
FAIRHILL COKING COAL PTY LTD

FAIRHILL FIGURE 10 POTENTIAL HABITAT FOR THREATENED SPECIES

Legend

-  Squatter Pigeon Habitat Assessment Site (as per Table 14)
-  Permanent Water Point
-  VM Watercourse (100/250K)
-  Buffered Permanent Water Point (1km)
-  Study Area
-  Mining Lease (Application)
-  Proposed Site Infrastructure
-  7 Year Pit Shell
- Threatened Species Potential Habitat**
-  Ornamental Snake
-  Low-Moderate Value Squatter Pigeon Habitat
-  Low Value Squatter Pigeon Habitat

Data Sources:
Mining Lease and Vegetation Management (100/250K) Watercourse datasets: the State of Queensland (Department of Natural Resources, Mines, and Energy) 2019; Squatter Pigeon Habitat Assessment Site, Threatened Species Potential Habitat, Permanent Water Point, Proposed Site Infrastructure, and 7 Year Pit Shell: SLR Consulting 2019.
Imagery Sources: 70cm Bowen Basin SISP PeriUrban 2012 Orthophoto Image Service: © State of Queensland (Department of Natural Resources, Mines, and Energy) 2019.
Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator
Datum: GDA 1994
Date: 4/07/2019



2.5.4 Pest Species

Eight invasive fauna species were identified during the fauna surveys, all of which commonly occur in disturbed habitats throughout Queensland. The following species were observed within the study area:

- Common Myna (*Acridotheres tristis*)
- European Rabbit (*Oryctolagus cuniculus*)
- Wild Boar (*Sus scrofa*)
- House Mouse (*Mus musculus*)
- Cane Toad (*Rhinella marina*)
- Feral Cat (*Felis catus*).

Domestic Cattle (*Bos Taurus*) and Horses (*Equus caballus*) were also recorded within the study area and likely impact native fauna through competition and destruction or modification of habitat.

2.6 Environmentally Sensitive Areas

The environmentally sensitive areas (ESAs) map for the study area shows multiple areas of Category B ESAs within the study area for the flora and fauna assessment, in the form of REs with an endangered biodiversity status. A review of the remnant RE mapping revealed that the mapped Category B ESAs equate to the mapped extent of RE 11.9.1, which has an endangered biodiversity status in the Regional Ecosystem Description Database. The mapped extent of Category B ESAs was subject to ground-truthing survey effort during the field survey program.

State-mapped remnant vegetation on Cooroora Creek shows a mixed polygon of REs 11.3.3, 11.3.25 and 11.9.1. Vegetation surveys undertaken on Cooroora Creek identified two remnant vegetation communities in this area, REs 11.9.1 and 11.3.25e. Additionally, two small mixed polygons of RE 11.9.1 and 11.3.25e were ground-truthed on a tributary of Sandy Creek, which is a tributary of Cooroora Creek, in the southern portion of the study area. Separation of these vegetation communities was not possible as RE 11.9.1 occurred adjacent to the watercourse but continued through the main channel and associated drainage features. River Red Gum was present and dominant to co-dominant along the bed and bank of the watercourse indicating RE 11.3.25e; however, Brigalow was also present and occurred as sub-dominant to co-dominant. These vegetation associations have been ground-truthed and mapped as mixed unit polygons, with the full extent of each polygon intended to be treated as Category B ESAs (due to the occurrence of RE 11.9.1 within each). The disturbance footprint for the project has been designed to avoid direct disturbance to these communities. The location of the target resource is such that the standard Category B ESA buffer of 1 km could not be implemented. A minimum buffer zone of 50m has been applied for the ground-truthed extent of RE 11.9.1, which includes vegetation in the south of the project area that is not included in the DNRME remnant vegetation mapping of the DES ESA mapping.

2.7 Areas with High Ecological Significance Values

2.7.1 Watercourse and Wetlands Habitat

The study area does not contain any wetland protection areas or wetlands of high ecological significance as shown on the map of referrable wetlands. The watercourses and drainage features present within the study are not 'high ecological value waters' as identified under the *Environmental Protection (Water) Policy 2009*. However, within the study area, a desktop assessment revealed polygons of potential groundwater dependent ecosystems (GDEs) along Cooroora Creek but none along Sandy Creek, (DNRME, 2019; BOM, 2019). All of the mapped GDEs on both mapping systems

identify moderate to high potential for terrestrial GDEs to occur. These are classified as “*quaternary alluvial aquifers with fluctuating, intermittent groundwater connectivity regime and unknown pH*” of low confidence (DNRME, 2019).

The smaller, ephemeral watercourses in the study area do not represent significant biodiversity or habitat values; however, the larger watercourses associated with the proposed project site (i.e. Cooroora Creek and Sandy Creek) are both receiving environments of the smaller watercourses on site. These creeks also represent higher biodiversity values, supporting a Brigalow-dominated riparian community and connectivity values at the local scale. The current disturbance footprint has been designed to avoid direct disturbance to habitat associated with Cooroora Creek and remnant vegetation along Sandy Creek.

At Fairhill, there is no surface expression of groundwater, and no aquatic GDEs were located during flora and fauna surveys at Fairhill. The ephemeral nature of the watercourses and gilgai depressions doesn't allow for water to be retained for long periods of time, and the only permanent water is within artificial stock dams and impoundments. The only exception is the northern ground-truthed vegetation community within Cooroora Creek. A man-made weir occurs on the southern boundary of this polygon, creating permanent water upstream which is used as a cattle watering point. Although surface water is retained in this area and some aquatic vegetation was noted here, it is artificial and only influenced by rainfall in the upstream catchment, not by groundwater expression.

2.7.2 Threatened Ecological Communities

Desktop surveys identified three EPBC Act listed threatened ecological communities (TECs) as potentially occurring within the local area as follows:

- Brigalow (*Acacia harpophylla* dominant and co-dominant)
- natural grasslands of the Queensland Central Highlands and northern Fitzroy Basin
- Weeping Myall Woodlands.

There were no state equivalent units shown on State-mapping and ground-truthing surveys did not record natural grasslands and Weeping Myall Woodland TECs within the study area. Some areas of remnant vegetation adjacent to portions of Cooroora Creek and Sandy Creek were ground-truthed as RE 11.9.1. This is an 'endangered' RE that contains Brigalow in the dominant layer. Although these areas contain Brigalow as one of the dominant tree species, groundcover was dominated by non-native species. Buffel Grass incursion from the surrounding non-remnant pastureland was evident throughout the area. Dense patches of Parthenium and Sabi Grass were also noted throughout this RE, thus reducing the cover of native species. Due to groundcover containing greater than 50% non-native perennial species, these areas of Brigalow-dominant vegetation do not meet the condition thresholds for protection under the EPBC Act. However, this vegetation community has been avoided in the current design with an additional minimum 50 m buffer around each polygon to minimise any potential disturbance.

2.7.3 Other High Environmental Value Matters

The proposed project site does not support any large tracts of remnant vegetation, significant habitat corridors or special biodiversity areas.

2.8 Prescribed Environmental Matters

2.8.1 Watercourses and Wetlands

As identified above, the study area does not contain any wetland protection areas or wetlands of high ecological significance as shown on the map of referrable wetlands. The watercourses and drainage features present within the study are not 'high ecological value waters' as identified under the Environmental Protection (Water) Policy 2009.

2.8.2 Regulated Vegetation

Regional ecosystems

The main remnant REs relevant to the proposed project were ground-truthed as mixed polygons of REs 11.3.25e/11.9.1. Other remnant vegetation communities were observed within the broader study area, as described in previous sections. Current mining and infrastructure plans avoid disturbance to all remnant and high value regrowth vegetation by design. The current proposed disturbance footprint of the project is located entirely within non-remnant vegetation.

Remnant vegetation associated with a watercourse

Remnant vegetation associated with a watercourse or drainage feature shown on the *Vegetation Management Watercourse and Drainage Feature Map* (as certified under the VM Act) is classified as a matter of state environmental significance under the Queensland environmental offsets framework. There are several watercourse and drainage features within the study area that are represented on the *Vegetation Management Watercourse and Drainage Feature Map*. The extent to which remnant vegetation associated with a watercourse is considered a protected matter is determined by the bioregional context and stream order of the watercourse or drainage feature.

Mapped watercourses and drainage features within the proposed disturbance area are all within non-remnant vegetation. As described above, the remnant REs associated with Cooroora Creek and Sandy Creek are avoided in the current design.

2.8.3 Connectivity Areas

The proposed disturbance area is located within a large patch of non-remnant vegetation in the form of cleared grazing pasture dominated by Buffel Grass. The broader area supports scattered highly fragmented patches of remnant vegetation. All areas of remnant vegetation have been avoided in the current design. There are no connectivity values within the proposed disturbance footprint for the project.

2.8.4 Protected Wildlife Habitat

None of the vegetation communities mapped within the study area are mapped as essential habitat on the DNRME essential habitat map. The proposed disturbance area does not include any areas shown on the flora survey trigger map as being 'high risk'.

No threatened flora or fauna species were detected within the study area during the survey periods. Two threatened fauna species, the Squatter Pigeon (southern) and the Ornamental Snake, have been recorded in the local area and therefore have a high likelihood of occurrence within the study area. These species are both listed as vulnerable under the EPBC Act and NC Act. High quality habitat for

the Ornamental Snake was mapped in the northern extent of the proposed disturbance area, adjacent to Cooroora Creek. These gilgai areas may equate to protected wildlife habitat due to the potential suitability for the Ornamental Snake. These areas have been avoided by design, including through the implementation of a minimum 50 m buffer zone for disturbance.

2.8.5 Protected Areas

There are no protected areas relevant to the study area.

2.8.6 Strategic Cropping Areas

An assessment of strategic cropping areas (SCAs), comprising a desktop review of available SCA trigger mapping provided by the DNRME. The desktop assessment did not identify any trigger mapped SCAs within the FHCP study area.

2.8.7 Primary Industry and Agricultural Value

Guidelines referenced within DES Guideline ESR/2015/1839 include State Planning Policy 2017 (SPP) under the *Planning Act 2016*. Included in the SPP are the Central Queensland and Mackay, Isaac and Whitsunday Regional Plans.

The *Regional Planning Interests Act 2014* (RPI Act) repeals the *Strategic Cropping Land Act 2011* and identifies and protects:

- priority agricultural areas
- priority living areas
- strategic environmental areas
- strategic cropping areas (formerly strategic cropping land).

The broad intent of the SPP, RPI Act and subsequent regional plans is to detail the economic and environmental interest of the state or part of the state, including agricultural land. Agricultural land in Queensland is considered to be a significant environmental value (EV) and central to Queensland's economic productivity.

Land suitability classes for the disturbance area indicated that the majority of the land is suitable for low quality grazing and/or grazing of native pastures with limited suitability for pasture improvement, with the remaining areas being assessed as not suitable for pastoral management.

2.8.8 Recreation and Aesthetic Value

The land within FHCP is privately owned and subsequently unavailable for recreational use. There are no national parks or conservation areas identified within FHCP or the immediate surrounds.

2.8.9 Industrial Value

Given the remote location of the FHCP, there is no recognised industrial value of the land to be impacted by the proposed project, other than its value to Fairhill Coking Coal Pty Ltd.

2.9 Cultural and Spiritual Value

The Western Kangoulu people are the traditional owners of lands underlying the proposed FHCP area. The Western Kangoulu people's Traditional Country is the area surrounding Emerald. They currently have a registered Native Title Claim (QC2013/002) over this area. This claim replaces previous claims in place including QC98/25 and QC99/6. Lumburra Bimbi is the corporate identity for the Western Kangoulu people. Lumburra Bimbi recognises the land under the title claim for the Western Kangoulu people is heavily disturbed by the mining and energy sectors. Under the previous iteration of the FHCP, representatives from Lumburra Bimbi were involved extensively in cultural heritage search and clearance for exploration drilling areas around EPC2177, which includes the area around the currently proposed FHCP disturbance.

It is worth noting that the waters of the Mackenzie river are considered to have cultural and spiritual EVs as per the *Environmental Protection (Water) Policy 2009, Mackenzie River Sub-Basin Environmental Values and Water Quality Objectives, Basin No. 130 (part), including all waters of the Mackenzie River Sub-basin September 2011*.

2.10 Aesthetic Qualities

The land within FHCP is privately owned within a remote location with very few neighbours. Entities that exist within the immediate surrounds include other mining companies and homesteads. The closest dwelling is located 3.5 km from the site (SE Group, 2018).

Establishment of office buildings, workshops and structures within the FHCP are not considered to have an impact to the aesthetic qualities of the surrounding environment.

2.11 Areas of Regional Interest

2.11.1 Overview

The RPI Act identifies and protects areas of Queensland that are of regional interest. The intent of the RPI Act is to manage the impact and support the coexistence of resource activities and other regulated activities in areas of regional interest. The RPI Act is supported by the Regional Planning Interests Regulation 2014 and seeks to establish an appropriate balance between protecting priority land uses and delivering economic projects for Queensland regions and protects:

- living areas in regional communities
- high-quality agricultural areas from dislocation
- strategic cropping land
- regionally important environmental areas.

Protections are provided to areas of regional interest as defined under the RPI Act for the following areas:

- a priority agricultural area
- a priority living area
- the strategic cropping area
- a strategic environmental area.

The RPI Act restricts the carrying out of resource or regulated activities where the activity is not exempt from the provisions of the RPI Act or a regional interests development approval has not been granted.

2.11.2 Findings

A desktop assessment was carried out to identify whether the FHCP area included areas of regional interest. A search of the FHCP area was conducted via the online development assessment mapping system provided by the Department of State Development, Manufacturing, Infrastructure and Planning (2018). The search did not identify any areas of regional interest within the project area.

In addition, as described earlier in this report, a desktop assessment did not identify any trigger mapped SCAs within the FHCP study area (NRC, 2018a).

2.12 Acid Sulfate Soils

Acid sulfate soils were not identified in the FHCP study area during the soils and land suitability assessment (NRC, 2018a). The FHCP study area is not located in a high-risk area for acid sulfate soils due to the project area being over 200 km inland from the coast of Queensland and above 140 mAHN.

3. Potential Impacts to Environmental Values

3.1 Site Diagram

3.1.1 Full Extent of the Proposed Disturbance Layout – Top Down View

The total mining lease area associated with the project is approximately 450 ha, although the intention is not to have this entire extent disturbed (Figure 2). The project will progressively rehabilitate so that overburden is backfilled to the previously strip-mined areas, essentially filling in the pit as mining progresses. The proposed site infrastructure for the FHCP is displayed in Figure 2.

3.2 Land Disturbance

3.2.1 Mineral Exploration

Exploration activities can contribute to potential and actual contamination due to poor waste management practices and spills. There have been no concerns raised regarding any wastes or spilt materials left by the exploration activities, indicating that good waste management practices have been undertaken during the project's exploration drilling programs.

All exploration activities conducted by the proponent have been conducted in accordance with the 'Eligibility criteria and standard conditions for exploration and mineral development projects' (ESR/2016/1985).

3.2.2 Extent of Disturbance

Figure 2 provides an overview of the extent of the proposed disturbance associated with the FHCP. As there is no plan to process coal product on site, disturbance is primarily limited to the open cut pits, overburden dumps, access tracks and haul roads, water storages and administration and workshop facilities.

Table 9 provides an overview of the disturbance footprint associated with the FHCP.

Table 9: FHCP disturbance footprint

INFRASTRUCTURE	DISTURBANCE (ha)
Open cut pits (including in pit dump)	289.3
Out of pit overburden dump	36.5
Go-line, administration and workshops	5.0
Mine-affected water storage	3.8
ROM	8.8
On-lease haul roads	13.9
Total	357.3

The open cut pit will extend to a depth of approximately 16 m, with a step highwall out to allow for a 60 m pit floor width. The total disturbance footprint for the FHCP is 357.3 ha and contains all direct and in-direct infrastructure facilities within the overall mine extent such as vehicle maintenance workshops, overburden dumps, water storages and transfer facilities (Figure 2).

3.2.3 Types of Disturbance

Key features proposed for disturbance relating to the FHCP include:

- open cut pit
- mine-affected water storages
- overburden dump
- administration and workshop facilities.

Each feature is discussed further below.

3.2.3.1 Open Cut Pit

The primary method of production is to drill and blast overburden, removing and stockpiling progressively using a combination of diggers, graders, dozers and trucks. A WIRTGEN surface miner is proposed to be operated on a 24/7 basis, loading extracted coal product into direct road transport (e.g. B-double prime-movers) for off site processing.

3.2.3.2 Mine-Affected Water Storages

Subject to detailed design and optimisation, up to three mine-affected water storages are proposed for FHCP, to be constructed to the immediate east of the proposed overburden dump in the north and adjacent to the box cut in the south. These storages will be constructed for the management and treatment of mine-affected water runoff. Full details of the water management plan for the site are included in the ATC Williams (2019) document appended to the Guideline Response for Water that forms part of this application.

Each dam will be protected from the ingress of flood event up to a Q100 surface water flows

3.2.3.3 Overburden Dump

Overburden for the initial box cut will be stockpiled on adjacent land to the north east as shown in Figure 2. As strip-mining progresses, overburden will be stockpiled behind the active strips in the open cut, backfilling the previously mined areas. This is a key element of the progressive rehabilitation strategy of the project. The dumps will be shaped as the mine progresses for the final land form as detailed in the draft Fairhill Mine Closure Plan.

3.2.3.4 Administration and Workshop Facilities

Demountable offices and ablution blocks will be utilised in a dedicated area, along with bunded fuel tanks, vehicle wash down facilities, a laydown yard, workshops and a ROM pad.

3.2.4 Land that will be Disturbed

Approximately 448.65 ha of land will be disturbed in total for the FHCP, although as previously described the intention is not to have that entire extent disturbed simultaneously. Progressive rehabilitation is a key feature of this project, with the overburden backfilling the previously strip-mined areas of the pit and being recontoured, topsoiled and reseeded each year. Full details of the mine closure strategy associated with this project are included in Appendix C5 of this report.

3.3 Proposed and Potential Releases

There are no proposed proactive releases associated with the FHCP.

3.3.1 Water Storage

There are a number of water storages on site, which are designed to capture potentially mine-affected stormwater runoff. It is important to note that with no processing proposed on site, there is no process water to be contained and the primary risk of impact to water is from stormwater coming in contact with exposed mining areas. Water quality analysis predicts the water quality in the containment dams to be relatively good, and that water is expected to be used for dust suppression on the project. As such, the risk of impacts to land from a proposed or unplanned release of water is limited to erosion and sediment control, as opposed to a risk of contamination.

3.3.2 Chemical Storage

A fuelling station is proposed to support mining operations. The fuel is proposed to be used by earthmoving machinery and light vehicles. Containment systems compliant with the appropriate standard are proposed to be utilised for all chemical and fuel storages (e.g. AS1940, AS3780 and AS4452) and include bunding of refuelling areas to minimise the risk of environmental harm.

3.4 Environmental Risk Assessment

3.4.1 Risk Assessment Approach

For each of the identified potential impacts for FHCP, a likelihood rating and consequence rating have been applied using the following matrix (Table 10). The initial risk rating has been determined prior to the implementation of control measures. Control measures have been developed as required for the environmental risks to ensure that the level of risk is maintained at an acceptable level (Table 11).

The risk methodology applied has been developed based on the Australian and New Zealand Standard AS/NZS for Risk Management – Principles and Guidelines (ISO 31000:2018).

Table 10: Risk assessment matrix used for FHCP

RISK ASSESSMENT MATRIX					
LIKELIHOOD OF OCCURRENCE	SEVERITY OF CONSEQUENCES				
	Catastrophic (5)	Major (4)	Moderate (3)	Minor (2)	Insignificant (1)
Almost certain (5)	10	9	8	7	6
Likely (4)	9	8	7	6	5
Possible (3)	8	7	6	5	4
Unlikely (2)	7	6	5	4	3
Rare (1)	6	5	4	3	2

Table 11: Assessment of risk scores for the FHCP risk assessment

RISK SCORE	RISK RATING	ACTION REQUIRED
9 – 10	Extreme	Immediate.
7 – 8	High	Action plan required. Senior management attention.
5 – 6	Moderate	Specific monitoring or procedures required.
2 – 4	Low	Management through routine procedures.

3.4.2 Results of Environmental Risk Assessment

The risk assessment methodology outlined in the previous section was applied to land aspects of the FHCP and the potential impacts were identified and rated. Table 12 outlines the results of the environmental risk assessment and ratings allocated based on the methodology applied to the construction and operation phases of the FHCP.

Table 12: Risk assessment for FHCP for the construction, operation and post closure phases of the project.

(L) = likelihood, (C) = consequence, (T) = total risk rating

EVENT / CIRCUMSTANCE	POTENTIAL IMPACT TO LAND	RISK RATING			RISK CONTROLS	RESIDUAL RISK RATING			TREATMENT/ CONTINGENCIES	MONITORING ACTIVITIES
		(L)	(C)	(T)		(L)	(C)	(T)		
Construction										
Vehicle movement	Generates dust that smothers nearby flora	4	3	7	Use of a water cart during construction to suppress dust.	3	3	6	If depositional dust monitors indicate deposited dust is in excess of the volume identified as qualifying as a nuisance, use of water carts will be increased.	Depositional dust monitoring will be set up around the site in accordance with the monitoring program suggested in the Guideline Response for Activities with Impacts to Air, which forms part of this application.
Vehicle movement	Impacts fauna through vehicle strike	5	2	7	Speed limits will be imposed on site access and haul roads.	3	2	5	If the fauna strike rate is considered to be high, speed limits will be revised and other management strategies will be implemented including options such as clearing roadside verges to provide greater driver visibility.	Roads will be checked to ensure speed limit signs are visible on each stretch of road.
Clearing activities	Clearing takes place outside allowable boundaries and impacts flora or fauna	3	3	6	Areas permitted to be cleared will be marked by survey before clearing commences.	2	3	5	Clearing outside permitted areas is a reportable incident and must be reported to the site environmental officer.	Survey data and aerial imagery taken of cleared areas will demonstrate cleared areas commensurate with the allowable extent of clearing within the EA.
Clearing activities	Tree felling and ground clearance impacts fauna species	5	3	8	The use of a fauna spotter-catcher during the vegetation-clearing and construction period is recommended to minimise the chances of injury to native fauna. The fauna spotter-catcher should have a current rehabilitation permit and should be present during clearing activities. The role of the spotter-catcher would be to advise on appropriate clearing methods to ensure animal escape paths are maintained and relocate fauna located within the disturbance area accordingly.	3	3	6	If the fauna casualty rate from clearing activities is considered to be high, the clearing activity will be halted and procedures reviewed by the fauna spotter-catchers, the site environmental officer and the mine manager.	The fauna spotter-catcher will prepare a report at the end of the clearing exercise that describes the impacts to fauna from the clearing activities.
Excavation activities	Excavation causes fauna entrapment	3	3	6	Excavated areas should be checked regularly for trapped fauna, with inspection occurring at least twice daily. These areas should be checked early in the morning for fauna that has become trapped overnight and again in the late afternoon for fauna that has become trapped over the course of the day. Safe egress points should be included to allow fauna to escape of their own accord. Any fauna that cannot escape of its own accord should be removed in a manner that is safe for both the animal and the person handling the animal. Dangerous fauna species such as snakes should only be handled by a suitably qualified and experienced person.	2	2	4	If fauna is reported to persist in becoming entrapped in site excavations, ingress and egress points will be examined and the opportunity to provide additional means of egress (e.g. netting surfaces to provide grip for animals to climb out of steep areas) will be investigated.	Morning and evening inspections of excavations for trapped fauna.
Topsoil clearing	Clearing and stockpiling of topsoil is conducted in a manner not conducive to maximising retention and future usability of the resource	4	4	8	Topsoil must be managed in accordance with the soil management methodology outlined in the Soils and Land Suitability Assessment included as Appendix C2 of this report.	3	3	6	If stockpiles are found to be poorly constructed, if vegetation is not taking on reseeded stockpiles or if erosion is seen to be impacting on stockpiles, the stockpiles must be carefully restructured to maximise material retention and fertility.	Topsoil stockpiles will be surveyed for height and vegetation cover on a quarterly basis. An ongoing topsoil material balance will be maintained by the site environmental officer for use in rehabilitation planning.

EVENT / CIRCUMSTANCE	POTENTIAL IMPACT TO LAND	RISK RATING			RISK CONTROLS	RESIDUAL RISK RATING			TREATMENT/ CONTINGENCIES	MONITORING ACTIVITIES
		(L)	(C)	(T)		(L)	(C)	(T)		
Vehicle movement	Weed transfer from vehicles traversing uncleared areas and moving around the landholder property	5	3	8	Vehicles will use wash down facilities at the mine upon arrival and departure. Weed and seed clearance certificates will be available for inspection on request. Vehicle movement will be restricted to site access roads. Vehicles will not be permitted to drive off road without a permit. A condition of the permit will be an up-to-date weed and seed certificate.	3	3	6	Contingency will be complaint driven and based on landholder feedback. Receipt of a complaint about weed spread considered to be valid will prompt a review of wash down policies and weed awareness.	Haul road and site access road verges will be inspected quarterly for evidence of weed species on the road verges.
Clearing activities	Erosion of cleared surfaces by wind/rainfall before adequate bunding or runoff capture infrastructure is in place	3	4	7	Erosion and sediment control structures and water management infrastructure must be constructed before large scale clearing associated with mining activities begins.	2	3	5	If a major weather event is predicted, or if clearing and stripping is seen to take place without infrastructure in place, clearing and stripping will be halted pending the installation of the appropriate control measures.	A site inspection will verify the appropriate bunding and water management control infrastructure is in place before each phase of mining disturbance commences.
Hydrocarbon spill	Spill from blown machinery hose or machinery leak, <20L	4	2	6	Machinery must be maintained as per the manufacturer's specifications. Records of machine maintenance must be kept at the maintenance workshop. Spills must be controlled and contained as soon as possible. Then, the spill must be reported and the spill must be cleaned up using appropriate the appropriate spill kit material. An incident report must be completed.	3	2	5	If the site environmental officer notes a large number of incident reports for spills <20L, machinery maintenance records must be inspected and spill awareness training included in prestart meetings.	Incident reports will be examined and acted upon accordingly.
Hydrocarbon spill	Spill from blown machinery hose or machinery leak, >20L	4	3	7	Machinery must be maintained as per the manufacturer's specifications. Records of machine maintenance must be kept at the maintenance workshop. Spills must be controlled and contained as soon as possible. Then, the spill must be reported and the spill must be cleaned up using appropriate the appropriate spill kit material. The site environmental officer must be informed as soon as possible and will inspect the cleaned site to establish the requirement, if any, for extraction and removal of contaminated soil or rock material for disposal or remediation. An incident report must be completed.	3	3	6	For spills in excess of 20L, machinery maintenance records will be examined.	Incident reports will be examined and acted upon accordingly. A report of clean-up activities including photographs will be produced.
Operation										
Hazardous material / hydrocarbon storage	Breach or spill from hazardous material storage area contaminates land, <20L	4	2	6	All hydrocarbons and chemicals are stored in appropriately bunded areas as per Australian Standards. Spill kits to be provided in areas where spills are likely, and routinely inspected and maintained. A spill response standard operating procedure (SOP) will be implemented at site. This SOP will incorporate best practice response to any spills including control, contain, contact, clean-up and communicate. The deadline for construction of hydrocarbon storage areas is prior to the onset of operational mining activities.	3	2	5	If the site environmental officer notes a large number of incident reports for spills <20L, machinery maintenance records must be inspected and spill awareness training included in prestart meetings.	Incident reports will be examined and acted upon accordingly.

EVENT / CIRCUMSTANCE	POTENTIAL IMPACT TO LAND	RISK RATING			RISK CONTROLS	RESIDUAL RISK RATING			TREATMENT/ CONTINGENCIES	MONITORING ACTIVITIES
		(L)	(C)	(T)		(L)	(C)	(T)		
Hazardous material / hydrocarbon storage	Breach or spill from hazardous material storage area contaminates land, >20L, <100L	4	3	7	All hydrocarbons and chemicals are stored in appropriately bunded areas as per Australian Standards. Spill kits to be provided in areas where spills are likely, and routinely inspected and maintained. A spill response SOP will be implemented at site. This SOP will incorporate best practice response to any spills including: control, contain, contact, clean-up and communicate. The deadline for construction of hydrocarbon storage areas is prior to the onset of operational mining activities.	3	2	5	Spills >20L and <100L must be reported to the area supervisor immediately and the site environmental officer as soon as possible.	Incident reports will be examined and acted upon accordingly.
Hazardous material / hydrocarbon storage	Breach or spill from hazardous material storage area contaminates land, >100L	4	4	8	All hydrocarbons and chemicals are stored in appropriately bunded areas as per Australian Standards. Spill kits to be provided in areas where spills are likely, and routinely inspected and maintained. A spill response SOP will be implemented at site. This SOP will incorporate best practice response to any spills including: control, contain, contact, clean-up and communicate. The deadline for construction of hydrocarbon storage areas is prior to the onset of operational mining activities.	2	4	6	Spills in excess of 100L must be immediately reported to the area supervisor and the site environmental officer, with further reporting in accordance with the instructions in the SOP.	Incident reports will be examined and acted upon accordingly.
Vehicle movement	Generates dust which smothers nearby flora	4	3	7	Use of water carts during operations to suppress dust.	3	3	6	If depositional dust monitors indicate deposited dust is in excess of the volume identified as qualifying as a nuisance, use of water carts will be increased.	Depositional dust monitoring will be set up around the site in accordance with the monitoring program suggested in the Guideline Response for Activities with Impacts to Air, which forms part of this application.
Vehicle movement	Impacts fauna through vehicle strike	5	2	7	Speed limits will be imposed on site access and haul roads.	3	2	5	If the fauna strike rate is considered to be high, speed limits will be revised and other management strategies will be implemented including options such as clearing roadside verges to provide greater driver visibility.	Roads will be checked to ensure speed limit signs are visible on each stretch of road.
Clearing activities	Progressive clearing takes place outside allowable boundaries and causes a disturbance footprint in excess of that authorised in the Environmental Authority (EA)	3	3	6	Areas permitted to be cleared will be marked by survey before clearing commences.	2	3	5	Clearing outside permitted areas is a reportable incident and must be reported to the site environmental officer.	Survey data and aerial imagery taken of cleared areas will demonstrate cleared areas commensurate with the allowable extent of clearing within the EA.
Post Closure										
Open pit	Geotechnical instability causes pit wall collapse, impacting stability of the surrounding landscape	4	3	7	Final pit walls will be reshaped to an angle that supports long- term geotechnical stability.	2	3	5	A geotechnical review of the site will be conducted if the pit integrity is seen to change during post closure monitoring.	Post closure monitoring will continue until site has been relinquished. Full details are included in the Mine Closure Plan included as Appendix C5 of this guideline response.
Open pit	Geotechnical instability poses a risk of harm to humans and wildlife	4	3	7	Final pit walls will be reshaped to an angle that supports long- term geotechnical stability. Exclusion bunding and fencing to be installed post closure to prevent access by wildlife and livestock.	2	3	5	A geotechnical review of the site will be conducted if the pit integrity is seen to change during post closure monitoring.	Post closure monitoring will continue until site has been relinquished. Full details are included in the Mine Closure Plan included as Appendix C5 of this guideline response.

EVENT / CIRCUMSTANCE	POTENTIAL IMPACT TO LAND	RISK RATING			RISK CONTROLS	RESIDUAL RISK RATING			TREATMENT/ CONTINGENCIES	MONITORING ACTIVITIES
		(L)	(C)	(T)		(L)	(C)	(T)		
Open pit	Geotechnical instability poses a risk of harm to humans and wildlife	4	5	9	Final pit walls will be reshaped to an angle that supports long-term geotechnical stability. Exclusion bunding and fencing to be installed post closure to prevent access by wildlife and livestock. Signage will be included around the fencing to warn against access by humans.	1	5	6	In the event someone is injured after gaining access to the post closure landforms and that access is deemed to not be the result of mischief, site access will be reviewed and areas will be referenced/signposted to prevent access.	Post closure monitoring will continue until site has been relinquished. Full details are included in the Mine Closure Plan included as Appendix C5 of this guideline response.
Overburden dump	Geotechnical instability causes slumping or erosion gullies, impacting the mobility of sediment and material off the dump surfaces into the surrounding landscape	4	3	7	The final overburden dumps will be reprofiled to be in keeping with the surrounding landscape and be geotechnically stable. The dumps will be shaped to shed water efficiently to reduce the impact of erosion. Dumps will be revegetated with a species in keeping with the surrounding landscape to reduce the exposure of land to the elements.	2	3	5	If the dumps are deemed to be performing in a substandard fashion in terms of the level of erosion/material loss/sediment dispersion/revegetation, works will be undertaken to remediate the issue.	Post closure monitoring will continue until site has been relinquished. Full details are included in the Mine Closure Plan included as Appendix C5 of this guideline response.
Overburden dump	Unsuccessful revegetation causes exposure of dump surface to erosive factors, resulting in sheet and rill erosion and sediment movement off the dump surface	4	3	7	The final overburden dumps will be reprofiled to be in keeping with the surrounding landscape and be geotechnically stable. The dumps will be shaped to shed water efficiently to reduce the impact of erosion. Dumps will be revegetated with a species in keeping with the surrounding landscape to reduce the exposure of land to the elements.	2	3	5	If the dumps are deemed to be performing in a substandard fashion in terms of the level of erosion/material loss/sediment dispersion/revegetation, works will be undertaken to remediate the issue.	Post closure monitoring will continue until site has been relinquished. Full details are included in the Mine Closure Plan included as Appendix EC5 of this guideline response.
Vehicle movement	Vehicle movement from offsite to onsite and around rehabilitated areas during monitoring spreads weed seed	3	3	6	Vehicles must go through local wash down facilities before and after attending site.	2	3	5	If instances of weed spread are noted in revegetation monitoring post closure, weed control procedures for monitoring contractors will be reviewed.	Post closure monitoring will continue until site has been relinquished. Full details are included in the Mine Closure Plan included as Appendix C5 of this guideline response.

3.5 Acid-Producing Rock

Results of the Overburden and Potential Coal Reject Characterisation Report (NRC, 2018b) included with this report as Appendix C4, indicate that there is negligible potential for acid rock drainage to occur. Of the 27 samples that were taken, 100% were classified as non-acid forming (NAF). Additionally, the materials sampled have considerable buffering capacity, which is considered significant enough to buffer any acid produced by waste rock.

All 27 overburden samples were subjected to initial acid base account geochemical testing.

Specifically:

- pH (1:2)
- electrical conductivity (EC) (1:2)
- total sulfur (wt%)
- Australian Standard Leaching Procedure (ASLP) metal concentrations
- bulk rock trace metals
- acid neutralising capacity (ANC)
- net acid producing potential
- net acid generation pH 4.5
- net acid generation pH 7.

In addition, major ion analysis and heavy metal concentrations of EC 1:5 samples along with a full metal suite of overburden samples were conducted.

The ANC of samples varied from 2.5 to 120 kg H₂SO₄/tonne. The median value of ANC was 55 kg H₂SO₄/tonne.

As the geochemical characteristics of FHCP waste rock can be classed as NAF (100%), there are currently no specific requirements to design overburden dumps specifically with the purpose of encapsulating potentially acid forming (PAF) material. The large neutralising capacity of the overburden waste further ensures that any potential acid formation will most likely not occur.

Average EC and pH of 1:2 leachate extract waters suggest runoff/seepage associated with waste rock storage will be alkaline and fresh to moderately fresh. Salinity is not likely to pose a problem throughout the site; however, specific requirements for the management of alkaline waters may be necessary in the future. Ongoing analyses are recommended during the initial and ongoing stages of operation.

3.6 Overburden

As outlined in the Overburden and Potential Coal Reject Characterisation Report (NRC, 2018b) included as Appendix C4 of this guideline response, the geochemical characteristics of the FHCP waste rock are classed as NAF (100%) with no specific requirements to design overburden dumps specifically with the purpose of encapsulating PAF material currently.

3.7 Tailings

Coal product produced at the FHCP will be trucked off site for processing at already established infrastructure in the region. As such, there is no requirement to manage process tailings on the site.

3.8 Onsite Waste Storage Facilities

Due to the relatively short-term nature of operations proposed to occur onsite, regulated waste is proposed to be stored in contractor supplied waste containers and collected by an approved third-party contractor. Recyclable waste will also be transported off site by a suitably licensed contractor. A small general waste landfill will be maintained within the overburden dump.

3.9 Areas of Regional Interest

As described earlier in the EVs section of this report, no areas of regional interest were identified within the FHCP area. Therefore, no areas of regional interest are expected to be impacted by the proposed work.

4. Proposed Management Practices

4.1 Land Disturbance Mitigation

To mitigate the extent and severity of land disturbance and impact to existing land uses, Futura Resources are in constant contact with all impact land holders and will continue to negotiate with the landholders in relation to existing use of land within the project area. Access to land within the project area not subject to mining activities will be limited where there are safety concerns for landholders or livestock. The continuation of existing land use practices such as grazing will be investigated for these areas.

Where roads and other linear infrastructure intersects landholder properties, crossing points will be established in conjunction with landholders to allow for continued movement of livestock, people and equipment within the landholder's property. The design of crossing points will vary depending on the nature of the linear infrastructure (e.g. roads, power lines) and the frequency of use. The proponent will negotiate compensation with the landholders for the impacts to agricultural activities and farm infrastructure. This may include the establishment of alternative farm infrastructure.

Land use adjacent to the project area includes agricultural, areas with remnant vegetation, cleared areas and coal mining. Land uses associated with urban development, tourism, recreation or other business other than mining will not be impacted by the project.

4.1.1 Mine Closure Plan

A key element of the proposed FHCP is the proponent's commitment to progressive rehabilitation throughout the life of mine. With this commitment, a draft mine close plan has been drafted and attached in Appendix C5.

Mining will commence via an initial box-cut to the east of the proposed waste rock dumps, with formed strips running northeast to southwest progressively moving in an upslope north-westerly direction. Mine development is planned based on the formation of two defined pits (northern and southern), initially offset by some 50 m to avoid the Glencore water pipeline easement. The shallow overburden will be removed using truck and excavator/shovel supported by dozers, with cast blasting used as required on specific portions of the waste material. The majority of waste material will remain in-pit, with cast and doze materials directed into the void of the previous strip, and truck and shovel excavator placed on top of earlier cast and doze waste placement.

The overburden wastes in the first year will be hauled and placed over the dozer push spoil out of the pit dump. This will be undertaken during steady state strip mining to backfill the pit to approximately the original topography, creating a low-cost rehabilitated landform.

The backfilled overburden will be topsoiled, ripped and seeded with a vegetation mix in keeping with the surrounding landscape.

The post mining land use will predominantly be consistent with pre-mining land uses, being beef cattle grazing. Post-mining land use and closure objectives for the FHCP is a rehabilitated landscape that is supportive of pre-mining land uses (e.g. grazing) which also meets the requirements of:

- Safe to humans and wildlife
- Non-polluting
- Stable
- Able to sustain an agreed post-mining land use.

Rehabilitation design strategies, timeframes and success criteria are included in the Fairhill Coal Project Mine Closure Plan, included with this guideline response as Appendix C5.

The Fairhill Coal Project Mine Closure Plan is considered a live document that will undergo annual review and continuous improvement throughout the FHCP mine life with detail increasing as the mine moves towards closure. It is acknowledged that with the changes in the current legislative system surrounding mine closure, the introduction of the *Mineral and Energy Resources (Financial Provisioning) Act 2018* will influence the closure planning process in the future. This plan has been developed prior to the Act coming in to effect and guidelines being developed by DES, therefore will undergo revision as the closure planning process evolves.

4.2 Water Management

The current design of the final landform would exist as a clean water catchment, which would generally drain either to the west (to the final voids) or to the watercourses to the east. The final landforms will be subject to investigation works and detailed design and would typically include assessment of the water chemistry, surrounding environment and consideration of infrastructure to remain post closure (subject to relevant agreements).

4.2.1 Final Voids

Following mine closure, the mine rehabilitation design shows two primary final pit voids formed against the western batter slopes of the overburden dump. It is expected (although unconfirmed) that the final voids would naturally fill with surface water runoff from the upstream natural catchment and rehabilitated dump batters over time, however this will be minimised where possible with the final land form diverting clean water around the void. These final void water bodies may be expected to subsequently interact with local groundwater resources, acting as a source of recharge for local aquifers, potentially raising local groundwater levels.

The water quality in the final voids would be expected to improve over time as the revegetated surfaces of the rehabilitated overburden dump establish and mature, thus reducing the mobilisation of sediments and remnant salinity associated with the operational phase of the mine. Final water levels in the voids have not been assessed, however these voids could overflow during rainfall events discharging to either Cooroorah Creek or Sandy Creek (ATC Williams 2019).

4.2.2 Drainage Systems

The final landform design will need to consider shaping of effective drainage lines in order to shed surface runoff without causing erosion of the final land surface. In the establishment phase, this will comprise cleaning of all drains, landscaping and placement of a soil layer that is followed with revegetation. Permanent drainage will be designed and constructed for long term durability, which could include increasing capacity, reducing gradients or providing erosion protection as required.

4.3 Contaminant Management

The mining activities that will be conducted as part of the FHCP can have the potential to disturb contaminants, if they are present within the boundary of the project site. As addressed earlier in this report, a desktop assessment and preliminary site investigation together with a review of the DES CLR and EMR, indicate that there is no existing contaminated land at the FHCP area.

In the unlikely event that land contamination exists within the project area, it will be most likely to be contained within the immediate surface layers or immediately below the surface layer of soil. Mining activities require that these surface soil layers and overburden are to be stripped and stockpiled onsite to gain access to the coal or for the construction of surface mining infrastructure. Should any suspect soils be identified as being contaminated from visual/odour indications, they will be segregated in a separate stockpile pending further investigation.

If suspected contaminated sites are indeed located, they will be inspected for visual evidence of contamination. Examples of these visual indicators include:

- soil staining
- un-natural or chemical odour
- vegetation die-back.

If significant contamination is observed during topsoil or overburden stripping activities, these materials will be stockpiled separately pending further investigation. Once stockpiled, the suspected contaminated soils will be strictly managed, including stormwater management, to mitigate the risk of release of contaminants into the receiving environment.

Representative samples of any suspected contaminated stockpiled material will be analysed and interpreted by suitably qualified and experienced personnel. Should the analysed materials be confirmed to be contaminated, a management strategy for those impacted soils will be developed. Potential management strategies may include onsite retention, land farming and reuse and/or offsite disposal to an appropriately licenced facility.

The FHCP has the potential to contaminate land from activities including hydrocarbon spills from machinery during maintenance and refuelling activities, burst hydraulic hosing on mine machinery during mining activities and as a result of spills at the fuel storage and handling areas. Additional potential sources of contamination include chemical spills from chemical storage and handling areas and waste rock management areas.

Measures for the avoidance, mitigation and management of potential land contamination as a result of the project activities will include but are not be limited to:

- Applying the relevant Australian or industry standards and codes of practice (e.g. AS1940, AS3780 and AS4452) for the handling and storage of hazardous materials such as chemicals, lubricants and fuels to minimise the risk of environmental harm.
- Developing and implementing emergency response and spill response procedures to minimise any impacts that could occur as a result of releases of hazardous materials.
- Ensuring that appropriate spill response and containment materials and equipment are available onsite.
- Ensuring that staff are adequately trained in identifying potential land contamination aspects.
- Ensuring that staff are appropriately trained in handling, storing and containment practices for chemicals, fuels and hazardous materials.
- Assessing, reporting and recording contamination events in accordance with documented operational procedures.

As there is no onsite processing proposed, there will be no contaminant by-product of processing to be managed at the site.

4.4 Environmentally Sensitive Areas Management

The primary mechanism for managing impacts to ESAs is through the implementation of buffer zones. The location and extent of ESAs associated with the project were ground-truthed as part of the field survey programs. Multiple locations supporting endangered RE 11.9.1, which equates to a Category B ESA, were surveyed within the study area. The disturbance footprint of the project has been designed such that these areas are entirely avoided by design and will be retained within the landscape. A further buffer of at least 50 m has been applied to avoid direct disturbance and reduce the risk of edge effects to these communities. The location of the target resource is such that the standard buffer of 1 km could not be applied. However, given these Category B ESA areas are located within areas of cleared grazing pasture, and the proposed disturbance is restricted to areas that have already been cleared for existing land uses, it is unlikely the proposed disturbance represents an increased risk of disturbance to these communities.

4.5 Prescribed Environmental Matters – Offsets

Impacts to vegetation communities and flora and fauna habitat will be avoided by design, with the disturbance footprint for the project restricted to areas of non-remnant vegetation. The proposed project area supports low habitat values, with no features relevant to EVNT or otherwise conservation significant species or communities. Species-specific assessments for EVNT flora and fauna species were conducted through preparation of the Terrestrial Flora and Fauna Technical Report (Appendix C3). With reference to the criteria specified in the Queensland Environmental Offsets Policy Significant Residual Impact Guideline, the proposed action is unlikely to result in 'significant residual impacts' to any prescribed environmental matters. No environmental offsets are proposed as part of the impact management approach for the project.

4.6 Biodiversity Management

Remnant patches containing endangered RE 11.9.1 along Cooroora Creek and Sandy Creek have been purposefully avoided in the current design and the application of appropriate buffer zones to each polygon are included to avoid any potential impacts. Although mapped as non-remnant vegetation, the gilgai area to the south of Cooroora Creek is considered high-quality habitat for the Ornamental Snake and disturbance to this ephemeral watercourse is also avoided in the current design. Avoiding disturbance to this area also ensures a larger buffer zone to the endangered RE 11.9.1 along portions of Cooroora Creek.

The Squatter Pigeon has been recorded in close proximity to the study area and is considered likely to occur occasionally within the proposed disturbance footprint. Vehicle strike represents a general threat to native fauna species, but is particularly relevant to the Squatter Pigeon, a ground-dwelling species that inhabits bare ground and low grassland such as on roadsides. The following controls are proposed to minimise the likelihood of vehicle strike in general, with a focus on reducing the likelihood of death or injury to Squatter Pigeons if present:

- Site inductions or toolbox meetings will include information about sensitive aspects of the environment in which personnel are working, including the risk of injury or death to Squatter Pigeons from vehicles.
- Due to the ground dwelling nature of the species, all vehicles will remain on existing access tracks and roads wherever possible.
- Clearing works will be carried out in a sequential manner, where possible, that allows fauna to escape to natural areas away from construction works.

- Speed limits will be implemented as appropriate for the condition of the roads and access tracks on site. Locations of Squatter Pigeon sightings should be recorded and a limit of 20 km/h is recommended within 200m of locations where Squatter Pigeons have been regularly observed.
- Existing dams on Cooroora Creek that allow water to be retained throughout the dry season will be retained.
- The introduction of new permanent water sources as part of mine infrastructure will influence the activities of Squatter Pigeons during the dry season. These and other birds are likely to congregate near water bodies—efforts should be made where possible to distance traffic from water sources to avoid potential mortality.

4.7 Acid Mine Drainage Management

As addressed earlier in this report, the results of the Overburden and Potential Coal Reject Characterisation Report (NRC, 2018b), included with this report as Appendix C4 indicate that there is negligible potential for acid rock drainage to occur.

4.8 Overburden Management

As outlined in the Overburden and Potential Coal Reject Characterisation Report (NRC, 2018b), included as Appendix C4 of this guideline response, the geochemical characteristics of the FHCP waste rock are classed as NAF (100%) with no specific requirements to design overburden dumps specifically with the purpose of encapsulating PAF material currently.

No tailings will be stored on site with all coal washing and resulting waste tailings proposed to be disposed of at the Gregory Crinum mine.

5. Rehabilitation

5.1 Rehabilitation of the Site

A key element of the proposed FHCP is the proponent's commitment to progressive rehabilitation.

Mining will commence via an initial box-cut to the north of the proposed waste rock dumps, with formed strips running northeast to southwest progressively moving in an upslope north-westerly direction. Mine development is planned based on the formation of two defined pits (northern and southern), initially offset by some 50m. The shallow overburden will be removed using truck and excavator/shovel supported by dozers, with cast blasting used as required on specific portions of the waste material. The majority of waste material will remain in-pit, with cast and doze materials directed into the void of the previous strip, and truck and shovel excavator placed on top of earlier cast and doze waste placement.

The overburden wastes in the first year will be hauled and placed over the dozer push spoil out of the pit dump. This will be undertaken during steady state strip mining to backfill the pit to approximately the original topography, creating a low-cost rehabilitated landform.

The backfilled overburden will be topsoiled, ripped and seeded with a vegetation mix in keeping with the surrounding landscape. A review of environmental data (e.g. groundwater, surface water, environmental monitoring data, audit outcomes) will be undertaken during the progressive rehabilitation process to ensure that progressive rehabilitation objectives are met and compliance with approvals requirements is managed (e.g. compliance with the site's EA).

Rehabilitation design strategies, timeframes and success criteria are included in the Fairhill Coal Project Mine Closure Plan, included with this guideline response as Appendix C5.

5.2 Proposed Monitoring Strategy

Tongway and Hindley (2004) developed the landscape function analysis (LFA) as CSIRO's principal method for mine rehabilitation assessment. LFA is an indicator-based monitoring procedure that evaluates soil surface processes to examine how well a landscape is working as a biophysical system in relation to disturbance or rehabilitation.

LFA monitoring methods comprise assessing a suite of parameters at different landscape positions on each site, namely on flats, slopes and in troughs. Repeated edaphic (soil properties) and biological measurements are taken over time for various parameters that indicate changes in ecosystem function as rehabilitation proceeds. The goal of rehabilitation is to achieve a self-sustaining landscape. A self-sustaining ecosystem would not require further additions of nutrients, seed, water or other management inputs.

The CSIRO LFA method, as detailed by Tongway and Hindley (2004), would be used to inform the monitoring program design; however, some modification to this method may be required to address the site-specific variables at the FHCP.

LFA is typically conducted as an annual monitoring event and Fairhill Coking Coal Pty Ltd has made this commitment to rehabilitation monitoring throughout the life of mine. The results of the LFA monitoring and recommendations will be discussed in the Operational Performance Reports presented following rehabilitation and completion of site activities.

In general, the LFA method would involve monitoring of the following three groups of sites:

- natural site(s):

- disturbed analogue(s) may be utilised due to the presence of stock (grazing pressure) to consider the impact of stock.
- rehabilitated areas:
 - reference sites for rehabilitation performance, successful or otherwise.
- disturbance areas:
 - ROM pad
 - Site infrastructure (buildings, workshops, laydown areas)
 - access tracks and haul roads
 - footprints of waste stockpiles/dumps.

Analogue sites would be chosen as close as possible to the rehabilitated area so that the same climatic and environmental conditions existed at both sites to the extent possible.

Specific LFA monitoring sites are yet to be selected; however, the LFA methodology would be applied to each of the identified domains. This program would survey the rehabilitated areas and record percentage of plant cover, identify plant species present and note the development of erosional features in comparison to a neighbouring analogue site.

6. References

- ATC Williams. (2018). Fairhill coal project water management assessment. Prepared for Fairhill Coking Coal Pty Ltd, November 2018.
- Department of Mines and Energy (DME) (1995). Technical guidelines for the environmental management of exploration and mining in Queensland, Land suitability techniques.
- Department of Primary Industries & Department of Housing, Local Government and Planning (1993). Planning Guidelines: The identification of good quality agricultural land.
- Department of State Development, Manufacturing, Infrastructure and Planning (2018). Development Assessment Mapping System. Retrieved from <https://dams.dsdipl.esriaustraliaonline.com.au/damappingsystem/?accordions=Other%20State%20Planning%20Matters,Areas%20of%20Regional%20Interest>
- Dickens, J., & Malone, E. J. (1973). Geology of the Bowen Basin, Queensland. Department of Minerals and Energy Bureau of Mineral Resources Geology and Geophysics, Bulletin 130.
- Environmental Earth Sciences. (2012). Soil and land suitability assessment, Wilton coal project. Report Number 611023, Version 2.
- Galloway, R. W. (1967a). Chapter 2: Summary Description of the Isaac-Comet Area. Lands of the Isaac-Comet Area, Queensland Land Research Series No.19.
- Galloway, R.W. (1967b). Geology of the Isaac-Comet Area. Chapter 5 of Lands of the Isaac-Comet Area, Queensland, Land Research series No.19. CSIRO.
- Jensen, A.R. (1975). Permo Triassic Stratigraphy and sedimentation in the Bowen Basin, Queensland. BMR Bulletin 154, AGP S Canberra.
- Northern Resource Consultants (NRC). (2017). Waste rock characterisation of the Wilton coal project. Townsville.
- NRC. (2018a). Fairhill coal project soils and land suitability assessment. Report prepared for Fairhill Coking Coal Pty Ltd. August 2018.
- NRC. (2018b). Overburden and potential coal reject characterisation report. Report prepared for Fairhill Coking Coal Pty Ltd. November 2018.
- Prouza, V. (1977). Coal exploration, South Central Bowen Basin, Mt. Stuart-Comet Area, Geological Survey Queensland, Record 1977/27.
- R. E. Ltd. (2010). Washpool coal project geochemical assessment of overburden and potential coal reject materials.
- ROM Resources. (2013). Minescape model report and 2012 JORC resource statement. Report prepared for Fairhill Coking Coal Pty Ltd.
- Saunders Havill Group. (2011). Wilton coal flora and fauna technical report. 24 November 2011.
- SE Group. (2018). Fairhill coal project air quality assessment. Brisbane.
- Sliwa, R., Hamilton, S., Hodgkinson, J. & Draper, J. (2008). Bowen Basin structural geology, an interpretation based on airborne geophysics and file explorations data. Published Map, CSIRO and Queensland Government, Department of Mines and Energy.
- Tongway, D. J., & Hindley, N.L. (2004). *Landscape function analysis. Procedures for monitoring and assessing landscapes*. CSIRO Sustainable Ecosystems, Canberra.

U. A. Ltd. (2006). Geochemical characterisation and assessment of overburden and potential coal reject material at the Ensham central project. Appendix A of the Ensham EIS.

Appendix summary

Appendix C1:	Fairhill Coal Project Environmental Management Register (EMR) and Contaminated Land Register (CLR) Search Response
Appendix C2:	Fairhill Coal Project Soils and Land Suitability Assessment
Appendix C3:	Fairhill Coal Project Flora and Fauna Technical Report
Appendix C4:	Fairhill Coal Project Overburden and Potential Coal Reject Characterisation Report
Appendix C5:	Fairhill Coal Project Mine Closure Plan

Appendix C1

Fairhill Coal Project Environmental Management Register (EMR) and Contaminated Land Register (CLR) Search Response

Appendix C2

Fairhill Coal Project Soils and Land Suitability Assessment

Appendix C3

Fairhill Coal Project Flora and Fauna Technical Report (SLR, 2019)

Appendix C4

Fairhill Coal Project Overburden and Potential Coal Reject Characterisation Report

Appendix C5

Fairhill Coal Project Mine Closure Plan



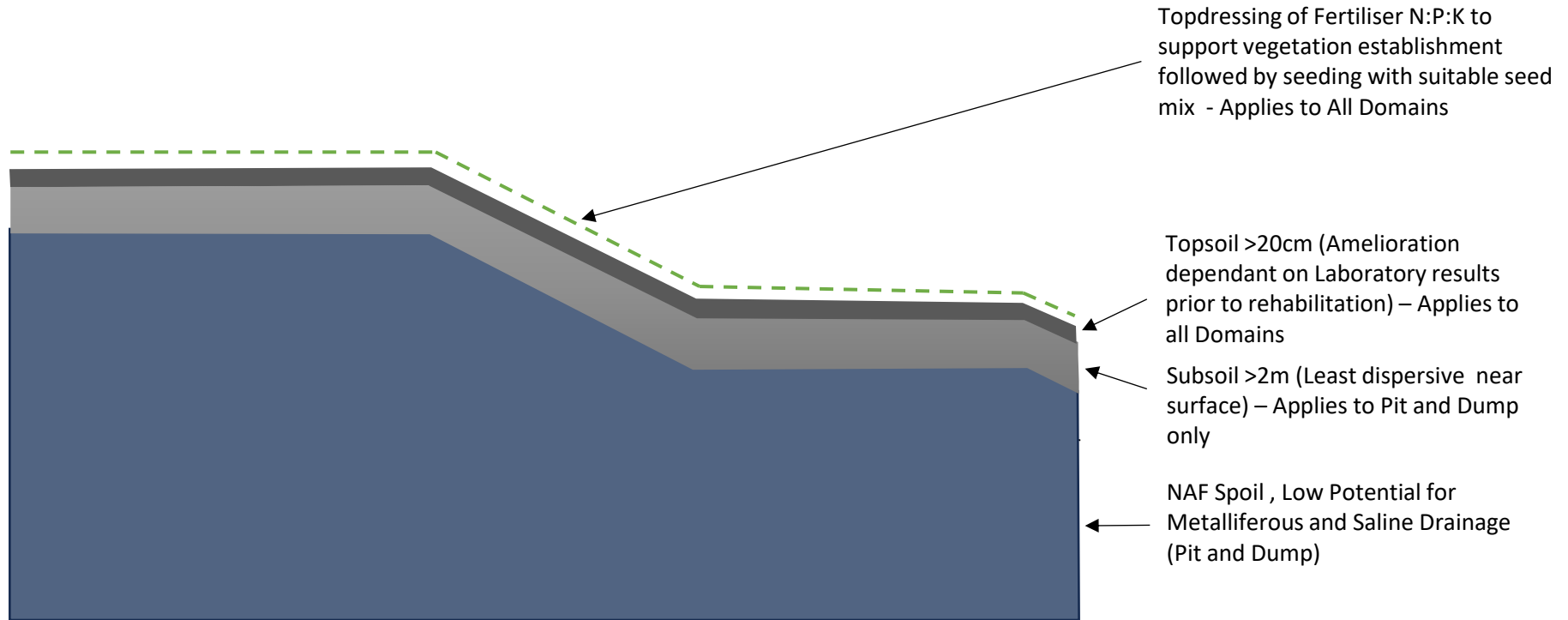
Cover Design

Fairhill PRCP – January 2024

FUTURA RESOURCES

Cover Design - Adapted to suit Domains

Schematic to Illustrate Cover Design



Objective of Cover System – Successful Rehabilitation to achieve a PMLU of Low intensity Cattle Grazing

Methodology –

- **Dozer Push** - Re-shaping involves using dozer push to push the material into shape and spread topsoil
- **Truck and Shovel** for carting rock /growth media
- **Broadcast Seeding** – spread seed

Note – This is simplification of the Cover Design



Northern Resource
CONSULTANTS

Fairhill Coal Project

Appendix C5 Mine Closure Plan

July 2019

prepared for
Fairhill Coking Coal Pty Ltd

Ver 4

Contact Information	Details
Organisation	Northern Resource Consultants Pty Limited
Contact Person	Marty Costello
Phone	07 4772 6500
Email	marty@northres.com.au
Mail	12 Cannan Street, South Townsville QLD, 4810
ABN	55 126 894 693
Project number	623.17171.00000

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1. Overview

1.1 Introduction

This report was originally provided as supporting information for a site-specific environmental authority for Fairhill Coking Coal on MLA700043. The application was received by the Department of Environment and Science (DES) on 19 December 2018 (application reference ZENDESK 11657).

Note that this report (Ver 4) has been revised in accordance with Appendix A of information request provided by DES dated 04 March 2019.

1.1.1 Scope

This preliminary Mine Closure Plan incorporates rehabilitation strategies and objectives for the Fairhill coal project (FHCP) to ensure that the closure of the Fairhill coal mine meets the Department of Environment and Heritage Protection (EHP) guideline *Rehabilitation requirements for mining resource activities, Version 2* (EHP, 2014) being:

- Safe to humans and wildlife
- Non-polluting
- Stable
- Able to sustain an agreed post-mining land use.

This closure plan has been drafted to align with the guidelines for *Integrated Mine Closure – Good Practice Guide (ICMM)*.

1.1.2 Project overview

The FHCP is intended as a bituminous coking coal production mine, utilising a shallow open cut method to selectively mine targeted coal seams. The coal material contains a high proportion of vitrinite (70%–80%), producing a high-quality bituminous coking coal. Coal quality results indicate a washed coal product that is suitable for the export coking coal market.

A staged open cut mine plan has been developed that targets an annual Run of Mine (ROM) coal production rate of approximately 1.7 million tonnes per annum (Mtpa) after an initial ramp up in year one. The planned mine life is seven years.

Mining will commence via an initial box-cut to the west of the proposed waste rock dump, with formed strips running northeast to southwest progressively moving in an upslope north-westerly direction. Mine development is planned based on formation of two defined pits (northern and southern), initially offset by some 50 m so to not impact the Glencore owned Oaky Creek water pipeline. The shallow overburden will be removed using truck and excavator/shovel supported by dozers, with cast blasting used as required on specific portions of the waste material. The majority of waste material will remain in-pit, with cast and doze materials directed into the void of the previous strip, and truck and shovel excavator placed on top of earlier cast and doze waste placement.

The overburden wastes in the first year will be hauled and placed over the dozer push spoil out of the pit dump. This will be undertaken during steady state strip mining to backfill the pit to approximately the original topography, creating a low-cost rehabilitated landform.

Mining the raw product coal resource will involve the use of a WIRTGEN surface miner to continuously strip mine shallow coal from inter-burden. The surface miner will load excavated material into B-Double trucks for direct road transport to an offsite location for processing.

A fleet of 30t excavators will work in conjunction with the surface miner to strip inter-burden, ensuring efficient collection of raw product to be trucked to nearby facilities for processing.

The schedule of production and material movements for the project is summarised in **Table 1**.

Table 1: FHCP mining schedule

	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7
Clear and grub (m ²)	835,000	1,750,000	1,850,000	1,500,000	800,000	1,347,000	1,449,400
ROM coal (t)	850,000	1,700,000	1,700,000	1,700,000	1,700,000	1,700,000	1,700,000
Coking product (t)	246,676	489,866	488,520	488,460	482,324	439,169	477,668
Thermal product (t)	178,627	354,731	353,839	353,712	349,269	318,036	345,917
Total product (t)	425,304	844,597	842,358	842,172	831,593	757,205	823,585
Total volume spoil moved (bcm)	8,248,140	6,555,702	7,740,406	6,914,292	8,927,185	10,949,158	10,723,208

1.1.3 Existing land use

The regional land use in the Emerald area of the Bowen Basin region is generally rural with some coal mining activities. Rural land uses are predominately cattle grazing and irrigated/rain-fed broad acre cropping.

A large proportion of the prime agricultural land in the region surrounding the proposed FHCP is situated on the flood plain of the Nogoa River around Emerald and to the east, supplied by Fairbairn Dam. Cattle grazing is the dominant land use in the FHCP tenement with much of the flatter land around the southern and eastern areas cleared. Tracks, fences, dams and yards are present across the area for the purpose of cattle grazing.

1.1.4 Existing soils conditions

Three dominant soil types were identified within the FHCP study area as detailed in the sub-sections below.

1.1.4.1 Red dermosol

Red Dermosol was identified and described as a shallow red soil profile with a structured B2 horizon but lacking strong texture contrast. Red Dermosol was described on lowlands and plains with no microrelief and poor drainage. Primary erosive processes were noted to be primarily sheet erosion and the area had been previously cleared for grazing activities (SLR, 2018).

Soil texture was a sandy loam in the A horizon with weak sub-angular blocky structure, trending to light clay loam with moderate sub-angular structure at depth. Surface soils were slightly alkaline throughout and salinity was very low. The Emerson aggregate test (EAT) categorised the soil horizons as being

susceptible to dispersion despite the exchangeable sodium percentage (ESP) being below 5% in sub soils, suggesting dispersion would not be problematic (SLR, 2018).

Representative chemical, nutrient and micronutrient levels of Grey Dermosol soils is provided in **Table 2**.

Table 2 Representative chemical, nutrient and micronutrient levels of Red Dermosol soils

Soil chemical analysis					
EC ($\mu\text{S}/\text{cm}$)	Chloride (mg/kg)	CEC (meq/100g)	ESP (%)	Ca:Mg ratio	
270	39	-	-	-	
380	160	-	-	-	
49	8	17	1.0	4.7	
Soil nutrient analysis					
Total organic carbon (%w/w)	Total phosphorous (mg/kg)	Nitrate/Nitrite as NOx as N (mg/kg)	Total Kjeldahl nitrogen (mg/kg)	Total nitrogen (mg/kg)	
1.3	5	0.9	960	960	
1.0	3	0.9	790	800	
0.85	15	-	-	-	
Micronutrients					
Copper (mg/kg)	Iron (mg/kg)	Manganese (mg/kg)	Molybdenum (mg/kg)	Sulfur (mg/kg)	Zinc (mg/kg)
2.1	15	10	<0.10	7	0.26
-	-	-	-	4	-

1.1.4.2 Grey dermosol

Grey Dermosol was identified and described as a moderately deep grey soil profile with a structured B2 horizon but lacking strong texture contrast. Grey Dermosol was described on lowlands and plains with no microrelief and poor drainage. Primary erosive processes were noted to be sheet erosion and the area had been previously cleared for grazing activities (SLR, 2018).

Soil texture was a light clay with weak sub-angular blocky structure, trending to medium to heavy clay with moderate sub-angular blocky structure at depth. Surface soils were slightly alkaline and trended to moderately alkaline at depth. Gypsum fragments were noted in sub-soil horizons. Salinity increased from a rating of medium severity to extreme severity at depth and ESP was noted to be severely dispersive trending to highly dispersive with depth (SLR, 2018).

Representative chemical, nutrient and micronutrient levels of Grey Dermosol soils is provided in **Table 3**.

Table 3 Representative chemical, nutrient and micronutrient levels of Grey Dermosol soils

Soil chemical analysis						
pH (lab) (1:5)	Electrical conductivity (EC) ($\mu\text{S}/\text{cm}$)	Chloride (mg/kg)	CEC (meq/100g)	ESP (%)	Ca:Mg ratio	
7.9	250	180	-	-	-	
8.6	900	1100	53	17.2	1.9	
8.6	980	1200	56	13.4	2.6	
Soil nutrient analysis						
Total organic carbon (%w/w)	Total phosphorous (mg/kg)	Nitrate/Nitrite as NOx as N (mg/kg)		Total Kjeldahl nitrogen (mg/kg)	Total nitrogen (mg/kg)	
1.8	7	20		1300	1400	
1.5	3	-		-	-	
1.2	3	-		-	-	
Micronutrients						
Boron (mg/kg)	Copper (mg/kg)	Iron (mg/kg)	Manganese (mg/kg)	Molybdenum (mg/kg)	Sulfur (mg/kg)	Zinc (mg/kg)
1.2	1.6	20	19	<0.10	7	0.43

1.1.4.3 Brown dermosol

Brown Dermosol was identified and described as a moderately deep brown soil profile with a structured B2 horizon but lacking strong texture contrast. Brown Dermosol was described on planes and lowland slopes with no microrelief and poor drainage. Primary erosive processes were noted to be sheet erosion and the area had been previously cleared for grazing activities (SLR, 2018).

Soil texture was a medium clay with weak sub-angular blocky structure, trending to sandy clay with moderate sub-angular structure at depth. Surface soils were slightly alkaline and trended to moderately alkaline at depth. Gypsum fragments were noted in sub-soil horizons. Salinity varied throughout the soil profile but generally decreased with depth and while the EAT described each horizon as being susceptible to dispersion, ESP was less than 5% (SLR, 2018).

Representative chemical, nutrient and micronutrient levels of Brown Dermosol soils is provided in **Table 4**.

Table 4 Representative chemical, nutrient and micronutrient levels of Brown Dermosol soils

Soil chemical analysis							
Depth (m)	pH (lab) (1:5)	EC (µS/cm)	Chloride (mg/kg)	CEC (meq/100g)	ESP (%)	Ca:Mg ratio	
0.00 to 0.20	8.3	270	39	-	-	-	
0.20 to 0.50	8.9	380	160	-	-	-	
0.50 to 0.70	7.1	49	8	17	1.0	4.7	
Soil nutrient analysis							
Depth (m)	Total organic carbon (%w/w)	Total phosphorous (mg/kg)	Nitrate/Nitrite as NOx as N (mg/kg)	Total Kjeldahl nitrogen (mg/kg)	Total nitrogen (mg/kg)		
0.00 to 0.20	1.3	5	0.9	960	960		
0.20 to 0.50	1.0	3	0.9	790	800		
0.50 to 0.70	0.85	15	-	-	-		
Micronutrients							
Depth (m)	Boron (mg/kg)	Copper (mg/kg)	Iron (mg/kg)	Manganese (mg/kg)	Molybdenum (mg/kg)	Sulfur (mg/kg)	Zinc (mg/kg)
0.00 to 0.20	0.92	2.1	15	10	<0.10	7	0.26
0.20 to 0.50	-	-	-	-	-	4	-

1.1.5 Flora

A total of 71 flora species from 27 families were recorded within the study area. All flora species observed throughout the study area are common and widespread throughout the region in eucalypt and *Acacia* woodland communities and improved pastures. The floristic composition is generally consistent within each of the mapped units, with some disturbance from fire, cattle grazing, ringbarking and exotic weeds being evident throughout (NRC, 2018b).

1.1.5.1 Threatened flora species

No threatened or near threatened flora species (as listed under the EPBC Act or NC Act) were identified during the vegetation surveys, despite targeted surveys in suitable habitat (NRC, 2018b).

1.1.5.2 Pest species

The number of pest flora species observed within the study area was moderate, comprising around 17.1% of total flora species identified. Although a moderate diversity of pest species was recorded, some (Buffel Grass, Mimosa Bush and Parthenium) formed dense scattered communities found throughout the study area (NRC, 2018b).

Significant weed species recorded include Parthenium, Common Pest Pear (*Opuntia stricta**), Prickly Pear (*Opuntia tomentosa**) and Harrisia Cactus (*Harrisia martinii**), which are restricted invasive plants under the *Biosecurity Act 2014*. Parthenium and Mimosa Bush were recorded throughout the study area on the margins of watercourses and drainage features (NRC, 2018b).

2. Fauna species

Numerous fauna species were identified within the study area over the survey periods using a variety of different observational and trapping techniques. The following sections provide a brief discussion of the species observed for each taxonomic group.

2.1 Mammals

A total of 30 species of mammals were recorded within the study area over the survey periods. The assemblage recorded is typical of similar habitat types in the region and the species recorded are generally common. Bats showed the greatest diversity of all mammal groups, with at least 13 and as many as 16 species identified from call data collected. While some calls could not be clearly distinguished between several species, most of these species are not listed as threatened or near threatened under the NC Act or EPBC Act (NRC, 2018b).

No mammals listed as near threatened or threatened were observed within the study area; however, evidence of the Short-beaked Echidna (*Tachyglossus aculeatus aculeatus*, listed as special least concern under the NC Act) was observed in the form of termite mound excavation at fauna trapping site 3 in the southwest of the study site (NRC, 2018b).

There are no habitat features unique to the study area on which this species would be relying, and the area does not represent a link between other habitat areas. It is unlikely that any disturbance within the study area would result in:

- a long-term decrease in the size of the local population
- a reduced extent of occurrence of the species
- fragmentation of the existing population
- the formation of genetically distinct populations because of habitat isolation
- disruption to ecologically significant locations for the species.

It is therefore unlikely there would be any significant impacts to the Short-beaked Echidna because of the proposed development.

2.2 Reptiles

Nineteen species of reptiles from eight families were observed within the study area. All these species are common and widespread throughout similar habitats within the broader region.

No evidence of any reptiles listed as near threatened or threatened was observed within the study area (NRC, 2018b).

2.3 Amphibians

Eleven amphibian species from three families were recorded within the study area, all of which are common and widespread in the local area. Most native amphibian observations were restricted to areas adjacent to permanent water or within larger watercourses.

The majority of recorded frog species were actively calling during the 2017 survey period and the majority of species were active after a small amount of rainfall during the 2018 survey.

The introduced Cane Toad (*Rhinella marina**) was encountered near drainage lines and other water sources throughout the study area. No amphibians listed as near threatened or threatened were identified during the survey periods (NRC, 2018b).

2.4 Birds

A total of 77 species of bird were observed within the study area during the survey period. This species assemblage includes a number of both sedentary and nomadic species. The majority of species observed are common in similar habitats throughout the region. No threatened or near threatened bird species were observed during the survey program. However, some locally occurring threatened bird species have the potential to occur within the study area, but it is unlikely that the proposed disturbance will affect individuals or populations of these species (NRC, 2018b).

2.5 Pest species

Eight invasive fauna species were identified during the fauna surveys, all of which commonly occur in disturbed habitats throughout Queensland. The following species were observed within the study area:

- Common Myna (*Acridotheres tristis**)
- European Rabbit (*Oryctolagus cuniculus**)
- Wild Boar (*Sus scrofa**)
- House Mouse (*Mus musculus**)
- Cane Toad (*Rhinella marinus**)
- Feral Cat (*Felis catus**)

Domestic Cattle (*Bos Taurus**) and Horses (*Equus caballus**) were also recorded within the study area and likely impact native fauna through competition and destruction or modification of habitat (NRC, 2018b).

3. Closure Obligations and Commitments

3.1 Statutory obligations

There are a number of legislative frameworks that are relevant to the closure and rehabilitation of the FHCP that require consideration during planning and undertaking of closure and rehabilitation activities and include (but are not limited to):

- *Environmental Protection Act 1994*
- *Environmental Regulation 2008*
- *Environmental Protection (Waste) Policy 2000*
- *Environmental Protection (Waters) Policy 2009*
- *Environmental Protection (Air) Policy 2008*

- *Mineral Resources Act 1989* and Regulations
- *Nature Conservation Act, 1992*
- *Vegetation Management Act, 1999.*

3.1.1 Environmental Protection Act 1994 and Regulations

Environmental Protection Act 1994 (EP Act) and *Environmental Protection Regulation 2008* (EP Reg) are administered through the Queensland Department of Environment and Science (DES), and which issues EAs related to mining and/or petroleum activities. This regulation specifically governs rehabilitation for mining and principles on prevention of environmental harm. Section 125(1)(l)(i)(e) of the EP Act describes the requirements of applications for site specific or variation environmental authority which includes details for how the land the subject of the application will be rehabilitated after each relevant activity ceases. The administering authority must be satisfied with the rehabilitation before it can certify progressive rehabilitation for part of a mining project or accept the surrender of an EA for the whole or part of a project.

Section 264 of the EP Act states that in order to achieve lease relinquishment, a final rehabilitation report must be submitted to the administering authority. The administering authority will assess the report and determine whether the conditions of the EA and closure criteria have been achieved before approving the surrender application.

3.1.2 Mineral Resources Act 1989 and Regulations

The *Mineral Resources Act 1989* (MR Act) and *Mineral Resources Regulation 2013* are mainly administered through the Queensland Department of Natural Resources, Mines and Energy (DNRME). This Act provides a framework to regulate mining tenures and royalties and requires remediation of mines, boreholes, infrastructure and associated disturbance areas.

Under the *Environmental Protection and Other Legislation Amendment Act 2000*, provisions in the MR Act relating to environmental management of mines were transferred, with amendments, to the EP Act. An application to surrender or a mining lease will only be processed after the EA over the subject area has been surrendered.

3.1.3 Mineral and Energy Resources (Financial Provisioning) Act 2018) (MERFP)

The Queensland Government has been working to improve rehabilitation and financial assurance outcomes in the resources sector through a reform package. In November 2018, the *Mineral Energy Resources (Financial Provisioning) Bill 2018* was passed. The now Act has two main purposes:

1. *To create the Mineral and Energy Resources (Financial Provisioning) Act 2018 that establishes a financial provisioning scheme to deal with the environmental impacts of resource activities; and*
2. *To amend the Environmental Protection Act 1994 to introduce the new requirements for plans for the progressive closure and rehabilitation of mined land.*

The Act proposes to introduce a new requirement for Progressive Rehabilitation and Closure Plans (PRCPs) to maximise progressive rehabilitation and provide for meeting rehabilitation conditions to allow surrender of EAs. The outcome of the process is a stand-alone PRCP schedule, approved by the administering authority, which will contain milestones with completion dates for achieving progressive rehabilitation of all existing and future mining operations and associated mining activities.

Non-use management areas (NUMAs) are identified as those that cannot sustain a post-mining land use after rehabilitation is ended. NUMAs will have management milestones (significant events or steps necessary to achieve best practice management of the area and minimise risks to the environment) while other areas will have rehabilitation milestones (significant events or steps necessary to rehabilitate the land to be safe and structurally stable, ensure no environmental harm by anything on or in the land and sustain a post-mining land use).

PRCPs will be publicly available and include rehabilitation activities and duration, information on the consultation process (including planned consultations), the post-mining land use, and rehabilitation strategies.

3.2 Closure guidance and reference material

Several guidance documents have been referred to in the development of the Fairhill Coal Project Mine Closure Plan and include:

- Australia and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resources Management Council of Australia and New Zealand (ARMCANZ) – Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC & ARMCANZ, 2000).
- Guidelines for preparing mine closure plans, May 2015 (Department of Mines and Energy (DME), 2015).
- International Council on Mining and Metals – Planning for integrated mine closure: toolkit (ICMM, 2008).
- Leading practice sustainable development program for the mining industry: A guide to leading practice sustainable development in mining (Department of Resources, Energy and Tourism, 2011).
- Leading practice sustainable development program for the mining industry: Mine closure and completion (Department of Foreign Affairs and Trade (DFAT), 2016a).
- Leading practice sustainable development program for the mining industry: Mine rehabilitation (DFAT, 2016b).
- Leading practice sustainable development program for the mining industry: Risk assessment and management (DFAT, 2016c).
- Strategic Framework for Mine Closure (Australian and New Zealand Minerals and Energy Council, 2000).
- Eligibility Criteria and Standard Conditions for Exploration and Mineral Development Projects (DES, 2016)
- Rehabilitation Requirements for Mining Resource Activities (DES, 2014)
- Final rehabilitation report for resource activities other than mining (DES 2016)
- National Strategy for Ecologically Sustainable Development (COAG 1992)
- Technical guidelines for the environmental management of exploration and mining in Queensland (DME, 1995)
- Environmental Offsets Policy 2011
- Planning for Integrated Mine Closure Toolkit (ICMM 2008)
- Strategic Framework for Mine Closure (ANZMEC 2000)
- Leading Practice Sustainable Development Program for the Mining Industry – Mine Closure, Mine Rehabilitation and Tailings Management (Commonwealth Department of Resources and Northern Australia and Foreign Affairs 2016)
- A Guide to Leading Practice Sustainable Development in Mining 2011

- Enduring Value (2015)
- Australian Coal Association Research Program (ACARP) Guidelines and Reports
- International Financial Reporting Standards (IFRS)
- Best Practice Environmental management in the Mining Industry Series

3.3 Closure commitments

The Fairhill Coal Project Mine Closure Plan is considered a live document that will undergo annual review and continuous improvement throughout the FHCP mine life with detail increasing as the mine moves towards closure. Figure 1 provides an overview of the mine closure planning process as outlined in *Guidelines for preparing mine closure plans* (DME, 2015) and adapted from DFAT (2016a, 2016b, 2016c) and ICMM (2008).

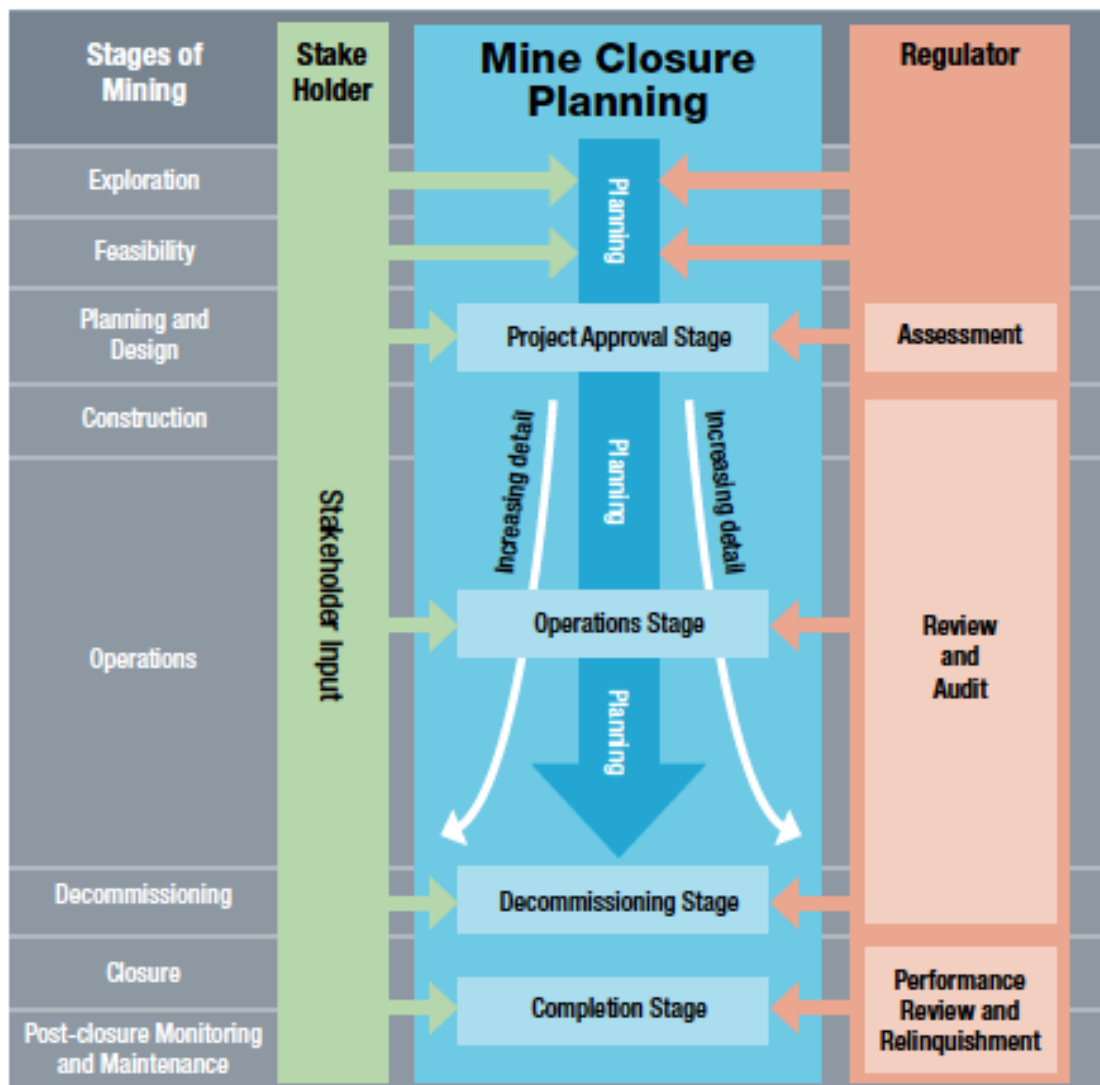


Figure 2 Integrating stages of mining and mine closure planning
(adapted from DITR 2006, ICMM 2008)

Figure 1: Overview of the mine closure planning process (DME, 2015).

It's acknowledged that with the changes in the current legislative system surrounding mine closure, the introduction of the *Mineral and Energy Resources (Financial Provisioning) Act 2018* will influence the closure planning process in the future. This plan has been developed prior to the commencement of relevant provisions of the MERFP Act, therefore will undergo revision as the closure planning process evolves.

3.4 Stakeholder engagement

3.4.1 Identified stakeholders and interested parties

A list of stakeholders relevant to the FHCP is provided in **Table 5**. This list will be reviewed and further developed during the establishment of the stakeholder consultation and closure committee.

Table 5: Identified stakeholders for the FHCP

STAKEHOLDER	ASSOCIATION
Peter and Denise Comiskey (Lyra Park)	Landholder
Kerry Hayes (Mayor)	Central Highlands Regional Council
Gail Godwin-Smith (Deputy Mayor)	Central Highlands Regional Council
Daniel Fletcher (General Manager Communities)	Central Highlands Regional Council
Ergon Energy	Regional power provider
Local schools and educational facilities	
Regional residents and local community	
Health care and Emergency services	
Traditional owners	Western Kangoulou people
Neighbouring landholders	

3.4.2 Stakeholder consultation and closure committee

To effectively co-ordinate stakeholder consultation and planning for the closure of the FHCP, the establishment of a closure committee is required. The committee will include key Fairhill Coking Coal Pty Ltd personnel in the closure process as well as interested, potentially affected stakeholders and community members and will be established in the short term (i.e. within the first year of operations).

The scope of the committee is to provide a forum for community members, groups and/or organisations with a strong interest in the mine closure process undertaken by Fairhill Coking Coal Pty Ltd to receive regular updates on activities and processes and provide feedback in relation to the closure of the FHCP. Suggested committee members include, but not limited to, the following:

- Fairhill Coking Coal Pty Ltd General Manager (Chairperson).
- Fairhill Coking Coal Pty Ltd Community Liaison.
- Fairhill Coking Coal Pty Ltd Environmental Adviser.
- Fairhill Coking Coal Pty Ltd earthworks contractor representative.
- Local traditional owners.

- Interested stakeholders including (but not limited to) those listed in Table 5.

In the event of mine closure, whether that be planned, unplanned or a temporary transition into care and maintenance, there is a palpable effect on project stakeholders that is best managed by the proponent. Implementation of a stakeholder consultation plan can assist the mine operator in managing their social responsibility.

3.5 Cultural heritage

The Western Kangoulu people are the traditional owners of lands underlying the proposed FHCP area. The Western Kangoulu people's Traditional Country is the area surrounding Emerald. They currently have a registered Native Title Claim (QC2013/002) over this area. This claim replaces previous claims in place including QC98/25 and QC99/6. Lumburra Bimbi is the corporate identity for the Western Kangoulu people. Lumburra Bimbi recognises the land under the title claim for the Western Kangoulu people is heavily disturbed by the mining and energy sectors. Under the previous iteration of the FHCP, representatives from Lumburra Bimbi were involved extensively in cultural heritage search and clearance for exploration drilling areas around EPC 2177, which included the area around the proposed disturbance. Engagement of the Western Kangoulu people will be a key component of mine closure and inclusion and input will be sought as part of the stakeholder closure committee and closure success.

4. Post-Mining Land Use and Closure Objectives

4.1 Closure objectives

DES guideline *Rehabilitation requirements for mining resource activities* (DES, 2014) outlines a rehabilitation hierarchy similar to the waste hierarchy that has been considered when establishing post-mining land use and closure objectives. The hierarchy (from most preferred to least preferred) is:

- Avoid disturbance that will require rehabilitation
- Reinstatement a 'natural' ecosystem as similar as possible to the original ecosystem
- Develop an alternative outcome that has a higher economic value than the previous land use
- Reinstatement previous land use (e.g. grazing)
- Develop lower land use
- Leave the site in an unusable condition or with a potential to generate future pollution or adversely affect environmental values.

4.2 Expected disturbance areas

The FHCP includes the following infrastructure items:

- Open cut pits (with in-pit dumps) referred to as 'open cut pit' in this report
- Out of pit overburden dumps referred to as 'overburden dump' in this report
- Access tracks and haul roads
- Water storage infrastructure
- Administration, workshop buildings, ROM pad, maintenance areas, etc.

An overview of the proposed disturbance areas is provided in **Table 6**. The total proposed disturbance as a result of the FHCP is 448.65ha.

Table 6: FHCP proposed disturbances

CLOSURE DOMAIN	DESCRIPTION	DISTURBANCE (ha)
Domain 1	Open cut pit (incl. in-pit dumping)	322.62
Domain 2	Overburden dump	31.92
Domain 3	Access tracks and haul roads	78.02
Domain 4	Water storage infrastructure	5.76
Domain 5	Mine infrastructure, including site office, ROM pad and workshop buildings	10.28
Total		448.65

4.3 Closure domains

To assist in planning for rehabilitation, the FHCP has been segregated into the following mine domains as shown in Figure 2:

- Domain 1: Open cut pit
- Domain 2: Overburden dump
- Domain 3: Access tracks and haul roads
- Domain 4: Water storage infrastructure
- Domain 5: Mine infrastructure, including site office, ROM pad and workshop buildings.

Each of these domains will require rehabilitation works and associated costing for financial liability.

4.4 Post-mining land use

The regional land use in the Emerald area (including the FHCP) is generally rural with some coal mining activities. Review of historical land uses has identified grazing activities as the primary land use within the FHCP area with significant land clearing for pasture improvement identified to have occurred.

The proposed post-mining land use for the FHCP is grazing. Refer Figure 3 for the Post Closure Land Use Map.

For rehabilitation objectives to be appropriate for the site, the site has been separated into individual closure domains each of which need to be developed to fulfil the requirements of the proposed post closure land use.

Pending landholder negotiations some infrastructure may be retained post-closure for grazing purposes. Tracks, fences and yards may be retained to assist a grazing post closure land use. Clean water dams (for water storage and stock watering) may also be compatible with the proposed post closure land use and may form part of the infrastructure negotiated with landholder(s) for retention post closure.

Infrastructure, not compatible with the proposed post closure land use, will be dismantled and transported to a nearby site(s) for re-use or alternatively demolished and removed/disposed offsite.

Supporting infrastructure such as water pipelines, pumping infrastructure, and electrical infrastructure (i.e. powerlines) is also compatible with the proposed closure land use and may also remain if required by a future landholder(s). The details of infrastructure to be retained will be determined in the mine closure planning process.

For further detail on post mining land use and rehabilitation strategies, refer **Section 5.2**.

4.5 Rehabilitation goals and completion criteria

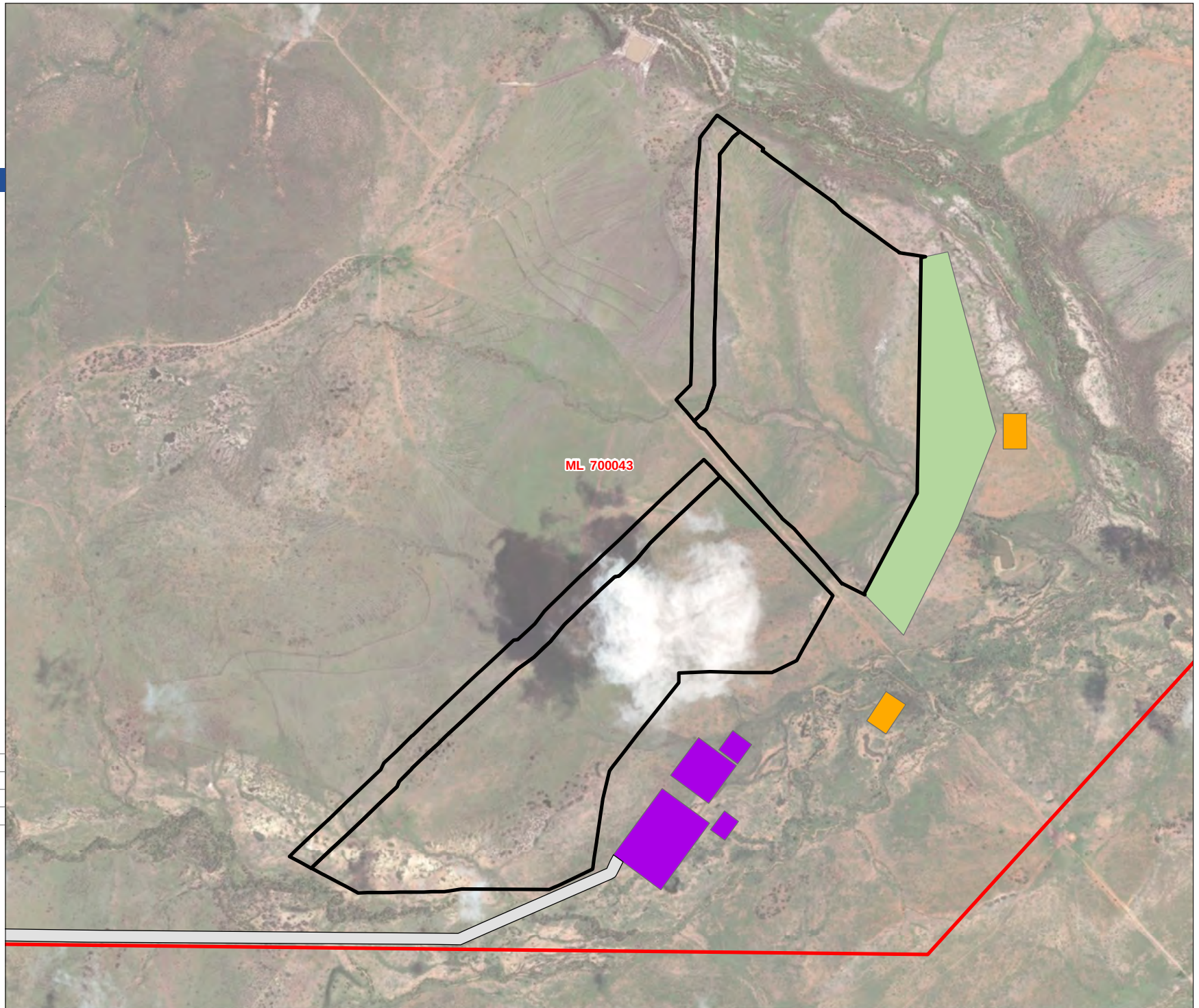
Completion criteria are important to ensure a clear definition of successful rehabilitation is established for each closure domain. Completion criteria for each domain aligning with the proposed post closure land use have been detailed in **Table 7**.

Fairhill Coal Project

Closure Domain Map

FIGURE 2

-  Open Cut Pit (Incl. backfilled pit voids)
-  Overburden Dump
-  Access tracks and haul roads
-  Water Storage Infrastructure
-  Mine infrastructure, including site office, ROM pad and workshop buildings
-  Mining Lease



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Projection: GDA94 MGA zone 55
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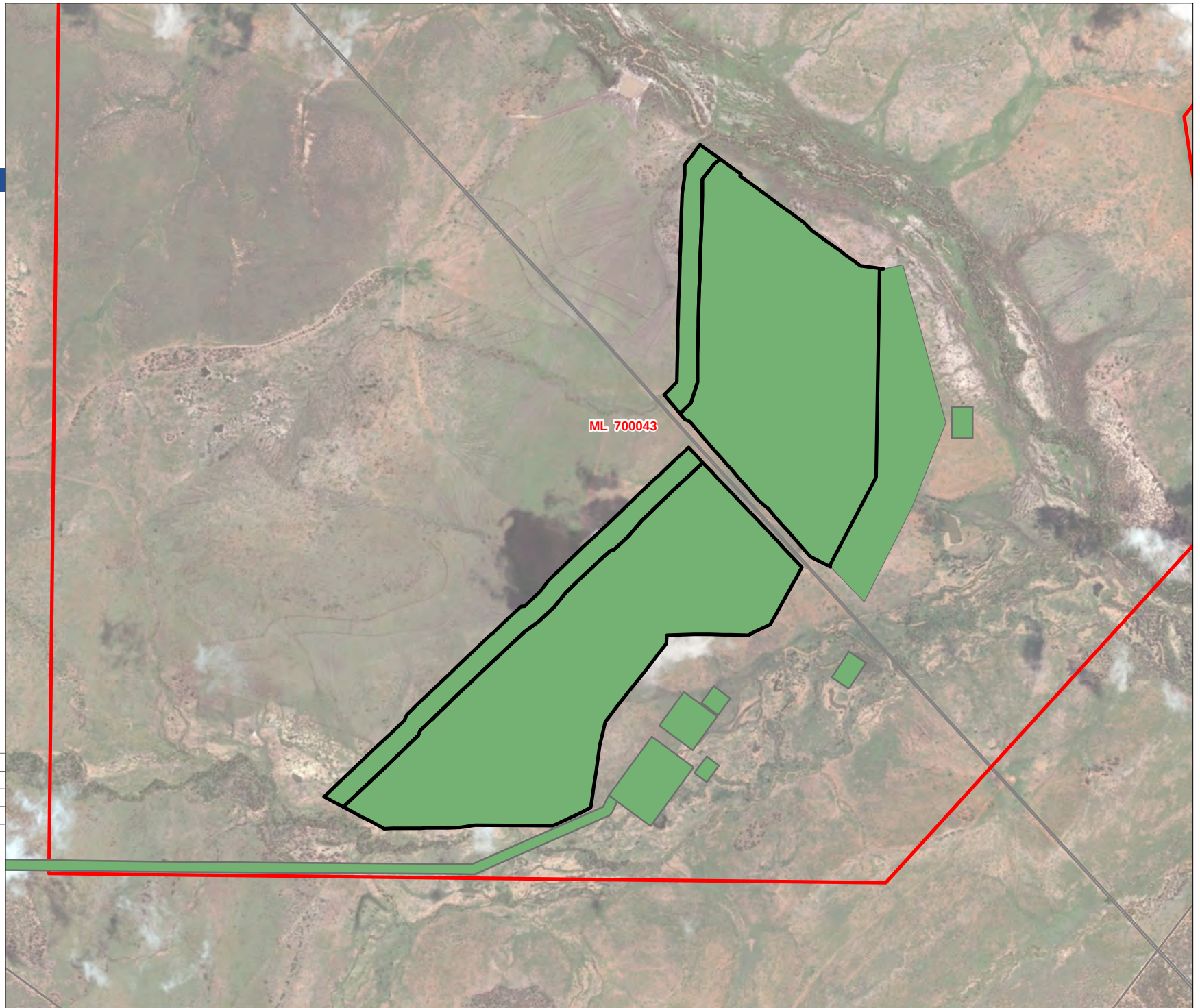


Fairhill Coal Project

Post-Closure Land Use

FIGURE 3

-  Open Cut Pit (Incl. backfilled pit voids)
-  Grazing Land
-  Mining Lease



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Table 7: Completion criteria for FHCP closure domains

DOMAIN	REHABILITATION GOAL	REHABILITATION OBJECTIVES	INDICATORS	COMPLETION CRITERIA
Open cut pit	Achieve the proposed post closure land use -	Pit slopes are geotechnically stable Achieve sustainable vegetation cover Surface water inside the pit suitable for grazing purposes	Slopes are geotechnically stable Stable non-erosive slopes Stable non-erosive surface areas (backfilled voids) Surface water quality	Achieve geotechnical stability demonstrated by geotechnical monitoring regime. LFA monitoring sites achieve comparable results to relevant analogue site(s) LFA monitoring sites achieve comparable results to relevant analogue site(s) Water quality in the pit achieve stock water quality demonstrated by surface water quality monitoring regime.
Overburden dump	Achieve the proposed post closure land use	Dump is geotechnically stable Achieve sustainable vegetation cover	Slopes are geotechnically stable Stable non-erosive slopes	Achieve geotechnical stability demonstrated by geotechnical monitoring regime. LFA monitoring sites achieve comparable results to relevant analogue site(s)
Mine infrastructure: Access tracks and haul roads	Achieve the proposed post closure land use	Mine infrastructure is removed (unless take over agreement is in place with the landholder) and suitable vegetation cover is in place	Stable non-erosive areas	LFA monitoring sites achieve comparable results to relevant analogue site(s)

DOMAIN	REHABILITATION GOAL	REHABILITATION OBJECTIVES	INDICATORS	COMPLETION CRITERIA
Mine infrastructure: Water Storage Infrastructure	Achieve the proposed post closure land use	Mine infrastructure is removed (unless take over agreement is in place with the landholder) and suitable vegetation cover is in place	Stable non-erosive areas	LFA monitoring sites achieve comparable results to relevant analogue site(s)
Mine infrastructure: Site office, ROM pad, and workshop buildings	Achieve the proposed post closure land use	Mine infrastructure is removed (unless take over agreement is in place with the landholder) and suitable vegetation cover is in place	Stable non-erosive surfaces	Infrastructure that remains are taken over by the land owner as per agreement LFA monitoring sites achieve comparable results to relevant analogue site(s)

As part of the site operational procedures a geotechnical monitoring regime will be developed to monitor slope stability of the open cut pit and overburden dump. Monitoring will commence during operations and will continue throughout the life of the mine including closure and post closure. The geotechnical monitoring regime will be updated throughout the Life of Mine (LoM) to remain relevant. Geotechnical monitoring will play a key role in demonstrating stable land forms and achievement of specified closure criteria. The geotechnical monitoring regime will be developed and implemented by a suitable qualified individual.

As with the geotechnical monitoring, an LFA monitoring regime will also be developed as part of the site operational procedures. Relevant monitoring locations and analogue or reference sites will be identified and monitored during the operational phase of the mine. LFA monitoring will continue throughout the life of the mine including closure and post closure. The LFA monitoring regime will be updated throughout the LoM to remain relevant. LFA will play a key role in demonstrating stable non-erosive slopes and rehabilitated areas and associated vegetation communities able to sustain the proposed end land use. The LFA monitoring regime will be developed and implemented by a suitable qualified individual.

As part of the surface monitoring regime in pit water quality monitoring will also commence as part of the operational phase of the mine. The results of input water quality will be used as inputs into a water quality model to obtain insight into expected post closure surface water quality compared to stock water quality standards. Relevant monitoring locations will be identified and monitored during the operational phase of the mine. In pit surface water monitoring will continue throughout the life of the mine including closure. The in-pit surface water monitoring regime will be updated throughout the LoM to remain relevant. In pit water quality monitoring will play a key role in developing a surface water quality model demonstrating expected post closure water quality compared to stock watering water quality standards but also showing that stock watering water quality standards will be achieved post closure.

5. Progressive Rehabilitation and Closure

5.1 Progressive rehabilitation

The FHCP will be progressively rehabilitated to manage the overall disturbance generated at any one time. Review of environmental data (e.g. groundwater, surface water, environmental monitoring data and audit outcomes) will be undertaken during the progressive rehabilitation process to ensure that progressive rehabilitation objectives are met and compliance with approvals requirements are managed (e.g. compliance with the site's Environmental Authority).

5.1.1 Acid producing rock

As outlined in the Overburden and Potential Coal Reject Characterisation Report (Northern Resource Consultants (NRC), 2018a) and summarised below, the assessment of the waste rock from a total of 27 samples with a varied spatial distribution and drill depth concluded that 100% of waste rock overburden and coal reject material associated with the planned mine operations were classified as non-acid forming. In addition to this finding, the sandstones and siltstones inter-burden have a large acid neutralising capacity, which further limits the potential for acid production.

The above findings were supported by the geochemical analyses and classifications undertaken for FHCP in conjunction with geochemical analyses and classifications analysis investigations undertaken at surrounding mine sites (Ensham, Washpool and Wilton) that indicate there is negligible potential for acid rock drainage to occur.

All 27 overburden samples were subjected to initial acid-base account geochemical testing, specifically:

- pH (1:2)

- electrical conductivity (EC) (1:2)
- total sulfur (wt%)
- Australian standard leaching procedure metal concentrations
- bulk rock trace metals
- acid neutralising capacity
- net acid producing potential
- net acid generation pH 4.5
- net acid generation pH 7.

In addition, major ion analysis and heavy metal concentrations of EC 1:5 samples and a full metal suite of overburden samples were also conducted.

Findings from these assessments indicated that metalliferous runoff/seepage will not pose a problem to the receiving environment. The mobility of metals is greatly reduced by the alkaline conditions present within the overburden.

The leachate EC and pH of 1:2 analysis indicate that runoff/seepage associated with waste rock storage will be alkaline to moderately fresh. Salinity is not likely to pose a problem; however, specific actions for the management of alkaline waters may be necessary in the future.

5.1.2 Overburden management

The sandstones and siltstones inter-burden have a large acid neutralising capacity, therefore further limiting the potential for acid production. Metalliferous runoff/seepage has been assessed as not posing a problem; however, monitoring of specific actions for the management of alkaline waters may be necessary in the future.

The overburden from the initial box-cut strip (year 1) will be hauled and placed over the dozer push spoil out of pit dump. The out of pit dump will be run northeast to southwest adjacent to the year 1 mine path. The final design of the out of pit dump will incorporate best practice design while incorporating practical adaptations associated with the location of these features within the local landscape (including rock armouring for areas affected by flooding). Consideration of the final landform design will pay particular attention to slope angles and lengths with slope angles in the vicinity of 30 degrees and slope lengths less than 20m. The incorporation of berms and contour banks to control water runoff volumes and velocities will form part of both operational and final design. As the geochemical composition of the overburden is considered stable, the incorporation of concave slopes into the final landform may be possible to improve infiltration and the reduction of runoff thereby lowering the potential for side slope erosion. The height of the overburden dump will be kept to a minimum and will be designed to blend in with the surrounding landscape. As mentioned above, the slope angle of 30 degrees will typify those within the surrounding landscape.

Waste dump design trial(s) will be initiated in the first year of operations to trial appropriate slope angles and design to achieve a stable landform. Future iterations of the closure plan will reflect the information gathered during the trial(s) and it is likely that the proposed final landform design will be amended to reflect the learnings from these trial(s).

Following the construction of the out of pit overburden landform during the first year of mining operations, the remaining overburden to be stripped during subsequent mining years will be progressively backfilled into the year 1 void and subsequent voids during the steady state strip mining operations. The final landform will be a backfilled landscape that approximately mirrors the original topography (though slightly raised above the natural surface), creating a low-cost rehabilitated landform.

5.1.3 Site water management

As detailed in the Water Management Assessment report (ATC Williams, 2018), the current design of the final landform represents the extent of rehabilitation works on completion of mining activity. Following mine closure, (which included shaping and rehabilitation) of the final landform profile, surface water is expected to concentrate in the final depression(s) formed to the west of the rehabilitated in-pit dump. Inflows into the final landscape depression(s) would originate from the western slopes of the rehabilitated in-pit dump. The eastern slopes of the rehabilitated waste rock dump (WRD) would shed to the natural water courses draining to the east. Further assessment and monitoring of the final depression(s) is required to determine the expected long-term behavior and drainage; however, the risk of overtopping to either the Cooroora Creek to the north or Sandy Creek to the south has been assessed as extremely unlikely with the consequence of Harm to Humans, General Environmental Harm and General Economic Loss or Property Damage being assessed as Low (ATC Williams, 2018). The storage capacity within the depressions are considered to be in excess of the Probable Maximum Precipitation (PMP) event for the site and for this reason overtopping is considered extremely unlikely.

5.1.3.1 Residual voids (final voids)

As discussed in **Section 5.1.3**, it is possible for the final depressions to pool surface runoff naturally over time. Through ongoing mine planning and design, this would be minimised and where possible eliminated to provide a naturally draining structure whereby minimal water would pool.

If surface water pooling occur in the final depressions the water quality in the final depression(s) is expected to improve over time as the revegetated surfaces of the rehabilitated overburden dumps establish and mature, thus reducing the mobilisation of sediments and remnant salinity associated with the operational phase of the mine. Surface water levels in the depression(s) will be determined by the capacity of the Surface Water Dams (SWDs). Surface water in the depressions will be located in in-pit sumps (depending capacity) and will be pumped to the SWDs (again depending capacity) for treatment, cattle watering and/or release to the environment as appropriate.

Water quality monitoring and modelling will be undertaken during the operational phase of the mine to provide insight into post closure water quality and how it compares to stock water quality guidelines. The achievement of stock water quality post closure is aligned with grazing which is the current proposed post closure land use.

At this point in the project slope percentages less than 30 percent (approximately 17 degrees) are planned. It is assumed that slopes will be safe, geotechnical stable and able to sustain vegetation communities that will support the post closure land use. This assumption needs to be tested during operations through standalone slope trial(s) (likely associated with the ongoing trial(s) since Year 1 on the WRDs) or progressive rehabilitation. Geotechnical and LFA monitoring of this trial or progressive rehabilitated area(s) will provide insights into the sustainability of this landform from a post closure land use point of view. Results from this monitoring will be fed back into the closure planning process and appropriate corrective action implemented where needed. It is recognised that enormous differences in the erodibility of materials excavated during mining can alter management and the use of generic slope profile designs would unlikely to be consistently successful (DITR 2006). Lessons learnt from nearby mine sites such as Curragh, Ensham and Gregory-Crinum will be sought and employed at Fairhill.

A detailed analysis of alternative options to residual voids was not undertaken. Residual voids are an inevitable result of the employed mining method where the first year's waste/overburden is dumped in an out of pit waste dump. In consecutive years the void created by the prior years mining will be backfilled to the point where the final strip is reached. From this point of view in-pit dumping is maximised throughout the life of the mine, except the first year as there are no voids available to backfill. No overburden or waste will be available to fill the final strip except for the out of pit dumped overburden material stripped in Year 1. To remedy the final voids a cut/fill operation would be required to relocate the already rehabilitated and

stable waste dump into the final void. From an economic point of view this is not feasible as it would involve a significant rehandling cost.

Alternatively, to the significant rehandling cost described above, it is proposed that the final voids be sloped to less than 30 percent. By sloping the final voids to be less than 30 percent it is assumed that the slopes will be safe, stable and able to sustain vegetation communities to support the proposed post closure land use. At this point in time no additional stabilisation methods or safety controls are proposed. This may seem inappropriate, but it needs to be kept in mind that the final voids will only be created in year 7 of the project while progressive rehabilitation and slope trials will already start in Year 1. Lessons learned from onsite trial(s) and progressive rehabilitation will feed into the development of detailed closure plans for the voids which will render these landscaped depressions safe, stable and able to sustain the proposed post closure land use.

The final voids will not be used for water storage but will have the capacity to store water without overtopping in the case of the PMP flood event (ATC Williams, 2018). Water in the final pits will be confined to engineered design and constructed in-pit sumps. In the case of the design capacity of the sumps being exceeded by precipitation events the pit would act as a secondary containment without allowing for water to be discharged to the environment. Water from the in-pit sumps will be available for pumping to the SWDs for treatment/cattle watering /discharge to the environment.

Ongoing water quality monitoring will provide insight into in-pit water quality for comparison to stock watering quality standards. Ongoing water quality monitoring together with the need of the landholder post closure for stock watering dams will determine the presence of these in-pit sumps and associated water infrastructure in the final closure configuration. The option for continued use of in-pit water to sustain the proposed post closure land use is still considered a possibility.

Pit voids or the associated sloped depressions (post closure) will be located outside of the AEP (Annual Exceedance Probability) 1% flood zone. It is however evident that some areas of the final land form will be susceptible to flooding. The effect of flooding on these areas will be managed by flood protection bunds and armoured embankments (ATC Williams, 2018)

5.1.3.2 Drainage systems

The final landform design will consider shaping of effective drainage lines to shed surface runoff without causing erosion of the final land surface. During the establishment phase, this will likely comprise the construction of drains, landscaping and placement of a soil layer that is followed with revegetation. Slope trials(s) and lessons learned from progressive rehabilitation will feed into this process and the development of a detailed surface water management section in the closure plan.

Permanent drainage will be designed and constructed for long-term durability, which could include reducing gradients or providing erosion protection as required. Surface water runoff from the upstream catchment into the final voids will be managed by an engineered stormwater diversion system to prevent clean upstream surface water runoff from entering the pits. Upstream surface water run-off will be intercepted, and diverted for discharge to the environment (ATC William, 2018).

The conceptual end of life water management system prepared by ATC Williams (2019) is

5.1.4 Revegetation species

Broad ranges of native grasses were recorded with low abundance within the FHCP as detailed in the Terrestrial Flora and Fauna Technical Report (NRC, 2018b). Their presence demonstrates their suitability for these soil types, however, their low abundance is potentially a combination of selective grazing pressure and competition from Buffel Grass (*Cenchrus ciliaris*).

The following native grasses are recommended for rehabilitation; however, it is understood that the availability of commercial quantities of seed may be limited for some species:

- *Ancistrachne uncinulata* (Hooky grass)
- *Aristida calycina* (Dark Wiregrass)
- *Astrebla squarrosa* (Bull Mitchell Grass)
- *Cymbopogon refractus* (Barbwire Grass)
- *Dactyloctenium radulans* (Button Grass)
- *Enneapogon lindleyanus* (Wirey nineawn)
- *Eriachne mucronata* (Mountain Wanderrie Grass)
- *Heteropogon contortus* (Black Speargrass)
- *Themeda triandra* (Kangaroo Grass).

The stockpiling of topdressing materials for use in rehabilitation will facilitate retention of the woody plant seed bank, however, this seed bank is also likely to be dominated by seeds of the dominant aggressive pasture grasses and its use is likely to substantially reduce the effectiveness of any direct seeding with native grasses.

The use of Indian Couch (*Bothriochloa pertusa*), while not ideal, is not incompatible with the establishment of other native plant species; however, Buffel Grass is likely to outcompete native species and should be avoided. Regrowth of exotic pasture grasses should be managed through the use of selective herbicides prior to any direct seeding efforts in rehabilitation areas and should be incorporated into rehabilitation activities.

The following woody species are recommended for rehabilitation:

- *Acacia harpophylla* (Brigalow)
- *Acacia shirleyi* (Lancewood)
- *Alstonia constricta* (Bitterbark)
- *Atalaya hemiglauca* (Whitewood)
- *Carissa lanceolata* (Currant Bush)
- *Enchylaena tomentose* (Ruby Salt Bush)
- *Terminalia oblongata* (Yellow Wood).

Woody species will not be used in the rehabilitation of the high-risk cap as the presence of roots may cause preferential flow paths and enhance infiltration of surface water into the TSF.

The above species of trees and shrubs are recommended on the basis that they were commonly encountered on a variety of landforms and regional ecosystems within the FHCP, and would therefore be most tolerant of local conditions, and would result in vegetation communities that more closely resemble current vegetation communities present onsite. The sowing rates and species mixes to be used during revegetation will be determined based on consultation with stakeholders, future land holders and rehabilitation trials/progressive rehabilitation outcomes. Rehabilitation will aim to achieve similar density and abundance of species to what is currently found onsite pre-mining and be monitored against analogue sites. Revegetation to achieve grazing as the current proposed post closure land use is envisaged.

Monitoring and analogue LFA sites will be identified in the first year of operation. LFA monitoring sites will be amended (if required) through the LoM to adequately monitor progressive rehabilitation success and eventually rehabilitation success at closure and post closure.

5.1.5 Management of pests and weeds

The management of pests and weeds across the site will be undertaken through implementation of a pest and weed hygiene management plan. The plan will include but not limited to the following control measures:

- Prior to entering the site all vehicles and equipment must have been cleaned and certified weed free;
- Soil and plant-based materials that are to be brought onsite are to be certified as weed free by the supplier (e.g. accompanied by a Queensland Government weed hygiene declaration form or similar); and
- Regular site inspections of disturbed and rehabilitated areas will be undertaken to determine if weed establishment and proliferation is becoming an emergent issue a weed and pest control program to be implemented, if required.

5.2 Landform design and rehabilitation schedule

A conceptual final landform has been modelled for the FHCP (year 7) and is shown in **Figure 4** and **Figure 5**. The view in **Figure 4** is from the south-east looking down the southern sloped depression while **Figure 5** shows the modelled conceptual final land form looking from the northern sloped depression down the southern sloped depression. It is also important to note that the modelled conceptual final landform has been superimposed on the actual location in the landscape. The surrounding landscape is relatively featureless with the elevated backfilled voids and sloped depression fitting well into this landscape.

Comparing the conceptual final landform with the existing elevated topographical feature situated on the mining lease but to the north-east of the conceptual final land form (refer arrow **Figure 4** for the location, and **Figure 6** for the comparison) it is clear that similar slope angles are present in both the conceptual and the natural land forms. This demonstrates the compatibility of the proposed final landform with the natural landscape.

Refer to **Figure 7** for a slope analysis of the conceptual final landform showing slope angles not exceeding 30 percent. Cross-sections of the conceptual final landform and the associated profiles are displayed in **Figure 8**. Please note that due to scaling, the longer profiles may appear to have steeper slopes exceeding 30 percent. This is however not the case, as demonstrated shown in the slope analysis no slopes in the conceptual final land form exceeds 30 percent.

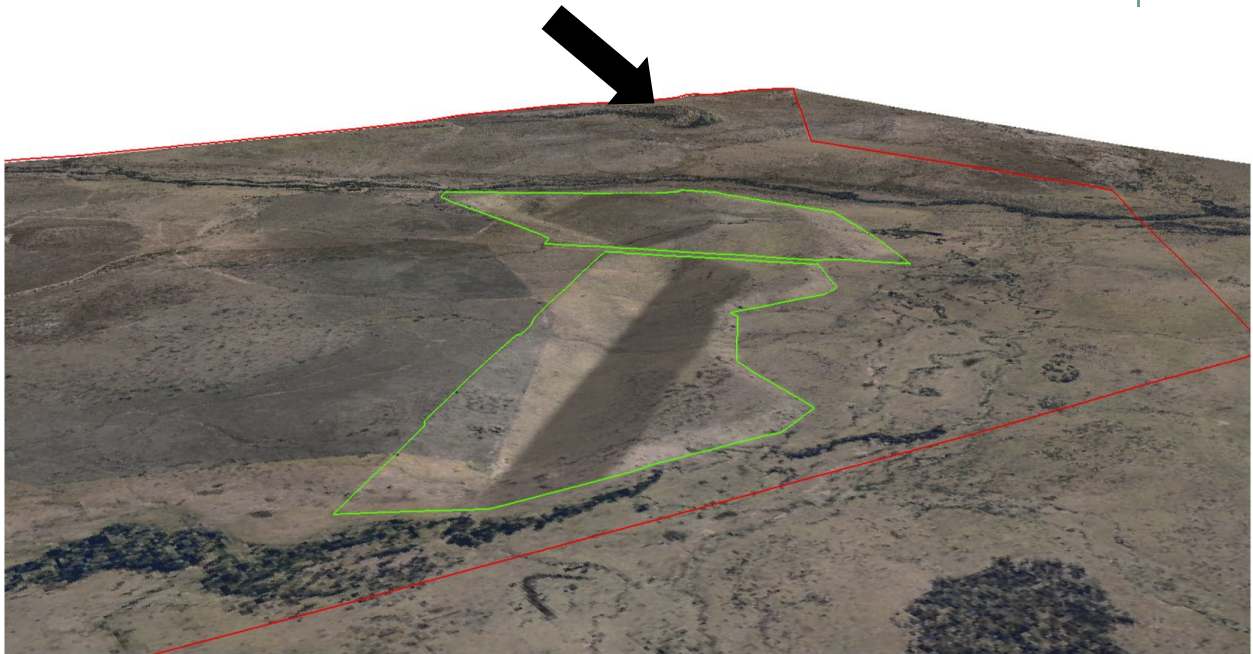


Figure 4 South-Eastern view of the Conceptual Final Landform



Figure 5 North-Western view of the Conceptual Final Landform

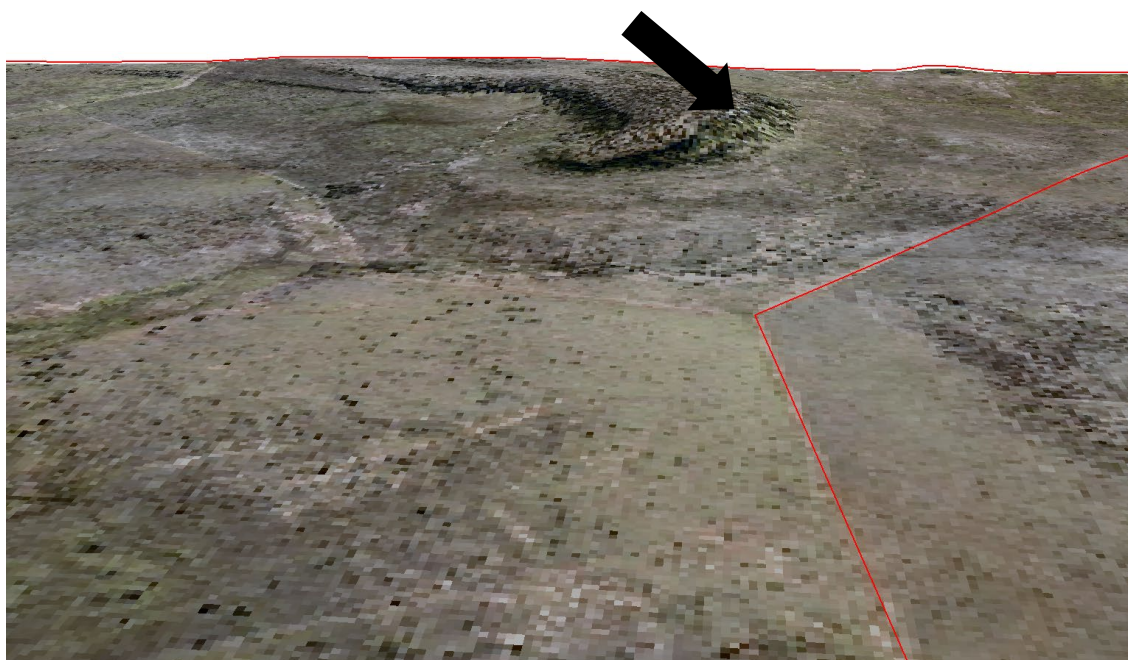
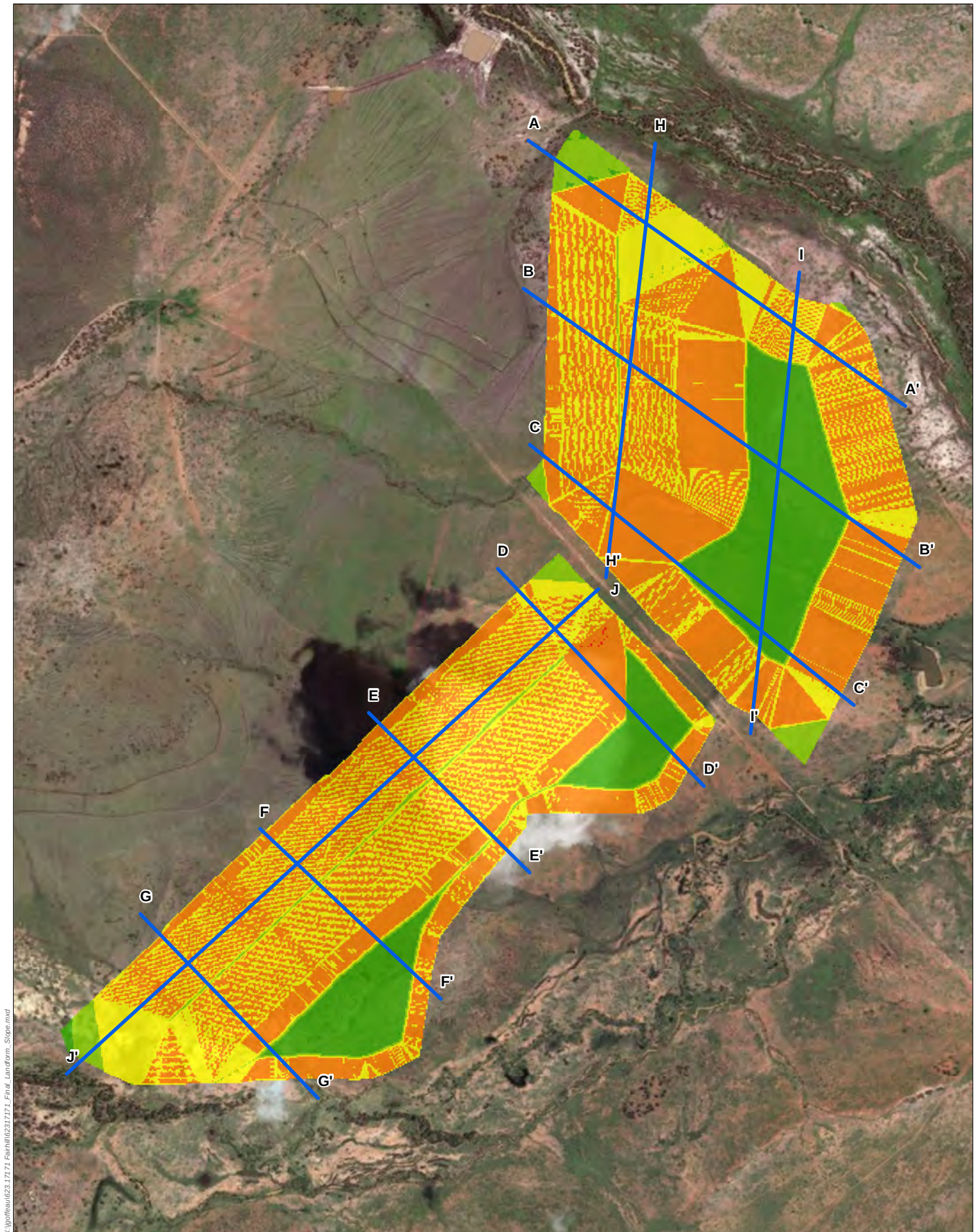


Figure 6 Slope Comparison to Natural Land Form

Progressive rehabilitation activities are described for each year of the LOM.

Surface areas relating to disturbance and associated topdressing strip volumes for each year of operation are detailed in **Table 8**.

Surface areas relating to progressive rehabilitation are included in **Table 9**. Activities within surface areas nominated for progressive rehabilitation include a combination of earthworks (e.g. bulk pushing, contouring, shaping of the overburden dump to final landforms), establishing appropriate drainage features and erosion and sediment controls (e.g. catch drains, berms), re-spreading of topdressing materials and establishment of vegetative cover (e.g. re-seeding). Surface areas nominated for progressive rehabilitation are indicative only and require on-ground assessment and confirmation throughout LoM. Further detail relating to rehabilitation activities is provided below.



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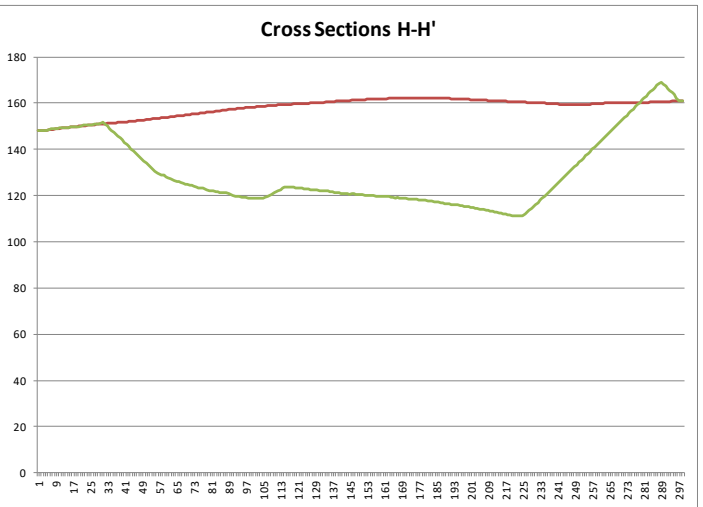
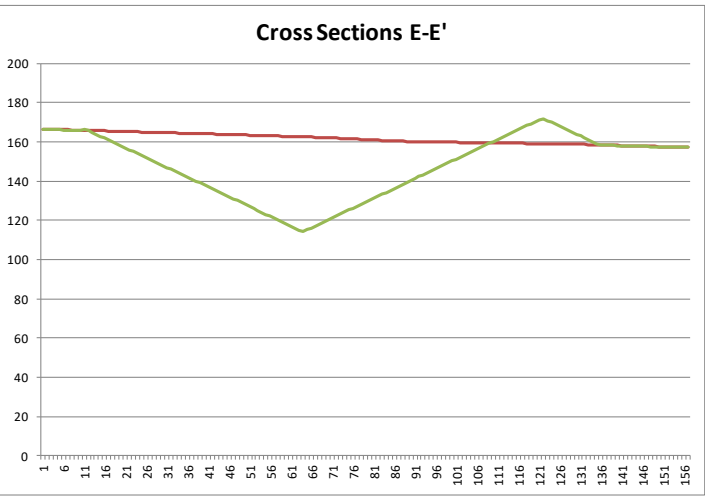
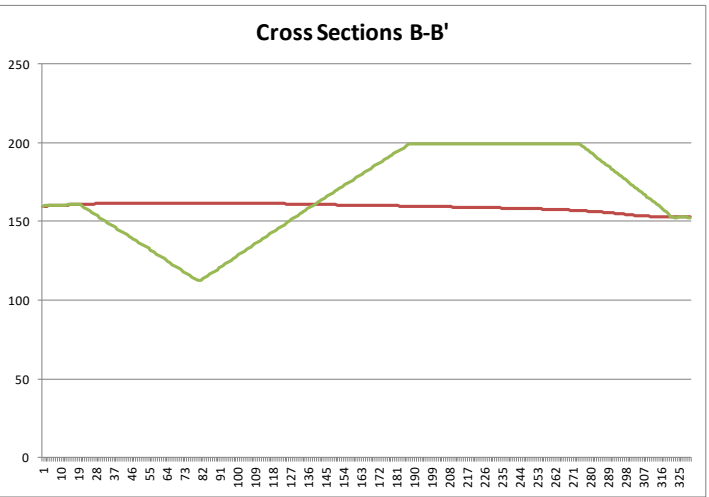
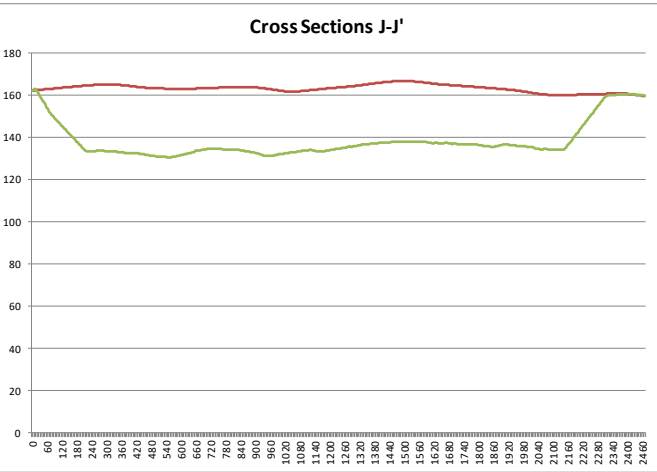
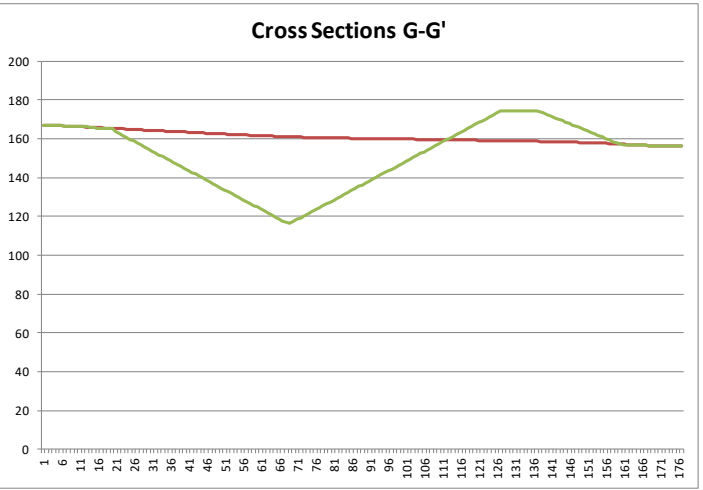
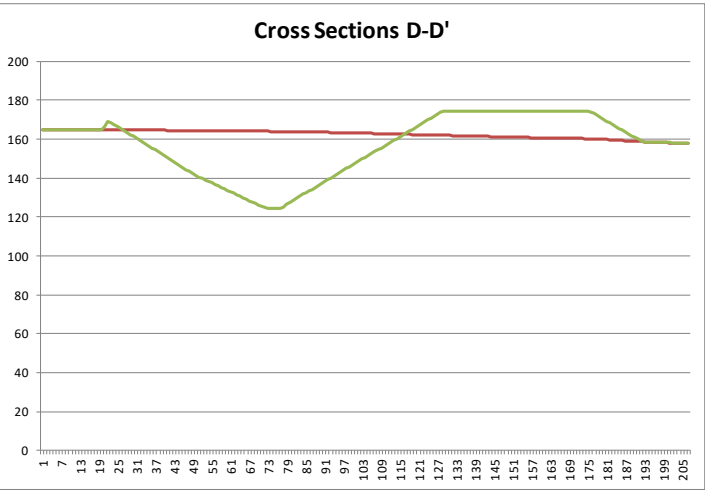
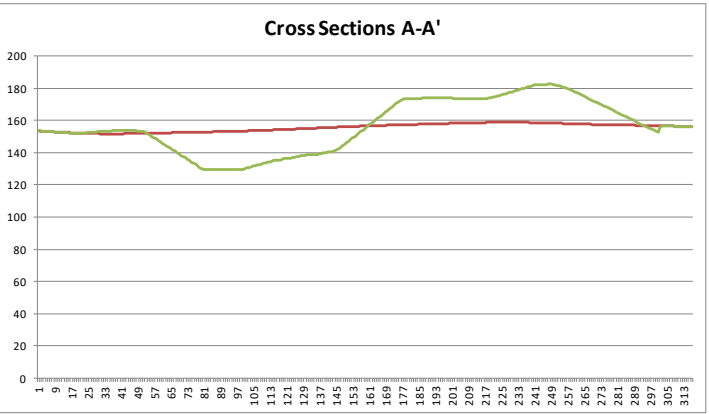
- Cross Sections
- Slope %**
- 0
- 0 - 10
- 10 - 20
- 20 - 30
- > 30

FAIRHILL MINE

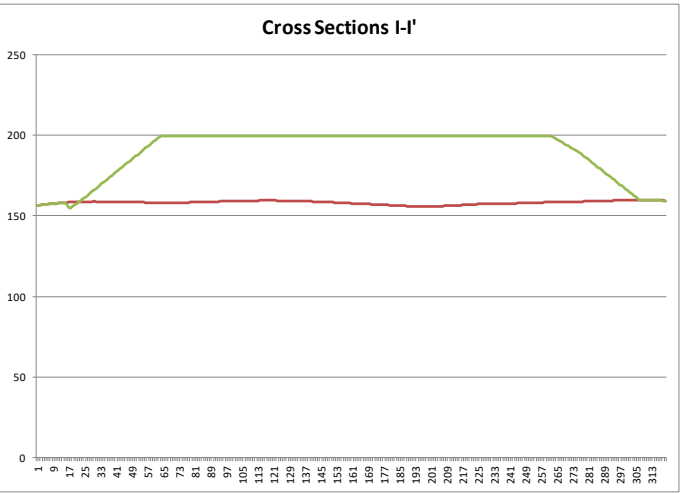
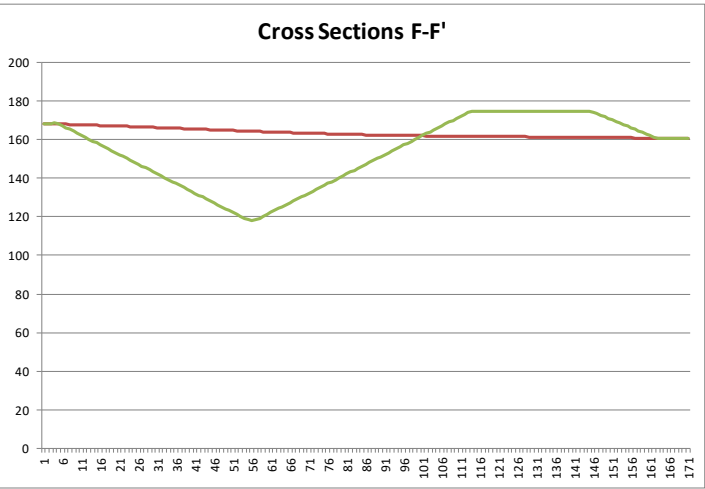
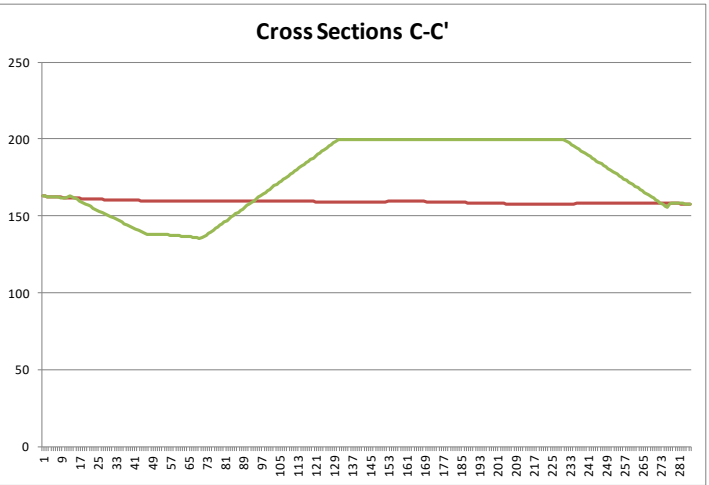
Final Landform

FIGURE 7

X:\gaffau\623-17171 Fairhill\62317171 Cross Sections Graphs.mxd



Graph scales differ (see accompanying figure for details)



Fri 05-Jul-2019

Sheet Size : A3



— Final Landform Elevation (mAHD)
— Existing Elevation (mAHD)

Note: all units are metres with cross section in west to east and north to south direction e.g. A to A'.

Fairhill Mine Final Landform Cross Sections

FIGURE 8

Table 8: Surface area disturbance and topdressing strip volumes for years 1-7 of the operation (indicative only)

YEAR	DISTURBANCE AREA (m ²)	TOPDRESSING STRIPPING DEPTH (m)	TOPDRESSING VOLUME (m ³)
Year 1	2,403,000	0.2	480,600
Year 2	520,850	0.2	104,170
Year 3	520,850	0.2	104,170
Year 4	520,850	0.2	104,170
Year 5	520,850	0.2	104,170
Year 6	520,850	0.2	104,170
Year 7	520,850	0.2	104,170

Table 9: Surface areas for progressive rehabilitation and associated topdressing volumes for years 1-7 of the operation (indicative only).

YEAR	REHABILITATION AREA (m ²)	TOPDRESSING RESPREAD DEPTH (m)	TOPDRESSING VOLUME (m ³)
Year 1	0	Not applicable	Not applicable
Year 2	520,850	0.2	104,170
Year 3	694,466	0.2	138,893
Year 4	694,466	0.2	138,893
Year 5	694,466	0.2	138,893
Year 6	1,121,600	0.2	224,320
Year 7	1,121,600	0.2	224,320

Refer **Section 1.1.4** for site representative soil quality information.

Throughout LoM (Life of Mine) opportunities will be pursued to identify/strip/stockpile subsoil material to supplement onsite topsoil volumes. Subsoil will be ameliorated/blended to supplement topsoil volumes where needed. It is likely that the subsoils associated with Red and Brown Dermosols will be better suited to supplement onsite topsoil volumes. Soil management practices will be captured in the PoO.

5.2.1 Year 1

As year 1 is the first year of operations, activities shall include the establishment of mine infrastructure, water storage infrastructure, access tracks and haul roads, clearing and grubbing of the initial proposed open cut pit area, stripping of topdressing resources prior to commencement of overburden extraction and strip mining.

Overburden material will be placed in an out of pit Waste Rock Dump (WRD). The WRD profile shall be designed to blend in with the surrounding landscape specifically from a height and slope angle perspective. The dump will also be designed and constructed to shed water while limiting erosion. Water

draining to the west from the WRD will be captured in a pit sump and pumped to SWD(s) for treatment, usage and/or discharge to the environment. Clean water runoff from the eastern side of the WRD will be allowed to shed offsite to the natural water courses. It is noted that operational management of the WRD will need to facilitate clean water drainage.

The stripped topdressing resources will be stockpiled separately and managed based on recommendations provided in the Fairhill Coal Project Soils and Strategic Cropping Land Assessment (NRC, 2018c). Management actions include (but are not limited to) stockpiling no higher than 3m (preferably no higher than 2m) and seeding of topdressing stockpiles with an appropriate cover species (e.g. Japanese Millet or Rye Grass).

LFA reference sites will be established within the first year of operations to provide suitable baseline reference for progressive rehabilitation and sign-off at closure. Additional to the establishment of the LFA monitoring/reference site locations, trial(s) will also commence to establish appropriate WRD configurations for a sustainable long-term landform.

The overall disturbance of the FHCP for year 1 is 240.30ha and includes 78.08ha associated with the haul roads.

5.2.2 Year 2

Activities for year 2 include the expansion of the open cut pit and the start of progressive backfilling of the initial void generated in year 1.

Progressive rehabilitation will commence and involve the shaping of initial out of pit overburden stockpiles and batters in accordance with the detailed Progress Rehabilitation and Closure Plan to be developed. Learnings from the ongoing trial(s) and progressive rehabilitation will feed into this process. Activities to prepare overburden berms and batters shall be carried out in anticipation of topdressing re-spreading.

Annual assessment of established LFA sites shall continue to be conducted to provide appropriate baseline data to inform rehabilitation activities and, where possible, monitor established rehabilitation sites. Evaluation of LFA sites shall also be conducted and, where necessary, additional sites included to allow for monitoring of rehabilitation success on overburden dumps. Trial(s) will commence to establish appropriate WRD configurations and rehabilitation methods for a sustainable long-term landform.

Rehabilitation tasks by domain

Domain 1: Open cut pit (incl. in-pit dumping)

Overburden material shall continue to be backfilled in-pit as the working front progresses. Backfilling of the open cut pit will minimise handling of overburden material and result in a reduced final disturbance footprint.

Domain 2: Overburden dump

Where the overburden profile has been established, activities to prepare berms and batters for topdressing respread shall be conducted (e.g. light roughening, preparation of drainage features, contouring, etc.). Erosion and sediment controls shall be established in accordance with the site Erosion and Sediment Control Plan and Water Management Assessment to ensure adequate drainage.

An assessment of the topdressing material physical and chemical status shall be undertaken to ensure that the topdressing material is supportive of revegetation. If necessary, management of topdressing through use of soil ameliorants (e.g. NPK fertiliser, gypsum, lime, etc.) shall be undertaken.

Once preparation of the overburden profile is completed, topdressing resources shall be respread to a depth of 0.2m. Topdressing material shall be lightly scarified and 'left rough' in preparation for seeding of select species.

Evaluation of LFA sites will be conducted and, where necessary, additional sites included to allow for monitoring of rehabilitation success on overburden dump and backfilled voids.

Domain 3: Access tracks and haul roads

Access tracks and haul roads shall remain established to support ongoing operations. No rehabilitation or closure activities are proposed.

Domain 4: Water storage infrastructure

Five water storages are to be operated to manage clean and dirty water onsite and shall be established to support ongoing operations. No rehabilitation or closure activities are proposed.

Domain 5: Mine infrastructure

Mine infrastructure (workshops, administration buildings, etc.) shall remain established to support ongoing operations. No rehabilitation or closure activities are proposed.

5.2.3 Year 3

Activities for year 3 include the expansion of the open cut pit and progressive backfilling of the year 2 void.

Progressive rehabilitation shall continue and will involve the backfilling and shaping of overburden within the year 1 void in accordance with the detailed Progressive Rehabilitation and Closure Plan. Activities to prepare overburden berms and batters shall be continued as areas become available for rehabilitation.

Annual assessment of established LFA sites shall continue to be conducted to provide appropriate baseline data to inform rehabilitation activities and, where possible, monitor established rehabilitation sites. Trial(s) will continue to establish appropriate WRD configurations and rehabilitation methods for a sustainable long-term landform.

Rehabilitation tasks by domain

Domain 1: Open cut pit (incl. in-pit dumping)

Overburden material shall continue to be backfilled as the working front progresses. Once preparation of the overburden profile is completed, topdressing resources shall be respread to a depth of 0.2m. Topdressing material shall be lightly scarified and 'left rough' in preparation for seeding of select species.

Domain 2: Overburden dump

Evaluation of LFA sites will be conducted and, where necessary, additional sites included to allow for monitoring of rehabilitation success on overburden dump and backfilled voids.

Domain 3: Access tracks and haul roads

Access tracks and haul roads shall remain established to support ongoing operations. No rehabilitation or closure activities are proposed.

Domain 4: Water storage infrastructure

Five water storages are to be operated to manage clean and dirty water onsite and shall be established to support ongoing operations. No rehabilitation or closure activities are proposed.

Domain 5: Mine infrastructure

Mine infrastructure (workshops, administration buildings, etc.) shall remain established to support ongoing operations. No rehabilitation or closure activities are proposed.

5.2.4 Year 4

Activities for year 4 include the expansion of the open cut pit and progressive backfilling and rehabilitation of year 3 void.

Progressive rehabilitation shall continue and will involve the shaping of overburden stockpiles and batters within the year 2 void in accordance with the Progressive Rehabilitation and Closure Plan. Activities to prepare overburden berms and batters shall be continued as areas become available for rehabilitation.

Annual assessment of established LFA sites shall continue to be conducted to provide appropriate baseline data to inform rehabilitation activities and, where possible, monitor established rehabilitation sites. Evaluation of LFA sites shall also be conducted and, where necessary, additional sites included to allow for monitoring of rehabilitation success on the overburden the dump and backfilled voids. Trial(s) will continue to establish appropriate WRD configurations and rehabilitation methods for a sustainable long-term landform.

Rehabilitation tasks by domain

Domain 1: Open cut pit (incl. in-pit dumping)

Overburden material shall continue to be backfilled as the working front progresses. Once preparation of the overburden profile is completed, topdressing resources shall be respread to a depth of 0.2m. Topdressing material shall be lightly scarified and 'left rough' in preparation for seeding of select species.

Domain 2: Overburden dump

Evaluation of LFA sites will be conducted and, where necessary, additional sites included to allow for monitoring of rehabilitation success on the overburden dump and backfilled voids.

Domain 3: Access tracks and haul roads

Access tracks and haul roads shall remain established to support ongoing operations. No rehabilitation or closure activities are proposed.

Domain 4: Water storage infrastructure

Five water storages are to be operated to manage clean and dirty water onsite to support ongoing operations. No rehabilitation or closure activities are proposed.

Domain 5: Mine infrastructure

Mine infrastructure (workshops, administration buildings, etc.) shall remain established to support ongoing operations. No rehabilitation or closure activities are proposed.

5.2.5 Year 5

Activities for year 5 include the expansion of the open cut pit and progressive backfilling of the year 4 void.

Progressive rehabilitation shall continue and will involve the shaping of overburden stockpiles and batters within the year 3 void in accordance with the Progressive Rehabilitation and Closure Plan. Activities to prepare overburden berms and batters shall be continued as areas become available for rehabilitation.

Annual assessment of established LFA sites shall continue to be conducted to provide appropriate baseline data to inform rehabilitation activities and, where possible, monitor established rehabilitation sites. Evaluation of LFA sites shall also be conducted and, where necessary, additional sites included to allow for monitoring of rehabilitation success on the overburden dump and backfilled voids. Trial(s) will continue to establish appropriate WRD configurations and rehabilitation methods for a sustainable long-term landform.

Rehabilitation tasks by domain

Domain 1: Open cut pit (incl. in-pit dumping)

Overburden material shall continue to be backfilled as the working front progresses. Once preparation of the overburden profile is completed, topdressing resources shall be respread to a depth of 0.2m. Topdressing material shall be lightly scarified and 'left rough' in preparation for seeding of select species.

Domain 2: Overburden dump

Evaluation of LFA sites will be conducted and, where necessary, additional sites included to allow for monitoring of rehabilitation success on overburden dump and backfilled voids.

Domain 3: Access tracks and haul roads

Access tracks and haul roads shall remain established to support ongoing operations. No rehabilitation or closure activities are proposed.

Domain 4: Water storage infrastructure

Five water storages are to be operated to manage clean and dirty water onsite to support ongoing operations. No rehabilitation or closure activities are proposed.

Domain 5: Mine infrastructure

Mine infrastructure (workshops, administration buildings, etc.) shall remain established to support ongoing operations. No rehabilitation or closure activities are proposed.

5.2.6 Year 6

Activities for year 6 include the expansion of the open cut pit and progressive backfilling of the year 5 void.

Progressive rehabilitation shall continue and will involve the shaping of overburden stockpiles and batters within the year 4 void in accordance with the Progressive Rehabilitation and Closure Plan. Activities to prepare overburden berms and batters shall be continued as areas become available for rehabilitation.

Annual assessment of established LFA sites shall continue to be conducted to provide appropriate baseline data to inform rehabilitation activities and, where possible, monitor established rehabilitation sites. Evaluation of LFA sites shall also be conducted and, where necessary, additional sites included to allow for monitoring of rehabilitation success on the overburden dump and backfilled voids. Trial(s) will continue to establish appropriate WRD configurations and rehabilitation methods for a sustainable long-term landform.

Rehabilitation tasks by domain

Domain 1: Open cut pit (incl. in-pit dumping)

Overburden material shall continue to be backfilled as the working front progresses. Once preparation of the overburden profile is completed, topdressing resources shall be respread to a depth of 0.2m. Topdressing material shall be lightly scarified and 'left rough' in preparation for seeding of select species.

Domain 2: Overburden dump

Evaluation of LFA sites will be conducted and, where necessary, additional sites included to allow for monitoring of rehabilitation success on overburden dump and backfilled voids.

Domain 3: Access tracks and haul roads

Access tracks and haul roads shall remain established to support ongoing operations. No rehabilitation or closure activities are proposed.

Domain 4: Water storage infrastructure

Five water storages are to be operated to manage clean and dirty water onsite to support ongoing operations. No rehabilitation or closure activities are proposed.

Domain 5: Mine infrastructure

Mine infrastructure (workshops, administration buildings, etc.) shall remain established to support ongoing operations. No rehabilitation or closure activities are proposed

5.2.7 Year 7

Activities for year 7 include the expansion of the open cut pit and progressive backfilling of the year 6 void.

Progressive rehabilitation shall continue and will involve the shaping of overburden stockpiles and batters within the year 5 void in accordance with the Progressive Rehabilitation and Closure Plan. Activities to prepare overburden berms and batters shall be continued as areas become available for rehabilitation.

Annual assessment of established LFA sites shall continue to be conducted to provide appropriate baseline data to inform rehabilitation activities and, where possible, monitor established rehabilitation sites. Evaluation of LFA sites shall also be conducted and, where necessary, additional sites included to allow for monitoring of rehabilitation success on the overburden dump and backfilled voids. Trial(s) will continue to establish appropriate WRD configurations and rehabilitation methods for a sustainable long-term landform.

Rehabilitation tasks by domain

Domain 1: Open cut pit (incl. in-pit dumping)

Overburden material shall continue to be backfilled as the working front progresses. Once preparation of the overburden profile is completed, topdressing resources shall be respread to a depth of 0.2m. Topdressing material shall be lightly scarified and 'left rough' in preparation for seeding of select species.

Domain 2: Overburden dump

Evaluation of LFA sites will be conducted and, where necessary, additional sites included to allow for monitoring of rehabilitation success on overburden dump and backfilled voids.

Domain 3: Access tracks and haul roads

Access tracks and haul roads shall remain established to support ongoing operations. No rehabilitation or closure activities are proposed.

Domain 4: Water storage infrastructure

Five water storages are to be operated to manage clean and dirty water onsite and shall be established to support ongoing operations. No rehabilitation or closure activities are proposed.

Domain 5: Mine infrastructure

Mine infrastructure (workshops, administration buildings, etc.) shall remain established to support ongoing operations. No rehabilitation or closure activities are proposed

5.2.8 Final landform design

Rehabilitation tasks by domain

The current conceptual final landform design is detailed in Figure 7, and represents the extent of rehabilitation associated with the proposed residual landscaped depressions and the out of pit

overburden dump. Clean water drainage is generally proposed to flow to the southwest or northeast (to the nearest watercourse) for discharge to the environment. In-pit water will be concentrated in in-pit sumps and pump to SWDs for treatment/usage and/or discharge to the environment. Final landforms shall be subject to stakeholder consultation, investigation works and detailed design, including assessment of water chemistry, surrounding environment and consideration of infrastructure to remain post-closure. Infrastructure to remain onsite for landholder use will be clarified, and formal agreements entered.

Domain 1: Open cut pit (incl. in-pit dumping)

The proposed final landform for the open cut pits is a landscaped depression capable of supporting grazing as a proposed post-closure land use. To achieve this final landform and outcome, a geotechnical and geochemical assessment shall be conducted to evaluate the long-term stability of the landform, ensuring that it is safe for humans and wildlife/livestock, non-polluting, stable and able to sustain the post-mining land use.

Domain 2: Overburden dump

The out of pit overburden dump profile will be finalised in accordance with the Progressive Rehabilitation and Closure Plan ensuring final landform design shall meet the objectives for rehabilitation including:

- Safe to humans and wildlife/livestock;
- Non-polluting;
- Stable; and
- Able to sustain an agreed post-mining land use.

Additional consideration will be given to the effectiveness of drainage system design, ensuring drainage is shaped to shed surface runoff without causing erosion to the final landform. Consolidation of erosion and sediment controls will be undertaken where permanent drainage controls are required to be constructed for long-term durability.

An assessment of the topdressing material physical and chemical status shall be undertaken to ensure that the topdressing material is supportive of revegetation. If necessary, management of topdressing through use of soil ameliorants (e.g. NPK fertiliser, gypsum, lime, etc.) will be undertaken. Blending with subsoil and/or amelioration of subsoil to supplement available topdressing will also be considered.

Annual assessment of established LFA sites shall continue to be conducted to provide appropriate baseline data to inform rehabilitation activities and, where possible, monitor established rehabilitation sites. Where rehabilitation has been identified to meet LFA requirements, rehabilitation objectives and stakeholder expectations, engagement with Department of Environment and Science (DES) shall be sought to commence relinquishment of lands as required.

Domain 3: Access tracks and haul roads

Review and discussion with the landholder(s) within the FHCP area shall be undertaken to assess which access tracks are to remain *in-situ* in support the proposed post-mining land use. Where there is no identified use for access tracks, rehabilitation shall be undertaken as follows:

- Deep rip of sub-soil layers to alleviate compaction;
- Shallow rip to alleviate compaction and prepare sub-soil for topdressing;
- Minor recontouring as required;
- Topdressing respread across ripped areas, left rough to 'key in' topdressing with sub-soil;
- Scarification of topdressing to promote aeration and infiltration into topdressing media; and
- Amelioration (if required) and seeding of topdressing material with the prescribed seed mix.

Haul roads utilised by the FHCP and not needed post closure will be rehabilitated using a similar methodology to access tracks.

Domain 4: Water storage infrastructure

Similar to access tracks and haul roads, review and discussion with the landholder(s) within the FHCP area shall be undertaken to assess which surface water dams and infrastructure (including in-pit sumps) are to remain *in-situ* in support of the post-mining land use. Where there is no identified use for these post closure they will be decommissioned, removed and disturbed areas rehabilitated.

Domain 5: Mine infrastructure

Mine infrastructure (e.g. workshops, administration buildings, etc.) not supporting the post closure land use and/or not wanted by landholders shall be deconstructed and removed from site. Demountable administration builds shall be removed and transported offsite and associated hardstand shall be removed. Compacted areas shall be rehabilitated in a similar fashion to access tracks and include:

- Deep rip of sub-soil layers to alleviate compaction;
- Shallow rip to alleviate compaction and prepare sub-soil for topdressing;
- Minor recontouring as required;
- Topdressing respread across ripped areas, left rough to 'key in' topdressing with sub-soil;
- Scarification of topdressing to promote aeration and infiltration into topdressing media; and
- Amelioration (if required) and seeding of topdressing material with the prescribed seed mix.

Workshop facilities shall be deconstructed and removed from site. Waste streams associated with workshop and operational activities (e.g. regulated wastes such as fuels and oils) shall be removed by an appropriately qualified third-party contractor. Associated hardstand areas shall be removed, and compacted areas rehabilitated in a similar fashion to access tracks including:

- Deep rip of sub-soil layers to alleviate compaction
- Shallow rip to alleviate compaction and prepare sub-soil for topdressing
- Minor recontouring as required
- Topdressing respread across ripped areas, left rough to "key in" topdressing with sub-soil
- Scarification of topdressing to promote aeration and infiltration into topdressing media
- Amelioration (if required) and seeding of topdressing material with the prescribed seed mix.

Infrastructure to be left *in-situ* will be identified through landholder consultation and a formal agreement entered.

6. Closure Risk Assessment

6.1 Risk assessment approach

For each of the identified potential impacts for the FHCP, a likelihood rating and consequence rating have been applied using the following matrix (**Table 10**). The initial risk rating has been determined prior to the implementation of control measures (**Table 11**). Control measures have been developed as required for the environmental risks to ensure that the level of risk is maintained at an acceptable level. The Risk Methodology applied has been developed based on the Australian and New Zealand Standard AS/NZS for Risk Management – Principles and Guidelines (ISO 31000:2009).

Table 10: Risk assessment matrix used for the FHCP

RISK ASSESSMENT MATRIX					
LIKELIHOOD OF OCCURRENCE	SEVERITY OF CONSEQUENCES				
	Catastrophic (5)	Major (4)	Moderate (3)	Minor (2)	Insignificant (1)
Almost certain (5)	10	9	8	7	6
Likely (4)	9	8	7	6	5
Possible (3)	8	7	6	5	4
Unlikely (2)	7	6	5	4	3
Rare (1)	6	5	4	3	2

Table 11: Assessment of risk scores for the FHCP risk assessment

RISK SCORE	RISK RATING	ACTION REQUIRED
9 – 10	Extreme	Immediate.
7 – 8	High	Action plan required. Senior management attention.
5 – 6	Moderate	Specific monitoring or procedures required.
2 – 4	Low	Management through routine procedures.

6.2 Result of environmental risk assessment

The risk assessment methodology outlined in the previous section was applied to closure aspects of the FHCP and the potential impacts were identified and rated. **Table 12** outlines the results of the environmental risk assessment and ratings allocated based on the methodology applied to the post-closure phase of the FHCP.

Table 12: Risk assessment for the FHCP for the post-closure phase of the project.

(L) = likelihood, (C) = consequence, (T) = total risk rating

EVENT / CIRCUMSTANCE	POTENTIAL IMPACT TO CLOSURE	RISK RATING			MITIGATION STRATEGIES/ CONTROLS	RESIDUAL RISK RATING			TREATMENT/ CONTINGENCIES	MONITORING ACTIVITIES
		(L)	(C)	(T)		(L)	(C)	(T)		
Post-closure										
Open pit	Geotechnical instability causes pit wall collapse, impacting stability of the surrounding landscape	4	3	7	Final pit walls will be reshaped to an angle that supports long-term geotechnical stability.	2	3	5	A geotechnical review of the site will be conducted if the pit integrity is seen to change during post-closure monitoring.	Post-closure monitoring will continue until site has been relinquished.
Open pit	Geotechnical instability poses a risk of harm to humans and wildlife/livestock	4	3	7	Final pit walls will be reshaped to an angle that support safe entry and egress to humans and animals.	2	3	5	A geotechnical review of the site will be conducted if the pit integrity is seen to change during post-closure monitoring.	Post-closure monitoring will continue until site has been relinquished.
Open pit	Geotechnical instability poses a risk of harm to humans and wildlife	4	5	9	Final pit walls will be reshaped to an angle that supports long-term geotechnical stability. Where safe egress and access is not possible signage/fencing and bunding to be installed as necessary.	1	5	6	In the event someone is injured after gaining access to the post-closure landforms and that access is deemed to not be the result of mischief, site access will be reviewed, and areas will be refenced/signposted to prevent access.	Post-closure monitoring will continue until site has been relinquished.
Open pit	Water quality does not meet ANZECC & ARMCANZ (2000) requirements for stock water	4	5	9	Current geochemical studies indicated limited potential for acid formation from both tailings and waste rock. Geochemical assessment to be conducted to support long-term pit water quality preferably stock water quality criteria.	2	3	5	A geochemical review of the site will be conducted if the water quality is seen to change during post-closure monitoring.	Post-closure monitoring will continue until site has been relinquished.
Overburden dump	Geotechnical instability causes slumping or erosion gullies, impacting the mobility of sediment and material off the dump surfaces into the surrounding landscape	4	3	7	The final overburden dump will be reprofiled to be in keeping with the surrounding landscape and be geotechnically stable. The dump will be shaped to shed water efficiently and to reduce the impact of erosion. The dump will be revegetated with local species in keeping with the surrounding landscape.	2	3	5	If the dump is deemed to be performing in a substandard fashion in terms of the level of erosion/material loss/sediment dispersion/revegetation, works will be undertaken to remediate the issue.	Post-closure monitoring will continue until site has been relinquished.
Overburden dump	Unsuccessful revegetation causes exposure of dump surface to erosive factors, resulting in sheet and rill erosion and sediment movement off the dump surface	4	3	7	The final overburden dump will be reprofiled to be in keeping with the surrounding landscape. The dump will be shaped to shed water efficiently to reduce the impact of erosion. Dump will be revegetated with a species in keeping with the surrounding landscape.	2	3	5	If the dump are deemed to be performing in a substandard fashion in terms of the level of erosion/material loss/sediment dispersion/revegetation, works will be undertaken to remediate the issue.	Post-closure monitoring will continue until site has been relinquished.
Vehicle movement	Vehicle movement from offsite to onsite and around rehabilitated areas during monitoring spreads weed seed	3	3	6	Vehicles must go through local wash down facilities before and after attending site.	2	3	5	If instances of weed spread are noted in revegetation monitoring post-closure, weed control procedures for monitoring contractors will be reviewed.	Post-closure monitoring will continue until site has been relinquished.

EVENT / CIRCUMSTANCE	POTENTIAL IMPACT TO CLOSURE	RISK RATING			MITIGATION STRATEGIES/ CONTROLS	RESIDUAL RISK RATING			TREATMENT/ CONTINGENCIES	MONITORING ACTIVITIES
Water management	Extreme rainfall event resulting in onsite water storages overtopping	4	5	9	Current studies indicate that the final voids will have enough capacity to buffer precipitation from the PMP event without overtopping to the environment. Post-closure water storage infrastructure and controls will be designed to manage a 1:100 ARI 1% AEP rainfall event. Post-closure water storage infrastructure to be designed and constructed by a suitably qualified person.	2	3	5	If capacity is considered to be insufficient to manage a 1:100 ARI 1% AEP rainfall event, a review of design and requirements shall be conducted by a suitably qualified person.	Post-closure monitoring will continue until site has been relinquished.
Water management	Seepage migration to groundwater	4	5	9	An appropriate groundwater monitoring program is to be developed and implemented by a suitably qualified person. The final voids will not be used for water storage, the engineered designed and constructed sumps however will store water. Installation of engineered containment and capture controls to be undertaken by a suitably qualified person. Depending on landholder(s) requirements in-pit sumps may be removed post closure.	2	3	5	If monitoring results indicate seepage migration to groundwater, an investigation shall be conducted by a suitably qualified person.	Post-closure monitoring will continue until site has been relinquished.
Flora	Failure of revegetation due to poor soil quality, poor soil pH, or the presence of soil contaminants / salts	3	3	6	Regular monitoring of soil quality and condition (qualitative and quantitative). Application of soil ameliorants (e.g. fertilisers) as necessary.	2	3	5	If instances of poor growth are noted in revegetation monitoring post-closure, weed control procedures for monitoring contractors will be reviewed.	Post-closure monitoring will continue until site has been relinquished.
Flora	Failure of revegetation due to native species becoming overwhelmed by weeds	3	3	6	Regular monitoring of vegetation condition (e.g. LFA surveys). Application of weed management strategies (e.g. herbicides) as necessary.	2	3	4	If instances of weed spread are noted in revegetation monitoring post-closure, weed control procedures for monitoring contractors will be reviewed.	Post-closure monitoring will continue until site has been relinquished.
Fauna	Risk of entrapment from design of final land forms Animals enter pits or climb dump and cannot exit the structures they have accessed	3	3	6	Designs of final landforms to consider animal access and egress. Regular inspections of landforms during development to identify animal entrapment.	2	2	4	If the dump are deemed to be performing in a substandard fashion in terms of the fauna entrapment, works will be undertaken to remediate the issue.	Post-closure monitoring will continue until site has been relinquished.
Contaminated land	Hydrocarbon spill <20L	5	3	8	Prestart inspections of machinery. Maintenance planning and scheduling. Spill kits located in machinery and regular maintenance.	2	2	4	In instances of high recurrence of spills, an investigation shall be conducted to determine the root cause.	Post-closure monitoring will continue until site has been relinquished.
Contaminated land	Hydrocarbon spill <100L	5	3	8	Removal of hydrocarbons prior to deconstruction of hydrocarbon storage tanks by a licence contractor. Spill kits located immediately adjacent to activities.	2	2	4	In instances of high recurrence of spills, an investigation shall be conducted to determine the root cause.	Post-closure monitoring will continue until site has been relinquished.
Contaminated land	Chemical spill <100L	5	3	8	Removal of chemicals prior to deconstruction of chemical storage tanks by a licence contractor. Spill kits located immediately adjacent to activities.	2	2	4	In instances of high recurrence of spills, an investigation shall be conducted to determine the root cause.	Post-closure monitoring will continue until site has been relinquished.
Pest management	Pest species impact rehabilitation success and biodiversity values	3	3	6	Implementation of a Pest Management Plan. Monitoring of rehabilitation areas for pest species.	2	2	4	Where pest species are identified within the Mining Lease, a plan to manage and remove pest species shall be implemented.	Throughout mine life and during post-closure monitoring until site has been relinquished.

EVENT / CIRCUMSTANCE	POTENTIAL IMPACT TO CLOSURE	RISK RATING			MITIGATION STRATEGIES/ CONTROLS	RESIDUAL RISK RATING			TREATMENT/ CONTINGENCIES	MONITORING ACTIVITIES
Weed management	Weed species impact rehabilitation success and biodiversity values	3	3	6	Implementation of a Weed Management Plan. Monitoring of rehabilitation for weed species. Ensuring weed hygiene procedures are developed and implemented.	2	2	4	Where weed species are identified within the Mining Lease, a plan to manage and remove weed species shall be implemented.	Throughout mine life and during post-closure monitoring until site has been relinquished.

7. Closure Monitoring and Maintenance

7.1 Collection and analysis of closure data

The collection and analysis of closure data for the FHCP is to provide evidence that the designed landscape is stable, with nutrient cycling and vegetation indices equal to or above those of a control transect within the analogue site. The results of rehabilitation monitoring will be the primary mechanism by which government departments and agencies determine rehabilitation and closure success.

7.2 Rehabilitation and revegetation monitoring

7.2.1 Monitoring methods – landscape function analysis

Tongway and Hindley (2004) developed the LFA, also known as the ecosystem function analysis, as CSIRO's principal method for mine rehabilitation assessment within the arid zone. LFA is an indicator-based monitoring procedure that evaluates soil surface processes to examine how well a landscape is working as a biophysical system in relation to disturbance or rehabilitation.

LFA monitoring methods comprise assessing a suite of parameters at different landscape positions on each site, namely on flats, slopes and in troughs. Repeated edaphic (soil properties) and biological measurements are taken over time for various parameters that indicate changes in ecosystem function as rehabilitation proceeds. The goal of rehabilitation is to achieve a self-sustaining landscape. A self-sustaining ecosystem would not need further additions of nutrients, seed, water or other management inputs.

The CSIRO LFA method, as detailed by Tongway and Hindley (2004), would be used to inform the monitoring program design; however, some modification to this method may be required to address the site-specific variables at FHCP.

LFA is typically conducted as an annual monitoring event and Fairhill Coking Coal Pty Ltd has made this commitment to rehabilitation monitoring throughout the LOM. The results of the LFA monitoring and recommendations will be discussed in the Operational Performance Reports presented following rehabilitation and completion of site activities.

In general, the LFA method would involve monitoring of the following three groups of sites:

- natural site(s):
 - disturbed analogue(s) may be utilised due to the presence of stock (grazing pressure) to consider the impact of stock.
- rehabilitated sites:
 - reference sites for rehabilitation performance, successful or otherwise.
- disturbance sites:
 - ROM pad
 - access tracks and haul roads
 - footprints of waste stockpiles/dump.

Analogue sites would be chosen as close as possible to the rehabilitated area so that the same climatic and environmental conditions existed at both sites to the extent possible.

Specific LFA monitoring sites are yet to be selected; however, the LFA methodology would be applied to each of the identified domains. This program would survey the rehabilitated areas and record percentage of plant cover, identify plant species present and note the development of erosional features in comparison to a neighbouring analogue site.

7.2.2 Rehabilitation maintenance and management

Maintenance of rehabilitation is an important aspect of successful rehabilitation practices required to address any deficiencies or areas of concern identified through ongoing monitoring and LFA. Maintenance activities may include:

- Minor earthworks or contouring to achieve drainage requirements;
- Reapplication of topsoil (e.g. to address scalds);
- Maintenance of erosion and sediment controls;
- Re-seeding or re-planting in areas of poor growth; and
- Pest and weed management.

Key aspects of rehabilitation maintenance include:

- Managing soil erosion/soil loss
- Promoting vegetation growth
- Maintaining integrity of drainage and water features
- Minimising risk of pest or weed success in rehabilitated areas.

The objective of rehabilitation management is for the rehabilitated area to be self-sustaining and resilient, requiring no additional management effort compared to that of surrounding areas. Significant aspects for rehabilitation management include, weeds, pest animals and erosion. Success criteria are such that that these issues need to be addressed prior to relinquishment of leases.

7.2.3 Pest and weed management

Pest and weed species have the potential to have a major impact on regional agricultural activities and success of rehabilitation across a mine site generally. There is also potential for pest and weed species to have a significant impact to biodiversity values of an ecosystem or rehabilitated areas. As such, pest and weed management plan will developed and implemented, if necessary, to ensure that the risk of pest and weed invasion is minimised

8. Financial Provision for Closure

8.1 Overview

The *Mineral and Energy Resources (Financial Provisioning) Act 2018* introduces a new requirement for Progressive Rehabilitation and Closure Plans (PRCPs) to maximise progressive rehabilitation and provide for meeting rehabilitation conditions to allow surrender of EAs.

The PRCP start date is proposed for the latter half of 2019 to better prepare industry and government, and existing operations will be transitioned to the new requirement over three years after that date. FHCP may require reporting under the PRCP process and development of a rehabilitation schedule which will likely be assessed for compliance. A PRCP schedule continues in force until the environmental authority for the relevant activities to which the PRCP schedule relates is cancelled or surrendered. A separate surrender application must be submitted for the PRCP schedule.

Associated with the PRCP, a guideline for preparing a PRCP is under development and will relate to the PRCP schedule, etc. Auditing of the PRCP schedule will be required 3-yearly and a report provided to the administering authority.

A guideline titled *Estimated Rehabilitation Cost Under the Environmental Protection Act 1994* was released to replace the guideline *Financial Assurance under the Environmental Protection Act 1994* to support commencement of the MERFP Bill and includes changing the Financial Assurance process to include renamed Estimated Rehabilitation Cost (ERC) calculators for resource activities. The new guideline includes a requirement for supporting information such as detailed explanation of disturbance, mine waste information (characterisation, volumes, rehabilitation strategy), shapefiles (existing disturbance, rehabilitation, domains), infrastructure detail (type, dimensions, levels) and materials balance.

The FHCP shall be required to provide an ERC for the project based on the proposed disturbance, and this provision shall be undertaken prior to the commencement of the mining activity and following the decision notice received in regard to the submission of the PRCP.

References

- ATC Williams. (2018). Fairhill coal project – Water management assessment. Prepared for Fairhill Coking Coal Pty Ltd.
- Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resources Management Council of Australia and New Zealand (ARMCANZ) (2000). Australian and New Zealand guidelines for fresh and marine water quality. ANZECC and ARMCANZ, Canberra, 1–103.
- Australian and New Zealand Minerals and Energy Council. (2000). Strategic framework for mine closure.
- Department of Environment and Science (DES). 2014. Rehabilitation requirements for mining resource activities, EM1122, Version 2.01.
- Department of Environment and Science (DES). 2019. Financial assurance under the Environmental Protection Act 1994, ESR/2015/1758.
- Department of Foreign Affairs and Trade (DFAT). (2016a). Leading practice sustainable development program for the mining industry: Mine closure and completion.
- Department of Industry, Innovation and Science. (2011). Leading practice sustainable development program for the mining industry: A guide to leading practice sustainable development in mining.
- Department of Mines and Energy (DME). (2015). Guidelines for preparing mine closure plans, May 2015.
- DFAT. (2016b). Leading practice sustainable development program for the mining industry: Mine rehabilitation.
- DFAT. (2016c). Leading practice sustainable development program for the mining industry: Risk assessment and development.
- Environmental Earth Sciences (2012). Soil and land suitability assessment, Wilton Coal Project, Report Number 611023, Version 2.
- International Council on Mining and Metals (ICMM). (2019). Planning for integrated mine closure: Toolkit (2nd Edition).
- Northern Resource Consultants (NRC). (2018a). Overburden and potential coal reject characterisation report.
- NRC. (2018b). Terrestrial flora and fauna technical report.
- NRC. (2018c). Fairhill coal project soils and strategic cropping land assessment.
- SLR. (2019). Soils and Land Suitability Assessment
- Tongway, D. J., & Hindley, N. I. (2004). Landscape function analysis: Procedures for monitoring and assessing landscapes with special reference to minesites and rangelands. Version 3.1. Canberra, ACT: CSIRO Sustainable ecosystems.