



Biophysical Strategic Agricultural Land Verification Assessment

Mangoola Coal Continued Operations Project

Prepared for Mangoola Coal Operations Pty Limited | 26 July 2018

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Biophysical Strategic Agricultural Land Verification Assessment

Report

Report B17193RP3 | Prepared for Mangoola Coal Operations Pty Limited | 26 July 2018

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Document Control

Version	Date	Prepared by	Reviewed by
V0-1	10 November 2017	K Drapala	T Rohde D Sullivan (Umwelt)
V0-2	3 April 2018	K Drapala	D Sullivan (Umwelt)
V1.0	22 May 2018	K Drapala	J Claridge, Mangoola
V1.1	15 June 2018	K Drapala	J Claridge
V1.2	26 July 2018	K Drapala	J Claridge



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Table of contents

Chapter 1	Introduction	5
1.1	Project Background	5
1.2	Project area	6
1.3	Policy framework	6
<hr/>		
Chapter 2	Strategic agricultural land assessment	11
2.1	Critical industry clusters	11
2.2	Biophysical strategic agricultural land	11
2.2.1	Statement of qualification	16
2.2.2	Interim protocol checklist	16
<hr/>		
Chapter 3	BSAL verification methods and initial steps	17
3.1	Introduction	17
3.2	Project Area	17
3.3	Water supply	17
3.4	Land access and mapping approach	17
3.5	Survey sampling density	18
3.6	Field based sampling methodology	19
3.6.1	Survey guidelines	19
3.6.2	Survey density	19
3.6.3	Site selection	19
3.6.4	Review of available mapping	20
3.6.5	Soils analysis	20
<hr/>		
Chapter 4	Soil descriptions	23
4.1	Overview	23
4.1.1	Results summary	23
4.2	Red-Orthic Tenosol	25
4.3	Brown Dermosol	29
4.4	Grey Sodosol	32
4.5	Grey Kurosol	36
4.6	Brown Chromosol	39
4.7	Comparison with soil mapping by others	43
<hr/>		
Chapter 5	BSAL verification	45
5.1	Exclusion criteria	45
5.1.1	Slope	45
5.1.2	Rock outcrop	45
5.1.3	Surface rockiness	45

Table of contents *(Cont'd)*

5.1.4	Gilgai	45
5.1.5	Soil fertility	45
5.1.6	Effective rooting depth	46
5.1.7	Drainage	46
5.1.8	Soil pH	46
5.1.9	Soil salinity	46
5.2	Results of BSAL assessment	47
Chapter 6 Conclusion		53
References		55

Appendices

A	Detailed site photographs
B	Laboratory accreditation and results
C	BSAL site verification assessment criteria and methods
D	Detailed BSAL site verification assessment table

Tables

2.1	Interim protocol checklist	16
3.1	Preliminary agricultural risk assessment (unmitigated scenario)	18
3.2	Laboratory analysis	21
3.3	Samples analysed from each soil type	21
4.1	Soil types in the project area	23
4.2	Basic Arenic Red-Orthic Tenosol typical soil profile summary	25
4.3	Basic Arenic Red-Orthic Tenosol soil chemistry result medians (and ranges)	27
4.4	Basic Arenic Red-Orthic Tenosol agricultural use summary	28
4.5	Dermosol typical soil profile summary	29
4.6	Sodic Eutrophic Brown Dermosol soil chemistry result medians (and ranges)	30
4.7	Dermosol agricultural use summary	32
4.8	Sodosol typical soil profile summary	33
4.9	Grey Sodosol soil chemistry result medians (and ranges)	34
4.10	Sodosol agricultural use summary	35
4.11	Kurosol typical soil profile summary	36

Tables

4.12	Magnesian-Natric Grey Kurosol soil chemistry result medians (and ranges)	37
4.13	Kurosol agricultural use summary	39
4.14	Chromosol typical soil profile summary	40
4.15	Mottled Mesotrophic Brown Chromosol soil chemistry result medians (and ranges)	41
4.16	Chromosol agricultural use summary	42
5.1	BSAL verification assessment by soil survey site	48
6.1	Detailed soil survey site photographs	A.0
6.2	BSAL verification assessment criteria methods used	C.1
6.3	BSAL verification assessments for detailed sites	D.1

Figures

1.1	Regional location of MCCO project area	8
1.2	MCCO Conceptual Project Layout	9
2.1	NSW Government mapped BSAL and CICs	14
2.2	Interim Protocol flow chart for the site assessment of BSAL	15
4.1	Soil type distribution	24
5.1	BSAL exclusion map	51

Photographs

4.1	Basic Arenic Red-Orthic Tenosol (site 29)	26
4.2	Sodic Eutrophic Brown Dermosol (site 12)	30
4.3	Mesotrophic Mesonatric Grey Sodosol (site 10)	33
4.4	Mottled Magnesian-Natric Grey Kurosols (site 48)	37
4.5	Mottled Mesotrophic Brown Chromosol (site 19)	40

1 Introduction

EMM Consulting Pty Limited (EMM) has been engaged by Mangoola Coal Operations Pty Limited (Mangoola) to complete a biophysical strategic agricultural land (BSAL) assessment (the assessment) for the Mangoola Coal Continued Operations Project (MCCO Project). The purpose of the assessment is to support an application for a Site Verification Certificate (SVC) as required by the *Upper Hunter Strategic Regional Land Use Plan 2012* (SRLUP) and to form part of an Environmental Impact Statement being prepared by Umwelt Australia Pty Ltd (Umwelt) to support an application for development consent under Division 4.1 of Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) for the MCCO Project.

1.1 Project Background

Mangoola Coal Mine is an existing open cut coal mine located approximately 20 kilometres (km) west of Muswellbrook and 10 km north of Denman in the Upper Hunter Valley of New South Wales (NSW) (Figure 1.1). Mangoola has operated the Mangoola Coal Mine in accordance with Project Approval (PA) 06_0014 (as modified) since mining commenced in September 2010.

The MCCO Project will allow for the continuation of mining at Mangoola Coal Mine into a new mining area to the immediate north of the existing operations. The MCCO Project Area is defined as the area including the existing approved operations for Mangoola Coal Mine along with the MCCO Additional Project Area as shown on Figure 1.1.

The MCCO Project generally comprises:

- open cut mining at up to the same rate as that currently approved (13.5 Million tonnes per annum (Mtpa) of run of mine (ROM) coal) using truck and excavator mining methods;
- mining in a new area located north of the existing Mangoola Coal Mine and Wybong Road, south of Ridglands Road and east of the 500 kV Electricity Transmission Line (ETL);
- construction of a haul road overpass over Big Flat Creek and Wybong Road to provide access from the existing mine to the MCCO Project;
- establishment of two out-of-pit overburden emplacement areas including a culvert crossing of Big Flat Creek to provide access to the emplacement area;
- distribution of overburden between the MCCO Project and Mangoola Coal Mine in order to optimise the final landform design of the integrated operation. The design of the emplacement areas and final landform will be refined throughout the assessment process;
- realignment of a portion of Wybong Post Office Road;
- the use of all existing or approved infrastructure and equipment for the Mangoola Coal Mine with some minor additions to the existing mobile equipment fleet;
- construction of a water management system to manage sediment laden water runoff, divert clean water catchment, provide flood protection from Big Flat Creek and provide for reticulation of mine water. The water management system will be connected to the Mangoola Coal Mine;

- establishment of a final landform in line with current design standards at Mangoola Coal Mine including use of micro-relief;
- rehabilitation of the MCCO Project using the same revegetation techniques as at Mangoola Coal Mine;
- a likely construction workforce of approximately 120 persons. No change to the existing approved operational workforce; and
- continued use of the mine access for the Mangoola Coal Mine and access to/from Wybong Road, Wybong Post Office Road or Ridgelands Road to the MCCO Project for construction, emergency services and ongoing operational environmental monitoring.

The MCCO Project is State Significant Development as defined under State Environmental Planning Policy (State and Regional Development) 2011 and requires development consent under Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act). A Preliminary Environmental Assessment (PEA) has been prepared for the MCCO Project and Secretary's Environmental Assessment Requirements (SEARs) (Ref No. SSD 8642) have been provided by the Department of Planning & Environment (DPE).

1.2 Project area

There are no proposed changes to the mining areas or approved disturbance areas at the existing and approved Mangoola Coal Mine as part of the MCCO Project with these areas being entirely within existing mining leases held by Mangoola. As such, the site verification certificate (SVC) application is only related to the land within the MCCO Additional Project Area (see Figure 1.2).

The MCCO Additional Project Area, is 1,053 hectares (ha) and is shown on Figure 1.2 . This area also represents the SVC application area for the Biophysical Strategic Agricultural Land (BSAL) assessment. The SVC application area comprises the area over which new mining leases may be required plus a 100 metre (m) buffer (the SVC application area), as per the *Interim protocol for site verification and mapping of biophysical strategic agricultural land* (OEH 2013) (the Interim Protocol), and is 1,243 ha. It is also shown on Figure 1.2.

It should be noted that under clause 17A(2) of the *State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007* (the Mining SEPP), mining development, as defined for the purposes of the SVC, does not include development on land outside of a proposed mining lease. Therefore, any MCCO Project components outside the proposed mining lease are not subject to the SVC process.

1.3 Policy framework

The site verification policy framework is set out in the SRLUP and Mining SEPP.

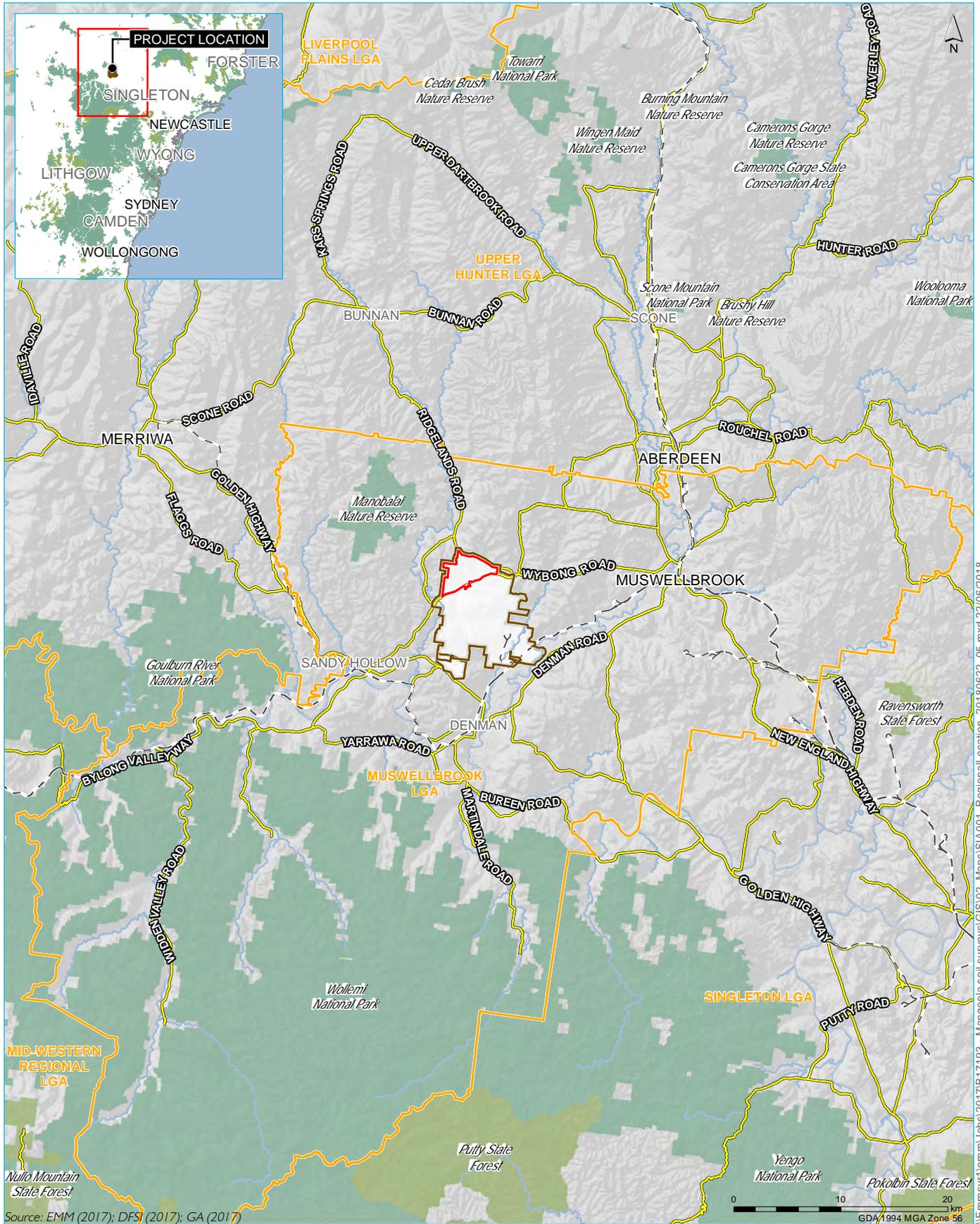
The NSW Government released the SRLUP in 2012 to “provide greater protection for valuable agricultural land and better balance competing land uses”. This was to be by “identifying and protecting strategic agricultural land, protecting valuable water resources and providing greater certainty for companies wanting to invest in mining and coal seam gas projects in regional NSW”. The SRLUP provides a strategic framework and a range of initiatives to balance agriculture and resource development.

The SVC process was established in 2013 by an amendment to the Mining SEPP. The Mining SEPP amendment included addition of the following aims in Clause 2(d):

- (i) to recognise the importance of agricultural resources, and
- (ii) to ensure protection of strategic agricultural land and water resources, and
- (iii) to ensure a balanced use of land by potentially competing industries, and
- (iv) to provide for the sustainable growth of mining, petroleum and agricultural industries.

The SRLUP seeks to identify and map the two categories of strategic agricultural land. First, land with a rare combination of natural resources which make it very valuable for agriculture (known as BSAL). Second, land which is important to a highly significant and clustered industry such as wine making or horse breeding, known as Critical Industry Clusters (CICs). Further discussion of BSAL and CICs is provided in Section 2.

The SRLUP applies to mining proposals that are State Significant Development under the Mining SEPP and require a new or extended mining lease. In such cases proponents are required to confirm whether or not they are to be situated on strategic agricultural land. The MCCO Project is a State significant mining proposal which requires a new mining lease and so the SRLUP applies.



KEY

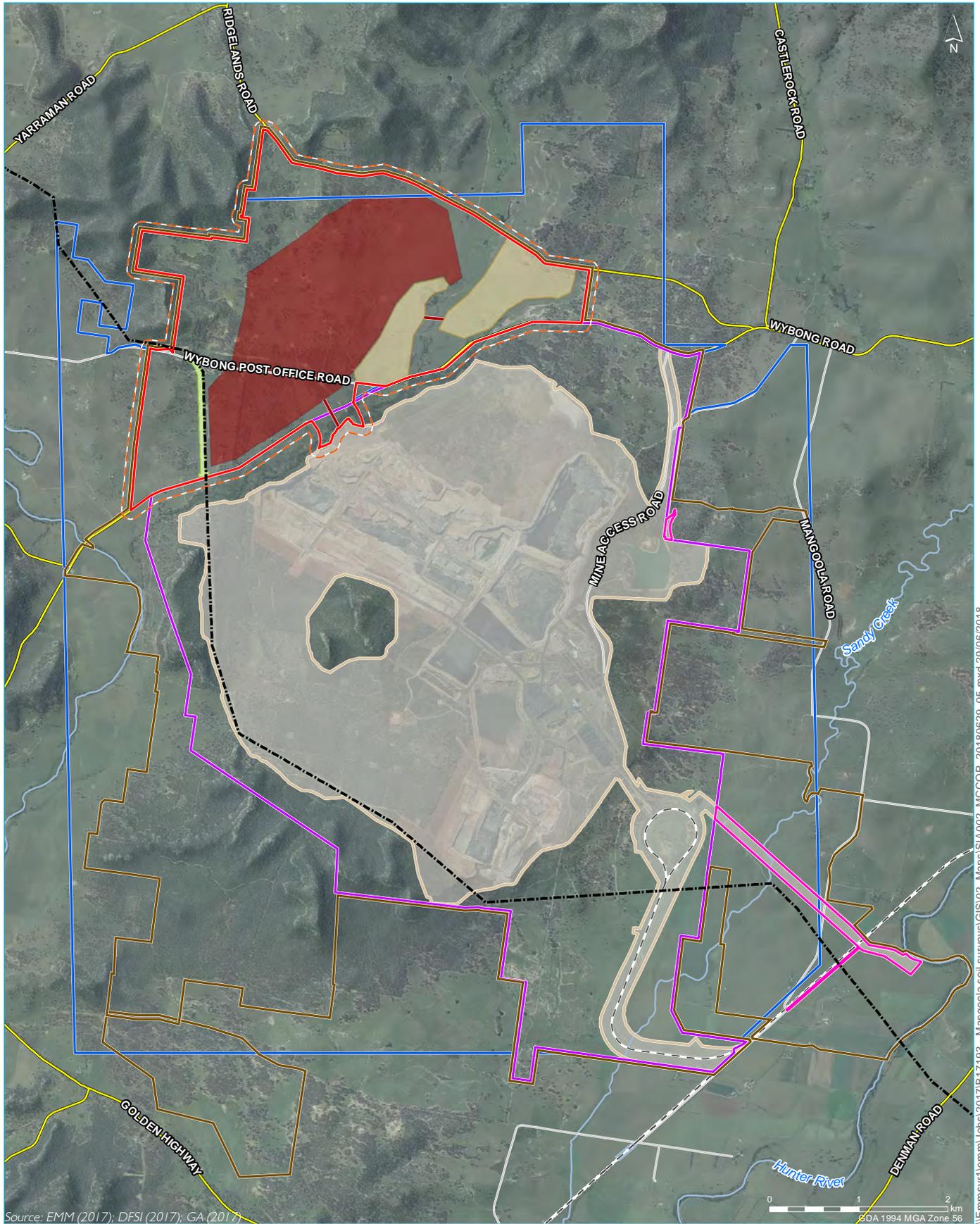
- MCCO project area
- MCCO additional project area
- Local Government Area (LGA) boundary
- Rail line
- Main road
- Watercourse / drainage line
- NPWS reserve
- State forest

Regional locality plan

Mangoola Coal Continued Operations Project
BSAL assessment
Figure 1.1



\\E:\msvr1\emm\Jobs\2017\B17193 - Mangoola soil surveys\GIS\02 - Maps\SI\A01_Regional_location_20180622_05.mxd 22/06/2018



Source: EMM (2017); DFSI (2017); GA (2017)

KEY

- | | | |
|--|--|--|
| ML 1626 | Approved Mangooka Coal Mine disturbance area | Indicative Wybong Post Office Road realignment |
| ML 1747 | AL9 boundary | 500kV transmission line |
| MCCO project area | Proposed overpass | Main road |
| MCCO additional project area | MCCO proposed additional mining area | Local road |
| MCCO additional project area - 100m buffer | Proposed emplacement area | Rail line |
| | | Watercourse / drainage line |

Mangooka Coal Continued Operations project layout

Mangooka Coal Continued Operations Project
BSAL assessment
Figure 1.2



2 Strategic agricultural land assessment

2.1 Critical industry clusters

The NSW Government (2012) *Draft Guideline for site verification of critical industry clusters* provides guidance for identifying the existence of CICs. They are mapped on the Strategic Agricultural Land Map (attached to the Mining SEPP) and comprise land which is important to a highly significant and clustered industry, such as wine making or horse breeding.

The draft guideline describes a CIC as a “localised concentration of interrelated productive industries based on an agricultural product that provides significant employment opportunities and contributes to the identity of the region”. It specifies that a CIC must meet the following criteria:

- there is a concentration of enterprises that provides clear development and marketing advantages and is based on an agricultural product;
- the productive industries are interrelated;
- it consists of a unique combination of factors such as location, infrastructure, heritage and natural resources;
- it is of a national and/or international importance;
- it is an iconic industry that contributes to the region’s identity; and
- it is potentially substantially impacted by coal seam gas or mining proposals.

There are two CICs in NSW (an equine and a viticulture CIC) which have been mapped in the Upper Hunter. The Strategic Agricultural Land Map within the Mining SEPP shows that there are no CICs within the MCCO Additional Project Area. The closest CIC areas are equine CIC located approximately 0.3 km from the south-west and directly north of the MCCO Additional Project Area (see Figure 2.1). The draft guideline states that “projects located outside the mapped CIC are not required to seek site verification”. The MCCO Project is outside any mapped CIC. Therefore, the SVC Application Area does not contain CICs and Mangoola is not required to seek a site verification or gateway certificate in respect of CICs.

2.2 Biophysical strategic agricultural land

BSAL is defined in the Interim Protocol as:

land with a rare combination of natural resources highly suitable for agriculture. These lands intrinsically have the best quality landforms, soil and water resources which are naturally capable of sustaining high levels of productivity and require minimal management practices to maintain this high quality. BSAL is able to be used sustainably for intensive purposes such as cultivation. Such land is inherently fertile and generally lacks significant biophysical constraints.

The NSW Government has mapped BSAL across the whole of NSW, based on a desktop study, and the resultant maps accompany the Mining SEPP. The BSAL shown on the maps comprises land which meets the following criteria (as described in the Interim Protocol):

- access to a reliable water supply; and

- access to a reliable water supply; and
- falls under soil fertility classes ‘high’ or ‘moderately high’ under the NSW Office of Environment and Heritage (OEH) *Draft Inherent General Fertility Mapping of NSW* (OEH 2017a), where it is also present with land capability classes I, II or III under OEH’s *Land and Soil Capability Mapping of NSW*; or
- falls under soil fertility classes ‘moderate’ under OEH’s *Draft Inherent General Fertility Mapping of NSW*, where it is also present with land capability classes I or II under OEH’s *Land and Soil Capability Mapping of NSW* (OEH 2017b).

These maps have generally not been verified by site investigations and site verification in accordance with the Interim Protocol is required to confirm whether or not land is actually BSAL.

The NSW Government’s BSAL Map within the Mining SEPP indicates that there is no BSAL in the MCCO Additional Project Area. Figure 2.1 presents the NSW Government’s regional scale BSAL map for the area. BSAL has been mapped nearby, south-west of the MCCO Additional Project Area adjacent to Wybong Creek. This land has not been confirmed as BSAL by site investigations.

Notwithstanding, the Interim Protocol states that “due to the regional scale of the maps, it is important that appropriate processes are in place to provide for verification that particular sites are in fact BSAL. Verification can apply to both mapped and unmapped BSAL areas.” The Mining SEPP requires certain types of development (including the MCCO Project) verify whether or not any land within the proposed mining lease areas is BSAL.

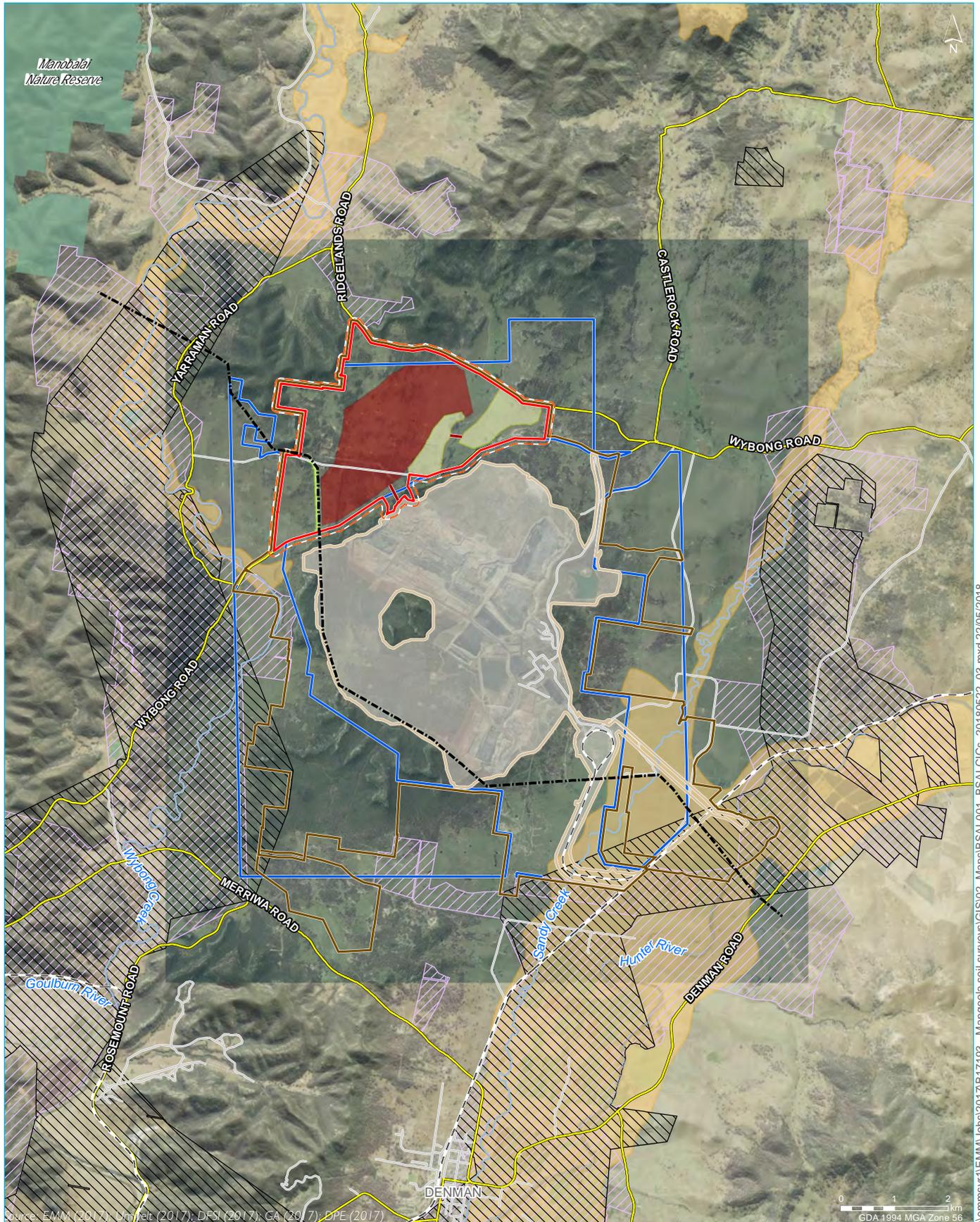
The Interim Protocol outlines the steps and criteria to establish whether an area is BSAL. The criteria relate to:

- slope;
- rock outcrop;
- surface rock fragments;
- gilgais;
- soil fertility;
- effective rooting depth to a physical barrier;
- soil drainage;
- soil pH;
- salinity; and
- effective rooting depth to a chemical barrier.

Figure 2.2 shows the order in which the site verification criteria must be assessed and the decision making sequence to establish whether or not BSAL is present at a particular site. For land to be classified as BSAL, it must meet all of the criteria in Figure 2.2. If any of the criteria are not met, the land is not BSAL and later steps in the assessment are not relevant. In addition, the Interim Protocol specifies a minimum area for BSAL of 20 ha. If the area subject to assessment falls below 20 ha at any point of the assessment

because of exclusion of land that does not meet the criteria, then the land is not BSAL and there is no need to continue the assessment. Therefore, for land to be classified as BSAL, it must have access to a reliable water supply; meet all of the criteria in Figure 2.2; and be a contiguous area of at least 20 ha. If any of these criteria are not met, the land is not BSAL. A detailed description of the BSAL classification rules and analysis methods used in this assessment is provided in Appendix B.

It is noted that Figure 2.2 is a direct extract from the Interim Protocol and has a misprint in Step 12. The actual effective rooting depth criteria for a site to be classified as BSAL (as used in the MCCO Project's assessment) is greater than or equal to 750 millimetres (mm) (not 75 mm). This is correctly shown in respect of physical barriers in Step 8 of the flow chart, and quoted elsewhere in the Interim Protocol in relation to chemical barriers, for example in Section 6.10: "BSAL soils must have an effective rooting depth to a chemical barrier greater or equal to 750 mm".



KEY

- | | | | |
|---|--------------------------------------|--|-----------------------------|
| MCCO project area | AL9 boundary | Indicative Wybong Post Office Road realignment | 500kV transmission line |
| MCCO additional project area | Proposed overpass | Biophysical Strategic Agricultural Land | Main road |
| MCCO additional project area - 100m buffer | MCCO proposed additional mining area | Critical Industry Cluster (Viticulture) | Local road |
| Approved Mangoolia Coal Mine disturbance area | Proposed emplacement area | Critical Industry Cluster (Equine) | Rail line |
| | | NPWS reserve | Watercourse / drainage line |

NSW Government mapped BSAL and CIC's

Mangoola Coal Continued Operations Project
BSAL assessment
Figure 2.1



\\emmsvr1\EMM\Jobs\2017\B17193 - Mangoola soil surveys\GIS\02 - Maps\BSAL001_BSALCICs_20180522_03.mxd 22/05/2018

Source: EMM (2017); DmJett (2017); DFSI (2017); GA (2017); DPE (2017)

0 1 2 km
GDA:1994 MGA Zone 56

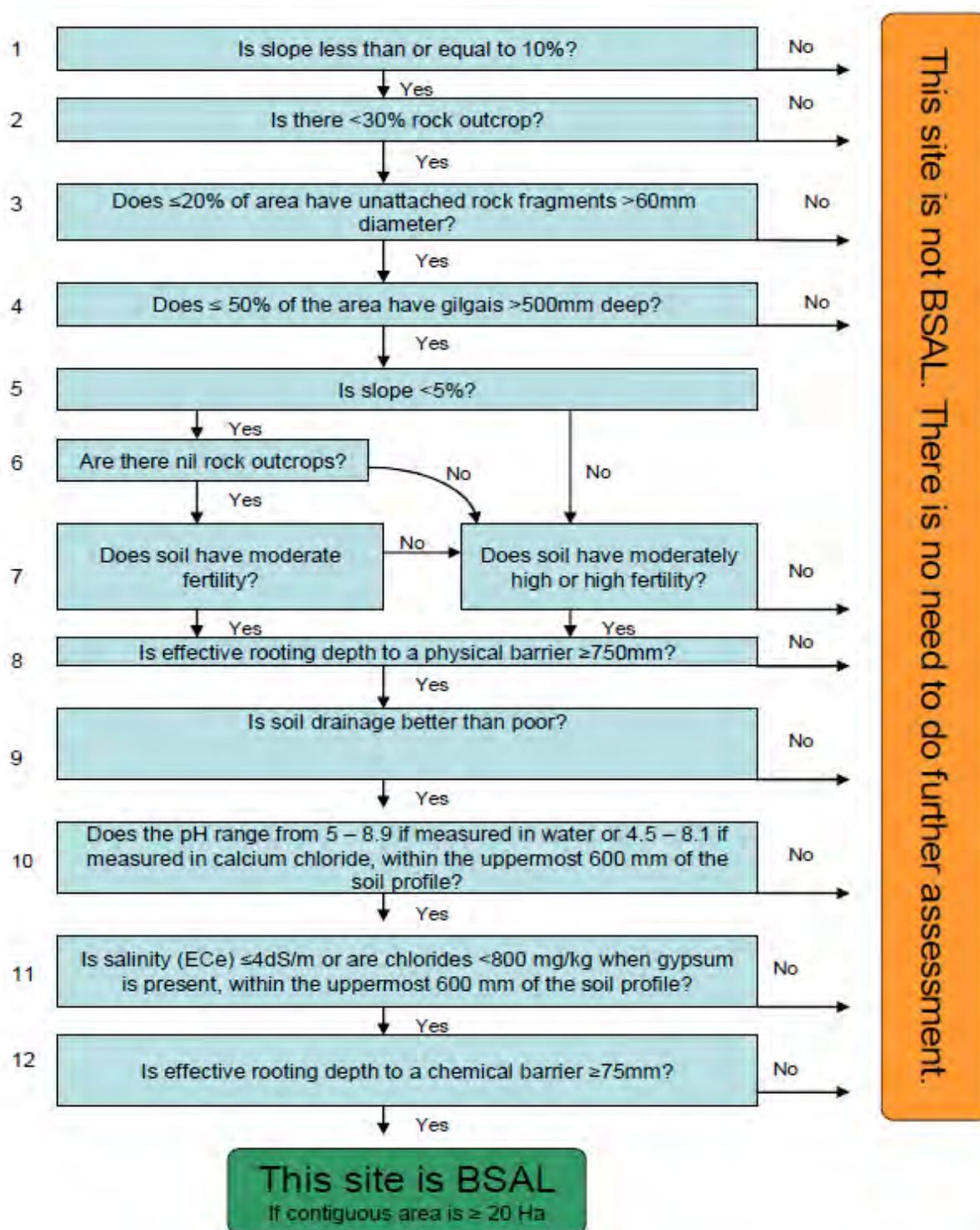


Figure 2.2 Interim Protocol flow chart for the site assessment of BSAL

2.2.1 Statement of qualification

This Biophysical Strategic Agricultural Land Verification Assessment report has been prepared by Kylie Drapala and Nicholas Jamson of EMM Consulting Pty Limited (EMM) in accordance with the Interim Protocol. Kylie is a senior soil scientist and Nicholas is a graduate soil scientist. The assessment and report have been reviewed and authorised by Dr Timothy Rohde, who is a certified professional soil scientist (Soil Science Australia).

2.2.2 Interim protocol checklist

The Interim Protocol provides a checklist of requirements for a BSAL site verification assessment report. The checklist is reproduced in Table 2.1, with reference to where each of the requirements has been addressed in this report.

Table 2.1 Interim protocol checklist

Requirement	Reference
Method, analysis and data	
A qualified soil scientist is overseeing the verification assessment and has signed off on the quality and extent of the work.	Sections 2.
Laboratories for soil samples are compliant with AS ISO/IEC17025.	Appendix B
Results with 15% of threshold levels are analysed in a laboratory.	Appendix B
All soil profile descriptions are recorded and submitted to the NSW Soil and Land Information System (SALIS).	Survey data was recorded on SALIS soil data cards and submitted to OEH for entry into the SALIS database.
Laboratory data is supplied to OEH using their standard spreadsheet templates.	Laboratory data has been provided to OEH in the OEH template.
Report	
Reporting requirements for site verification criteria as described in Appendix 1 of the Interim Protocol.	Table 5.1 and Appendix C.
Three 1:25,000 maps showing base level information, soil types and BSAL.	Figures 1.1, 4.1 and 5.1.
GIS output files and metadata statements.	GIS output files and metadata statements are provided with the SVC application.
Laboratory report.	Appendix B

3 BSAL verification methods and initial steps

3.1 Introduction

The Interim Protocol prescribes four initial steps in verifying BSAL:

- Step 1: identify the project area which will be assessed for BSAL;
- Step 2: confirm access to a reliable water supply;
- Step 3: choose the appropriate approach to map the soils information; and
- Step 4: risk assessment.

These steps are addressed in Sections 3.2 to 3.5 respectively. Section 3.6 describes the field-based survey methodology, including site selection and soils analysis, as well as a review of regional soil, geology and topographic mapping by others.

3.2 Project Area

The MCCO Additional Project Area is also the SVC application area, which is 1,053 ha and is shown in Figure 1.1. The BSAL verification assessment area comprises the SVC application area plus a 100 m buffer, as per the Interim Protocol, and is 1,243 ha. It is also shown on Figure 1.2. The MCCO Additional Project Area is predominately freehold land which is owned by Mangoola, with some crown land and public roads.

3.3 Water supply

The MCCO Additional Project Area has a reliable water supply, defined in the Interim Protocol as rainfall of 350 mm or more per annum in nine out of 10 years. Weather records from the nearby locations of Doyles Creek (61130) and Scone Airport AWS (061363) (BoM 2017) indicate that for the past 97 years (1920-2017) rainfall has been in the range of 320-1224 mm per annum with a mean of 647 mm at Doyles Creek and for 26 years (1991-2017), rainfall has been in the range of 362-902 mm per annum, with a mean of 625 mm at Scone airport (Bureau of Meteorology 2017).

The MCCO Additional Project Area is within the "North Coast Fractured and Porous Rock Groundwater Sources 2016" and it would be classified as less productive groundwater, not meeting the highly productive groundwater classification.

The MCCO Additional Project Area is also within the area covered by the "Water Sharing Plan for the Wybong Creek Water Source 2003", which was repealed and replaced by the "Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2009". Analysis of the requirements for reliable surface water resulted in a likely classification of not reliable surface water.

3.4 Land access and mapping approach

Sufficient land was able to be accessed within the SVC application area to satisfy on-site soil sampling density requirements specified in the Interim Protocol. The survey focused intensely on the proposed areas of disturbance with a reduced effort in fringe areas where no disturbance is proposed (example to west of proposed Wybong Post Office Road realignment).

A manual mapping method has been employed based on the site specific survey properties and landscape characteristics, including vegetation, topography, aerial imagery and existing soil and geological mapping.

The assessment and soil mapping has used soil type map units instead of soil landscape units. Soil landscape units are more appropriate for situations where there is more variability in soil types. They are typically used in areas where there may be a single dominant soil type but two or three common sub-dominants. For the MCCO Additional Project Area, soil map units were chosen due to the relatively low variability observed. The soil map units are referred to as 'soil types' in this report for simplicity.

3.5 Survey sampling density

To determine the density of soil sampling required, the Interim Protocol recommends risks to agricultural resources and enterprises be evaluated using guidance in Appendix 3 of the Interim Protocol. Risks can be classified as low, medium or high. The Interim Protocol stipulates that sampling densities should be one site per 25 to 400 ha (1:25,000 to 1:100,000) for low risk activities and one site per 5 to 25 ha (1:25,000) for high risk activities (Gallant et al. 2008).

The MCCO Project involves the continuation of mining at Mangoola Coal Mine into a new mining area to the immediate north of the existing operations on land which is not mapped BSAL, based on the NSW Government's BSAL map, an extract of which is shown in Figure 2.1. All infrastructure and disturbance will be on land largely owned by Mangoola. Direct surface disturbance for the MCCO Project, estimated at approximately 665 ha, will largely involve the MCCO proposed additional mining area and emplacement areas.

The development and operation of the mine will have long term impacts (≥ 20 years) on the direct mine area. Some stockpile and infrastructure areas would have a temporary land use change at that location. Post-mining, the mine infrastructure will be decommissioned and these areas rehabilitated.

Based on the above, a risk assessment was undertaken for the MCCO Additional Project Area using the risk ranking matrix in the Interim Protocol. The results are presented in Table 3.1. It is noted that, based on the consequence descriptors in Appendix 3 of the Interim Protocol, the preliminary risk assessments are for an unmitigated scenario, which is not realistic. In practice, mitigation and management measures will be developed and implemented to avoid and minimise impacts to agriculture.

Table 3.1 Preliminary agricultural risk assessment (unmitigated scenario)

Aspect	Probability ¹	Consequences ¹	Rating ¹	Comments
MCCO Additional Project Area	A - almost certain	1 - severe	A1 - high	<p>Applicable consequence descriptor from risk assessment matrix in Appendix 3 of Interim Protocol:</p> <p>Permanent and irreversible impacts.</p> <p>EMM comments: This risk rating applies only to the mining area where a final void will remain. Areas of infrastructure and overburden emplacement areas will be decommissioned and these areas rehabilitated to a state of similar land capability to their current state, allowing for a lower risk ranking.</p> <p>Despite the above the high risk ranking has been applied conservatively across the MCCO Additional Project Area.</p>

Note: 1. Based on the probability and consequence descriptors in Appendix 3 of the Interim Protocol and an unmitigated scenario, which is not realistic. In practice, mitigation and management measures will be implemented to avoid and minimise impacts to agriculture.

3.6 Field based sampling methodology

3.6.1 Survey guidelines

All field assessment methods used in this survey have been conducted in accordance with the following guidelines:

- *Guidelines for surveying soil and land resources* (McKenzie et al 2008);
- *Australian soil and land survey handbook* (NCST 2009);
- *The Australian soil classification* (Isbell 2002);
- *Soil data entry handbook* (DLWC 2001);
- *Interim protocol for site verification and mapping of biophysical strategic agricultural land* (NSW Government (NSWG 2013).

This survey has taken particular note of the requirements of the Interim protocol. The field survey therefore required investigation at three different levels of intensity (the sites):

- check sites - low intensity investigation, high repetition, randomised locations and a limited description;
- detailed sites - high intensity investigation, moderate repetition, randomised locations and a detailed description; and
- profiles pits - very high intensity investigation, low repetition, targeted locations and a detailed description.

3.6.2 Survey density

A soil survey density target of at least one site per 5-25 ha was adopted for BSAL verification purposes.

A total of 55 sites were surveyed within the MCCO Additional Project Area and an average survey density of about one site per 18 ha was achieved. The average survey density achieved meets the target adopted (as per the Interim Protocol), which was at least one site per 25 ha. Of the 55 sites, all were described in detail using the SALIS detailed soil data card to at least Suborder (of which 14 were subjected to laboratory analysis and classified to Family level). This is in accordance with the relevant guidelines. Due to small areas of coverage of two identified soil types (Kurosol and Chromosol), these only had two samples subjected to laboratory analysis, instead of the recommended three.

3.6.3 Site selection

Initial positioning of the soil survey sites was based on stratified random sampling across the MCCO Additional Project Area, though designed to provide a relatively even distribution of detailed and check sites. In accordance with the requirements of stratified random sampling, a greater frequency of sampling was proposed for soil types that cover a greater proportion of the MCCO Additional Project Area. Also, topographic maps were reviewed to ensure surveying was representative of the different landform types in the MCCO Additional Project Area.

The exact locations of the sites were finalised with consideration to land access constraints, site factors, past disturbance, vegetation cover, proposed disturbance locations and achieving good sample coverage. The sites are shown in Figure 4.1.

Soil survey sites for a BSAL assessment fall into three categories:

- Exclusion sites - fail a readily apparent landscape requirement for BSAL, such as excessive slope, rock outcrop, surface rockiness or gilgai micro relief. Soil profile descriptions or survey are not necessary.
- Detailed sites - soil profiles are described in sufficient detail to allow all major physical and chemical soil features of relevance to BSAL verification to be clearly established.
- Check sites - examined in sufficient detail to enable categorisation according to a soil type and soil map unit.

Guidance in the Interim Protocol and the National Committee on Soil and Terrain (NCST) (2009) *Australian Soil and Land Survey Field Handbook* (the Handbook) was followed in the site assessments. The Interim Protocol suggests that each soil type identified should be examined in detail and samples analysed from at least three sites from each of the soil types. The Handbook suggests:

- 10-30% of sites should be described in detail;
- 1-5% of the sites described in detail should be subject to soil analysis; and
- remaining sites should be used as check sites.

In this way, a total of 55 soil survey sites were assessed using the test pitting technique, all of which were recorded using the SALIS detailed soil data card (of which 14 were subjected to laboratory analysis). This meant that all relevant guidance in the Handbook was achieved or exceeded, with 100% of the sites described in detail and 25% of these subject to analysis.

For the purpose of BSAL verification, a site was defined as occurring within a 10-20 m radius of the point of observation of the soil profile. Soil profile data were recorded in the field on SALIS data cards. Photographic records of detailed sites and their soil profiles were taken in the field using a digital camera and are presented in Appendix A.

3.6.4 Review of available mapping

The soil survey sites were initially planned based on the proposed disturbance areas, a review of Australian Soil Resource Information System (ASRIS) regional soil maps, geology maps and topographic maps. Regional soil mapping and information from the NSW Government's online soil mapping database eSPADE, released in 2014, was also reviewed.

3.6.5 Soils analysis

Physical and chemical analysis was undertaken on selected soil samples at a NATA accredited laboratory (Table 3.2). A summary of the number of samples analysed from each soil type present in the MCCO Additional Project Area is presented in Table 3.3.

Table 3.2 Laboratory analysis

Physical analysis	Chemical analysis
dispersion; soil texture; other specified significant soil characteristics where these occurred.	organic carbon; pH (water and CaCl ₂); total and available nitrogen; available phosphorus; exchangeable potassium; cation exchange capacity; exchangeable sodium; exchangeable calcium; exchangeable magnesium; exchangeable aluminium; soluble cations; chloride; metals (copper, iron, zinc, manganese, aluminium, molybdenum); and electrical conductivity.

Table 3.3 Samples analysed from each soil type

Soil types	Number of sites subjected to laboratory analysis	Site numbers	No. of depths analysed
Tenosol	3	20, 21, 37	15
Dermosol	3	55(A1), 5, 12	15
Sodosol	5	10, 23, 43, 47	25
Kurosol	2	41, 48,	10
Chromosol	2	53, 19*	10

*Chromosols not mapped as under 20ha

4 Soil descriptions

4.1 Overview

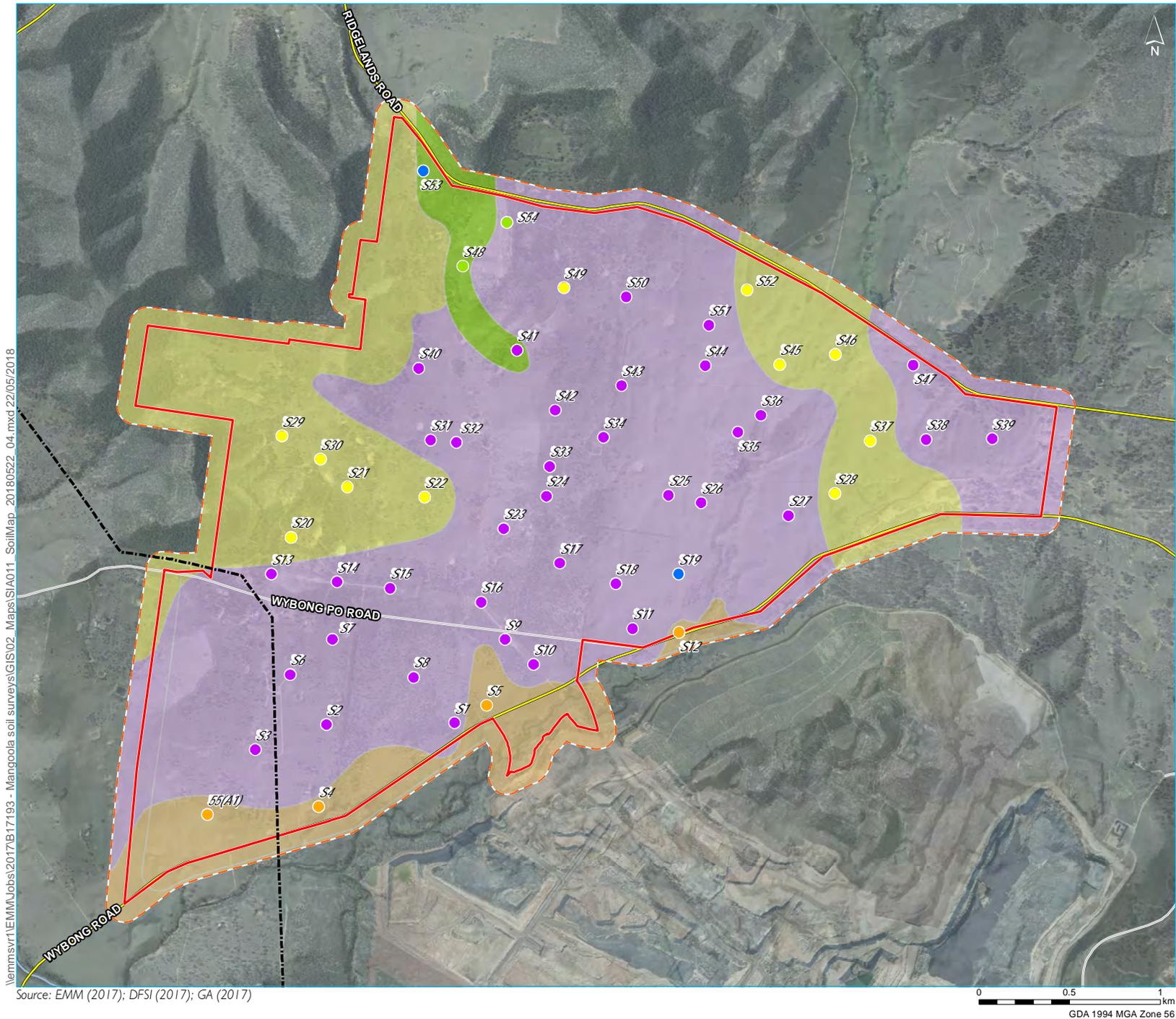
4.1.1 Results summary

The soil survey mapped four major soil types within the MCCO Additional Project Area (Table 4.1), Tenosols, Dermosols, Sodosols and Kurosols. Two Chromosol sites were identified however not mapped due to the singular locations and areas being under 20 ha. Laboratory analysis further identified the soil o Subgroup level as Mesotrophic Mesonatric Grey Sodosols, Basic Arenic Red-Orthic Tenosols, Magnesian-Natric Grey Kurosols, Sodic Eutrophic Brown Dermosols and Mottled Mesotrophic Brown Chromosols. Figure 4.1 presents the spatial distribution of the soil types within the MCCO Additional Project Area.

Table 4.1 Soil types in the project area

ASC ¹ order (Soil type)	Total area mapped within project area (inc. 100m buffer)	
	(ha)	(%)
Sodosol	769.1	61.8
Tenosol	328.9	26.4
Kurosol	33.5	2.8
Dermosol	111.0	8.9
Chromosol	0	0
TOTAL	1243²	99.9²

Note: 1 Australian Soil Classification
2 not 100% due to rounding



- KEY**
- MCCO additional project area
 - MCCO additional project area - 100m buffer
 - 500kV transmission line
 - Main road
 - Local road
 - Watercourse / drainage line
- Soil test pit**
- Chromosol
 - Dermosol
 - Kurosol
 - Sodosol
 - Tenosol
- Soil type**
- Dermosol
 - Kurosol
 - Sodosol
 - Tenosol

Soil type distribution of the project area

Mangoola Coal Continued Operations Project
 BSAL assessment
 Figure 4.1



\\lemmsv1\EMM\Jobs\2017\B17193 - Mangoola soil surveys\GIS\02 Maps\SIA011_SoilMap_20180522_04.mxd 22/05/2018

Source: EMM (2017); DFSI (2017); GA (2017)

0 0.5 1 km
 GDA 1994 MGA Zone 56

4.2 Red-Orthic Tenosol

Orthic Tenosols are characterised by a weakly developed B horizon, usually in terms of colour, texture or structure or a combination of these. These soils typically contain loamy sand to sandy loam in the A horizon and loamy sand textures throughout the B profile. The soil surface is without coarse fragments and of firm condition when dry. The identified basic arenic red-orthic Tenosols have coarse fragments distributed within the profile. There can be up to 2-10% small sized gravel distributed within the B horizon. The subsoils typically have no segregations or mottles. A soil profile description for a typical Arenic Red-Orthic Tenosol is provided in Table 4.2 and a general landscape is shown in Photograph 4.1.

Table 4.2 Basic Arenic Red-Orthic Tenosol typical soil profile summary

ASC:	Horizon name and average depth (m)	Colour, mottles and bleach	Moisture, laboratory pH (median) and drainage	Texture and structure	Coarse fragments, segregations and roots
	A1 0.0-0.19	Greyish brown, 7.5YR4/3 and no mottles or bleaching.	Dry, pH 5.7 and rapidly drained.	Sandy loam, weak pedality, sub-angular blocky structure.	No surface rock, few coarse fragments, no segregations and many roots.
	A2 0.19-0.40	Reddish brown 5YR4/4 and no mottles or bleaching	Moderately moist, pH 5.2 and rapidly drained.	Sandy loam, weak pedality, crumb structure.	Few coarse fragments, no segregations and few roots.
	B21 0.40-1.2 (some variation across sites)	Light red 2.5YR6/6 and no mottles or bleaching	Moderately moist, pH 5.9 and rapidly drained.	Loamy sand, weak pedality, crumb structure.	Few coarse fragments, no segregations

Notes: 1. Description in accordance with the Australian Soil and Land Survey Field Handbook (NCST 2009). Some profiles will vary
 2. pH are laboratory results and the median values are presented
 3. Based on profile no. 29



Photograph 4.1 **Basic Arenic Red-Orthic Tenosol (site 29)**

The Arenic Red-Orthic Tenosol soil unit occurred on slopes and crests of undulating hills on sandstone and conglomerate surface geology and along the slopes of Big Flat Creek.. It is expected that some Rudosol soils will occur on crests and upper slopes of hills to the very west of the MCCO Additional Project Area. This general mix of Tenosol and Rudosol soil is in agreement with the existing mapping. Land associated with this soil has been extensively cleared for grazing, however scattered pockets of vegetation remain. The steep hillslopes have remained vegetated.

The Basic Arenic Red-Orthic Tenosols are not strongly acid with pH generally above 5.5. The profile tends to be slightly gravelly with very weak to no pedality and a sandy texture. Arenic Tenosols tend to have low water holding capacity and the sandy textures tend to have very low inherent fertility (Peveirill et al 2005). The macronutrients (P,N,K) and the micronutrients (Ca, Mg, Na, Cu) are mostly low, which could restrict agriculture although fertiliser could amend these concentrations. The cation exchange capacity (CEC) is also very low, which also may present some fertility issues. While the soil profile extended beyond 1 m, the soils contained a sandy texture and low recorded fertility.

All soil chemistry results are given in Table 4.3. The soil chemistry constituent values highlighted in the 'soil sufficiency' column are agricultural industry benchmarks (Baker and Eldershaw 1993; Department of the Environment and Resource Management (DERM) 2011; Peveirill, Sparrow and Reuter 1999) and have been referenced in interpreting the laboratory results. The outcomes are presented in the comments column, and are in reference to the median values with increasing depth. A summary of the agricultural potential of the Basic Arenic Red-Orthic Tenosol is given in Table 4.4.

Table 4.3 Basic Arenic Red-Orthic Tenosol soil chemistry result medians (and ranges)

Constituents	Unit	Soil sufficiency ¹	A1 0-0.12	A2 0.12-0.4	B21 0.4-1.2	Comments on median values (in increasing depth)
pH _{water}	pH units	6.0-7.5	5.8 (5.6-6.2)	6.2 (6.2-6.2)	6.7 (6.1-7.6)	mild acidity (top of A horizon) to neutral (B horizon).
EC – saturated extract (EC _{se})	decise mins per metre (dS/m)	<1.9	0.18 (0.25-0.09)	0.09 (0.06-0.11)	0.18 (0.06-0.39)	Very low soil salinity.
Chloride (Cl ⁻)	Milligrams per kilogram (mg/kg)	<800	<10	<10	10 (<10-20)	Not restrictive.
Macronutrients						
Nitrite + Nitrate as N (Sol.)	mg/kg	>15	0.85 (0.4-1.4)	0.5 (0.4-0.6)	0.2 (0.1-0.5)	Deficient throughout profile.
Total N	mg/kg	>1500	502 (360-740)	165 (160-170)	117 (80-220)	Deficient.
P (Colwell)	mg/kg	>10	2.5 (2.5-2.5)	2.5 (2.5-2.5)	2.5 (3-7)	Deficient.
K (Acid Extract)	mg/kg	>117	366 (251-474)	329 (296-362)	288 (225-413)	Sufficient.
K (Total)	mg/kg	>150	7.5 (5-10)	7.5 (5-10)	6.1 (5-10)	Deficient.
Micronutrients						
Cu	mg/kg	>0.3	<1	<1	<1	Low (inconclusive).
Zn	mg/kg	>0.5 (pH<7) >0.8 (pH>7)	0.8 (0.5-1.43)	<1	<1	Moderate in A horizon, Low (inconclusive).
Mn	mg/kg	>2	19.0 (5.2-25.6)	8.4 (8.1-8.7)	4.7 (0.5-20.8)	High (A horizon) to moderate (B horizon).
Exchangeable cations						
CEC	milliequivalents per 100 grams (meq/100 g)	12-25	2.7 (2.5-3)	1.9 (1.8-2.1)	2.6 (1.3-5.2)	Very low.
Ca	meq/100 g	>5	1.4 (0.5-1.8)	1.2 (1-1.4)	0.7 (0.1-1.3)	Very low.
Mg	meq/	>1	0.95	0.4	1.5	Low (A horizon) to

Table 4.3 Basic Arenic Red-Orthic Tenosol soil chemistry result medians (and ranges)

Constituents	Unit	Soil sufficiency ¹	A1 0-0.12	A2 0.12-0.4	B21 0.4-1.2	Comments on median values (in increasing depth)
	100 g		(0.7-1.6)	(0.4-0.4)	(0.5-4.1)	moderate (B horizon).
Na	meq/100 g	<0.7	<0.1	<0.1	0.3 (0.1-0.5)	Very low.
K	meq/100 g	>0.3	0.3 (0.2-0.5)	0.25 (0.2-0.3)	0.3 (0.1-0.5)	Low
ESP	%	<6	1.1 (0.-2.8)	0.7 (0.5-0.9)	4.4 (0.1-16.2)	Non-sodic.
Ca:Mg ratio		>2	1.85 (0.3-2.6)	3 (2.5-3.5)	1.0 (0.05-2.6)	Stable A horizon. Unstable B horizon.
Organic Carbon (OC)	%	>1.2	0.82 (0.6-0.9)	<0.5	<0.5	Low (A1 horizon) to very low (A2 and B horizons).

Notes: 1. Plant sufficiency sources: Baker and Eldershaw (1993), DERM (2011) and Peverill, Sparrow and Reuter (1999).

2. Values in brackets are the ranges measured.

* These values are an approximation based on calculations using the lowest measurable level.

Table 4.4 Basic Arenic Red-Orthic Tenosol agricultural use summary

Elements	Comments
pH _{water}	Acidic at the surface, progressing to neutral with depth. Would restrict some agriculture.
EC	Very low salinity levels that would not restrict agriculture.
Cl	Acceptable chloride levels that would not restrict agriculture.
Fertility	
Macronutrients	Mostly low levels of macronutrients, which present fertility issues. Would restrict agriculture.
Micronutrients	Low to moderate levels of micronutrients. Would restrict some agriculture.
CEC	Very low CEC, which may present some fertility issues.
Fertility ranking	<p>Relative Fertility of ASC Classes (NSW Government 2013): Moderately low - Tenosol (order), Orthic (suborder), any (soil <1000mm and solum is light sandy textured (sandy to sandy loams) (Great group)</p> <p>EMM applied Relative Fertility of ASC Classes (lab and field data applied to Murphy et al. 2007): Moderately low (Group 2) - While the soils are deep the texture is sandy and the tested fertility is very low</p> <p>Explanation (Murphy et al. 2007): Low fertilities that generally only support plants suited to grazing. Generally deficient in nitrogen, phosphorus and many other elements.</p>
ESP	Low ESP at surface, some sodicity at depth, which may not restrict agriculture.
Ca:Mg ratio	A mostly stable Ca:Mg ratio in the topsoil, but decreasing with depth to levels that suggest soil instability.
OC	Indicative of good structural condition and structural stability in the A1 horizon. Low levels below this horizon.
Major limitations to agriculture	<p>Macronutrients (eg nitrate, total N, P, K extract)</p> <p>Micronutrients (eg Ca, Mg, Na)</p>

4.3 Brown Dermosol

Brown Dermosols are moderately to well developed depending on the landform element with which they are associated, and do not have strong texture contrast. The parent materials of Dermosols range from siliceous, intermediate to mafic in composition with siliceous and intermediate in the local area. The identified Sodic Eutrophic Brown Dermosols surface soils are of moderately high fertility, moderately permeable and poorly drained. The Dermosols have saline, sodic B horizons and very slightly acidic A horizons. The soil surface is mostly without coarse fragments and of firm condition. Eutrophic Brown Dermosols generally have few coarse fragments distributed in the lower A and upper B horizons. Subsoils commonly have red and orange mottling with no segregations. Sod and tussock marsh vegetation were observed in some locations. A soil profile description for a typical Sodic Eutrophic Brown Dermosols is provided in Table 4.5.

Table 4.5 Dermosol typical soil profile summary

ASC:	Horizon name and average depth (m)	Colour, mottles and bleach	Moisture, laboratory pH (median) and drainage	Texture and structure	Coarse fragments, segregations and roots
	A1 0.0-0.09	Greyish brown, 7.5YR4/3 and no mottles or bleaching.	Dry, pH 5.9 and imperfectly drained.	Sandy clay loam, strong pedality, sub-angular blocky structure.	No surface rock, few coarse fragments, no segregations and many roots.
	B21 0.09-0.60	Reddish brown 2.5YR4/4 and no mottles or bleaching	Moderately moist, pH 7.2 and poorly drained.	Medium clay, moderate pedality, sub-angular blocky structure.	Few coarse fragments, no segregations and few roots.
	B22 0.60-1.2	Dark brown 7.5YR3/3 and no mottles or bleaching	Moderately moist, pH 6.8 and poorly drained.	Medium clay, moderate pedality, sub-angular blocky structure.	Few coarse fragments, no segregations

- Notes:
1. Description in accordance with the Australian Soil and Land Survey Field Handbook (NCST 2009).
 2. pH are laboratory results and the median values are presented
 3. Based on profile no. 12. Some profiles will vary

Sodic Eutrophic Grey Dermosols occur on gently inclined rolling low hills associated with the localised back plain or meander of Big Flat Creek. Within the MCCO Additional Project Area, land use on this soil type is primarily for grazing (north of Wybong Road) with riparian zones adjacent to Big Flat Creek south of Wybong Road remaining vegetated (Photograph 4.2).



Photograph 4.2 Sodic Eutrophic Brown Dermosol (site 12)

Eutrophic Brown Dermosols are of moderately high fertility. The Sodic Eutrophic Brown Dermosols of the site are low to moderate fertility, moderately permeable, poorly drained and have saline and sodic subsoils with slightly acidic A horizons.

Soil chemistry results are given in Table 4.6, the soil chemistry constituent values highlighted in the 'soil sufficiency' column are agricultural industry benchmarks (Baker and Eldershaw 1993; Department of the Environment and Resource Management (DERM) 2011; Peverill, Sparrow and Reuter 1999) and have been referenced in interpreting the laboratory results. The outcomes are presented in the comments column, and are in reference to the median values with increasing depth. A summary of the agricultural potential of Sodic Eutrophic Brown Dermosols is given in Table 4.7.

Table 4.6 Sodic Eutrophic Brown Dermosol soil chemistry result medians (and ranges)

Constituents	Unit	Soil sufficiency ¹	A1 0-0.09	B21 0.09-0.6	B22 0.6-1.2	Comments on median values (in increasing depth)
pH _{water}	pH units	6.0-7.5	5.9 (5.8-6)	6.4 (4.7-8.5)	5.8 (4.5-8.5)	Generally neutral to alkaline.
EC _{se}	dS/m	<1.9	0.3 (0.1-0.7)	3.5 (0.06-10.0)	3.3 (0.09-9.8)	Low soil salinity (A horizon), saline B horizon, except site 12
Cl	mg/kg	<800	43 (10-110)	618 (5-1540)	596 (5-1780)	Median is not restrictive. Site 5 and A1(55) exceed in lower B horizon.

Table 4.6 Sodic Eutrophic Brown Dermosol soil chemistry result medians (and ranges)

Constituents	Unit	Soil sufficiency ¹	A1 0-0.09	B21 0.09-0.6	B22 0.6-1.2	Comments on median values (in increasing depth)
Macronutrients						
Nitrite + Nitrate as N (Sol.)	mg/kg	>15	0.35 (0.05-0.6)	0.12 (0.05-0.4)	0.23 (0.05-0.6)	Deficient throughout profile.
Total N	mg/kg	>1500	1696 (1,160-2,030)	354 (120-780)	243 (120-360)	Sufficient (A horizon) deficient in upper B horizon.
P (Colwell)	mg/kg	>10	4.8 (2.5-6)	<5	<5	Very low
K (Acid Extract)	mg/kg	>117	473 (467-481)	350 (270-404)	402 (295-539)	Sufficient
K (Total)	mg/kg	>150	15 (5-20)	7.2 (5-20)	6.6 (5-10)	Deficient
Micronutrients						
Cu	mg/kg	>0.3	0.5 (0.5-0.5)	0.72 (5-20)	0.79 (0.5-1.37)	Low (inconclusive) A horizon, moderate B horizon.
Zn	mg/kg	>0.5 (pH<7) >0.8 (pH>7)	2.3 (0.5-3.45)	0.5 (0.5-0.5)	0.5 (0.5-0.5)	Moderate A horizon, Low (inconclusive) B horizon.
Mn	mg/kg	>2	79.7 (24.3-119)	17 (133-54.2)	4.7 (0.5-10.1)	Moderate (A horizon) to very low (B horizon).
Exchangeable cations						
CEC	meq/100g	12-25	8.1 (6.-9.8)	9.5 (0.4-18.3)	11.7 (9.8-13.3)	Low (A horizon, upper B horizon) moderate B horizon
Ca	meq/100g	>5	3.5 (3.4-3.7)	2.0 (0.3-4.4)	2.4 (1.3-3.2)	Low throughout profile
Mg	meq/100g	>1	3.4 (1.8-5)	5.6 (0.1-11.4)	6.9 (5-8.4)	Moderate throughout profile
Na	meq/100g	<0.7	0.25 (0.05-0.5)	1.49 (0.05-3.1)	1.8 (0.6-3.2)	Low in A horizon to very high (B horizon)
K	meq/100g	>0.3	0.86 (0.8-0.9)	0.36 (0.1-0.7)	0.36 (0.3-0.4)	High (A horizon) to mod (B horizons).
ESP	%	<6	3 (0.7-5.4)	13.4 (0.1-30.3)	15.2 (5.1-24.2)	Sodic B horizon
Ca:Mg ratio		>2	1.2 (0.7-2)	0.4 (0.1-1.3)	0.3 (0.1-0.6)	Unstable soil profile
OC	%	>1.2	1.8 (1.4-2)	0.35 (0.25-0.9)	0.25 (0.25-0.25)	Mod (A horizon) to v low (B horizons).

Notes: 1. Plant sufficiency sources: Baker and Eldershaw (1993), DERM (2011) and Pevevill, Sparrow and Reuter (1999).

2. Values in brackets are the ranges measured.

* These values are an approximation based on calculations using the lowest measurable level.

Table 4.7 Dermosol agricultural use summary

Elements	Comments
pH _{water}	Mildly acidic throughout the profile. Would restrict some agriculture.
EC	Saline B horizon that may restrict some agriculture.
Cl	Acceptable chloride levels that would not restrict agriculture.
Fertility	
Macronutrients	Deficient in some macronutrients, which present fertility issues. Would restrict agriculture.
Micronutrients	Low to moderate levels of micronutrients. Would restrict some agriculture.
CEC	Very low CEC, which may present some fertility issues.
Fertility ranking	<p>Relative Fertility of ASC Classes (NSW Government 2013): Moderately high - Dermosol (order), Brown(sub-order), Eutrophic (Great group)</p> <p>EMM applied Relative Fertility of ASC Classes (lab and field data applied to Murphy et al. 2007): Moderately low (Group 2) - Classified due to sodic subsoil and low fertility</p> <p>Explanation (Murphy et al. 2007): Low fertilities that generally only support plants suited to grazing. Generally deficient in soluble N, P and many other elements. Highly sodic subsoils.</p>
ESP	Moderate ESP at surface, High sodicity in B horizon from 0.1 m. Would restrict agriculture.
Ca:Mg ratio	Low Ca:Mg ratio in the topsoil and decreasing with depth to levels that suggest high soil instability.
OC	Indicative of good structural condition in the A1 horizon. Low levels below this horizon.
Major limitations to agriculture	<p>Macronutrients (eg nitrate and nitrite, P, total K)</p> <p>Micronutrients (eg Ca, Na, Cu)</p>

4.4 Grey Sodosol

Grey Sodosols show strong texture contrast with sandy clay loams over light to medium clays. These soils are generally not highly acidic with pH above 5.5 and have highly sodic B horizons. The Sodosols are associated with surface geology which is siliceous to intermediate in composition. The surface is generally hard setting. The identified Mesotrophic Mesonatric Grey Sodosols have very low agricultural potential with high sodicity. This can lead to high erodibility, poor structure and low permeability. A soil profile description for a typical Mesotrophic Mesonatric Grey Sodosols is provided in Table 4.8.

The Mesotrophic Mesonatric Grey Sodosol is the most common soil type across the MCCO Additional Project Area, occurring on all slopes and crests of low rolling hills in the lower west, centre and far east of the project area (Photograph 4.3). Land characterised by this soil type has been extensively cleared associated with historical grazing activities.

Table 4.8 Sodosol typical soil profile summary

ASC:	Horizon name and average depth (m)	Colour, mottles and bleach	Moisture, laboratory pH (median) and drainage	Texture and structure	Coarse fragments, segregations and roots
	A1 0.0-0.10	Brown, 7.5YR4/3 and no mottles or bleaching.	Dry, pH 6.0 and imperfectly drained.	Sandy clay loam, strong pedality, sub-angular blocky structure.	No surface rock, no coarse fragments, no segregations and many roots.
	A2 0.10-0.20	Light gray 10YR7/2 dry, no mottles, bleaching	Dry, pH 6.7 and imperfectly drained	Sandy loam, massive, sandy structure,	Abundant fine gravel fragments, no segregations.
	B21 0.20-0.85	Dark brown 7.5YR3/3 and no mottles or bleaching	Moderately moist, pH 7.9 and poorly drained.	Light medium clay, strong pedality, sub-angular blocky structure.	Few coarse fragments, no segregations and few roots.
	B22 0.85-1.20	Dark brown 7.5YR3/3 and no mottles or bleaching	Moderately moist, pH 8.0 and imperfectly drained.	Light medium clay, strong pedality, sub-angular blocky structure.	Few coarse fragments, no segregations

- Notes:
1. Description in accordance with the Australian Soil and Land Survey Field Handbook (NCST 2009).
 2. pH are laboratory results and the median values are presented
 3. Based on profile no 10. Some profiles will vary



Photograph 4.3 Mesotrophic Mesonatric Grey Sodosol (site 10)

The pH of the surface is slightly acidic progressing to neutral with depth. The macronutrients (N, P, K) and the micronutrients (Cu, Ca, Mg) are mostly low which could restrict agriculture, although fertiliser could amend these concentrations. The CEC is also very low, which also may present some fertility issues. Salinity and Cl concentrations become restrictive in the B horizon from 0.2 m. Salt tolerant species (ie *junkus acutus*) have been identified on this soil type, particularly around sites 11 and 18. High sodicity and small Ca to Mg ratios indicate an unstable subsoil prone to dispersion.

All soil chemistry results are given in Table 4.9. The soil chemistry constituent values highlighted in the 'soil sufficiency' column are agricultural industry benchmarks (Baker and Eldershaw 1993; Department of the Environment and Resource Management (DERM) 2011; Peverill, Sparrow and Reuter 1999) and have been referenced in interpreting the laboratory results. The outcomes are presented in the comments column, and are in reference to the median values with increasing depth. A summary of the agricultural potential of Mesotrophic Mesonatric Grey Sodosols is presented in Table 4.10.

Table 4.9 Grey Sodosol soil chemistry result medians (and ranges)

Constituents	Unit	Soil sufficiency ¹	A1 0-0.10	A2 0.10-0.2	B21 0.2-0.85	B22 0.85-1.2	Comments on median values (in increasing depth)
pH _{water}	pH units	6.0-7.5	5.55 (5.4-5.7)	6.3 (6.0-6.6)	7.0 (5.4-9.1)	7.7 (5.9-8.9)	Mild acidity (top of A horizon) to mildly alkaline (B horizon).
EC _{se}	dS/m	<1.9	0.24 (0.1-0.38)	0.22 (0.09-0.36)	1.56 (0.08-6.52)	3.69 (3.04-4.50)	Subsoil salinity
Cl	mg/kg	<800	13.7 (<10-30)	11 (<10-20)	357 (<10-1640)	692 (400-1140)	Restrictive subsoil
Macronutrients							
Nitrite + Nitrate as N (Sol.)	mg/kg	>15	0.26 (005-0.5)	0.48 (0.2-1.1)	0.22 (0.05-0.6)	0.15 (0.05-0.3)	Extremely low throughout profile.
Total N	mg/kg	>1500	1412 (570-2110)	400 (140-930)	224 (120-310)	282 (70-420)	Deficient.
P (Colwell)	mg/kg	>10	4.3 (<5-10)	<5	3.5 (<5-7)	<5	Very low.
K (Acid Extract)	mg/kg	>117	461 (369-566)	212 (100-315)	214 (100-365)	256 (100-363)	Sufficient.
K (Total)	mg/kg	>150	11.25 (5-20)	<10	<10	<10	Deficient throughout profile
Micronutrients							
Cu	mg/kg	>0.3	<0.5	<0.5	<0.5	<0.5	Low (inconclusive).
Zn	mg/kg	>0.5 (pH<7) >0.8 (pH>7)	1.4 (0.5-1.96)	<0.5	<0.5	<0.5	Sufficient (A horizon), low (inconclusive) B horizon.
Mn	mg/kg	>2	24.3 (17.6-33.8)	2.6 (0.5-9.33)	<1	<1	High (A horizon) to very low (B horizon).
Exchangeable cations							
CEC	meq/100g	12-25	6.3 (3.6-9.3)	4.6 (1.9-7.9)	8.5 (1.8-13.9)	8.5 (7.3-11.5)	Very low.
Ca	meq/	>5	3.4	1.8	0.5	1.65	Low (A horizon) to

Table 4.9 Grey Sodosol soil chemistry result medians (and ranges)

Constituents	Unit	Soil sufficiency ¹	A1 0-0.10	A2 0.10-0.2	B21 0.2-0.85	B22 0.85-1.2	Comments on median values (in increasing depth)
	100g		(2.1-4.4)	(0.9-3.2)	(0.1-0.9)	(0.5-2.4)	moderate (B horizon).
Mg	meq/100g	>1	1.95 (0.8-3.5)	2.1 (0.5-4)	5.4 (0.9-8.4)	5.0 (4.0-7.1)	Moderate (A horizons) to high (B horizon).
Na	meq/100g	<0.7	0.15 (0.05-0.4)	0.36 (0.05-0.8)	1.95 (0.3-3.4)	1.65 (1.2-2.2)	Very low.
K	meq/100g	>0.3	0.7 (0.4-0.9)	0.28 (0.2-0.5)	0.29 (0.05-0.7)	0.15 (0.1-0.2)	Moderate (A1 horizon) to low (A2 and B horizons).
ESP	%	<6	2.1 (0.8-3.9)	7.7 (3.5-14.1)	23.7 (14-3.5)	19.4 (15.2-27.3)	Sodic (A2 and B horizon).
Ca:Mg ratio		>2	2.15 (1.2-3.4)	1.26 (0.6-2.2)	0.18 (0.05-0.8)	0.32 (0.1-0.5)	Stable A horizon. Unstable B horizon.
OC	%	>1.2	2.25 (1.4-2.8)	0.59 (0.25-1.1)	0.3 (0.25-0.6)	0.25 (0.25-0.25)	Moderate (A1 horizon) to very low (A2 and B horizons).

Notes: 1. Plant sufficiency sources: Baker and Eldershaw (1993), DERM (2011) and Peverill, Sparrow and Reuter (1999).

2. Values in brackets are the ranges measured.

* These values are an approximation based on calculations using the lowest measurable level.

Table 4.10 Sodosol agricultural use summary

Elements	Comments
pH _{water}	Slightly acidic at the surface, progressing to neutral with depth.
EC	Moderate subsoil salinity that would restrict some agriculture.
Cl	Acceptable chloride levels that would not restrict agriculture.
Fertility	
Macronutrients	Mostly low levels of macronutrients, which present fertility issues. Would restrict agriculture.
Micronutrients	Low to moderate levels of micronutrients. Would restrict some agriculture.
CEC	Very low CEC, which may present some fertility issues.
Fertility ranking	Relative Fertility of ASC Classes (NSW Government 2013): Moderately low - Sodosol (order), Grey (suborder), any (great group) EMM applied Relative Fertility of ASC Classes (lab and field data applied to Murphy et al. 2007): Moderately low - Group 2 Explanation (Murphy et al. 2007): Low fertilities that generally only support plants suited to grazing. Generally deficient in phosphorus, P and many other elements.
ESP	Low ESP at surface, sodicity from 0.1 m which would restrict agriculture.
Ca:Mg ratio	A mostly stable Ca:Mg ratio in the topsoil, but decreasing with depth to levels that suggest soil instability.
OC	Indicative of good structural condition and structural stability in the A1 horizon. Low levels below this horizon.
Major limitations to agriculture	Macronutrients (eg nitrate, total N, P, K) Micronutrients (eg Ca, Mg, Na)

Table 4.10 Sodosol agricultural use summary

Elements	Comments
	Sodicity (ESP > 6 in the subsoil)

4.5 Grey Kurosol

A very small percentage of the MCCO Additional Project Area is covered by Magnesian-Natric Grey Kuro sols. These soils have a strong texture contrast with a strongly acid B horizon that may or may not be sodic. They appear to be a transition soil associated with gentle to moderate slopes and influenced by their location in the landscape and the quaternary depositional geology (Photograph 4.4). Magnesian-Natric Grey Kuro sols have very low agricultural potential with high acidity (pH < 5.5) and low chemical fertility. Moisture loving vegetation profiles were observed in areas of open depressions. A soil profile description for a typical Magnesian-Natric Grey Kuro sols is provided in Table 4.11.

Table 4.11 Kurosol typical soil profile summary

ASC:	Horizon name and average depth (m)	Colour, mottles and bleach	Moisture, laboratory pH (median) and drainage	Texture and structure	Coarse fragments, segregations and roots
	A1 0.0-0.10	Brown, 7.5YR4/3 and no mottles or bleaching.	Dry, pH 6.0 and poorly drained.	Sandy clay loam, moderate pedality, sub-angular blocky structure.	No surface rock, no coarse fragments, no segregations and many roots.
	A2 0.10-0.90	Dull brown 7.5YR5/3 and no mottles or bleaching	Dry, pH 6.2 and poorly drained.	Sandy loam, single grained, sandy fabric.	Many coarse fragments, no segregations and few roots.
	B21 0.90-1.20	Dark brown 7.5YR3/3, Many orange and grey mottles.	Moderately moist, pH 5.2 and poorly drained.	Medium clay, moderate pedality, sub-angular blocky structure.	Few coarse fragments, no segregations

- Notes:
1. Description in accordance with the Australian Soil and Land Survey Field Handbook (NCST 2009).
 2. pH are laboratory results and the median values are presented
 3. Based on profile no 48. Some profiles vary.



Photograph 4.4 Mottled Magnesian-Natric Grey Kurosols (site 48)

The Grey Kurosol is acidic in the upper B horizon and mildly acidic throughout the horizon. The surface is generally hard set with no surface fragments but fine gravel dispersed through the A horizon. The soil type has been cleared for grazing in the project area. The macronutrients (P, K) and the micronutrients (Cu, Ca, Mg) are mostly low which could restrict agriculture, although fertiliser could amend these concentrations. The CEC is also very low, which also may present some fertility issues.

Soil chemistry results for the Magnesian-Natric Grey Kurosol are presented in Table 4.12. The soil chemistry constituent values highlighted in the 'soil sufficiency' column are agricultural industry benchmarks (Baker and Eldershaw 1993; Department of the Environment and Resource Management (DERM) 2011; Peverill, Sparrow and Reuter 1999) and have been referenced in interpreting the laboratory results. The outcomes are presented in the comments column, and are in reference to the median values with increasing depth. A summary of the agricultural potential of Mottled Magnesian-Natric Grey Kurosol is presented in Table 4.13.

Table 4.12 Magnesian-Natric Grey Kurosol soil chemistry result medians (and ranges)

Constituents	Unit	Soil sufficiency ¹	A1 0-0.10	A2 0.10-0.9	B21 0.9-1.2	Comments on median values (in increasing depth)
pH _{water}	pH units	6.0-7.5	5.6 (5.5-5.8)	6.1 (5.9-6.6)	5.1 (4.9-5.5)	Mild acidity (top of A horizon) to acidity (B horizon).
EC _{se}	dS/m	<1.9	0.19 (0.1-0.25)	0.72 (0.03-4.07)	0.19 (0.08-0.31)	Very low soil salinity.
Cl	mg/kg	<800	6.6 (<5-10)	<5	12.5 (<5-20)	Not restrictive.

Table 4.12 Magnesian-Natric Grey Kurosol soil chemistry result medians (and ranges)

Constituents	Unit	Soil sufficiency ¹	A1 0-0.10	A2 0.10-0.9	B21 0.9-1.2	Comments on median values (in increasing depth)
Macronutrients						
Nitrite + Nitrate as N (Sol.)	mg/kg	>15	5.4 (2.2-10.7)	0.5 (0.1-1)	0.3 (0.2-0.5)	Very low throughout profile.
Total N	mg/kg	>1500	1236 (1,000-1,510)	255 (150-380)	215 (140-310)	Deficient.
P (Colwell)	mg/kg	>10	<5	<5	<5	Very low.
K (Acid Extract)	mg/kg	>117	408 (291-495)	145 (100-235)	220 (100-350)	Sufficient in profile.
K (Total)	mg/kg	>150	11.6 (5-20)	<5	<5	Very low
Micronutrients						
Cu	mg/kg	>0.3	<5	<5	<5	Low (inconclusive).
Zn	mg/kg	>0.5 (pH<7) >0.8 (pH>7)	3.2 (1.0-7.3)	<5	<5	Sufficient (A horizon), low (inconclusive) in B.
Mn	mg/kg	>2	45.3 (26.4-58.5)	3.11 (0.5-6.6)	<5	High (A horizon) to low (B horizon).
Exchangeable cations						
CEC	meq/100g	12-25	5.06 (4.3-5.8)	2.81 (2.2-3.4)	9.4 (5.6-13)	Very low.
Ca	meq/100g	>5	3.3 (2.9-4.1)	1.58 (0.7-2.2)	0.16 (0.05-0.3)	Low (A horizon) to very low (B horizon).
Mg	meq/100g	>1	1.06 (0.8-1.3)	0.9 (0.6-1.6)	4.7 (2.7-6.6)	Moderate (A1 and B horizons).
Na	meq/100g	<0.7	0.5 (<0.5-0.5)	0.05 (0.05-0.1)	0.98 (0.05-2.01)	Very low.
K	meq/100g	>0.3	0.5 (0.3-0.8)	0.12 (0.05-0.2)	0.28 (0.05-0.5)	Mod (A1 horizon) to very low (A2 and B horizon).
ESP	%	<6	0.73 (0.4-1.3)	2.25 (0.7-5.4)	12.9 (2.4-24.3)	Sodic subsoil (transition soil sample).
Ca:Mg ratio		>2	3.1 (2.7-3.6)	1.9 (0.4-3.3)	<0.1	Stable A horizon. Unstable B horizon.
OC	%	>1.2	2.3 (1.3-2.9)	0.7 (0.6-0.8)	<0.5	Moderate (A1 horizon) to very low (B horizon).

Notes: 1. Plant sufficiency sources: Baker and Eldershaw (1993), DERM (2011) and Peverill, Sparrow and Reuter (1999).

2. Values in brackets are the ranges measured.

* These values are an approximation based on calculations using the lowest measurable level.

Table 4.13 Kurosol agricultural use summary

Elements	Comments
pH _{water}	Acidic at the surface, progressing to neutral with depth. Would restrict some agriculture.
EC	Very low salinity levels that would not restrict agriculture.
Cl	Acceptable chloride levels that would not restrict agriculture.
Fertility	
Macronutrients	Mostly very low levels of macronutrients, which present fertility issues. Would restrict agriculture.
Micronutrients	Low to moderate levels of micronutrients. Would restrict some agriculture.
CEC	Very low CEC, which may present some fertility issues.
Fertility ranking	<p>Relative Fertility of ASC Classes (NSW Government 2013): Moderately low - Kurosol (order), any (suborder), Magnesic-Natric (Great group)</p> <p>EMM applied Relative Fertility of ASC Classes (lab and field data applied to Murphy et al. 2007): Moderately low (Group 2)</p> <p>Explanation (Murphy et al. 2007): Low fertilities that generally only support plants suited to grazing. Generally deficient in phosphorus, P and many other elements.</p>
ESP	Low ESP at surface, some sodicity at depth, which may not restrict agriculture.
Ca:Mg ratio	A mostly stable Ca:Mg ratio in the topsoil, but decreasing with depth to levels that suggest soil instability.
OC	Indicative of good structural condition and structural stability in the A1 horizon. Low levels below this horizon.
Major limitations to agriculture	<p>Macronutrients (eg nitrate, total N, potassium, K)</p> <p>Micronutrients (eg Ca, Mg, Na)</p>

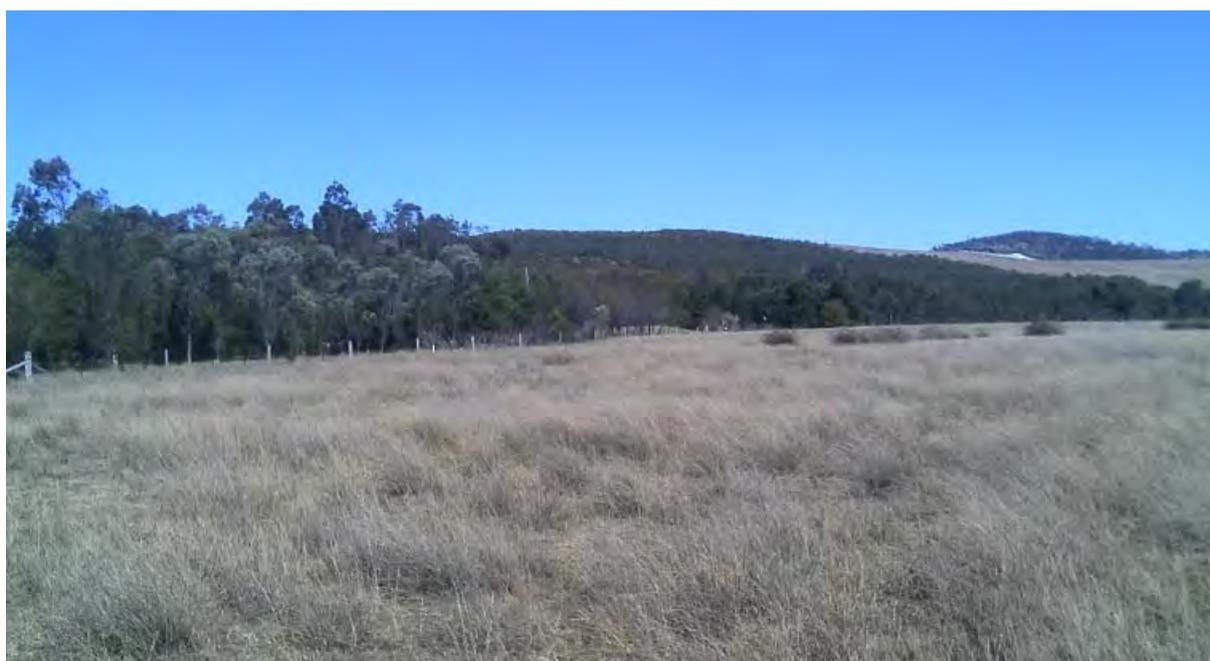
4.6 Brown Chromosol

Two surveyed soil profiles have been classified as Mottled Mesotrophic Brown Chromosols (site 19 and 53). These are soils with a strong texture contrast between the A and B horizons and where the upper part of the B horizon is neither sodic or acidic. The Chromosols on site may be a boundary, or transition soil type. The sites occur on gently undulating hills (Photograph 4.5). Chromosols have moderate agricultural potential with moderate chemical fertility and water-holding capacity. They can be susceptible to soil acidification and soil structure decline. A soil profile description for a typical Mottled Mesotrophic Brown Chromosol is shown in Table 4.14.

Table 4.14 Chromosol typical soil profile summary

ASC:	Horizon name and average depth (m)	Colour, mottles and bleach	Moisture, laboratory pH (median) and drainage	Texture and structure	Coarse fragments, segregations and roots
	A1 0.0-0.10	Brown, 7.5YR4/3 and no mottles or bleaching.	Dry, pH 5.8 and moderately drained.	Sandy clay loam, moderate pedality, sub-angular blocky structure.	No surface rock, no coarse fragments, no segregations and many roots.
	A2 0.10-0.50	Dull brown 10YR4/2 and no mottles	Dry, pH 6.0 and imperfectly drained.	Sandy loam, weak pedality, sandy fabric.	Common coarse fragments, no segregations and few roots.
	B21 0.50-1.20	Dull brown 7.5YR3/3	Moderately moist, pH 7.0 and poorly drained.	Light clay, moderate pedality, sub-angular blocky structure.	Common coarse fragments, no segregations

- Notes:
1. Description in accordance with the Australian Soil and Land Survey Field Handbook (NCST 2009).
 2. pH are laboratory results and the median values are presented
 3. based on profile no. 54. Some profiles will vary



Photograph 4.5 Mottled Mesotrophic Brown Chromosol (site 19)

The Brown Chromosol surface is soft with no surface fragments but fine gravel dispersed through the lower A horizon and B horizon. The soil type has been cleared for grazing in the MCCO Additional Project Area. The soil chemistry results show levels contributing to very poor actual soil fertility. The macronutrients (potassium, P and K) and the micronutrients (Cu, Ca and Mg) are very low which could restrict agriculture, although fertiliser could amend these concentrations. The CEC is also very low, which also may present some fertility issues.

Soil chemistry results for the Mottled Mesotrophic Brown Chromosol are presented in Table 4.15. The soil chemistry constituent values highlighted in the 'soil sufficiency' column are agricultural industry benchmarks (Baker and Eldershaw 1993; Department of the Environment and Resource Management (DERM) 2011; Peverill, Sparrow and Reuter 1999) and have been referenced in interpreting the laboratory results. The outcomes are presented in the comments column, and are in reference to the median values with increasing depth. A summary of the agricultural potential of Mottled Mesotrophic Brown Chromosol is presented in Table 4.16.

Table 4.15 Mottled Mesotrophic Brown Chromosol soil chemistry result medians (and ranges)

Constituents	Unit	Soil sufficiency ¹	A1 0-0.10	A2 0.10-0.5	B21 0.5-1.2	Comments on median values (in increasing depth)
pH _{water}	pH units	6.0-7.5	6.0 (5.5-6.6)	6.5 (6.5-6.6)	7.4 (7.1-7.8)	Neutral profile.
EC _{se}	dS/m	<1.9	0.30 (0.25-0.35)	0.08 (0.05-0.11)	0.25 (0.13-0.31)	Very low soil salinity.
Cl	mg/kg	<800	<10	<10	20 (<10-50)	Not restrictive.
Macronutrients						
Nitrite + Nitrate as N (Sol.)	mg/kg	>15	7.5 (4.3-10.7)	0.8 (0.4-1.8)	0.3 (0.3-0.4)	Very low throughout profile.
Total N	mg/kg	>1500	1065 (1,000-1,130)	176 (110-260)	136 (130-150)	Deficient.
P (Colwell)	mg/kg	>10	<5	<5	<5	Very low.
K (Acid Extract)	mg/kg	>117	423 (408-439)	236 (235-237)	300 (300-300)	Sufficient in profile.
K (Total)	mg/kg	>150	25 (20-30)	<10	<10	Very low
Micronutrients						
Cu	mg/kg	>0.3	<0.5	<0.5	<0.5	Low (inconclusive).
Zn	mg/kg	>0.5 (pH<7) >0.8 (pH>7)	1.25 (1.0-1.4)	<1	<1	Sufficient (A horizon), low (inconclusive) in B.
Mn	mg/kg	>2	42 (33-51)	9.6 (3.6-19)	3.5 (1.4-5.6)	High (A horizon) to moderate (B horizon).
Exchangeable cations						
CEC	meq/100g	12-25	4.2 (4.2-4.3)	2.5 (2-2.9)	2.2 (1.1-3.8)	Very low.
Ca	meq/100g	>5	2.6 (2.4-2.9)	1.6 (1.4-2)	1.0 (0.6-1.8)	Low (A horizon) to very low (B horizon).
Mg	meq/100g	>1	0.9 (0.8-1)	0.5 (0.2-0.8)	1.0 (0.5-1.7)	Low (A1 and B horizons).

Table 4.15 Mottled Mesotrophic Brown Chromosol soil chemistry result medians (and ranges)

Constituents	Unit	Soil sufficiency ¹	A1 0-0.10	A2 0.10-0.5	B21 0.5-1.2	Comments on median values (in increasing depth)
Na	meq/100g	<0.7	<0.1	<0.1	0.1 <0.1-0.1)	Very low.
K	meq/100g	>0.3	0.5 (0.4-0.7)	0.2 (0.1-0.3)	0.1 (0.1-0.1)	Mod (A1 horizon) to very low (A2 and B horizon).
ESP	%	<6	0.27 (0.05-0.5)	1.1 (0.5-1.8)	1.3 (<1-3.7)	Low in profile.
Ca:Mg ratio		>2	3 (2.4-3.6)	4.0 (2.1-7.0)	0.9 (0.7-1)	Stable A horizon. Unstable B horizon.
OC	%	>1.2	1.6 (1.3-1.9)	<1	<1	Moderate (A1 horizon) to very low (B horizon).

Notes: 1. Plant sufficiency sources: Baker and Eldershaw (1993), DERM (2011) and Peverill, Sparrow and Reuter (1999).

2. Values in brackets are the ranges measured.

* These values are an approximation based on calculations using the lowest measurable level.

Table 4.16 Chromosol agricultural use summary

Elements	Comments
pH _{water}	Neutral throughout profile. Would not restrict agriculture.
EC	Very low salinity levels that would not restrict agriculture.
Cl	Acceptable chloride levels that would not restrict agriculture.
Fertility	
Macronutrients	Mostly very low levels of macronutrients, which present fertility issues. Would restrict agriculture.
Micronutrients	Low to moderate levels of micronutrients. Would restrict some agriculture.
CEC	Very low CEC, which may present some fertility issues.
Fertility ranking	Relative Fertility of ASC Classes (NSW Government 2013): Moderately High - Chromosol (order), any (suborder), Mesotrophic (Great group) EMM applied Relative Fertility of ASC Classes (lab and field data applied to Murphy et al. 2007): Moderately low (Group 2) Explanation (Murphy et al. 2007): Low fertilities that generally only support plants suited to grazing. Generally deficient in phosphorus, P and many other elements.
ESP	Low ESP, which may not restrict agriculture.
Ca:Mg ratio	A mostly stable Ca:Mg ratio in the topsoil, but decreasing with depth to levels that suggest soil instability.
OC	Indicative of good structural condition and structural stability in the A1 horizon. Low levels below this horizon.
Major limitations to agriculture	Macronutrients (eg nitrate, total N, P, K) Micronutrients (eg Ca, Mg, Na)

4.7 Comparison with soil mapping by others

The ASRIS and eSPADE soil mapping in the MCCO Additional Project Area are very similar and have been grouped together for this comparison. There are some broad similarities between the existing ASRIS and eSPADE soil mapping, and the field-based soil survey results from this assessment, in terms of soil orders present and general patterns of distribution. The comparison results are summarised below.

Southern border of the MCCO Additional Project Area:

- ASRIS and eSPADE mapping: Dominated by Sodosols;
- EMM soil survey: Sodosols, with Dermosols adjacent to Big Flat Creek.

Western and north-western part of the MCCO Additional Project Area:

- ASRIS and eSPADE mapping: dominated by Tenosols/Rudosols and Sodosols;
- EMM soil survey: dominated by a larger expanse of Tenosols. It is expected that Rudosols may occur on the steeper slopes on the very western edge of the MCCO Additional Project Area. A small area of Kurosols occurs in the north-west.

Eastern and central parts of the MCCO Additional Project Area:

- ASRIS and eSPADE mapping: dominated by Sodosols only;
- EMM soil survey: dominated by Sodosols with an expanse of Tenosols towards the eastern side of the MCCO Additional Project Area.

The ASRIS or eSPADE mapping did not identify any Kurosols or Dermosols within the MCCO Additional Project Area. Field investigations found the Sodosols and Tenosols to be the dominant soil types, in agreement with the existing soil mapping, with the Kurosol and Dermosol occurring in smaller areas. The ASRIS and eSPADE data was not used further in this assessment. The assessments and soil mapping within this report have been based on results of field surveys and laboratory analyses from the current study, which were conducted in accordance with the Interim Protocol. In particular, the field and laboratory investigations for this study provided information which confirmed the presence or absence of various soil orders, including the following:

- Kurosols: small area of Kurosol identified in the north-west. These soils were texture contrast, all with acidic B horizons and one sample also confirmed as having a sodic B horizon; and
- Dermosols: small areas of Dermosols were identified adjacent to Big Flat Creek on the southern border of the MCCO Additional Project Area. Some of these sites had sodic B horizons. The structure of these soils varied between sites, however they did not have a strong texture contrast.

5 BSAL verification

For land to be classified as BSAL it must have access to a reliable water supply; meet all of the criteria presented in Figure 2.2; and be a contiguous area of at least 20 ha. Under the Interim Protocol if any individual criterion is not met, the site is not BSAL. The BSAL verification criteria have been evaluated for the MCCO Additional Project Area, based on analysis of field, laboratory and remotely sensed data. Section 2.2 explains the BSAL exclusion criteria and more detail is provided in Appendix C. Section 5.2 presents the results of the BSAL assessment and more detail is provided in Appendix D.

5.1 Exclusion criteria

5.1.1 Slope

A slope assessment for the MCCO Additional Project Area was conducted using a digital elevation model and site observations were made using a hand held clinometer. Areas with slopes greater than 10% were identified as BSAL exclusion areas.

5.1.2 Rock outcrop

The area of rock outcrop at each soil survey site, estimated as a percentage of the survey site, was determined by visual inspection in the field and recorded on SALIS data cards. Sites with 30% or greater rock outcrop were identified as BSAL exclusion areas.

5.1.3 Surface rockiness

Rockiness refers to the presence of unattached coarse rock fragments and/or rock outcrops at the soil surface. The area of surface rockiness, estimated as a percentage of each survey site, as well as the physical characteristics and size of rock fragments, was determined in the field and recorded on SALIS data cards. Sites with greater than 20% coverage of unattached rock fragments, with diameters larger than 60 mm, were identified as BSAL exclusion areas.

5.1.4 Gilgai

Gilgai microrelief is a natural soil feature of mounds and depressions commonly associated with cracking clays or Vertosols. The review of NSW regional soils mapping indicated that gilgai microrelief was unlikely to be present within the MCCO Additional Project Area and this was supported by the field observations.

Under the Interim Protocol, sites with average gilgai depressions deeper than 500 mm over more than 50% of the area are identified as BSAL exclusion areas. However, in the MCCO Additional Project Area no significant areas of gilgai were identified and thus no areas were excluded as BSAL on this basis.

5.1.5 Soil fertility

Soil types with fertility less than 'moderate', based on the relative fertility of ASC classes presented in Appendix 2 of the Interim Protocol, were identified as BSAL exclusion areas. This was based on the soil type distribution map presented as Figure 4.1.

The BSAL assessment has proceeded using the criteria of the Interim Protocol. In addition to this actual soil fertility has been assessed for the site soils using chemical analysis and agricultural industry 'soil

sufficiency' benchmarks sourced from Baker and Eldershaw (1993); Department of the Environment and Resource Management (DERM) (2011), and Peverill, Sparrow and Reuter (1999).

5.1.6 Effective rooting depth

Effective rooting depth refers to the depth of soil in which roots can function effectively. That is, above any physical or chemical barrier.

Physical and chemical barriers were identified in the field and recorded on SALIS data cards, and/or by laboratory analysis. In the context of BSAL, the depth of soil material from the surface to a physical barrier such as bedrock, weathered rock, hard pans or continuous gravel layers was noted during field surveys. Chemical barriers were identified based on laboratory analysis of soil profile samples, being where limiting values of soil pH, chloride content, electrical conductivity, exchangeable sodium percentage and/or the calcium to magnesium ratio (Ca:Mg) exist.

Survey sites with a physical or chemical barrier to rooting depth at less than 750 mm were identified as BSAL exclusion areas.

5.1.7 Drainage

The hydrology at soil survey sites was observed in the field and recorded on SALIS data cards. Poorly drained sites were identified as BSAL exclusion areas. Poorly drained sites were defined as those in low-lying landscapes with drainage restrictions and potential for waterlogging.

5.1.8 Soil pH

Soil pH was measured in the laboratory and occasionally in the field. Sites where the pH in the uppermost 600 mm of the soil profile was outside of the range 5.0-8.9, measured in water, were identified as BSAL exclusion areas.

5.1.9 Soil salinity

Soil salinity was measured in the laboratory. Sites where soil salinity in the uppermost 600 mm of the soil profile had any of the following properties were identified as BSAL exclusion areas:

- electrical conductivity of greater than 4 deciSiemens per metre (dS/m); or
- the presence of chlorides at 800 milligrams/kilogram (mg/kg) or more, with gypsum present.

5.2 Results of BSAL assessment

Detailed survey sites in the MCCO Additional Project Area which were subject to soil analysis (Table 3.3) have been classified according to their soil type under the ASC, to family level. These survey sites were assessed against each of the BSAL criteria specified in the Interim Protocol, to determine whether or not the criterion is satisfied. These analysed survey sites represent the soil types on site and it is assumed that the results will apply across all other survey sites not laboratory analysed. The detailed results are provided in Appendix D and summarised in Table 5.1, using the following code:

- yes (Y) highlighted in green, for a decisive 'yes' to meeting the subject criterion for BSAL;
- no (N) highlighted in orange, where a site fails the BSAL verification criteria but assessment against subsequent criteria is required to determine whether the site is BSAL or not (applies to criteria 5 to 7b); and
- N highlighted in red, for a decisive 'no' to meeting the subject criterion, meaning the site is excluded as BSAL on this basis alone.

Table 5.1 BSAL verification assessment by soil survey site

Site no. ¹	ASC soil type (to Sub Group)	BSAL verification criteria															Is the site BSAL?
		Water	1	2	3	4	5	6	7a	7b	8	9	10	11	12	Area	
		Access to reliable water supply?	Slope ≤ 10%?	< 30% rock outcrop?	≤ 20% of area has unattached rock fragments > 60 mm diameter?	≤ 50% of the area has gilgais > 500 mm deep?	Slope < 5%?	Nil rock outcrops?	Moderate soil fertility or higher? (applicable for sites <5% slope)	Moderately high or high soil fertility? Applicable for sites > 5% and <10% slope)	Effective rooting depth to physical barrier is ≥750 mm?	Soil drainage is better than poor?	pH 5-8.9 if measured in water or 4.5-8.1 if measured in calcium chloride, within the uppermost 600 mm of the soil profile?	Salinity is ≤ 4 dS/m or chlorides < 800 mg/kg when gypsum is present, within the uppermost 600 mm of the soil profile?	Effective rooting depth to a chemical barrier is ≥750 mm?	Is the contiguous area ≥20 ha?	
20	Basic Arenic Red-Orthic Tenosol	Y	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y	Y	No
21	Basic Arenic Red-Orthic Tenosol	Y	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y	Y	No
37	Basic Arenic Red-Orthic Tenosol	Y	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y	Y	No
55A1	Sodic Eutrophic Brown Dermosol	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	N	N	Y	No
5	Sodic Eutrophic Brown Dermosol	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	N	Y	N	N	Y	No
12	Mottled-Sodic Eutrophic Brown Dermosol	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	N	Y	Y	Y	Y	No
10	Mesotrophic Hypernatric Grey Sodosol	Y	Y	Y	Y	Y	Y	Y	N	N	Y	Y	N	N	N	Y	No
23	Mesotrophic Mottled-Hypernatric Grey Sodosol	Y	Y	Y	Y	Y	Y	Y	N	N	Y	N	Y	Y	Y	Y	No

Table 5.1 BSAL verification assessment by soil survey site

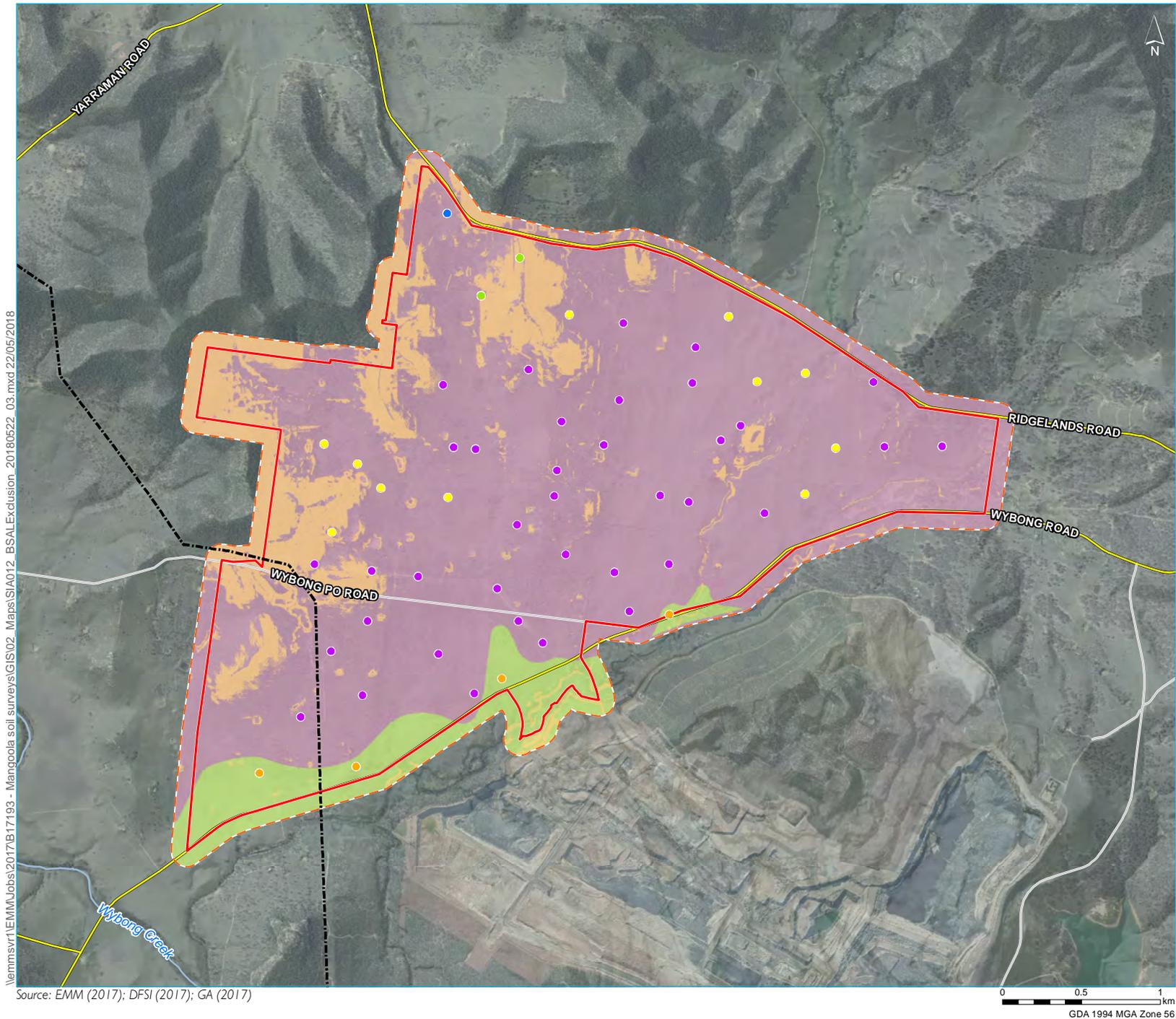
Site no. ¹	ASC soil type (to Sub Group)	BSAL verification criteria															Is the site BSAL?
		Water	1	2	3	4	5	6	7a	7b	8	9	10	11	12	Area	
		Access to reliable water supply?	Slope ≤ 10%?	< 30% rock outcrop?	≤ 20% of area has unattached rock fragments > 60 mm diameter?	≤ 50% of the area has gilgais > 500 mm deep?	Slope < 5 %?	Nil rock outcrops?	Moderate soil fertility or higher? (applicable for sites <5% slope)	Moderately high or high soil fertility? Applicable for sites > 5% and <10% slope)	Effective rooting depth to physical barrier is ≥750 mm?	Soil drainage is better than poor?	pH 5-8.9 if measured in water or 4.5-8.1 if measured in calcium chloride, within the uppermost 600 mm of the soil profile?	Salinity is ≤ 4 dS/m or chlorides < 800 mg/kg when gypsum is present, within the uppermost 600 mm of the soil profile?	Effective rooting depth to a chemical barrier is ≥750 mm?	Is the contiguous area ≥20 ha?	
43	Mesotrophic Mottled-Mesonatric Grey Sodosol	Y	Y	Y	Y	Y	Y	Y	N	N	Y	N	Y	Y	Y	Y	No
47	Mesotrophic Mesonatric Grey Sodosol	Y	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	N	N	Y	No
41	Mottled Magnesic-Natric Grey Kurosol	Y	Y	Y	Y	Y	Y	Y	N	N	Y	N	Y	Y	Y	Y	No
48	Mottled Magnesic-Natric Grey Kurosol	Y	Y	Y	Y	Y	N	Y	N	N	Y	N	Y	Y	Y	Y	No
19	Mottled Mesotrophic Brown Chromosol	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	N	No
53	Mottled Mesotrophic Brown Chromosol	Y	Y	Y	Y	Y	Y	Y	N	N	Y	N	Y	Y	Y	N	No

Note: 1. Refer to Figure 4.1 for the locations of survey sites.

The results in Table 5.1 show that there is no BSAL in the MCCO Additional Project Area or wider assessment area (inclusive of 100m buffer). Most areas and/or soils fail the BSAL tests on multiple criteria. The principal exclusion criteria across the assessment area are shown in Figure 5.1 and are summarised as follows:

- physical and chemical soil characteristics for BSAL exclusion areas:
 - Sodic Eutrophic Brown Dermosols were excluded because of generally poor drainage. Chemical tests also showed the soils have very low actual fertility;
 - Mesotrophic Mesonatric Grey Sodosols were excluded because of low soil fertility and chemical barriers;
 - Mottled Magnesian-Natric Grey Kurosols were excluded because of low soil fertility and drainage.
 - Mottled Mesotrophic Brown Chromosols were excluded due to their area although chemical tests showed the soils have very low actual fertility.
- steep slope BSAL exclusion areas (slopes greater than 10%) occur in much of the western part of the MCCO Additional Project Area associated with an elevated ridge (as shown on Figure 5.1). Some central hills also contain slopes greater than 10%.

Most soils also do not meet other BSAL criteria. For example many of the soils have high salinity (ECe greater than 4 dS/m and/or chloride greater than or equal to 800 mg/kg) and chemical barriers to plant rooting such as sodicity (exchangeable sodium percentage greater than or equal to 15%). Further detail is provided in the BSAL verification assessment tables in Appendix D.



- KEY**
- MCCO additional project area
 - MCCO additional project area - 100m buffer
 - 500kV transmission line
 - Main road
 - Local road
 - Watercourse / drainage line
- Soil test pit**
- Chromosol
 - Dermosol
 - Kurosol
 - Sodosol
 - Tenosol
- BSAL exclusion criteria**
- Slope (percent rise) > 10%
 - Moderately low fertility
 - Chemical or physical barrier

\\lemmsvr1\EMM\Jobs\2017\B17193 - Mangoola soil surveys\GIS\02 Maps\IA012_BSA\Exclusion_20180522_03.mxd 22/05/2018

Source: EMM (2017); DFSI (2017); GA (2017)

BSAL exclusion map

Mangoola Coal Continued Operations Project
BSAL assessment
Figure 5.1



0 0.5 1 km
GDA 1994 MGA Zone 56

6 Conclusion

A robust site verification assessment has been conducted, by certified professional soil scientists, following the relevant guidelines. This has included field surveys, laboratory analyses and geospatial slope analysis techniques to analyse soils and landforms across the assessment area and determine whether the BSAL criteria shown in Figure 2.2 were met. The BSAL verification assessment area was defined as the land that may be subject to a future mining lease application plus a 100 m buffer. This resulted in a total assessment area of approximately 1,193 ha.

Field-based site surveys and laboratory analyses of soils were undertaken based on recommendations in the Handbook and Interim Protocol. Soil type boundaries were identified by manual mapping methods based on existing information, survey results, geology and topography.

Five soil types were identified in the SVC application area: Tenosols, Dermosols, Sodosols, Kurosols, and Chromosols. Only four of these were mapped based on area, greater than 20 hectares, with the Chomosol excluded.

Each soil type was assessed against the BSAL verification criteria and no soil type was found to satisfy the criteria, with most failing multiple physical and chemical criteria. In addition, an analysis of slope in the MCCO Additional Project Area determined that some land failed the slope criterion. The result is that no CIC or BSAL is present in the MCCO Additional Project Area or wider assessment area, a conclusion that is consistent with the results of the NSW Government's BSAL mapping.

Based on the assessment results, Mangoola are required to apply for a SVC as opposed to a Gateway Certificate. This BSAL verification assessment has been prepared in accordance with the Interim Protocol to accompany the SVC application. As the MCCO Project is not on Strategic Agricultural Land, the Gateway Process does not apply and the project does not need to go through the gateway process. Nonetheless any agricultural impacts will be comprehensively assessed through an Agricultural Impact Statement that will form part of the EIS, and will be assessed by the relevant agencies at the development application stage.

References

- Baker DE & Eldershaw VJ 1993, *Interpreting soil analyses*, Department of Primary Industries, Queensland.
- BOM, 2017, *Climate classification maps*, Australian Government Bureau of Meteorology (accessed on 2nd August 2017 at http://www.bom.gov.au/jsp/ncc/climate_averages/climate-classifications/index.jsp)
- CSIRO, 2014, Australian soil resource information system, (accessed on 2nd August 2017 at <http://www.asris.csiro.au/>).
- DERM 2011, *Guidelines for applying the proposed strategic cropping land criteria*, Department of Environment and Resource Management. (accessed 22 November 2013, <http://www.nrm.qld.gov.au/land/planning/pdf/strategic-cropping/scl-guidelines.pdf>)
- DLWC, 2001, *Soil data entry handbook*, 3rd Edition, Department of Land and Water Conservation.
- DPI, 2012, *Upper Hunter Strategic Regional Land Use Policy*. New South Wales Government.
- Gallant JC, McKenzie NJ, McBratney AB, 2008, Scale. In 'Guidelines for surveying soil and land resources' (Eds NJ McKenzie, M J Grundy, R Webster, AJ Ringrose-Voase) 27–43. Second Edition. (CSIRO Publishing: Collingwood).
- Isbell RF, 2002, *The Australian soil classification*, CSIRO Publishing, Melbourne.
- McKenzie NJ, Grundy MJ, Webster R & Ringrose-Voase AJ, 2008, 2nd Edition, *Guidelines for surveying soil and land resources*, CSIRO Publishing, Melbourne.
- Murphy BW, Eldridge DJ, Chapman GA and McKane DJ 2007, *Soils of New South Wales in Soils their properties and management* (3rd edition), Eds PEV Charman and BW Murphy, Oxford University Press: Melbourne.
- NCST, 2009, 3rd edition, *Australian soil and land survey handbook*, National Committee on Soil and Terrain CSIRO Publishing, Melbourne.
- NSW Government, 2012, *Draft Guideline for site verification of critical industry clusters*
- NSW Government, 2013, *Interim protocol for site verification and mapping of biophysical strategic agricultural land*, New South Wales Government.
- NSW Government, 2016, *Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources*, New South Wales Government.
- NSW Office of Water (NOW) 2013c, *Reliable surface water in NSW June 2013*, spatial data set, received on 1 October 2014.
- OEH, 2017a, *Inherent soil fertility mapping of NSW*. Version 1.6 (v131024), Office of Environment and Heritage (<http://www.environment.nsw.gov.au/eSpadeWebapp/>).
- OEH, 2017b, *Land and Soil Capability Mapping of NSW*. Version 2.5 (v131024), Office of Environment and Heritage (<http://www.environment.nsw.gov.au/eSpadeWebapp/>)

Peeverill KI, Sparrow LA, Reuter DJ (eds) 1999, *Soil analysis: interpretation manual*, CSIRO Publishing, Collingwood.

Stace, H.C.T, Hubble, G.D., Brewer, R, Northcote, K.H, Sleeman, J.R, Mulcahy, M.J, and Hallsworth, E.G 1968, *A Handbook of Australian Soils*, Rellim, Glenside, SA, Australia.

Appendix A

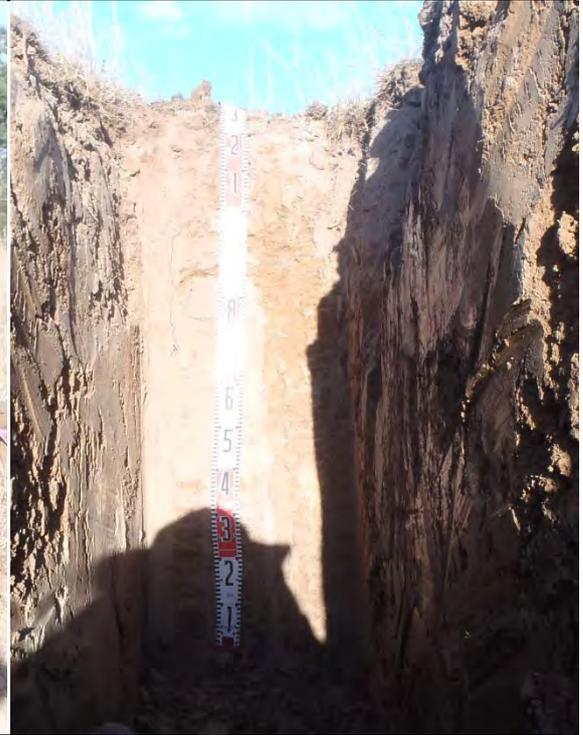
Detailed site photographs

Site Landscape

Profile

DERMOSOL

A1



5



12



SODOSOL

10



23



43



47

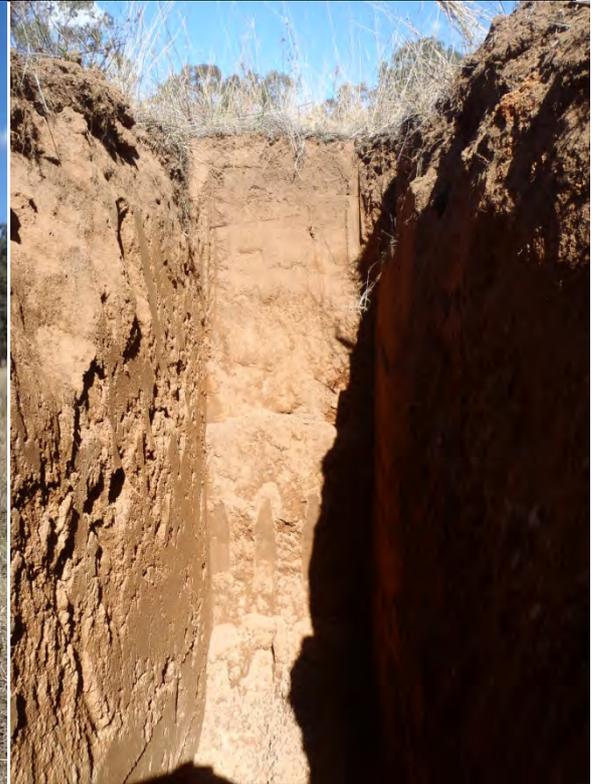


TENOSOL

20



21



37



KUROSOL

41



48



CHROMOSOL

19



53



Appendix B

Laboratory accreditation and results

NATA Accredited Laboratory

National Association of Testing Authorities, Australia
(ABN 59 004 379 748)

has accredited

Australian Laboratory Services Pty Ltd
Brisbane Laboratory
ALS Environmental Laboratory, ALS Mineral
Laboratory

following demonstration of its technical competence
to operate in accordance with

ISO/IEC 17025

This facility is accredited in the field of

CHEMICAL TESTING

for the tests, calibrations and measurements shown on the
Scope of Accreditation issued by NATA



Jennifer Evans
Chief Executive Officer

Date of accreditation: 10 April 1970
Accreditation number: 825
Corporate Site Number: 818



WORLD RECOGNISED
ACCREDITATION

NATA is Australia's government-endorsed laboratory accreditor, and a leader in accreditation internationally. NATA is a signatory to the international mutual recognition arrangements of the International Laboratory Accreditation Cooperation (ILAC) and the Asia Pacific Laboratory Accreditation Cooperation (APLAC).



NATA ACCREDITED LABORATORY

National Association of Testing Authorities, Australia

(ABN 59 004 379 748)

has accredited

Australian Laboratory Services Pty Ltd Brisbane Microbiological Laboratory

following demonstration of its technical competence to operate in accordance with

ISO/IEC 17025

This facility is accredited in the field of

BIOLOGICAL TESTING

for the tests shown on the *Scope of Accreditation* issued by NATA

Jennifer Evans

Chief Executive Officer

Date of issue: 15 September 2016

Date of accreditation: 16 June 2010

Accreditation number: 825

Corporate Site Number: 18958

CERTIFICATE OF ANALYSIS

Work Order : EB1718053 Amendment : 1 Client : EMM CONSULTING PTY LTD Contact : MS KYLIE DRAPALA Address : 1/4 87 WICKHAM TERRACE SPRING HILL QLD 4000 Telephone : 07 3839 1800 Project : Mangoola BSAL Order number : ---- C-O-C number : ---- Sampler : NICK JAMSON Site : ---- Quote number : SYBQ/202/16 No. of samples received : 40 No. of samples analysed : 40	Page : 1 of 23 Laboratory : Environmental Division Brisbane Contact : Customer Services EB Address : 2 Byth Street Stafford QLD Australia 4053 Telephone : +61-7-3243 7222 Date Samples Received : 01-Sep-2017 16:30 Date Analysis Commenced : 04-Sep-2017 Issue Date : 16-Oct-2017 09:36
--	--



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.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Andrew Epps	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Andrew Epps	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Ben Felgendrejeris		Brisbane Acid Sulphate Soils, Stafford, QLD
Greg Vogel	Laboratory Manager	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
∅ = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- ED006 (Exchangeable Cations on Alkaline Soils): It is recognised that the Exchangeable K LCS biases low, however this is deemed acceptable as the target concentration is at LOR and the Cation Exchange Capacity LCS is within acceptable limits.
- 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.
- ED007 (Exchangeable Cations): Calcium/Magnesium ratio could not be determined as both the Calcium and Magnesium results were less than reportable limits for sample EB1718053-028 (S23 (30-50cm) A2).
- EK057G (Nitrite as N): Sample EB1718053_022 (S10 (10-20cm) A2) was diluted due to matrix interference. LOR adjusted accordingly.
- Amendment (16/10/2017): This report has been amended as a result of a request to change sample identification numbers (IDs) received by ALS from K.Drapala on 16/10/2017. All analysis results are as per the previous report.
- 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	S47 (0-7cm)	S47 (7-13cm)	S47 (13-33cm)	S47 (40-60cm)	S47 (80-110cm)
Client sampling date / time				[22-Aug-2017]	[22-Aug-2017]	[22-Aug-2017]	[22-Aug-2017]	[22-Aug-2017]	
Compound	CAS Number	LOR	Unit	EB1718053-001	EB1718053-002	EB1718053-003	EB1718053-004	EB1718053-005	
				Result	Result	Result	Result	Result	
EA001: pH in soil using 0.01M CaCl extract									
pH (CaCl2)	----	0.1	pH Unit	4.5	4.7	7.5	7.4	5.3	
EA002 : pH (Soils)									
pH Value	----	0.1	pH Unit	5.4	6.0	8.2	8.1	5.9	
EA008: Calcium Carbonate Equivalent									
CaCO3 Equivalent	----	0.01	%	4.64	1.82	2.39	2.54	0.60	
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm	40	26	496	582	455	
EA055: Moisture Content (Dried @ 105-110°C)									
Moisture Content	----	1.0	%	3.2	2.0	12.3	13.1	5.6	
EA058: Emerson Aggregate Test									
Color (Munsell)	----	-	-	Very Dark Grayish Brown	Dark Gray	Dark Gray	Dark Gray	Grayish Brown	
Texture	----	-	-	Sandy Clay Loam	Sandy Clay Loam	Sandy Clay Loam	Sandy Clay Loam	Sandy Clay Loam	
Emerson Class Number	EC/TC	-	-	3	3	2	2	2	
ED005: Exchange Acidity									
Exchange Acidity	----	0.1	meq/100g	0.1	----	----	----	<0.1	
Exchangeable Aluminium	----	0.1	meq/100g	<0.1	----	----	----	<0.1	
ED006: Exchangeable Cations on Alkaline Soils									
Exchangeable Calcium	----	0.2	meq/100g	----	----	1.9	1.8	----	
Exchangeable Magnesium	----	0.2	meq/100g	----	----	4.0	4.1	----	
Exchangeable Potassium	----	0.2	meq/100g	----	----	<0.2	<0.2	----	
Exchangeable Sodium	----	0.2	meq/100g	----	----	1.2	1.4	----	
Cation Exchange Capacity	----	0.2	meq/100g	----	----	7.3	7.5	----	
Exchangeable Sodium Percent	----	0.2	%	----	----	16.5	18.6	----	
Calcium/Magnesium Ratio	----	0.2	-	----	----	0.5	0.4	----	
ED007: Exchangeable Cations									
Exchangeable Calcium	----	0.1	meq/100g	4.4	3.2	----	----	----	
Exchangeable Magnesium	----	0.1	meq/100g	3.5	3.6	----	----	----	
Exchangeable Potassium	----	0.1	meq/100g	0.9	0.5	----	----	----	
Exchangeable Sodium	----	0.1	meq/100g	0.4	0.5	----	----	----	
Cation Exchange Capacity	----	0.1	meq/100g	9.3	7.9	----	----	----	
Exchangeable Sodium Percent	----	0.1	%	3.9	6.3	----	----	----	
Calcium/Magnesium Ratio	----	0.1	-	1.2	0.9	----	----	----	
Magnesium/Potassium Ratio	----	0.1	-	3.8	6.6	----	----	----	



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	S47 (0-7cm)	S47 (7-13cm)	S47 (13-33cm)	S47 (40-60cm)	S47 (80-110cm)
Client sampling date / time					[22-Aug-2017]	[22-Aug-2017]	[22-Aug-2017]	[22-Aug-2017]	[22-Aug-2017]
Compound	CAS Number	LOR	Unit		EB1718053-001	EB1718053-002	EB1718053-003	EB1718053-004	EB1718053-005
					Result	Result	Result	Result	Result
ED008: Exchangeable Cations									
Exchangeable Calcium	----	0.1	meq/100g	----	----	----	----	----	2.4
Exchangeable Magnesium	----	0.1	meq/100g	----	----	----	----	----	7.1
Exchangeable Potassium	----	0.1	meq/100g	----	----	----	----	----	0.2
Exchangeable Sodium	----	0.1	meq/100g	----	----	----	----	----	1.8
Cation Exchange Capacity	----	0.1	meq/100g	----	----	----	----	----	11.5
Exchangeable Sodium Percent	----	0.1	%	----	----	----	----	----	15.2
Calcium/Magnesium Ratio	----	0.1	-	----	----	----	----	----	0.3
Magnesium/Potassium Ratio	----	0.1	-	----	----	----	----	----	46.4
ED021: Bicarbonate Extractable Potassium (Colwell)									
Bicarbonate Extractable K (Colwell)	----	10	mg/kg	531	315	284	278		<200
ED040S : Soluble Sulfate by ICPAES									
Sulfate as SO4 2-	14808-79-8	10	mg/kg	10	<10	140	240		190
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	10	mg/kg	30	20	400	650		580
ED092: DTPA Extractable Metals									
Ø Copper	7440-50-8	1.00	mg/kg	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
Ø Iron	7439-89-6	1.00	mg/kg	94.6	60.6	9.85	9.34		3.50
Ø Manganese	7439-96-5	1.00	mg/kg	21.3	9.33	<1.00	<1.00		<1.00
Ø Zinc	7440-66-6	1.00	mg/kg	1.96	<1.00	<1.00	<1.00		<1.00
ED093S: Soluble Major Cations									
Calcium	7440-70-2	10	mg/kg	<10	<10	<10	20		<10
Magnesium	7439-95-4	10	mg/kg	<10	<10	<10	20		<10
Sodium	7440-23-5	10	mg/kg	30	20	350	560		460
Potassium	7440-09-7	10	mg/kg	10	<10	<10	<10		<10
EG005T: Total Metals by ICP-AES									
Aluminium	7429-90-5	50	mg/kg	6580	4630	7380	8150		3540
Molybdenum	7439-98-7	2	mg/kg	<2	<2	<2	<2		<2
EK055: Ammonia as N									
Ammonia as N	7664-41-7	20	mg/kg	<20	<20	<20	<20		<20
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N (Sol.)	14797-65-0	0.1	mg/kg	0.3	0.3	<0.1	<0.1		<0.1
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N (Sol.)	14797-55-8	0.1	mg/kg	0.1	0.8	0.3	<0.1		0.2



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	S47 (0-7cm)	S47 (7-13cm)	S47 (13-33cm)	S47 (40-60cm)	S47 (80-110cm)
Client sampling date / time				[22-Aug-2017]	[22-Aug-2017]	[22-Aug-2017]	[22-Aug-2017]	[22-Aug-2017]	
Compound	CAS Number	LOR	Unit	EB1718053-001	EB1718053-002	EB1718053-003	EB1718053-004	EB1718053-005	
				Result	Result	Result	Result	Result	
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	0.4	1.1	0.3	<0.1	0.2	
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	20	mg/kg	2110	930	420	270	70	
EK062: Total Nitrogen as N (TKN + NOx)									
^ Total Nitrogen as N	----	20	mg/kg	2110	930	420	270	70	
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	2	mg/kg	174	115	39	32	26	
EK080: Bicarbonate Extractable Phosphorus (Colwell)									
Bicarbonate Ext. P (Colwell)	----	5	mg/kg	<5	<5	<5	<5	<5	
EP004: Organic Matter									
Organic Matter	----	0.5	%	4.9	1.9	0.6	0.5	<0.5	
Total Organic Carbon	----	0.5	%	2.8	1.1	<0.5	<0.5	<0.5	



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	S43 (0-10cm) A1	S43 (10-40cm) A21	S43 (47-67cm) A22	S43 (69-89cm) B2	S43 (1-1.2cm) B2
Client sampling date / time				[23-Aug-2017]	[23-Aug-2017]	[23-Aug-2017]	[23-Aug-2017]	[23-Aug-2017]	
Compound	CAS Number	LOR	Unit	EB1718053-006	EB1718053-007	EB1718053-008	EB1718053-009	EB1718053-010	
				Result	Result	Result	Result	Result	
EA001: pH in soil using 0.01M CaCl extract									
pH (CaCl2)	----	0.1	pH Unit	4.6	5.6	5.4	4.3	4.1	
EA002 : pH (Soils)									
pH Value	----	0.1	pH Unit	5.5	6.4	6.6	5.6	5.4	
EA008: Calcium Carbonate Equivalent									
CaCO3 Equivalent	----	0.01	%	0.65	1.57	1.88	0.34	0.04	
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm	21	8	15	63	75	
EA055: Moisture Content (Dried @ 105-110°C)									
Moisture Content	----	1.0	%	1.3	1.2	2.5	11.4	8.2	
EA058: Emerson Aggregate Test									
Color (Munsell)	----	-	-	Very Dark Grayish Brown	Light Gray	Light Brownish Gray	Light Yellowish Brown	Reddish Brown	
Texture	----	-	-	Gravelly Sand	Gravelly Sand	Loamy Sand	Sandy Clay Loam	Sandy Clay Loam	
Emerson Class Number	EC/TC	-	-	8	8	2	1	1	
ED005: Exchange Acidity									
Exchange Acidity	----	0.1	meq/100g	0.2	----	----	0.5	1.3	
Exchangeable Aluminium	----	0.1	meq/100g	0.1	----	----	0.4	1.1	
ED007: Exchangeable Cations									
Exchangeable Calcium	----	0.1	meq/100g	2.7	1.1	0.9	0.9	0.6	
Exchangeable Magnesium	----	0.1	meq/100g	0.8	0.5	1.6	8.9	8.8	
Exchangeable Potassium	----	0.1	meq/100g	0.6	0.2	0.2	0.7	0.6	
Exchangeable Sodium	----	0.1	meq/100g	<0.1	<0.1	0.4	2.6	2.6	
Cation Exchange Capacity	----	0.1	meq/100g	4.3	1.9	3.1	13.6	13.9	
Exchangeable Sodium Percent	----	0.1	%	0.8	3.5	14.1	20.0	20.5	
Calcium/Magnesium Ratio	----	0.1	-	3.4	2.2	0.6	0.1	<0.1	
Magnesium/Potassium Ratio	----	0.1	-	1.4	3.4	7.9	12.6	15.2	
ED021: Bicarbonate Extractable Potassium (Colwell)									
Bicarbonate Extractable K (Colwell)	----	10	mg/kg	378	<200	<200	257	299	
ED040S : Soluble Sulfate by ICPAES									
Sulfate as SO4 2-	14808-79-8	10	mg/kg	10	<10	10	40	50	
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	10	mg/kg	10	<10	<10	20	30	
ED092: DTPA Extractable Metals									



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	S43 (0-10cm) A1	S43 (10-40cm) A21	S43 (47-67cm) A22	S43 (69-89cm) B2	S43 (1-1.2cm) B2
Client sampling date / time				[23-Aug-2017]	[23-Aug-2017]	[23-Aug-2017]	[23-Aug-2017]	[23-Aug-2017]	
Compound	CAS Number	LOR	Unit	EB1718053-006	EB1718053-007	EB1718053-008	EB1718053-009	EB1718053-010	
				Result	Result	Result	Result	Result	
ED092: DTPA Extractable Metals - Continued									
Ø Copper	7440-50-8	1.00	mg/kg	<1.00	<1.00	<1.00	<1.00	<1.00	
Ø Iron	7439-89-6	1.00	mg/kg	94.9	7.23	11.4	69.1	92.2	
Ø Manganese	7439-96-5	1.00	mg/kg	17.6	<1.00	<1.00	<1.00	<1.00	
Ø Zinc	7440-66-6	1.00	mg/kg	1.77	<1.00	<1.00	<1.00	<1.00	
ED093S: Soluble Major Cations									
Calcium	7440-70-2	10	mg/kg	<10	<10	<10	<10	<10	
Magnesium	7439-95-4	10	mg/kg	<10	<10	<10	<10	<10	
Sodium	7440-23-5	10	mg/kg	<10	<10	10	40	40	
Potassium	7440-09-7	10	mg/kg	20	<10	<10	<10	<10	
EG005T: Total Metals by ICP-AES									
Aluminium	7429-90-5	50	mg/kg	3800	2920	4280	10800	12500	
Molybdenum	7439-98-7	2	mg/kg	<2	<2	<2	<2	<2	
EK055: Ammonia as N									
Ammonia as N	7664-41-7	20	mg/kg	<20	<20	<20	<20	<20	
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N (Sol.)	14797-65-0	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N (Sol.)	14797-55-8	0.1	mg/kg	<0.1	0.2	0.4	0.6	0.5	
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	<0.1	0.2	0.4	0.6	0.5	
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	20	mg/kg	1330	190	140	250	260	
EK062: Total Nitrogen as N (TKN + NOx)									
^ Total Nitrogen as N	----	20	mg/kg	1330	190	140	250	260	
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	2	mg/kg	175	83	55	40	48	
EK080: Bicarbonate Extractable Phosphorus (Colwell)									
Bicarbonate Ext. P (Colwell)	----	5	mg/kg	10	<5	<5	<5	<5	
EP004: Organic Matter									
Organic Matter	----	0.5	%	3.4	0.5	<0.5	0.5	<0.5	
Total Organic Carbon	----	0.5	%	2.0	<0.5	<0.5	<0.5	<0.5	



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	A1 (0-9cm) A1	A1 (90-30cm) B21	A1 (30-50cm) B21	A1 (50-80cm) B21	A1 (85-110cm) B22
Client sampling date / time				[27-Aug-2017]	[27-Aug-2017]	[27-Aug-2017]	[27-Aug-2017]	[27-Aug-2017]	
Compound	CAS Number	LOR	Unit	EB1718053-011	EB1718053-012	EB1718053-013	EB1718053-014	EB1718053-015	
				Result	Result	Result	Result	Result	
EA001: pH in soil using 0.01M CaCl extract									
pH (CaCl2)	----	0.1	pH Unit	4.8	5.9	8.2	8.5	8.5	
EA002 : pH (Soils)									
pH Value	----	0.1	pH Unit	6.0	7.0	8.8	9.0	9.0	
EA008: Calcium Carbonate Equivalent									
CaCO3 Equivalent	----	0.01	%	0.96	1.11	1.93	7.81	3.87	
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm	21	47	631	1170	1150	
EA055: Moisture Content (Dried @ 105-110°C)									
Moisture Content	----	1.0	%	3.4	7.4	15.0	15.8	18.5	
EA058: Emerson Aggregate Test									
Color (Munsell)	----	-	-	Brown	Brown	Brown	Brown	Grayish Brown	
Texture	----	-	-	Sandy Loam	Sandy Clay Loam	Sandy Clay Loam	Sandy Clay Loam	Sandy Clay Loam	
Emerson Class Number	EC/TC	-	-	3	1	1	3	3	
ED005: Exchange Acidity									
Exchange Acidity	----	0.1	meq/100g	<0.1	----	----	----	----	
Exchangeable Aluminium	----	0.1	meq/100g	<0.1	----	----	----	----	
ED006: Exchangeable Cations on Alkaline Soils									
Exchangeable Calcium	----	0.2	meq/100g	----	----	1.4	1.3	1.3	
Exchangeable Magnesium	----	0.2	meq/100g	----	----	6.4	7.0	8.4	
Exchangeable Potassium	----	0.2	meq/100g	----	----	0.3	0.4	0.4	
Exchangeable Sodium	----	0.2	meq/100g	----	----	2.1	2.4	3.2	
Cation Exchange Capacity	----	0.2	meq/100g	----	----	10.3	11.1	13.3	
Exchangeable Sodium Percent	----	0.2	%	----	----	20.1	22.1	24.2	
Calcium/Magnesium Ratio	----	0.2	-	----	----	0.2	<0.2	<0.2	
Magnesium/Potassium Ratio	----	0.2	-	----	----	20.3	19.6	19.9	
ED007: Exchangeable Cations									
Exchangeable Calcium	----	0.1	meq/100g	3.4	4.4	----	----	----	
Exchangeable Magnesium	----	0.1	meq/100g	3.6	11.4	----	----	----	
Exchangeable Potassium	----	0.1	meq/100g	0.9	0.7	----	----	----	
Exchangeable Sodium	----	0.1	meq/100g	0.2	1.8	----	----	----	
Cation Exchange Capacity	----	0.1	meq/100g	8.1	18.3	----	----	----	
Exchangeable Sodium Percent	----	0.1	%	3.0	9.8	----	----	----	
Calcium/Magnesium Ratio	----	0.1	-	0.9	0.4	----	----	----	
Magnesium/Potassium Ratio	----	0.1	-	4.0	15.9	----	----	----	



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	A1 (0-9cm) A1	A1 (90-30cm) B21	A1 (30-50cm) B21	A1 (50-80cm) B21	A1 (85-110cm) B22
Client sampling date / time				[27-Aug-2017]	[27-Aug-2017]	[27-Aug-2017]	[27-Aug-2017]	[27-Aug-2017]	
Compound	CAS Number	LOR	Unit	EB1718053-011	EB1718053-012	EB1718053-013	EB1718053-014	EB1718053-015	
				Result	Result	Result	Result	Result	
ED021: Bicarbonate Extractable Potassium (Colwell)									
Bicarbonate Extractable K (Colwell)	----	10	mg/kg	467	361	384	404	539	
ED040S : Soluble Sulfate by ICPAES									
Sulfate as SO4 2-	14808-79-8	10	mg/kg	<10	<10	140	260	280	
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	10	mg/kg	10	60	1020	1540	1780	
ED092: DTPA Extractable Metals									
Ø Copper	7440-50-8	1.00	mg/kg	<1.00	<1.00	<1.00	<1.00	1.37	
Ø Iron	7439-89-6	1.00	mg/kg	73.4	36.4	13.1	10.7	11.8	
Ø Manganese	7439-96-5	1.00	mg/kg	24.3	1.36	1.33	1.45	<1.00	
Ø Zinc	7440-66-6	1.00	mg/kg	<1.00	<1.00	<1.00	<1.00	<1.00	
ED093S: Soluble Major Cations									
Calcium	7440-70-2	10	mg/kg	<10	<10	<10	20	10	
Magnesium	7439-95-4	10	mg/kg	<10	<10	20	50	40	
Sodium	7440-23-5	10	mg/kg	10	60	830	1250	1400	
Potassium	7440-09-7	10	mg/kg	<10	<10	10	20	20	
EG005T: Total Metals by ICP-AES									
Aluminium	7429-90-5	50	mg/kg	6850	7250	14500	17200	22600	
Molybdenum	7439-98-7	2	mg/kg	<2	<2	<2	<2	<2	
EK055: Ammonia as N									
Ammonia as N	7664-41-7	20	mg/kg	<20	<20	<20	<20	<20	
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N (Sol.)	14797-65-0	0.1	mg/kg	<0.1	<0.1	<0.1	0.2	<0.1	
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N (Sol.)	14797-55-8	0.1	mg/kg	<0.1	<0.1	0.1	0.2	0.6	
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	<0.1	<0.1	0.1	0.4	0.6	
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	20	mg/kg	1160	780	270	310	250	
EK062: Total Nitrogen as N (TKN + NOx)									
^ Total Nitrogen as N	----	20	mg/kg	1160	780	270	310	250	
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	2	mg/kg	206	138	92	106	114	
EK080: Bicarbonate Extractable Phosphorus (Colwell)									



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	A1 (0-9cm) A1	A1 (90-30cm) B21	A1 (30-50cm) B21	A1 (50-80cm) B21	A1 (85-110cm) B22
Client sampling date / time				[27-Aug-2017]	[27-Aug-2017]	[27-Aug-2017]	[27-Aug-2017]	[27-Aug-2017]	
Compound	CAS Number	LOR	Unit	EB1718053-011	EB1718053-012	EB1718053-013	EB1718053-014	EB1718053-015	
				Result	Result	Result	Result	Result	
EK080: Bicarbonate Extractable Phosphorus (Colwell) - Continued									
Bicarbonate Ext. P (Colwell)	----	5	mg/kg	<5	<5	<5	<5	<5	
EP004: Organic Matter									
Organic Matter	----	0.5	%	3.4	1.5	0.5	0.5	<0.5	
Total Organic Carbon	----	0.5	%	2.0	0.9	<0.5	<0.5	<0.5	



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	S20 (0-7cm) A1	S20 (10-30cm) A2	S20 (30-50cm) B2	S20 (50-70cm) B2	S20 (70-100cm) B2
Client sampling date / time				[26-Aug-2017]	[26-Aug-2017]	[26-Aug-2017]	[26-Aug-2017]	[26-Aug-2017]	
Compound	CAS Number	LOR	Unit	EB1718053-016	EB1718053-017	EB1718053-018	EB1718053-019	EB1718053-020	
				Result	Result	Result	Result	Result	
EA001: pH in soil using 0.01M CaCl extract									
pH (CaCl2)	----	0.1	pH Unit	4.7	5.1	5.4	6.3	6.2	
EA002 : pH (Soils)									
pH Value	----	0.1	pH Unit	5.6	6.4	6.6	7.6	7.4	
EA008: Calcium Carbonate Equivalent									
CaCO3 Equivalent	----	0.01	%	1.57	0.09	1.16	2.49	0.80	
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm	11	10	17	22	28	
EA055: Moisture Content (Dried @ 105-110°C)									
Moisture Content	----	1.0	%	<1.0	2.4	3.1	3.6	3.5	
EA058: Emerson Aggregate Test									
Color (Munsell)	----	-	-	Strong Brown	Yellowish Red	Yellowish Red	Reddish Yellow	Brown	
Texture	----	-	-	Gravelly Sand	Sandy Loam	Sandy Loam	Gravelly Sand	Sandy Loam	
Emerson Class Number	EC/TC	-	-	8	2	2	8	2	
ED005: Exchange Acidity									
Exchange Acidity	----	0.1	meq/100g	0.2	----	----	----	----	
Exchangeable Aluminium	----	0.1	meq/100g	0.2	----	----	----	----	
ED006: Exchangeable Cations on Alkaline Soils									
Exchangeable Calcium	----	0.2	meq/100g	----	----	----	<0.2	<0.2	
Exchangeable Magnesium	----	0.2	meq/100g	----	----	----	1.3	1.6	
Exchangeable Potassium	----	0.2	meq/100g	----	----	----	<0.2	<0.2	
Exchangeable Sodium	----	0.2	meq/100g	----	----	----	<0.2	0.3	
Cation Exchange Capacity	----	0.2	meq/100g	----	----	----	1.3	1.9	
Exchangeable Sodium Percent	----	0.2	%	----	----	----	<0.2	16.2	
Calcium/Magnesium Ratio	----	0.2	-	----	----	----	<0.2	<0.2	
ED007: Exchangeable Cations									
Exchangeable Calcium	----	0.1	meq/100g	0.5	0.1	0.2	----	----	
Exchangeable Magnesium	----	0.1	meq/100g	1.6	3.2	4.1	----	----	
Exchangeable Potassium	----	0.1	meq/100g	0.2	0.2	0.2	----	----	
Exchangeable Sodium	----	0.1	meq/100g	<0.1	0.3	0.5	----	----	
Cation Exchange Capacity	----	0.1	meq/100g	2.5	3.8	5.2	----	----	
Exchangeable Sodium Percent	----	0.1	%	2.8	6.9	10.5	----	----	
Calcium/Magnesium Ratio	----	0.1	-	0.3	<0.1	<0.1	----	----	
Magnesium/Potassium Ratio	----	0.1	-	6.8	18.3	16.8	----	----	
ED021: Bicarbonate Extractable Potassium (Colwell)									



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	S20 (0-7cm) A1	S20 (10-30cm) A2	S20 (30-50cm) B2	S20 (50-70cm) B2	S20 (70-100cm) B2
Client sampling date / time				[26-Aug-2017]	[26-Aug-2017]	[26-Aug-2017]	[26-Aug-2017]	[26-Aug-2017]	
Compound	CAS Number	LOR	Unit	EB1718053-016	EB1718053-017	EB1718053-018	EB1718053-019	EB1718053-020	
				Result	Result	Result	Result	Result	
ED021: Bicarbonate Extractable Potassium (Colwell) - Continued									
Bicarbonate Extractable K (Colwell)	----	10	mg/kg	251	225	250	279	284	
ED040S : Soluble Sulfate by ICPAES									
Sulfate as SO4 2-	14808-79-8	10	mg/kg	<10	<10	<10	10	20	
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	10	mg/kg	<10	<10	10	<10	20	
ED092: DTPA Extractable Metals									
Ø Copper	7440-50-8	1.00	mg/kg	<1.00	<1.00	<1.00	<1.00	<1.00	
Ø Iron	7439-89-6	1.00	mg/kg	10.4	10.2	5.88	5.81	6.11	
Ø Manganese	7439-96-5	1.00	mg/kg	5.22	<1.00	<1.00	<1.00	<1.00	
Ø Zinc	7440-66-6	1.00	mg/kg	<1.00	<1.00	<1.00	<1.00	<1.00	
ED093S: Soluble Major Cations									
Calcium	7440-70-2	10	mg/kg	<10	<10	<10	<10	<10	
Magnesium	7439-95-4	10	mg/kg	<10	<10	<10	<10	<10	
Sodium	7440-23-5	10	mg/kg	<10	10	10	20	30	
Potassium	7440-09-7	10	mg/kg	<10	<10	<10	<10	<10	
EG005T: Total Metals by ICP-AES									
Aluminium	7429-90-5	50	mg/kg	4180	4800	6130	6650	6990	
Molybdenum	7439-98-7	2	mg/kg	<2	<2	<2	<2	<2	
EK055: Ammonia as N									
Ammonia as N	7664-41-7	20	mg/kg	<20	<20	<20	<20	<20	
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N (Sol.)	14797-65-0	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N (Sol.)	14797-55-8	0.1	mg/kg	0.4	0.1	<0.1	<0.1	0.2	
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	0.4	0.1	<0.1	<0.1	0.2	
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	20	mg/kg	360	90	80	90	90	
EK062: Total Nitrogen as N (TKN + NOx)									
^ Total Nitrogen as N	----	20	mg/kg	360	90	80	90	90	
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	2	mg/kg	97	66	61	59	60	
EK080: Bicarbonate Extractable Phosphorus (Colwell)									



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	S20 (0-7cm) A1	S20 (10-30cm) A2	S20 (30-50cm) B2	S20 (50-70cm) B2	S20 (70-100cm) B2
Client sampling date / time				[26-Aug-2017]	[26-Aug-2017]	[26-Aug-2017]	[26-Aug-2017]	[26-Aug-2017]	
Compound	CAS Number	LOR	Unit	EB1718053-016	EB1718053-017	EB1718053-018	EB1718053-019	EB1718053-020	
				Result	Result	Result	Result	Result	
EK080: Bicarbonate Extractable Phosphorus (Colwell) - Continued									
Bicarbonate Ext. P (Colwell)	----	5	mg/kg	<5	<5	<5	<5	<5	
EP004: Organic Matter									
Organic Matter	----	0.5	%	1.0	<0.5	<0.5	<0.5	<0.5	
Total Organic Carbon	----	0.5	%	0.6	<0.5	<0.5	<0.5	<0.5	



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	S10 (0-10cm) A1	S10 (10-20cm) A2	S10 (30-50cm) A2	S10 (60-85cm) B21	S10 (85-110cm) B22
Client sampling date / time				[25-Aug-2017]	[25-Aug-2017]	[25-Aug-2017]	[25-Aug-2017]	[25-Aug-2017]	
Compound	CAS Number	LOR	Unit	EB1718053-021	EB1718053-022	EB1718053-023	EB1718053-024	EB1718053-025	
				Result	Result	Result	Result	Result	
EA001: pH in soil using 0.01M CaCl extract									
pH (CaCl2)	----	0.1	pH Unit	4.8	5.1	7.6	8.5	8.2	
EA002 : pH (Soils)									
pH Value	----	0.1	pH Unit	5.7	6.4	8.5	9.1	8.9	
EA008: Calcium Carbonate Equivalent									
CaCO3 Equivalent	----	0.01	%	1.06	2.08	1.57	1.47	1.72	
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm	20	25	346	974	672	
EA055: Moisture Content (Dried @ 105-110°C)									
Moisture Content	----	1.0	%	3.6	2.2	11.6	16.3	13.4	
EA058: Emerson Aggregate Test									
Color (Munsell)	----	-	-	Very Dark Grayish Brown	Very Dark Grayish Brown	Grayish Brown	Grayish Brown	Pale Brown	
Texture	----	-	-	Sandy Clay Loam	Sandy Clay Loam	Sandy Clay Loam	Sandy Clay Loam	Sandy Clay Loam	
Emerson Class Number	EC/TC	-	-	3	3	1	2	1	
ED005: Exchange Acidity									
Exchange Acidity	----	0.1	meq/100g	<0.1	----	----	----	----	
Exchangeable Aluminium	----	0.1	meq/100g	<0.1	----	----	----	----	
ED006: Exchangeable Cations on Alkaline Soils									
Exchangeable Calcium	----	0.2	meq/100g	----	----	0.8	0.7	0.5	
Exchangeable Magnesium	----	0.2	meq/100g	----	----	4.0	6.6	5.1	
Exchangeable Potassium	----	0.2	meq/100g	----	----	<0.2	0.2	0.2	
Exchangeable Sodium	----	0.2	meq/100g	----	----	1.4	2.8	2.2	
Cation Exchange Capacity	----	0.2	meq/100g	----	----	6.3	10.4	8.0	
Exchangeable Sodium Percent	----	0.2	%	----	----	21.6	27.2	27.3	
Calcium/Magnesium Ratio	----	0.2	-	----	----	<0.2	<0.2	<0.2	
Magnesium/Potassium Ratio	----	0.2	-	----	----	----	27.6	24.2	
ED007: Exchangeable Cations									
Exchangeable Calcium	----	0.1	meq/100g	4.4	2.2	----	----	----	
Exchangeable Magnesium	----	0.1	meq/100g	2.6	4.0	----	----	----	
Exchangeable Potassium	----	0.1	meq/100g	0.9	0.3	----	----	----	
Exchangeable Sodium	----	0.1	meq/100g	0.1	0.8	----	----	----	
Cation Exchange Capacity	----	0.1	meq/100g	8.0	7.4	----	----	----	
Exchangeable Sodium Percent	----	0.1	%	1.5	11.4	----	----	----	
Calcium/Magnesium Ratio	----	0.1	-	1.7	0.6	----	----	----	



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	S10 (0-10cm) A1	S10 (10-20cm) A2	S10 (30-50cm) A2	S10 (60-85cm) B21	S10 (85-110cm) B22
Client sampling date / time				[25-Aug-2017]	[25-Aug-2017]	[25-Aug-2017]	[25-Aug-2017]	[25-Aug-2017]	
Compound	CAS Number	LOR	Unit	EB1718053-021	EB1718053-022	EB1718053-023	EB1718053-024	EB1718053-025	
				Result	Result	Result	Result	Result	
ED007: Exchangeable Cations - Continued									
Magnesium/Potassium Ratio	----	0.1	-	3.0	13.0	----	----	----	
ED021: Bicarbonate Extractable Potassium (Colwell)									
Bicarbonate Extractable K (Colwell)	----	10	mg/kg	566	291	279	365	363	
ED040S : Soluble Sulfate by ICPAES									
Sulfate as SO4 2-	14808-79-8	10	mg/kg	<10	<10	160	340	170	
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	10	mg/kg	10	20	700	1640	1140	
ED092: DTPA Extractable Metals									
Ø Copper	7440-50-8	1.00	mg/kg	<1.00	<1.00	<1.00	<1.00	<1.00	
Ø Iron	7439-89-6	1.00	mg/kg	105	39.4	14.0	8.59	6.59	
Ø Manganese	7439-96-5	1.00	mg/kg	24.8	2.44	<1.00	<1.00	<1.00	
Ø Zinc	7440-66-6	1.00	mg/kg	1.55	<1.00	<1.00	<1.00	<1.00	
ED093S: Soluble Major Cations									
Calcium	7440-70-2	10	mg/kg	<10	<10	<10	<10	<10	
Magnesium	7439-95-4	10	mg/kg	<10	<10	<10	30	<10	
Sodium	7440-23-5	10	mg/kg	10	20	570	1360	820	
Potassium	7440-09-7	10	mg/kg	10	<10	<10	<10	<10	
EG005T: Total Metals by ICP-AES									
Aluminium	7429-90-5	50	mg/kg	7190	5410	13400	14700	14700	
Molybdenum	7439-98-7	2	mg/kg	<2	<2	<2	<2	<2	
EK055: Ammonia as N									
Ammonia as N	7664-41-7	20	mg/kg	<20	<20	<20	<20	<20	
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N (Sol.)	14797-65-0	0.1	mg/kg	<0.1	<0.2	<0.1	<0.1	<0.1	
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N (Sol.)	14797-55-8	0.1	mg/kg	0.1	0.2	0.1	0.1	<0.1	
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	0.1	0.2	0.1	0.1	<0.1	
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	20	mg/kg	1640	510	310	210	370	
EK062: Total Nitrogen as N (TKN + NOx)									
^ Total Nitrogen as N	----	20	mg/kg	1640	510	310	210	370	
EK067G: Total Phosphorus as P by Discrete Analyser									



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	S10 (0-10cm) A1	S10 (10-20cm) A2	S10 (30-50cm) A2	S10 (60-85cm) B21	S10 (85-110cm) B22
Client sampling date / time				[25-Aug-2017]	[25-Aug-2017]	[25-Aug-2017]	[25-Aug-2017]	[25-Aug-2017]	[25-Aug-2017]
Compound	CAS Number	LOR	Unit	EB1718053-021	EB1718053-022	EB1718053-023	EB1718053-024	EB1718053-025	
				Result	Result	Result	Result	Result	
EK067G: Total Phosphorus as P by Discrete Analyser - Continued									
Total Phosphorus as P	----	2	mg/kg	224	153	61	48	76	
EK080: Bicarbonate Extractable Phosphorus (Colwell)									
Bicarbonate Ext. P (Colwell)	----	5	mg/kg	<5	<5	<5	<5	<5	
EP004: Organic Matter									
Organic Matter	----	0.5	%	4.9	2.0	1.1	0.6	<0.5	
Total Organic Carbon	----	0.5	%	2.8	1.1	0.6	<0.5	<0.5	



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	S23 (0-10cm) A1	S23 (10-30cm) A2	S23 (30-50cm) A2	S23 (60-80cm) B2	S23 (100-120cm) B2
Client sampling date / time				[25-Aug-2017]	[25-Aug-2017]	[25-Aug-2017]	[25-Aug-2017]	[25-Aug-2017]	
Compound	CAS Number	LOR	Unit	EB1718053-026	EB1718053-027	EB1718053-028	EB1718053-029	EB1718053-030	
				Result	Result	Result	Result	Result	
EA001: pH in soil using 0.01M CaCl extract									
pH (CaCl2)	----	0.1	pH Unit	4.6	5.2	5.8	6.5	5.4	
EA002 : pH (Soils)									
pH Value	----	0.1	pH Unit	5.6	6.2	6.7	7.6	6.7	
EA008: Calcium Carbonate Equivalent									
CaCO3 Equivalent	----	0.01	%	0.50	2.39	2.03	1.57	1.06	
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm	14	7	12	82	85	
EA055: Moisture Content (Dried @ 105-110°C)									
Moisture Content	----	1.0	%	1.5	1.0	1.5	2.6	11.9	
EA058: Emerson Aggregate Test									
Color (Munsell)	----	-	-	Dark Brown	Light Brown	Light Brownish Gray	Grayish Brown	Light Brownish Gray	
Texture	----	-	-	Loamy Sand	Gravelly Sand	Gravelly Sand	Sandy Clay Loam	Sandy Clay Loam	
Emerson Class Number	EC/TC	-	-	3	8	8	2	1	
ED005: Exchange Acidity									
Exchange Acidity	----	0.1	meq/100g	0.2	----	----	----	----	
Exchangeable Aluminium	----	0.1	meq/100g	0.1	----	----	----	----	
ED006: Exchangeable Cations on Alkaline Soils									
Exchangeable Calcium	----	0.2	meq/100g	----	----	----	<0.2	----	
Exchangeable Magnesium	----	0.2	meq/100g	----	----	----	1.2	----	
Exchangeable Potassium	----	0.2	meq/100g	----	----	----	<0.2	----	
Exchangeable Sodium	----	0.2	meq/100g	----	----	----	0.6	----	
Cation Exchange Capacity	----	0.2	meq/100g	----	----	----	1.8	----	
Exchangeable Sodium Percent	----	0.2	%	----	----	----	33.5	----	
Calcium/Magnesium Ratio	----	0.2	-	----	----	----	<0.2	----	
ED007: Exchangeable Cations									
Exchangeable Calcium	----	0.1	meq/100g	2.1	1.6	0.7	----	0.1	
Exchangeable Magnesium	----	0.1	meq/100g	0.9	0.8	0.9	----	7.8	
Exchangeable Potassium	----	0.1	meq/100g	0.4	0.2	<0.1	----	0.3	
Exchangeable Sodium	----	0.1	meq/100g	<0.1	<0.1	0.3	----	3.4	
Cation Exchange Capacity	----	0.1	meq/100g	3.6	2.7	2.0	----	11.5	
Exchangeable Sodium Percent	----	0.1	%	2.3	3.6	14.0	----	29.3	
Calcium/Magnesium Ratio	----	0.1	-	2.3	2.0	0.8	----	<0.1	
Magnesium/Potassium Ratio	----	0.1	-	2.1	4.4	----	----	29.2	
ED021: Bicarbonate Extractable Potassium (Colwell)									



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	S23 (0-10cm) A1	S23 (10-30cm) A2	S23 (30-50cm) A2	S23 (60-80cm) B2	S23 (100-120cm) B2
Client sampling date / time				[25-Aug-2017]	[25-Aug-2017]	[25-Aug-2017]	[25-Aug-2017]	[25-Aug-2017]	
Compound	CAS Number	LOR	Unit	EB1718053-026	EB1718053-027	EB1718053-028	EB1718053-029	EB1718053-030	
				Result	Result	Result	Result	Result	
ED021: Bicarbonate Extractable Potassium (Colwell) - Continued									
Bicarbonate Extractable K (Colwell)	----	10	mg/kg	369	254	<200	<200	<200	
ED040S : Soluble Sulfate by ICPAES									
Sulfate as SO4 2-	14808-79-8	10	mg/kg	<10	<10	<10	60	30	
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	10	mg/kg	<10	<10	<10	60	50	
ED092: DTPA Extractable Metals									
Ø Copper	7440-50-8	1.00	mg/kg	<1.00	<1.00	<1.00	<1.00	<1.00	
Ø Iron	7439-89-6	1.00	mg/kg	43.9	15.4	6.12	6.44	29.0	
Ø Manganese	7439-96-5	1.00	mg/kg	33.8	<1.00	<1.00	<1.00	<1.00	
Ø Zinc	7440-66-6	1.00	mg/kg	<1.00	<1.00	<1.00	<1.00	<1.00	
ED093S: Soluble Major Cations									
Calcium	7440-70-2	10	mg/kg	<10	<10	<10	<10	<10	
Magnesium	7439-95-4	10	mg/kg	<10	<10	<10	<10	<10	
Sodium	7440-23-5	10	mg/kg	<10	<10	10	90	60	
Potassium	7440-09-7	10	mg/kg	<10	<10	<10	<10	<10	
EG005T: Total Metals by ICP-AES									
Aluminium	7429-90-5	50	mg/kg	4930	3360	2140	4880	12900	
Molybdenum	7439-98-7	2	mg/kg	<2	<2	<2	<2	<2	
EK055: Ammonia as N									
Ammonia as N	7664-41-7	20	mg/kg	<20	<20	<20	<20	<20	
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N (Sol.)	14797-65-0	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N (Sol.)	14797-55-8	0.1	mg/kg	0.5	0.5	<0.1	<0.1	0.2	
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	0.5	0.5	<0.1	<0.1	0.2	
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	20	mg/kg	570	230	160	120	260	
EK062: Total Nitrogen as N (TKN + NOx)									
^ Total Nitrogen as N	----	20	mg/kg	570	230	160	120	260	
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	2	mg/kg	202	89	64	45	47	
EK080: Bicarbonate Extractable Phosphorus (Colwell)									



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	S23 (0-10cm) A1	S23 (10-30cm) A2	S23 (30-50cm) A2	S23 (60-80cm) B2	S23 (100-120cm) B2
Client sampling date / time				[25-Aug-2017]	[25-Aug-2017]	[25-Aug-2017]	[25-Aug-2017]	[25-Aug-2017]	
Compound	CAS Number	LOR	Unit	EB1718053-026	EB1718053-027	EB1718053-028	EB1718053-029	EB1718053-030	
				Result	Result	Result	Result	Result	
EK080: Bicarbonate Extractable Phosphorus (Colwell) - Continued									
Bicarbonate Ext. P (Colwell)	----	5	mg/kg	<5	<5	5	7	<5	
EP004: Organic Matter									
Organic Matter	----	0.5	%	2.5	0.8	0.6	<0.5	<0.5	
Total Organic Carbon	----	0.5	%	1.4	<0.5	<0.5	<0.5	<0.5	



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	S21 (0-9cm) A1	S21 (9-19cm) A1	S21 929-39cm) A2	S21 (60-90cm) B2	S21 (90-120cm) B2
Client sampling date / time				[26-Aug-2017]	[26-Aug-2017]	[26-Aug-2017]	[26-Aug-2017]	[26-Aug-2017]	
Compound	CAS Number	LOR	Unit	EB1718053-031	EB1718053-032	EB1718053-033	EB1718053-034	EB1718053-035	
				Result	Result	Result	Result	Result	
EA001: pH in soil using 0.01M CaCl extract									
pH (CaCl2)	----	0.1	pH Unit	4.9	5.3	5.3	5.6	5.0	
EA002 : pH (Soils)									
pH Value	----	0.1	pH Unit	5.7	6.2	6.2	6.3	6.1	
EA008: Calcium Carbonate Equivalent									
CaCO3 Equivalent	----	0.01	%	1.77	1.21	1.06	1.01	1.36	
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm	18	7	4	4	4	
EA055: Moisture Content (Dried @ 105-110°C)									
Moisture Content	----	1.0	%	2.7	4.6	4.0	4.8	4.2	
EA058: Emerson Aggregate Test									
Color (Munsell)	----	-	-	Dark Brown	Dark Brown	Strong Brown	Strong Brown	Strong Brown	
Texture	----	-	-	Gravelly Sand	Gravelly Sand	Gravelly Sand	Gravelly Sand	Gravelly Sand	
Emerson Class Number	EC/TC	-	-	8	8	8	8	8	
ED005: Exchange Acidity									
Exchange Acidity	----	0.1	meq/100g	<0.1	----	----	----	----	
Exchangeable Aluminium	----	0.1	meq/100g	<0.1	----	----	----	----	
ED007: Exchangeable Cations									
Exchangeable Calcium	----	0.1	meq/100g	1.7	1.7	1.4	1.3	1.3	
Exchangeable Magnesium	----	0.1	meq/100g	0.7	0.8	0.4	0.9	0.5	
Exchangeable Potassium	----	0.1	meq/100g	0.4	0.4	0.2	0.2	0.3	
Exchangeable Sodium	----	0.1	meq/100g	<0.1	<0.1	<0.1	<0.1	<0.1	
Cation Exchange Capacity	----	0.1	meq/100g	2.8	2.8	2.1	2.5	2.2	
Exchangeable Sodium Percent	----	0.1	%	0.7	0.5	0.5	0.7	0.7	
Calcium/Magnesium Ratio	----	0.1	-	2.4	2.1	3.5	1.4	2.6	
Magnesium/Potassium Ratio	----	0.1	-	1.8	2.1	1.9	4.8	2.1	
ED021: Bicarbonate Extractable Potassium (Colwell)									
Bicarbonate Extractable K (Colwell)	----	10	mg/kg	381	359	296	240	285	
ED040S : Soluble Sulfate by ICPAES									
Sulfate as SO4 2-	14808-79-8	10	mg/kg	<10	<10	<10	<10	<10	
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	10	mg/kg	<10	<10	<10	<10	<10	
ED092: DTPA Extractable Metals									
ø Copper	7440-50-8	1.00	mg/kg	<1.00	<1.00	<1.00	<1.00	<1.00	



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	S21 (0-9cm) A1	S21 (9-19cm) A1	S21 929-39cm) A2	S21 (60-90cm) B2	S21 (90-120cm) B2
Client sampling date / time				[26-Aug-2017]	[26-Aug-2017]	[26-Aug-2017]	[26-Aug-2017]	[26-Aug-2017]	
Compound	CAS Number	LOR	Unit	EB1718053-031	EB1718053-032	EB1718053-033	EB1718053-034	EB1718053-035	
				Result	Result	Result	Result	Result	
ED092: DTPA Extractable Metals - Continued									
∅ Iron	7439-89-6	1.00	mg/kg	27.2	15.7	8.90	9.11	12.6	
∅ Manganese	7439-96-5	1.00	mg/kg	20.9	24.4	8.74	12.7	20.8	
∅ Zinc	7440-66-6	1.00	mg/kg	1.12	<1.00	<1.00	<1.00	<1.00	
ED093S: Soluble Major Cations									
Calcium	7440-70-2	10	mg/kg	<10	<10	<10	<10	<10	
Magnesium	7439-95-4	10	mg/kg	<10	<10	<10	<10	<10	
Sodium	7440-23-5	10	mg/kg	<10	<10	<10	<10	<10	
Potassium	7440-09-7	10	mg/kg	10	<10	<10	<10	<10	
EG005T: Total Metals by ICP-AES									
Aluminium	7429-90-5	50	mg/kg	3880	4280	3640	4340	3890	
Molybdenum	7439-98-7	2	mg/kg	<2	<2	<2	<2	<2	
EK055: Ammonia as N									
Ammonia as N	7664-41-7	20	mg/kg	<20	<20	<20	<20	<20	
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N (Sol.)	14797-65-0	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N (Sol.)	14797-55-8	0.1	mg/kg	1.4	0.6	0.4	0.1	0.5	
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	1.4	0.6	0.4	0.1	0.5	
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	20	mg/kg	740	380	170	140	220	
EK062: Total Nitrogen as N (TKN + NOx)									
^ Total Nitrogen as N	----	20	mg/kg	740	380	170	140	220	
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	2	mg/kg	120	109	74	89	88	
EK080: Bicarbonate Extractable Phosphorus (Colwell)									
Bicarbonate Ext. P (Colwell)	----	5	mg/kg	<5	<5	<5	<5	<5	
EP004: Organic Matter									
Organic Matter	----	0.5	%	1.5	1.6	0.5	<0.5	0.6	
Total Organic Carbon	----	0.5	%	0.9	0.9	<0.5	<0.5	<0.5	



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	S37 (0-12cm)	S37 (12-40cm)	S37 (50-63cm)	S37 (63-83cm)	S37 (90-120cm)
Client sampling date / time				[22-Aug-2017]	[22-Aug-2017]	[22-Aug-2017]	[22-Aug-2017]	[22-Aug-2017]	
Compound	CAS Number	LOR	Unit	EB1718053-036	EB1718053-037	EB1718053-038	EB1718053-039	EB1718053-040	
				Result	Result	Result	Result	Result	
EA001: pH in soil using 0.01M CaCl extract									
pH (CaCl2)	----	0.1	pH Unit	5.0	5.3	5.7	6.2	6.6	
EA002 : pH (Soils)									
pH Value	----	0.1	pH Unit	5.9	6.2	6.4	6.8	7.1	
EA008: Calcium Carbonate Equivalent									
CaCO3 Equivalent	----	0.01	%	1.42	1.52	1.88	1.06	0.04	
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm	12	8	10	10	10	
EA055: Moisture Content (Dried @ 105-110°C)									
Moisture Content	----	1.0	%	1.8	1.9	3.8	3.4	5.1	
EA058: Emerson Aggregate Test									
Color (Munsell)	----	-	-	Dark Brown	Strong Brown	Strong Brown	Strong Brown	Brownish Yellow	
Texture	----	-	-	Gravelly Sand	Gravelly Sand	Gravelly Sand	Gravelly Sand	Gravelly Sand	
Emerson Class Number	EC/TC	-	-	8	8	8	8	8	
ED005: Exchange Acidity									
Exchange Acidity	----	0.1	meq/100g	<0.1	----	----	----	----	
Exchangeable Aluminium	----	0.1	meq/100g	<0.1	----	----	----	----	
ED007: Exchangeable Cations									
Exchangeable Calcium	----	0.1	meq/100g	1.8	1.0	1.2	1.3	1.2	
Exchangeable Magnesium	----	0.1	meq/100g	0.7	0.4	0.6	0.8	0.8	
Exchangeable Potassium	----	0.1	meq/100g	0.5	0.3	0.4	0.3	0.2	
Exchangeable Sodium	----	0.1	meq/100g	<0.1	<0.1	<0.1	<0.1	<0.1	
Cation Exchange Capacity	----	0.1	meq/100g	3.0	1.8	2.2	2.5	2.4	
Exchangeable Sodium Percent	----	0.1	%	0.5	0.9	1.1	1.4	2.2	
Calcium/Magnesium Ratio	----	0.1	-	2.6	2.5	2.0	1.6	1.5	
Magnesium/Potassium Ratio	----	0.1	-	1.3	1.2	1.6	2.7	4.3	
ED021: Bicarbonate Extractable Potassium (Colwell)									
Bicarbonate Extractable K (Colwell)	----	10	mg/kg	474	362	413	330	288	
ED040S : Soluble Sulfate by ICPAES									
Sulfate as SO4 2-	14808-79-8	10	mg/kg	<10	<10	10	10	<10	
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	10	mg/kg	<10	<10	<10	<10	<10	
ED092: DTPA Extractable Metals									
Ø Copper	7440-50-8	1.00	mg/kg	<1.00	<1.00	<1.00	<1.00	<1.00	



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	S37 (0-12cm)	S37 (12-40cm)	S37 (50-63cm)	S37 (63-83cm)	S37 (90-120cm)
Client sampling date / time				[22-Aug-2017]	[22-Aug-2017]	[22-Aug-2017]	[22-Aug-2017]	[22-Aug-2017]	
Compound	CAS Number	LOR	Unit	EB1718053-036	EB1718053-037	EB1718053-038	EB1718053-039	EB1718053-040	
				Result	Result	Result	Result	Result	
ED092: DTPA Extractable Metals - Continued									
∅ Iron	7439-89-6	1.00	mg/kg	57.7	9.00	7.87	5.30	4.73	
∅ Manganese	7439-96-5	1.00	mg/kg	25.6	8.10	6.08	<1.00	<1.00	
∅ Zinc	7440-66-6	1.00	mg/kg	1.43	<1.00	<1.00	<1.00	<1.00	
ED093S: Soluble Major Cations									
Calcium	7440-70-2	10	mg/kg	<10	<10	<10	<10	<10	
Magnesium	7439-95-4	10	mg/kg	<10	<10	<10	<10	<10	
Sodium	7440-23-5	10	mg/kg	<10	<10	<10	<10	<10	
Potassium	7440-09-7	10	mg/kg	10	10	10	10	<10	
EG005T: Total Metals by ICP-AES									
Aluminium	7429-90-5	50	mg/kg	3040	2510	2890	3020	2770	
Molybdenum	7439-98-7	2	mg/kg	<2	<2	<2	<2	<2	
EK055: Ammonia as N									
Ammonia as N	7664-41-7	20	mg/kg	<20	<20	<20	<20	<20	
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N (Sol.)	14797-65-0	0.1	mg/kg	0.1	<0.1	<0.1	<0.1	<0.1	
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N (Sol.)	14797-55-8	0.1	mg/kg	1.0	0.6	0.3	0.2	0.2	
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	1.1	0.6	0.3	0.2	0.2	
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	20	mg/kg	530	160	130	110	110	
EK062: Total Nitrogen as N (TKN + NOx)									
^ Total Nitrogen as N	----	20	mg/kg	530	160	130	110	110	
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	2	mg/kg	361	108	126	121	117	
EK080: Bicarbonate Extractable Phosphorus (Colwell)									
Bicarbonate Ext. P (Colwell)	----	5	mg/kg	<5	<5	<5	7	<5	
EP004: Organic Matter									
Organic Matter	----	0.5	%	1.6	<0.5	<0.5	<0.5	<0.5	
Total Organic Carbon	----	0.5	%	0.9	<0.5	<0.5	<0.5	<0.5	

CERTIFICATE OF ANALYSIS

Work Order : **EB1720219**
Client : **EMM CONSULTING PTY LTD**
Contact : MS KYLIE DRAPALA
Address : 1/4 87 WICKHAM TERRACE
 SPRING HILL QLD 4000
Telephone : 07 3839 1800
Project : Mangoola BSAL
Order number : ----
C-O-C number : ----
Sampler : NICK JAMSON
Site : ----
Quote number : SYBQ/202/16
No. of samples received : 20
No. of samples analysed : 20

Page : 1 of 12
Laboratory : Environmental Division Brisbane
Contact : Customer Services EB
Address : 2 Byth Street Stafford QLD Australia 4053
Telephone : +61-7-3243 7222
Date Samples Received : 29-Sep-2017 13:40
Date Analysis Commenced : 03-Oct-2017
Issue Date : 11-Oct-2017 16:55



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.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Andrew Epps	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Andrew Epps	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Satishkumar Trivedi	Acid Sulfate Soils Supervisor	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
∅ = 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 EB1720219-020 as the required results for Magnesium/Potassium are below LOR.
- ED006(Exchangeable Cations on Alkaline Soils): Unable to calculate Calcium/Magnesium Ratio for EB1720219-020 as the required results for Calcium/Magnesium are below LOR.
- ED007(Exchangeable Cations): Unable to calculate Magnesium/Potassium Ratio for some samples as the required results for Magnesium/Potassium are below LOR.
- ED037 (Alkalinity): NATA accreditation does not cover the performance of this service.
- ED006 (Exchangeable Cations on Alkaline Soils): It is recognised that the Exchangeable K LCS biases low, however this is deemed acceptable as the target concentration is at LOR and the Cation Exchange Capacity LCS is within acceptable limits.
- 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	S41 10-30cm	S41 30-50cm	S41 0-10cm	S41 50-70cm	S41 90-120cm
Client sampling date / time				[24-Aug-2017]	[24-Aug-2017]	[24-Aug-2017]	[24-Aug-2017]	[24-Aug-2017]	
Compound	CAS Number	LOR	Unit	EB1720219-001	EB1720219-002	EB1720219-003	EB1720219-004	EB1720219-005	
				Result	Result	Result	Result	Result	
EA001: pH in soil using 0.01M CaCl extract									
pH (CaCl2)	----	0.1	pH Unit	5.0	5.1	4.8	4.0	3.9	
EA002 : pH (Soils)									
pH Value	----	0.1	pH Unit	5.9	6.0	5.5	5.5	5.3	
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm	5	5	22	42	47	
EA055: Moisture Content (Dried @ 105-110°C)									
Moisture Content	----	1.0	%	4.6	4.2	3.5	18.6	14.8	
EA058: Emerson Aggregate Test									
Color (Munsell)	----	-	-	Dark Grey	Brown	Dark Brown	Brown	Reddish Brown	
Texture	----	-	-	Rocks	Rocks	Rocks	Silty Clay Loam	Silty Clay Loam	
Emerson Class Number	EC/TC	-	-	8	8	8	1	1	
ED005: Exchange Acidity									
Exchange Acidity	----	0.1	meq/100g	<0.1	<0.1	<0.1	2.4	3.8	
Exchangeable Aluminium	----	0.1	meq/100g	<0.1	<0.1	<0.1	1.9	2.7	
ED007: Exchangeable Cations									
Exchangeable Calcium	----	0.1	meq/100g	1.1	1.8	4.1	0.1	<0.1	
Exchangeable Magnesium	----	0.1	meq/100g	0.8	0.9	1.3	4.8	6.6	
Exchangeable Potassium	----	0.1	meq/100g	0.1	0.1	0.3	0.5	0.5	
Exchangeable Sodium	----	0.1	meq/100g	0.1	<0.1	<0.1	1.7	2.1	
Cation Exchange Capacity	----	0.1	meq/100g	----	----	----	9.5	13.0	
Cation Exchange Capacity	----	0.1	meq/100g	2.2	3.0	5.8	----	----	
Exchangeable Sodium Percent	----	0.1	%	5.4	2.8	1.3	24.3	22.4	
Calcium/Magnesium Ratio	----	0.1	-	1.4	2.0	3.2	<0.1	<0.1	
Magnesium/Potassium Ratio	----	0.1	-	6.3	7.1	3.9	10.3	12.4	
ED021: Bicarbonate Extractable Potassium (Colwell)									
Bicarbonate Extractable K (Colwell)	----	10	mg/kg	<200	<200	291	331	350	
ED037: Alkalinity									
∅ Total Alkalinity as CaCO3	----	1	mg/kg	117	288	1310	288	207	
∅ Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/kg	117	288	1310	288	207	
∅ Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/kg	<5	<5	<5	<5	<5	
ED040S : Soluble Sulfate by ICPAES									
Sulfate as SO4 2-	14808-79-8	10	mg/kg	<10	<10	10	40	40	
ED045G: Chloride by Discrete Analyser									



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	S41 10-30cm	S41 30-50cm	S41 0-10cm	S41 50-70cm	S41 90-120cm
Client sampling date / time				[24-Aug-2017]	[24-Aug-2017]	[24-Aug-2017]	[24-Aug-2017]	[24-Aug-2017]	
Compound	CAS Number	LOR	Unit	EB1720219-001	EB1720219-002	EB1720219-003	EB1720219-004	EB1720219-005	
				Result	Result	Result	Result	Result	
ED045G: Chloride by Discrete Analyser - Continued									
Chloride	16887-00-6	10	mg/kg	<10	<10	10	20	20	
ED092: DTPA Extractable Metals									
Ø Copper	7440-50-8	1.00	mg/kg	<1.00	<1.00	<1.00	<1.00	<1.00	
Ø Iron	7439-89-6	1.00	mg/kg	22.8	29.6	191	76.3	44.3	
Ø Manganese	7439-96-5	1.00	mg/kg	<1.00	1.11	26.4	<1.00	<1.00	
Ø Zinc	7440-66-6	1.00	mg/kg	<1.00	<1.00	7.31	<1.00	<1.00	
ED093S: Soluble Major Cations									
Calcium	7440-70-2	10	mg/kg	<10	<10	<10	<10	<10	
Magnesium	7439-95-4	10	mg/kg	<10	<10	<10	<10	<10	
Sodium	7440-23-5	10	mg/kg	<10	<10	<10	40	30	
Potassium	7440-09-7	10	mg/kg	<10	<10	<10	<10	<10	
EG005T: Total Metals by ICP-AES									
Aluminium	7429-90-5	50	mg/kg	3060	2950	4260	9960	7200	
Molybdenum	7439-98-7	2	mg/kg	<2	<2	<2	<2	<2	
EK055: Ammonia as N									
Ammonia as N	7664-41-7	20	mg/kg	<20	<20	<20	<20	<20	
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N (Sol.)	14797-65-0	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N (Sol.)	14797-55-8	0.1	mg/kg	0.1	0.7	3.3	0.2	0.2	
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	0.1	0.7	3.3	0.2	0.2	
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	20	mg/kg	260	380	1510	310	230	
EK062: Total Nitrogen as N (TKN + NOx)									
^ Total Nitrogen as N	----	20	mg/kg	260	380	1510	310	230	
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	2	mg/kg	86	107	221	72	45	
EK080: Bicarbonate Extractable Phosphorus (Colwell)									
Bicarbonate Ext. P (Colwell)	----	5	mg/kg	<5	<5	<5	<5	<5	
EP004: Organic Matter									
Organic Matter	----	0.5	%	0.8	1.5	5.1	0.6	<0.5	
Total Organic Carbon	----	0.5	%	<0.5	0.8	2.9	<0.5	<0.5	



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	S48 110-130cm	S48 90-110cm	S48 0-10cm	S48 20-40cm	S48 50-80cm
Client sampling date / time				[24-Aug-2017]	[24-Aug-2017]	[24-Aug-2017]	[24-Aug-2017]	[24-Aug-2017]	
Compound	CAS Number	LOR	Unit	EB1720219-006	EB1720219-007	EB1720219-008	EB1720219-009	EB1720219-010	
				Result	Result	Result	Result	Result	
EA001: pH in soil using 0.01M CaCl extract									
pH (CaCl2)	----	0.1	pH Unit	4.0	4.1	4.7	5.1	4.7	
EA002 : pH (Soils)									
pH Value	----	0.1	pH Unit	4.9	5.0	5.8	6.1	5.9	
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm	16	12	11	3	3	
EA055: Moisture Content (Dried @ 105-110°C)									
Moisture Content	----	1.0	%	14.6	9.0	4.3	3.4	4.7	
EA058: Emerson Aggregate Test									
Color (Munsell)	----	-	-	Yellowish Red	Yellowish Red	Dark Brown	Dark Brown	Dark Brown	
Texture	----	-	-	Silty Clay Loam	Silty Clay Loam	Rocks	Rocks	Rocks	
Emerson Class Number	EC/TC	-	-	4	4	8	8	8	
ED005: Exchange Acidity									
Exchange Acidity	----	0.1	meq/100g	4.3	2.7	0.2	----	0.4	
Exchangeable Aluminium	----	0.1	meq/100g	3.5	2.1	<0.1	----	0.3	
ED007: Exchangeable Cations									
Exchangeable Calcium	----	0.1	meq/100g	0.3	0.2	3.0	2.2	0.7	
Exchangeable Magnesium	----	0.1	meq/100g	4.7	2.7	1.1	0.9	1.6	
Exchangeable Potassium	----	0.1	meq/100g	0.1	<0.1	0.8	0.2	<0.1	
Exchangeable Sodium	----	0.1	meq/100g	0.1	<0.1	<0.1	<0.1	<0.1	
Cation Exchange Capacity	----	0.1	meq/100g	9.5	5.6	5.1	----	2.7	
Cation Exchange Capacity	----	0.1	meq/100g	----	----	----	3.4	----	
Exchangeable Sodium Percent	----	0.1	%	2.4	2.8	0.4	0.7	2.0	
Calcium/Magnesium Ratio	----	0.1	-	<0.1	<0.1	2.7	2.4	0.4	
Magnesium/Potassium Ratio	----	0.1	-	31.6	----	1.4	3.7	----	
ED021: Bicarbonate Extractable Potassium (Colwell)									
Bicarbonate Extractable K (Colwell)	----	10	mg/kg	<200	<200	495	235	<200	
ED037: Alkalinity									
∅ Total Alkalinity as CaCO3	----	1	mg/kg	126	108	414	216	90	
∅ Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/kg	126	108	414	216	90	
∅ Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/kg	<5	<5	<5	<5	<5	
ED040S : Soluble Sulfate by ICPAES									
Sulfate as SO4 2-	14808-79-8	10	mg/kg	20	20	<10	<10	<10	
ED045G: Chloride by Discrete Analyser									



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	S48 110-130cm	S48 90-110cm	S48 0-10cm	S48 20-40cm	S48 50-80cm
Client sampling date / time				[24-Aug-2017]	[24-Aug-2017]	[24-Aug-2017]	[24-Aug-2017]	[24-Aug-2017]	
Compound	CAS Number	LOR	Unit	EB1720219-006	EB1720219-007	EB1720219-008	EB1720219-009	EB1720219-010	
				Result	Result	Result	Result	Result	
ED045G: Chloride by Discrete Analyser - Continued									
Chloride	16887-00-6	10	mg/kg	<10	<10	<10	<10	<10	
ED092: DTPA Extractable Metals									
∅ Copper	7440-50-8	1.00	mg/kg	<1.00	<1.00	<1.00	<1.00	<1.00	
∅ Iron	7439-89-6	1.00	mg/kg	11.8	9.94	67.6	8.54	6.88	
∅ Manganese	7439-96-5	1.00	mg/kg	<1.00	<1.00	58.5	6.30	<1.00	
∅ Zinc	7440-66-6	1.00	mg/kg	<1.00	<1.00	1.02	<1.00	<1.00	
ED093S: Soluble Major Cations									
Calcium	7440-70-2	10	mg/kg	<10	<10	<10	<10	<10	
Magnesium	7439-95-4	10	mg/kg	<10	<10	<10	<10	<10	
Sodium	7440-23-5	10	mg/kg	10	<10	<10	<10	<10	
Potassium	7440-09-7	10	mg/kg	<10	<10	10	<10	<10	
EG005T: Total Metals by ICP-AES									
Aluminium	7429-90-5	50	mg/kg	10800	4800	5850	5330	4630	
Molybdenum	7439-98-7	2	mg/kg	<2	<2	<2	<2	<2	
EK055: Ammonia as N									
Ammonia as N	7664-41-7	20	mg/kg	<20	<20	<20	<20	<20	
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N (Sol.)	14797-65-0	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N (Sol.)	14797-55-8	0.1	mg/kg	0.5	0.3	2.2	0.6	0.2	
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	0.5	0.3	2.2	0.6	0.2	
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	20	mg/kg	180	140	1200	320	160	
EK062: Total Nitrogen as N (TKN + NOx)									
^ Total Nitrogen as N	----	20	mg/kg	180	140	1200	320	160	
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	2	mg/kg	76	112	228	148	127	
EK080: Bicarbonate Extractable Phosphorus (Colwell)									
Bicarbonate Ext. P (Colwell)	----	5	mg/kg	<5	<5	<5	<5	<5	
EP004: Organic Matter									
Organic Matter	----	0.5	%	0.7	<0.5	4.9	1.1	0.6	
Total Organic Carbon	----	0.5	%	<0.5	<0.5	2.8	0.6	<0.5	



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	S5 70-90cm	S5 90-120cm	S5 30-50cm	S5 10-30cm	S5 0-10cm
Client sampling date / time				[27-Aug-2017]	[27-Aug-2017]	[27-Aug-2017]	[27-Aug-2017]	[27-Aug-2017]	
Compound	CAS Number	LOR	Unit	EB1720219-011	EB1720219-012	EB1720219-013	EB1720219-014	EB1720219-015	
				Result	Result	Result	Result	Result	
EA001: pH in soil using 0.01M CaCl extract									
pH (CaCl2)	----	0.1	pH Unit	5.7	6.1	5.6	5.8	5.1	
EA002 : pH (Soils)									
pH Value	----	0.1	pH Unit	6.0	7.1	6.4	6.8	6.0	
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm	755	282	581	108	86	
EA055: Moisture Content (Dried @ 105-110°C)									
Moisture Content	----	1.0	%	12.4	8.0	14.9	10.2	5.0	
EA058: Emerson Aggregate Test									
Color (Munsell)	----	-	-	Brown	Greyish Brown	Greyish Brown	Greyish Brown	Dark Greyish Brown	
Texture	----	-	-	Silty Clay Loam	Sandy Clay	Silty Clay Loam	Silty Clay Loam	Silty Loam	
Emerson Class Number	EC/TC	-	-	2	1	1	1	7	
ED005: Exchange Acidity									
Exchange Acidity	----	0.1	meq/100g	----	----	----	----	0.1	
Exchangeable Aluminium	----	0.1	meq/100g	----	----	----	----	<0.1	
ED007: Exchangeable Cations									
Exchangeable Calcium	----	0.1	meq/100g	----	1.6	----	3.5	3.4	
Exchangeable Magnesium	----	0.1	meq/100g	----	5.3	----	8.2	5.0	
Exchangeable Potassium	----	0.1	meq/100g	----	0.3	----	0.5	0.8	
Exchangeable Sodium	----	0.1	meq/100g	----	3.1	----	1.6	0.5	
Cation Exchange Capacity	----	0.1	meq/100g	----	----	----	----	9.8	
Cation Exchange Capacity	----	0.1	meq/100g	----	10.4	----	13.9	----	
Exchangeable Sodium Percent	----	0.1	%	----	30.3	----	11.7	5.4	
Calcium/Magnesium Ratio	----	0.1	-	----	0.3	----	0.4	0.7	
Magnesium/Potassium Ratio	----	0.1	-	----	15.9	----	16.0	6.6	
ED008: Exchangeable Cations									
Exchangeable Calcium	----	0.1	meq/100g	1.6	----	2.4	----	----	
Exchangeable Magnesium	----	0.1	meq/100g	4.6	----	6.3	----	----	
Exchangeable Potassium	----	0.1	meq/100g	0.2	----	0.3	----	----	
Exchangeable Sodium	----	0.1	meq/100g	1.0	----	1.3	----	----	
Cation Exchange Capacity	----	0.1	meq/100g	7.6	----	10.4	----	----	
Exchangeable Sodium Percent	----	0.1	%	13.9	----	12.4	----	----	
Calcium/Magnesium Ratio	----	0.1	-	0.3	----	0.4	----	----	
Magnesium/Potassium Ratio	----	0.1	-	17.8	----	19.8	----	----	
ED021: Bicarbonate Extractable Potassium (Colwell)									



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	S5 70-90cm	S5 90-120cm	S5 30-50cm	S5 10-30cm	S5 0-10cm
Client sampling date / time				[27-Aug-2017]	[27-Aug-2017]	[27-Aug-2017]	[27-Aug-2017]	[27-Aug-2017]	
Compound	CAS Number	LOR	Unit	EB1720219-011	EB1720219-012	EB1720219-013	EB1720219-014	EB1720219-015	
				Result	Result	Result	Result	Result	
ED021: Bicarbonate Extractable Potassium (Colwell) - Continued									
Bicarbonate Extractable K (Colwell)	----	10	mg/kg	331	270	364	358	472	
ED037: Alkalinity									
∅ Total Alkalinity as CaCO ₃	----	1	mg/kg	414	450	864	783	2380	
∅ Bicarbonate Alkalinity as CaCO ₃	71-52-3	1	mg/kg	414	450	864	783	2380	
∅ Carbonate Alkalinity as CaCO ₃	3812-32-6	1	mg/kg	<5	<5	<5	<5	<5	
ED040S : Soluble Sulfate by ICPAES									
Sulfate as SO ₄ 2-	14808-79-8	10	mg/kg	250	60	180	10	30	
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	10	mg/kg	1290	410	960	140	110	
ED092: DTPA Extractable Metals									
∅ Copper	7440-50-8	1.00	mg/kg	1.11	<1.00	1.24	1.21	<1.00	
∅ Iron	7439-89-6	1.00	mg/kg	19.6	5.10	39.7	39.2	91.4	
∅ Manganese	7439-96-5	1.00	mg/kg	54.2	6.76	9.52	18.6	96.0	
∅ Zinc	7440-66-6	1.00	mg/kg	<1.00	<1.00	<1.00	<1.00	3.45	
ED093S: Soluble Major Cations									
Calcium	7440-70-2	10	mg/kg	10	<10	<10	<10	<10	
Magnesium	7439-95-4	10	mg/kg	20	<10	10	<10	<10	
Sodium	7440-23-5	10	mg/kg	850	290	650	90	70	
Potassium	7440-09-7	10	mg/kg	<10	<10	<10	<10	20	
EG005T: Total Metals by ICP-AES									
Aluminium	7429-90-5	50	mg/kg	8210	6740	11700	11000	9370	
Molybdenum	7439-98-7	2	mg/kg	<2	<2	<2	<2	<2	
EK055: Ammonia as N									
Ammonia as N	7664-41-7	20	mg/kg	<20	<20	<20	<20	<20	
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N (Sol.)	14797-65-0	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	0.4	
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N (Sol.)	14797-55-8	0.1	mg/kg	0.3	<0.1	<0.1	<0.1	0.2	
EK059G: Nitrite plus Nitrate as N (NO_x) by Discrete Analyser									
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	0.3	<0.1	<0.1	<0.1	0.6	
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	20	mg/kg	190	120	300	540	2030	
EK062: Total Nitrogen as N (TKN + NO_x)									



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	S5 70-90cm	S5 90-120cm	S5 30-50cm	S5 10-30cm	S5 0-10cm
Client sampling date / time				[27-Aug-2017]	[27-Aug-2017]	[27-Aug-2017]	[27-Aug-2017]	[27-Aug-2017]	
Compound	CAS Number	LOR	Unit	EB1720219-011	EB1720219-012	EB1720219-013	EB1720219-014	EB1720219-015	
				Result	Result	Result	Result	Result	
EK062: Total Nitrogen as N (TKN + NOx) - Continued									
^ Total Nitrogen as N	----	20	mg/kg	190	120	300	540	2030	
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	2	mg/kg	103	70	77	100	268	
EK080: Bicarbonate Extractable Phosphorus (Colwell)									
Bicarbonate Ext. P (Colwell)	----	5	mg/kg	<5	<5	<5	<5	6	
EP004: Organic Matter									
Organic Matter	----	0.5	%	0.7	<0.5	0.7	0.9	2.3	
Total Organic Carbon	----	0.5	%	<0.5	<0.5	<0.5	0.5	1.4	



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	S12 0-10cm	S12 10-25cm	S12 50-70cm	S12 90-120cm	S12 25-40cm
Client sampling date / time				[27-Aug-2017]	[27-Aug-2017]	[27-Aug-2017]	[27-Aug-2017]	[27-Aug-2017]	
Compound	CAS Number	LOR	Unit	EB1720219-016	EB1720219-017	EB1720219-018	EB1720219-019	EB1720219-020	
				Result	Result	Result	Result	Result	
EA001: pH in soil using 0.01M CaCl extract									
pH (CaCl2)	----	0.1	pH Unit	4.8	4.7	4.6	4.5	7.4	
EA002 : pH (Soils)									
pH Value	----	0.1	pH Unit	5.8	5.9	5.8	5.6	8.6	
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm	17	7	22	11	133	
EA055: Moisture Content (Dried @ 105-110°C)									
Moisture Content	----	1.0	%	4.8	5.9	11.8	7.6	6.3	
EA058: Emerson Aggregate Test									
Color (Munsell)	----	-	-	Very Dark Brown	Brown	Brown	Brown	Brown	
Texture	----	-	-	Silty Loam	Silty Clay Loam	Silty Clay Loam	Sandy Clay	Silty Clay Loam	
Emerson Class Number	EC/TC	-	-	7	4	4	1	4	
ED005: Exchange Acidity									
Exchange Acidity	----	0.1	meq/100g	<0.1	<0.1	0.3	<0.1	----	
Exchangeable Aluminium	----	0.1	meq/100g	<0.1	<0.1	0.2	<0.1	----	
ED006: Exchangeable Cations on Alkaline Soils									
Exchangeable Calcium	----	0.2	meq/100g	----	----	----	----	0.3	
Exchangeable Magnesium	----	0.2	meq/100g	----	----	----	----	<0.2	
Exchangeable Potassium	----	0.2	meq/100g	----	----	----	----	<0.2	
Exchangeable Sodium	----	0.2	meq/100g	----	----	----	----	<0.2	
Cation Exchange Capacity	----	0.2	meq/100g	----	----	----	----	0.4	
Exchangeable Sodium Percent	----	0.2	%	----	----	----	----	<0.2	
ED007: Exchangeable Cations									
Exchangeable Calcium	----	0.1	meq/100g	3.7	1.6	3.2	2.8	----	
Exchangeable Magnesium	----	0.1	meq/100g	1.8	1.2	7.5	5.0	----	
Exchangeable Potassium	----	0.1	meq/100g	0.9	0.5	0.4	0.3	----	
Exchangeable Sodium	----	0.1	meq/100g	<0.1	<0.1	0.6	1.6	----	
Cation Exchange Capacity	----	0.1	meq/100g	----	----	12.1	----	----	
Cation Exchange Capacity	----	0.1	meq/100g	6.5	3.4	----	9.8	----	
Exchangeable Sodium Percent	----	0.1	%	0.7	0.9	5.1	16.5	----	
Calcium/Magnesium Ratio	----	0.1	-	2.0	1.3	0.4	0.6	----	
Magnesium/Potassium Ratio	----	0.1	-	1.9	2.6	17.0	16.0	----	
ED021: Bicarbonate Extractable Potassium (Colwell)									
Bicarbonate Extractable K (Colwell)	----	10	mg/kg	481	343	372	295	341	
ED037: Alkalinity									



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	S12 0-10cm	S12 10-25cm	S12 50-70cm	S12 90-120cm	S12 25-40cm
Client sampling date / time				[27-Aug-2017]	[27-Aug-2017]	[27-Aug-2017]	[27-Aug-2017]	[27-Aug-2017]	
Compound	CAS Number	LOR	Unit	EB1720219-016	EB1720219-017	EB1720219-018	EB1720219-019	EB1720219-020	
				Result	Result	Result	Result	Result	
ED037: Alkalinity - Continued									
∅ Total Alkalinity as CaCO3	----	1	mg/kg	1650	819	369	126	2390	
∅ Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/kg	1650	819	369	126	2300	
∅ Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/kg	<5	<5	<5	<5	90	
ED040S : Soluble Sulfate by ICPAES									
Sulfate as SO4 2-	14808-79-8	10	mg/kg	<10	<10	30	20	40	
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	10	mg/kg	10	<10	<10	<10	140	
ED092: DTPA Extractable Metals									
∅ Copper	7440-50-8	1.00	mg/kg	<1.00	<1.00	<1.00	<1.00	<1.00	
∅ Iron	7439-89-6	1.00	mg/kg	107	19.1	22.7	5.79	16.7	
∅ Manganese	7439-96-5	1.00	mg/kg	119	37.1	10.1	3.60	27.5	
∅ Zinc	7440-66-6	1.00	mg/kg	3.12	<1.00	<1.00	<1.00	<1.00	
ED093S: Soluble Major Cations									
Calcium	7440-70-2	10	mg/kg	<10	<10	<10	<10	<10	
Magnesium	7439-95-4	10	mg/kg	<10	<10	<10	<10	<10	
Sodium	7440-23-5	10	mg/kg	<10	<10	20	<10	130	
Potassium	7440-09-7	10	mg/kg	20	<10	<10	<10	<10	
EG005T: Total Metals by ICP-AES									
Aluminium	7429-90-5	50	mg/kg	5670	5160	13600	6100	5200	
Molybdenum	7439-98-7	2	mg/kg	<2	<2	<2	<2	<2	
EK055: Ammonia as N									
Ammonia as N	7664-41-7	20	mg/kg	<20	<20	<20	<20	<20	
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N (Sol.)	14797-65-0	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N (Sol.)	14797-55-8	0.1	mg/kg	0.4	<0.1	<0.1	<0.1	<0.1	
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	0.4	<0.1	<0.1	<0.1	<0.1	
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	20	mg/kg	1900	400	360	120	280	
EK062: Total Nitrogen as N (TKN + NOx)									
^ Total Nitrogen as N	----	20	mg/kg	1900	400	360	120	280	
EK067G: Total Phosphorus as P by Discrete Analyser									



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	S12 0-10cm	S12 10-25cm	S12 50-70cm	S12 90-120cm	S12 25-40cm
Client sampling date / time				[27-Aug-2017]	[27-Aug-2017]	[27-Aug-2017]	[27-Aug-2017]	[27-Aug-2017]	
Compound	CAS Number	LOR	Unit	EB1720219-016	EB1720219-017	EB1720219-018	EB1720219-019	EB1720219-020	
				Result	Result	Result	Result	Result	
EK067G: Total Phosphorus as P by Discrete Analyser - Continued									
Total Phosphorus as P	----	2	mg/kg	297	147	129	112	126	
EK080: Bicarbonate Extractable Phosphorus (Colwell)									
Bicarbonate Ext. P (Colwell)	----	5	mg/kg	6	<5	<5	<5	<5	
EP004: Organic Matter									
Organic Matter	----	0.5	%	3.4	0.8	0.6	0.6	<0.5	
Total Organic Carbon	----	0.5	%	2.0	<0.5	<0.5	<0.5	<0.5	

CERTIFICATE OF ANALYSIS

Work Order : **EB1721328**
Client : **EMM CONSULTING PTY LTD**
Contact : MS KYLIE DRAPALA
Address : 1/4 87 WICKHAM TERRACE
 SPRING HILL QLD 4000
Telephone : 07 3839 1800
Project : Mangoola BSAL
Order number : ----
C-O-C number : ----
Sampler : NICHOLAS JAMSON
Site : ----
Quote number : SYBQ/202/16
No. of samples received : 10
No. of samples analysed : 10

Page : 1 of 8
Laboratory : Environmental Division Brisbane
Contact : Customer Services EB
Address : 2 Byth Street Stafford QLD Australia 4053
Telephone : +61-7-3243 7222
Date Samples Received : 16-Oct-2017 14:20
Date Analysis Commenced : 17-Oct-2017
Issue Date : 25-Oct-2017 13:30



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.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Ben Felgendrejeris		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



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.

- ED021 (Bicarbonate Extractable K Colwell) LOR for some samples have been raised due to matrix interference.
- ED006 (Exchangeable Cations on Alkaline Soils): Magnesium/Potassium ratio could not be determined as both the Magnesium and Potassium results were less than reportable limits for some samples.
- 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	S53, 0-10cm A1	S53, 10-30cm A2	S53, 30-50cm A2	S53, 50-70cm B2	S53, 100-120cm B2
Client sampling date / time				24-Aug-2017 00:00					
Compound	CAS Number	LOR	Unit	EB1721328-001	EB1721328-002	EB1721328-003	EB1721328-004	EB1721328-005	
				Result	Result	Result	Result	Result	
EA001: pH in soil using 0.01M CaCl extract									
pH (CaCl2)	----	0.1	pH Unit	4.7	5.5	5.8	6.2	6.6	
EA002 : pH (Soils)									
pH Value	----	0.1	pH Unit	5.5	6.5	6.6	7.1	7.8	
EA008: Calcium Carbonate Equivalent									
CaCO3 Equivalent	----	0.01	%	4.88	4.82	7.09	7.92	4.72	
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm	27	6	6	16	35	
EA055: Moisture Content (Dried @ 105-110°C)									
Moisture Content	----	1.0	%	4.1	4.3	4.6	6.6	7.1	
EA058: Emerson Aggregate Test									
Color (Munsell)	----	-	-	Very Dark Brown	Dark Brown	Dark Brown	Brown	Brown	
Texture	----	-	-	Sand	Sand	Sand	Sandy Loam	Sandy Loam	
Emerson Class Number	EC/TC	-	-	8	8	8	3	3	
ED005: Exchange Acidity									
Exchange Acidity	----	0.1	meq/100g	<0.1	----	----	----	----	
Exchangeable Aluminium	----	0.1	meq/100g	<0.1	----	----	----	----	
ED006: Exchangeable Cations on Alkaline Soils									
Exchangeable Calcium	----	0.2	meq/100g	----	----	----	----	0.7	
Exchangeable Magnesium	----	0.2	meq/100g	----	----	----	----	1.0	
Exchangeable Potassium	----	0.2	meq/100g	----	----	----	----	<0.2	
Exchangeable Sodium	----	0.2	meq/100g	----	----	----	----	<0.2	
Cation Exchange Capacity	----	0.2	meq/100g	----	----	----	----	1.7	
Exchangeable Sodium Percent	----	0.2	%	----	----	----	----	<0.2	
Calcium/Magnesium Ratio	----	0.2	-	----	----	----	----	0.7	
ED007: Exchangeable Cations									
Exchangeable Calcium	----	0.1	meq/100g	----	2.0	1.7	1.8	----	
Exchangeable Magnesium	----	0.1	meq/100g	----	0.6	0.8	1.7	----	
Exchangeable Potassium	----	0.1	meq/100g	----	0.2	0.1	0.1	----	
Exchangeable Sodium	----	0.1	meq/100g	----	<0.1	<0.1	0.1	----	
Cation Exchange Capacity	----	0.1	meq/100g	----	2.9	2.7	3.8	----	
Exchangeable Sodium Percent	----	0.1	%	----	0.8	1.8	3.7	----	
Calcium/Magnesium Ratio	----	0.1	-	----	3.3	2.1	1.0	----	
Magnesium/Potassium Ratio	----	0.1	-	----	2.3	5.6	16.7	----	
ED008: Exchangeable Cations									



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	S53, 0-10cm A1	S53, 10-30cm A2	S53, 30-50cm A2	S53, 50-70cm B2	S53, 100-120cm B2
Client sampling date / time				24-Aug-2017 00:00					
Compound	CAS Number	LOR	Unit	EB1721328-001	EB1721328-002	EB1721328-003	EB1721328-004	EB1721328-005	
				Result	Result	Result	Result	Result	
ED008: Exchangeable Cations - Continued									
Exchangeable Calcium	----	0.1	meq/100g	2.9	----	----	----	----	
Exchangeable Magnesium	----	0.1	meq/100g	0.8	----	----	----	----	
Exchangeable Potassium	----	0.1	meq/100g	0.4	----	----	----	----	
Exchangeable Sodium	----	0.1	meq/100g	<0.1	----	----	----	----	
Cation Exchange Capacity	----	0.1	meq/100g	4.3	----	----	----	----	
Exchangeable Sodium Percent	----	0.1	%	<0.1	----	----	----	----	
Calcium/Magnesium Ratio	----	0.1	-	3.6	----	----	----	----	
Magnesium/Potassium Ratio	----	0.1	-	2.2	----	----	----	----	
ED021: Bicarbonate Extractable Potassium (Colwell)									
Bicarbonate Extractable K (Colwell)	----	10	mg/kg	439	235	<200	<200	<200	
ED040S : Soluble Sulfate by ICPAES									
Sulfate as SO4 2-	14808-79-8	10	mg/kg	<10	<10	<10	10	30	
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	10	mg/kg	<10	<10	<10	<10	<10	
ED092: DTPA Extractable Metals									
Ø Copper	7440-50-8	1.00	mg/kg	<1.00	<1.00	<1.00	<1.00	<1.00	
Ø Iron	7439-89-6	1.00	mg/kg	93.0	9.83	4.46	5.42	5.90	
Ø Manganese	7439-96-5	1.00	mg/kg	51.0	6.67	3.62	5.61	3.72	
Ø Zinc	7440-66-6	1.00	mg/kg	1.46	<1.00	<1.00	<1.00	<1.00	
ED093S: Soluble Major Cations									
Calcium	7440-70-2	10	mg/kg	<10	<10	<10	<10	<10	
Magnesium	7439-95-4	10	mg/kg	<10	<10	<10	<10	<10	
Sodium	7440-23-5	10	mg/kg	<10	<10	<10	20	40	
Potassium	7440-09-7	10	mg/kg	20	<10	<10	<10	<10	
EG005T: Total Metals by ICP-AES									
Aluminium	7429-90-5	50	mg/kg	4500	4030	4220	6540	10300	
Molybdenum	7439-98-7	2	mg/kg	<2	<2	<2	<2	<2	
EK055: Ammonia as N									
Ammonia as N	7664-41-7	20	mg/kg	<20	<20	<20	<20	<20	
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N (Sol.)	14797-65-0	0.1	mg/kg	0.1	<0.1	<0.1	<0.1	<0.1	
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N (Sol.)	14797-55-8	0.1	mg/kg	10.6	1.0	0.4	0.4	0.4	



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	S53, 0-10cm A1	S53, 10-30cm A2	S53, 30-50cm A2	S53, 50-70cm B2	S53, 100-120cm B2
Client sampling date / time				24-Aug-2017 00:00					
Compound	CAS Number	LOR	Unit	EB1721328-001	EB1721328-002	EB1721328-003	EB1721328-004	EB1721328-005	
				Result	Result	Result	Result	Result	
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	10.7	1.0	0.4	0.4	0.4	
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	20	mg/kg	990	260	150	150	130	
EK062: Total Nitrogen as N (TKN + NOx)									
^ Total Nitrogen as N	----	20	mg/kg	1000	260	150	150	130	
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	2	mg/kg	199	98	76	58	61	
EK080: Bicarbonate Extractable Phosphorus (Colwell)									
Bicarbonate Ext. P (Colwell)	----	5	mg/kg	<5	<5	<5	<5	<5	
EP004: Organic Matter									
Organic Matter	----	0.5	%	2.3	0.7	0.6	0.6	<0.5	
Total Organic Carbon	----	0.5	%	1.3	<0.5	<0.5	<0.5	<0.5	



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)		Client sample ID			S19, 0-10cm A1	S19, 11-25cm A3	S19, 25-45cm B21	S19, 75-95cm B21	S19, 95-120cm B22
		Client sampling date / time			27-Aug-2017 00:00	27-Aug-2017 00:00	27-Aug-2017 00:00	27-Aug-2017 00:00	27-Aug-2017 00:00
Compound	CAS Number	LOR	Unit	EB1721328-006	EB1721328-007	EB1721328-008	EB1721328-009	EB1721328-010	
				Result	Result	Result	Result	Result	
EA001: pH in soil using 0.01M CaCl extract									
pH (CaCl2)	----	0.1	pH Unit	5.5	4.2	5.5	5.7	6.3	
EA002 : pH (Soils)									
pH Value	----	0.1	pH Unit	6.6	6.6	6.6	6.6	7.4	
EA008: Calcium Carbonate Equivalent									
CaCO3 Equivalent	----	0.01	%	3.85	3.28	3.54	2.97	3.95	
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm	25	7	6	7	47	
EA055: Moisture Content (Dried @ 105-110°C)									
Moisture Content	----	1.0	%	2.3	2.5	3.5	4.1	7.0	
EA058: Emerson Aggregate Test									
Color (Munsell)	----	-	-	Very Dark Brown	Dark Brown	Dark Brown	Dark Yellowish Brown	Dark Yellowish Brown	
Texture	----	-	-	Sand	Sand	Sand	Sand	Sandy Loam	
Emerson Class Number	EC/TC	-	-	8	8	8	8	2	
ED006: Exchangeable Cations on Alkaline Soils									
Exchangeable Calcium	----	0.2	meq/100g	----	----	----	----	0.6	
Exchangeable Magnesium	----	0.2	meq/100g	----	----	----	----	0.5	
Exchangeable Potassium	----	0.2	meq/100g	----	----	----	----	<0.2	
Exchangeable Sodium	----	0.2	meq/100g	----	----	----	----	<0.2	
Cation Exchange Capacity	----	0.2	meq/100g	----	----	----	----	1.1	
Exchangeable Sodium Percent	----	0.2	%	----	----	----	----	<0.2	
Calcium/Magnesium Ratio	----	0.2	-	----	----	----	----	1.0	
ED007: Exchangeable Cations									
Exchangeable Calcium	----	0.1	meq/100g	2.4	1.6	1.6	1.4	----	
Exchangeable Magnesium	----	0.1	meq/100g	1.0	0.6	0.3	0.2	----	
Exchangeable Potassium	----	0.1	meq/100g	0.7	0.3	0.3	0.3	----	
Exchangeable Sodium	----	0.1	meq/100g	<0.1	<0.1	<0.1	<0.1	----	
Cation Exchange Capacity	----	0.1	meq/100g	4.2	2.6	2.3	2.0	----	
Exchangeable Sodium Percent	----	0.1	%	0.5	0.5	0.8	1.7	----	
Calcium/Magnesium Ratio	----	0.1	-	2.4	2.7	5.3	7.0	----	
Magnesium/Potassium Ratio	----	0.1	-	1.6	1.7	1.0	0.8	----	
ED021: Bicarbonate Extractable Potassium (Colwell)									
Bicarbonate Extractable K (Colwell)	----	10	mg/kg	408	237	<200	<200	300	
ED040S : Soluble Sulfate by ICPAES									



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	S19, 0-10cm A1	S19, 11-25cm A3	S19, 25-45cm B21	S19, 75-95cm B21	S19, 95-120cm B22
Client sampling date / time				27-Aug-2017 00:00					
Compound	CAS Number	LOR	Unit	EB1721328-006	EB1721328-007	EB1721328-008	EB1721328-009	EB1721328-010	
				Result	Result	Result	Result	Result	
ED040S : Soluble Sulfate by ICPAES - Continued									
Sulfate as SO4 2-	14808-79-8	10	mg/kg	<10	<10	<10	<10	30	
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	10	mg/kg	<10	<10	<10	<10	50	
ED092: DTPA Extractable Metals									
Ø Copper	7440-50-8	1.00	mg/kg	<1.00	<1.00	<1.00	<1.00	<1.00	
Ø Iron	7439-89-6	1.00	mg/kg	29.7	9.00	6.04	5.29	7.93	
Ø Manganese	7439-96-5	1.00	mg/kg	33.1	19.0	9.35	<1.00	1.41	
Ø Zinc	7440-66-6	1.00	mg/kg	1.04	<1.00	<1.00	<1.00	<1.00	
ED093S: Soluble Major Cations									
Calcium	7440-70-2	10	mg/kg	<10	<10	<10	<10	<10	
Magnesium	7439-95-4	10	mg/kg	<10	<10	<10	<10	<10	
Sodium	7440-23-5	10	mg/kg	<10	<10	<10	<10	50	
Potassium	7440-09-7	10	mg/kg	30	<10	<10	<10	<10	
EG005T: Total Metals by ICP-AES									
Aluminium	7429-90-5	50	mg/kg	2760	2600	2420	2160	3280	
Molybdenum	7439-98-7	2	mg/kg	<2	<2	<2	<2	<2	
EK055: Ammonia as N									
Ammonia as N	7664-41-7	20	mg/kg	<20	<20	<20	<20	<20	
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N (Sol.)	14797-65-0	0.1	mg/kg	0.3	<0.1	<0.1	<0.1	<0.1	
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N (Sol.)	14797-55-8	0.1	mg/kg	4.0	0.7	0.4	1.8	0.3	
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	4.3	0.7	0.4	1.8	0.3	
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	20	mg/kg	1130	220	140	110	130	
EK062: Total Nitrogen as N (TKN + NOx)									
^ Total Nitrogen as N	----	20	mg/kg	1130	220	140	110	130	
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	2	mg/kg	176	108	90	107	66	
EK080: Bicarbonate Extractable Phosphorus (Colwell)									
Bicarbonate Ext. P (Colwell)	----	5	mg/kg	<5	<5	<5	<5	<5	
EP004: Organic Matter									



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	S19, 0-10cm A1	S19, 11-25cm A3	S19, 25-45cm B21	S19, 75-95cm B21	S19, 95-120cm B22
Client sampling date / time				27-Aug-2017 00:00					
Compound	CAS Number	LOR	Unit	EB1721328-006	EB1721328-007	EB1721328-008	EB1721328-009	EB1721328-010	
				Result	Result	Result	Result	Result	
EP004: Organic Matter - Continued									
Organic Matter	----	0.5	%	3.3	0.9	0.7	<0.5	0.6	
Total Organic Carbon	----	0.5	%	1.9	0.5	<0.5	<0.5	<0.5	

Appendix C

BSAL site verification assessment criteria and methods

Table 6.2 BSAL verification assessment criteria methods used

Assessment item	Reference in Interim Protocol	Assessment criteria	Assessment method
Reliable water source			
Within area mapped using Bureau of Meteorology (BoM) data as having 350 millimetres (mm) and above rainfall 9 out of 10 years?	Page 4	The site is within the mapped area.	BOM climate records analysed.
Overlying a groundwater source declared by NOW as highly productive groundwater?	Page 4	The site is within the mapped area.	Project area overlaid on the New South Wales NOW (2013a) assessment layer. It is within North Coast Fractured and Porous Rock Groundwater Sources (NSWG 2016) and it would be classified as less productive groundwater, not meeting the highly productive groundwater classification.
Within the area mapped by NOW as being within 150 metres (m) of a highly reliable surface water supply?	Page 4	The site is within the mapped area.	Project area overlaid on the New South Wales NOW (2013a) assessment layer and compared to the Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2009.
Soils and landscape verification			
1. Is slope less than or equal (\leq) to 10%?	Page 2	Slope \leq 10%.	Site observations made using estimates and a hand held clinometer. GIS analysis of slope using a digital elevation model (DEM) created from light detection and ranging (LIDAR) data.
2. Is there less than (<) 30% rock outcrop?	Page 22	Less than 30% rock outcrop	Presence of outcropping bedrock was recorded in the field as an average density within a 10 m radius surrounding the survey site. Visual assessment recorded on a soil and land information system (SALIS) data card using the method described by McDonald et al. (2009).
3. Does \leq 20% of area have unattached rock fragments greater than (>) 60 mm in diameter?	Page 22	Less than or equal to 20% of the area has unattached rock fragments >60 mm in diameter.	Unattached surface rock fragments with an average maximum dimension larger than 60 mm were recorded in the field as an average density within a 10 m radius surrounding the surveys site. Visual assessment recorded on a SALIS data card using the method described by McDonald et al. (2009).
4. Does \leq 50% of the area have gilgais >500 mm deep?	Page 22 and page 23	Gilgais with depression depth (vertical interval) greater than 500 mm cover \leq 50% of site.	Initial visual assessment for presence. None noted.
5. Is slope <5%?	Page 21	Slope <5%.	Site observations made using estimates and a hand held clinometer. GIS analysis of slope using a DEM created from LIDAR data.
6. Are there nil rock outcrops?	Page 22	No rock outcrops	Presence of outcropping bedrock was recorded in the field as an average density within a 10 m

			radius surrounding the surveys site. Visual assessment recorded on a SALIS data card using the method described by McDonald et al. (2009).
7(a). Does soil have moderate fertility?	Page 23 and Page 28, Appendix 2, Table 6	Fertility ranking of moderate.	Fertility ranking initially assigned to each soil type using the Interim Protocol, Appendix 2, Table 6, which is a ranking of inherent soil fertility based on the Australian soil classification (ASC) (Isbell 2002). This table is an adaptation of Table 8.2 in Murphy et al. (2007) and correlates the ASC with the approximate equivalent Great Soil Groups (Stace et al. 1968). Additional analysis of agricultural fertility characteristics were made with reference to Table 8.2 in Murphy et al. (2007). This analysis was based on laboratory analysis results for samples collected in the soil survey. Soil fertility was categorised based on a combination of pH, electrical conductivity (EC), chloride (Cl), plant available water capacity (PAWC), macronutrients, micronutrients, cation exchange capacity (CEC), exchangeable sodium percentage (ESP) and organic carbon. This analysis was made using the agricultural industry benchmarks of Baker and Eldershaw 1993, DERM 2011 and Peverill, Sparrow and Reuter 1999.
7(b). Does soil have moderately high or high fertility?	Page 23 and Page 28, Appendix 2, Table 6	Fertility ranking of moderately high or high.	Fertility ranking initially assigned to each soil type using the Interim Protocol, Appendix 2, Table 6, which is a ranking of inherent soil fertility based on the ASC (Isbell 2002). This table is an adaptation of Table 8.2 in Murphy et al. (2007) and correlates the ASC with the approximate equivalent Great Soil Groups (Stace et al. 1968). Additional analysis of agricultural fertility characteristics were made with reference to Table 8.2 in Murphy et al. (2007). This analysis was based on laboratory analysis results for samples collected in the soil survey. Soil fertility was categorised based on a combination of pH, EC, Cl, PAWC, macronutrients, micronutrients, CEC, ESP and organic carbon. This analysis was made using the agricultural industry benchmarks of Baker and Eldershaw 1993, DERM 2011 and Peverill, Sparrow and Reuter 1999.
8. Is effective rooting depth to a physical barrier greater than or equal to (\geq) 750 mm?	Page 25 and Page 26	Rooting depth to a physical barrier \geq 750 mm?	A visual assessment was made during the field inspection (and recorded on a SALIS data card) for presence of compacted layers and/or pans as defined by McDonald and Isbell (2009) pp 192-195. These comprise gravelly/rocky layers that include both coarse fragments (defined in McDonald et al. (2009) pp 139- 143) and segregations (defined in McDonald and Isbell (2009) pp 195-198). That is, soil horizons >100 mm thick containing >20% (volume) of coarse fragments and/or segregations >60 mm in diameter.

9. Is soil drainage better than poor?	Page 23 and Page 24	Soil drainage better than poor.	Soil drainage rankings are defined in McDonald and Isbell (2009) and were recorded in the field on a SALIS data card.
10. Does the pH range from 5 to 8.9 if measured in water or 4.5 to 8.1 if measured in calcium chloride, within the upper 600 mm of soil profile?	Page 24	pH between 5 and 8.9, measured in water, within the uppermost 600 mm of the soil profile.	pH was measured by laboratory analysis in a 1:5 soil:water suspension, in accordance with method 4A1 in Rayment and Lyons (2011).
11. Is salinity (ECe) \leq 4 deciSiemens (dS)/m or are chlorides $<$ 800 milligrams per kilogram (mg/kg) when gypsum is present, within the uppermost 600 mm of the soil profile?	Page 25	Salinity (ECe) \leq 4dS/m or chlorides $<$ 800 mg/kg when gypsum is present, within the uppermost 600 mm of the soil profile.	Two methods of measuring soil salinity were used: <ul style="list-style-type: none"> • electrical conductivity of a 1:5 soil:water suspension (EC1:5), measured in dS/m (Method 3A1, Rayment & Lyons 2011); and • concentration of soluble chloride (Cl) in a 1:5 soil:water suspension, measured in mg/kg (Method 5A2, Rayment & Lyons 2011). EC 1:5 was converted to electrical conductivity in a saturated extract (ECe) by using a conversion factor dependent on the field texture of the soil. The conversion factor was based on Slavich and Petterson (1993).
12. Is effective rooting depth to a chemical barrier \geq 750 mm?	Page 25 and Page 26	pH (1:5 soil:water) is between 5.0 and-8.9 ECe $<$ 4dS/m (or chlorides 800mg/kg when gypsum is present) ESP $<$ 15 Ca:Mg ratio $>$ 0.1	Measured in laboratory analysis.
Minimum area			
Contiguous area is \geq 20 hectares (ha).	Page 27	A contiguous area equal to or exceeding 20 ha.	GIS analysis of the soil polygon or subject landform feature.

Appendix D

Detailed BSAL site verification assessment table

Table 6.3 BSAL verification assessments for detailed sites

Criteria	Site number and ASC			
	47 - Sodosol	43 - Sodosol	A1(55) - Dermosol	37 - Tenosol
Reliable water source - Only 1 POSITIVE RESULT required				
Within the area mapped using Bureau of Meteorology (BoM) data as having 350 mm and above rainfall 9 out of 10 years?	Within the mapped area			
Overlying a groundwater source declared by NSW Office of Water (NOW) as highly productive groundwater?	Less productive groundwater	Less productive groundwater	Less productive groundwater	Less productive groundwater
Within the area mapped by NOW as being within 150 m of a highly reliable surface water supply?	Not within 150m of highly reliable surface water supply.	Not within 150m of highly reliable surface water supply.	Not within 150m of highly reliable surface water supply.	Not within 150m of highly reliable surface water supply.
Soils and landscape verification - All POSITIVE RESULTS required				
Is the slope ≤10%	4%	3%	3%	3%
Is there <30% rock outcrop?	0%	0%	0%	0%
Does ≤20% of area have unattached rock fragments >60 mm diameter?	0%	0%	0%	0%
Does ≤50% of area have gilgais >500 mm deep?	0%	0%	0%	0%
Only 1 POSITIVE RESULT required				
Is slope between 5% and 10%? And does soil have moderately high or high fertility?	NA	NA	NA	NA
Is slope <5%? And are there SOME rock outcrops? And does soil have moderately high or high fertility?	4% Slope + 0% Outcrops + Mod. low fert.	3% Slope + 0% Outcrops + Mod. low fert.	3% Slope + 0% Outcrops + Mod. high fert.	3% Slope + 0% Outcrops + Mod. low fert.
Is slope <5%? And are there NIL rock outcrops? And does soil have moderate fertility?	4% Slope + 0% Outcrops + Mod. low fert.	3% Slope + 0% Outcrops + Mod. low fert.	3% Slope + 0% Outcrops + Mod. high fert.	3% Slope + 0% Outcrops + Mod. low fert.
All POSITIVE RESULTS required				
Is effective rooting depth to a physical barrier ≥750 mm?	No physical barrier	No barrier ≤750 mm	No barrier ≤750 mm	No barrier ≤750 mm
Is soil drainage better than poor?	Imperfect	Poor	Mod' well drained	Rapid
Is pH _{water} 5-8.9 within the upper 600 mm?	5.4-8.2	5.5-6.6	6.0-9.0	5.9-6.4
Is salinity within the upper 600 mm (ECe) ≤4 dS/m or chloride <800 mg/kg when gypsum is present?	ECe range 0.38-5.5 + Cl <650	ECe range 0.13-0.35 + Cl <20	ECe range 0.29-10.0 + Cl >800	ECe range 0.17-0.20 + Cl <10
Is effective rooting depth to a chemical barrier ≥750 mm?	Barrier at 400 mm (ESP 18.6%)	No barrier ≤750 mm	Barrier at 300 mm (ESP 20.1%)	No barrier ≤750 mm
Minimum area - All POSITIVE RESULTS required				
Does the biophysical resource have a contiguous area of ≥20 ha?	>20 ha	>20 ha	>20 ha	>20 ha
Is the site BSAL?	NOT BSAL	NOT BSAL	NOT BSAL	NOT BSAL
Comments on pass/failure criteria	Failed fertility and chemical barrier criteria	Failed fertility and physical barrier	Failed fertility and chemical barrier criteria	Failed fertility criteria

Criteria	Site number and ASC			
	20 - Tenosol	10 - Sodosol	23 - Sodosol	21 - Tenosol
Reliable water source - Only 1 POSITIVE RESULT required				
Within the area mapped using Bureau of Meteorology (BoM) data as having 350 mm and above rainfall 9 out of 10 years?	Within the mapped area			
Overlying a groundwater source declared by NSW Office of Water (NOW) as highly productive groundwater?	Less productive groundwater	Less productive groundwater	Less productive groundwater	Less productive groundwater
Within the area mapped by NOW as being within 150 m of a highly reliable surface water supply?	Not within 150m of highly reliable surface water supply.	Not within 150m of highly reliable surface water supply.	Not within 150m of highly reliable surface water supply.	Not within 150m of highly reliable surface water supply.
Soils and landscape verification - All POSITIVE RESULTS required				
Is the slope ≤10%	3%	3%	4%	3%
Is there <30% rock outcrop?	0%	0%	0%	0%
Does ≤20% of area have unattached rock fragments >60 mm diameter?	0%	0%	0%	0%
Does ≤50% of area have gilgais >500 mm deep?	0%	0%	0%	0%
Only 1 POSITIVE RESULT required				
Is slope between 5% and 10%? And does soil have moderately high or high fertility?	NA	NA	NA	NA
Is slope <5%? And are there SOME rock outcrops? And does soil have moderately high or high fertility?	3% Slope + 0% Outcrops + Mod. low fert.	3% Slope + 0% Outcrops + Mod. low fert.	4% Slope + 0% Outcrops + Mod. low fert.	3% Slope + 0% Outcrops + Mod. low fert.
Is slope <5%? And are there NIL rock outcrops? And does soil have moderate fertility?	3% Slope + 0% Outcrops + Mod. low fert.	3% Slope + 0% Outcrops + Mod. low fert.	4% Slope + 0% Outcrops + Mod. low fert.	3% Slope + 0% Outcrops + Mod. low fert.
All POSITIVE RESULTS required				
Is effective rooting depth to a physical barrier ≥750 mm?	No barrier ≤750 mm			
Is soil drainage better than poor?	Well drained	Imperfect	Poor	Rapid
Is pH _{water} 5-8.9 within the upper 600 mm?	5.6-7.6	5.7-9.1	5.6-7.5	5.7-6.3
Is salinity within the upper 600 mm (ECe) ≤4 dS/m or chloride <800 mg/kg when gypsum is present?	ECe range 0.15-0.30 + Cl <10-20	ECe range 0.19-9.25 + Cl >800	ECe range 0.23 - 1.59 + Cl <10-60	ECe range 0.06-0.30 + Cl <10
Is effective rooting depth to a chemical barrier ≥750 mm?	No barrier ≤750 mm	Barrier at 600mm (ESP 27.2)	No barrier ≤750 mm	No barrier ≤750 mm
Minimum area - All POSITIVE RESULTS required				
Does the biophysical resource have a contiguous area of ≥20 ha?	>20 ha	>20 ha	>20 ha	>20 ha
Is the site BSAL?	NOT BSAL	NOT BSAL	NOT BSAL	NOT BSAL
Comments on pass/failure criteria	Failed fertility criteria	Failed fertility and chemical barrier criteria	Failed fertility and drainage criteria	Failed fertility criteria

Criteria	Site number and ASC			
	5 - Dermosol	12 - Dermosol	41 - Kurosol	48 - Kurosol
Reliable water source - Only 1 POSITIVE RESULT required				
Within the area mapped using Bureau of Meteorology (BoM) data as having 350 mm and above rainfall 9 out of 10 years?	Within the mapped area	Within the mapped area	Within the mapped area	Within the mapped area
Overlying a groundwater source declared by NSW Office of Water (NOW) as highly productive groundwater?	Less productive groundwater	Less productive groundwater	Less productive groundwater	Less productive groundwater
Within the area mapped by NOW as being within 150 m of a highly reliable surface water supply?	Not within 150m of highly reliable surface water supply.	Not within 150m of highly reliable surface water supply.	Not within 150m of highly reliable surface water supply.	Not within 150m of highly reliable surface water supply.
Soils and landscape verification - All POSITIVE RESULTS required				
Is the slope ≤10%	3%	2%	5%	6%
Is there <30% rock outcrop?	0%	0%	0%	0%
Does ≤20% of area have unattached rock fragments >60 mm diameter?	0%	0%	0%	0%
Does ≤50% of area have gilgais >500 mm deep?	0%	0%	0%	0%
Only 1 POSITIVE RESULT required				
Is slope between 5% and 10%? And does soil have moderately high or high fertility?	NA	NA	5% slope+ Mod low fert.	6% slope + Mod low fert.
Is slope <5%? And are there SOME rock outcrops? And does soil have moderately high or high fertility?	3% slope + 0% Outcrops + Mod. high fert.	2% slope + 0% Outcrops + Mod. high fert.	5% slope + 0% Outcrops + Mod. low fert.	6% slope + 0% Outcrops + Mod. low fert.
Is slope <5%? And are there NIL rock outcrops? And does soil have moderate fertility?	3% slope + 0% Outcrops + Mod. high fert.	2% slope + 0% Outcrops + Mod. high fert.	5% slope + 0% Outcrops + Mod. low fert.	6% slope + 0% Outcrops + Mod. low fert.
All POSITIVE RESULTS required				
Is effective rooting depth to a physical barrier ≥750 mm?	No barrier ≤750 mm	No barrier ≤750 mm	No barrier ≤750 mm	No barrier ≤750 mm
Is soil drainage better than poor?	Poor (mottled from 100mm)	Poor (mottled from 420mm)	Poor (mottled from 700mm)	Poor (Mottled from 900mm)
Is pH _{water} 5-8.9 within the upper 600 mm?	5.1 - 5.6	5.8-8.6	5.5-6.0	5.8-6.1
Is salinity within the upper 600 mm (ECe) ≤4 dS/m or chloride <800 mg/kg when gypsum is present?	ECe range0.73 - 4.9 + Cl 110-960	ECe range0.14-0.18 + Cl <10-140	ECe range0.18 - 0.36 + Cl<10 - 20	ECe range0.09-0.02 + Cl<10
Is effective rooting depth to a chemical barrier ≥750 mm?	Barrier at 100mm (ESP 11) and 300mm (ECe and Cl)	No barrier ≤750 mm	No barrier ≤750 mm	No barrier ≤750 mm
Minimum area - All POSITIVE RESULTS required				
Does the biophysical resource have a contiguous area of ≥20 ha?	>20 ha	>20 ha	>20 ha	>20 ha
Is the site BSAL?	NOT BSAL	NOT BSAL	NOT BSAL	NOT BSAL
Comments on pass/failure criteria	Failed fertility and drainage and chemical barrier criteria	Failed fertility and drainage criteria	Failed fertility and drainage criteria	Failed fertility and drainage criteria

Criteria	Site number and ASC	
	19 - Chromosol	53 - Chromosol
Reliable water source - Only 1 POSITIVE RESULT required		
Within the area mapped using Bureau of Meteorology (BoM) data as having 350 mm and above rainfall 9 out of 10 years?	Within the mapped area	Within the mapped area
Overlying a groundwater source declared by NSW Office of Water (NOW) as highly productive groundwater?	Less productive groundwater	Less productive groundwater
Within the area mapped by NOW as being within 150 m of a highly reliable surface water supply?	Not within 150m of highly reliable surface water supply.	Not within 150m of highly reliable surface water supply.
Soils and landscape verification - All POSITIVE RESULTS required		
Is the slope ≤10%	3%	6%
Is there <30% rock outcrop?	0%	0%
Does ≤20% of area have unattached rock fragments >60 mm diameter?	0%	0%
Does ≤50% of area have gilgais >500 mm deep?	0%	0%
Only 1 POSITIVE RESULT required		
Is slope between 5% and 10%? And does soil have moderately high or high fertility?	NA	6% slope+ Mod high fert.
Is slope <5%? And are there SOME rock outcrops? And does soil have moderately high or high fertility?	3% slope + 0% Outcrops + Mod. low fert.	6% slope + 0% Outcrops + Mod. low fert.
Is slope <5%? And are there NIL rock outcrops? And does soil have moderate fertility?	3% slope + 0% Outcrops + Mod. low fert.	6% slope + 0% Outcrops + Mod. low fert.
All POSITIVE RESULTS required		
Is effective rooting depth to a physical barrier ≥750 mm?	No barrier ≤750 mm	No barrier ≤750 mm
Is soil drainage better than poor?	Mod well drained	Poor (mottled from 500mm)
Is pH _{water} 5-8.9 within the upper 600 mm?	6.6-6.6	5.5-7.1
Is salinity within the upper 600 mm (ECe) ≤4 dS/m or chloride <800 mg/kg when gypsum is present?	ECe range 0.08-0.35 + Cl <10-50	ECe range 0.08-0.18 + Cl <10
Is effective rooting depth to a chemical barrier ≥750 mm?	No barrier ≤750 mm	No barrier ≤750 mm
Minimum area - All POSITIVE RESULTS required		
Does the biophysical resource have a contiguous area of ≥20 ha?	<20 ha	<20 ha
Is the site BSAL?	NO	NO
Comments on pass/failure criteria	No failed on area criteria	Failed area and drainage criteria

