Muswellbrook Coal Continuation Project

Soils assessment

Prepared for Muswellbrook Coal Company Limited | 22 April 2016

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Muswellbrook Coal Continuation Project

Final

Report J16011RP1 | Prepared for Muswellbrook Coal Company Limited | 22 April 2016

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Date	22 April 2016	Date	22 April 2016

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Document Control

Version	Date	Prepared by	Reviewed by
1	15 March 2016	Nicholas Jamson	Duncan Peake and Tim Rohde
2	1 April 2016	Nicholas Jamson	Duncan Peake and Tim Rohde
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1 Introduction

Muswellbrook coal mine (MCM) is an open cut coal mine operated by Muswellbrook Coal Company Limited (MCC). MCM is located, 3 kilometres (km) north-east of the township of Muswellbrook, in the Muswellbrook local government area (LGA) in New South Wales (NSW).

MCC has a long history of mining in the Muswellbrook area, with underground operations commencing at MCM in 1907 and open cut operations commencing in 1944. Underground operations ceased in the late 1990s; however open cut mining continues. MCC has development consent from Muswellbrook Shire Council (MSC) to mine within the No. 1 Open Cut Extension Area (Open Cut 1) (Development Consent No. DA 205/2002, as modified), with operations to be complete by 2020.

Additional coal resources have been identified within a previously rehabilitated area adjacent to Open Cut 1. While this area is within the development consent boundary, a modification to the existing development consent is required to modify the conceptual mine plan to allow mining of these additional resources, as well as extending the approved mine life and modifying the conceptual final landform (the modification).

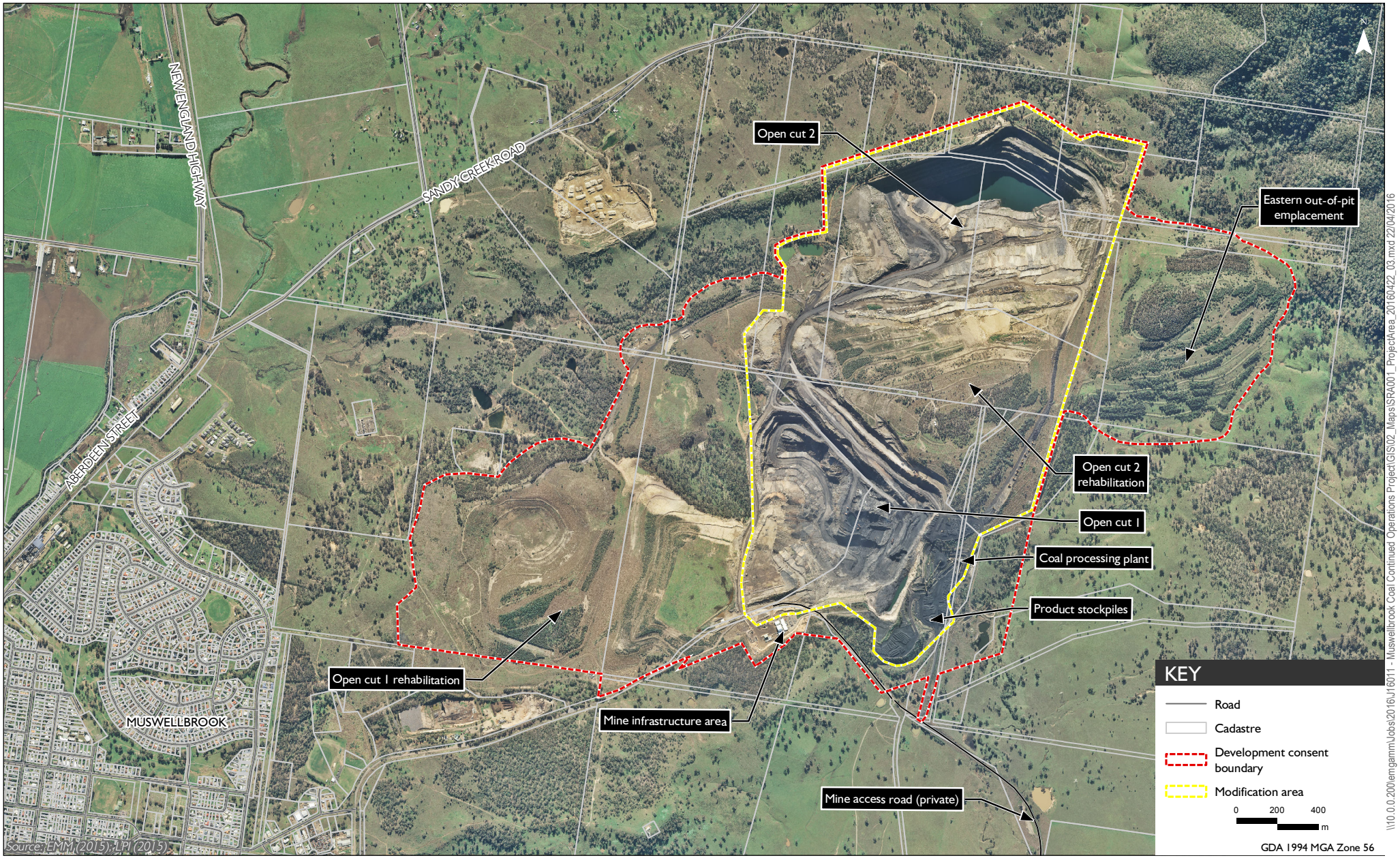
The modification would maximise the recovery of coal resources within ML 1562, ML 1304 and CCL 713 and would enable the recovery of approximately 4.2 million tonnes (Mt) of additional coal resources.

In summary the modification involves:

- extension of open cut mining operations in Open Cut 1;
- extension of the mine life, with operations to cease by the end of 2025;
- changes to the conceptual final landform within the modification area; and
- overburden emplacement in both Open Cut 1 and Open Cut 2, so as to achieve the conceptual final landform.

As the modification involves mining of a previously disturbed area that was used as an overburden dump, there would be no direct impact to previously undisturbed land.

No changes are proposed to the currently approved maximum production rate of 2 Mtpa, mining methods, coal processing, blasting methods, water management, waste management and handling, coal transport, access to site, employee numbers, hazardous substances and dangerous goods management.



Location of site

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Figure 1.1

1.1 Purpose of this report

EMM Consulting Pty Limited (EMM) was commissioned by MCC to assess the soils, and land and soil capability (LSC) of the modification. This assessment will accompany the Statement of Environment Effects (SEE) which will be submitted with an application to modify the existing development consent (DA 205/2002).

The assessment includes assessing the likely impacts of the modification on soils and LSC (OEH 2012) of the modification. As the modification is not a State Significant Development and only includes disturbed previously mined and rehabilitated land the assessment does not include the assessment of biophysical strategic agricultural land (BSAL) as described in the *Interim Protocol for Site Verification and Mapping of Biophysical Strategic Land* (NSWG 2013).

This assessment was prepared in conjunction with a *Land and Soil Capability Assessment* (EMM 2016) which is included as Appendix A. The assessment has been carried out in accordance with reference to relevant leading practice guidelines, standards, legislation and policies.

2 Method

2.1 Assessment process

The assessment comprised the following:

- a desktop review of existing information and the current state of the environment (section 3);
- a soil survey (the survey) to characterise soil types of the modification area, including laboratory analysis (section 4); and
- assessment of LSC using results from the soil survey (section 5).

2.2 Desktop review

Existing information on the modification area soils and the biophysical environment was sourced from the following regional mapping published by government departments. The relevant information has been summarised and presented in section 3.

- *NSW soil and land information system* (SALIS) (NSW OEH 2016);
- *NSW soil landscapes mapping* (NSW OEH 2016);
- *Great soil group mapping of NSW* (NSW OEH 2016);
- *Inherent soil fertility mapping* (NSW OEH 2016);
- *Land and soil capability classes mapping* (NSW OEH 2016);
- *Australian Soil Classification system soil type mapping of NSW* (NSW OEH 2016);
- *Hydrologic soil group mapping* (NSW OEH 2016); and
- *Soil profile attribute data* (SPADE) online database (NSW OEH 2016).

2.3 Soil survey

A survey was completed on 18 February 2016 to examine the soil and landform properties of the area subject to the modification. Samples were also taken for laboratory analysis. The survey was conducted with due regard for the following guidelines:

- *The Land And Soil Capability Assessment Scheme: Second Approximation* (NSW OEH 2012a);
- *Australian Soil And Land Survey Book* (NCST 2009); and
- *The Australian Soil Classification* (Isbell 2002).

Laboratory analysis of soil samples was guided by the *Interim Protocol For Site Verification And Mapping Of Biophysical Strategic Agricultural Land (NSW OEH 2012b)* and *The Land And Soil Capability Assessment Scheme: Second Approximation* (NSW OEH 2012a).

2.3.1 Sample site selection and density

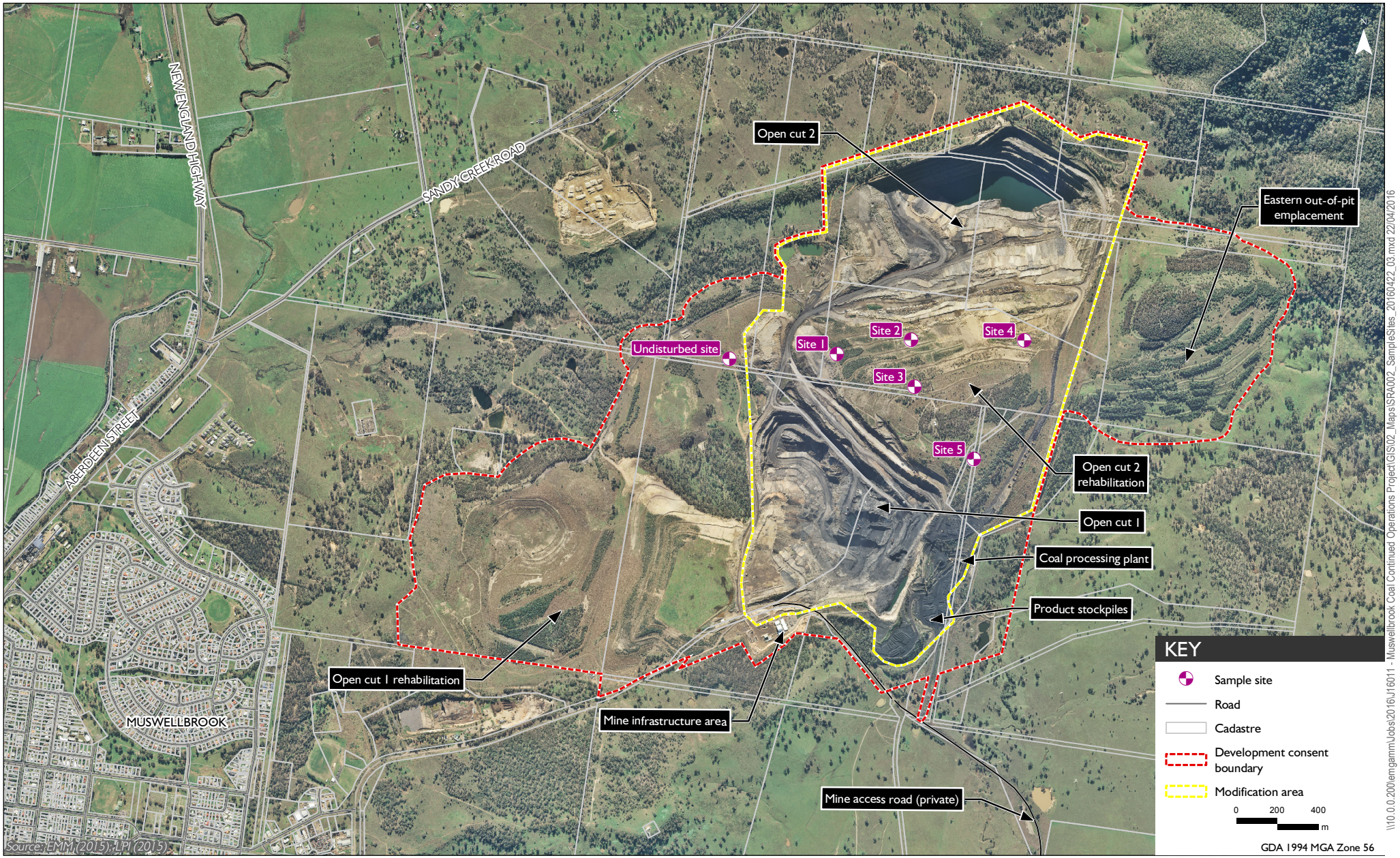
i Selection

Initial positioning of the sample sites was based on grid sampling with the intention of providing a relatively even distribution of sites across the modification area. The final location of the sites was chosen with consideration to land access constraints and other site factors, eg particularly whether the site was covered with soil or not. These constraints meant that some sites initially identified were not available or suitable for surveying, as parts of the modification area consist of overburden dumps that have not been rehabilitated or re-spread with topsoil. In these inaccessible or unsuitable areas, the nearest available locations with similar landscape features were sampled and spatial co-ordinates recorded. The final sites are shown in Table 2.1 and Figure 2.1.

Table 2.1 Soil sample sites

Site	X coordinate[1]	Y coordinate[1]
01	0305511	6430793
02	0305869	6430858
03	0305886	6430634
04	0306419	6430856
05	0306175	6430280
Undisturbed	0304987	6430770

Notes: 1. X coordinates = easting, Y coordinates = northing (UTM 56).



Location of sample sites

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Figure 2.1

ii Density

Five samples sites were chosen in the modification area, and one additional site outside the modification area, resulting in a survey density of approximately one site per 25 hectares (ha).

2.3.2 Sampling method

i Photographs

Photographs were taken of the soil surface and surrounding area at each site facing north, south east and west.

ii Profile description

A hand auger was used to extract a soil profile core. The soil profile was described in the field for the following physical characteristics:

- Electrical conductivity (EC) and pH using a portable pH/EC meter (Aqua-CP/A model) in a 1:5 soil:deionised water suspension;
- permeability and drainage;
- site and slope morphology;
- boundaries (shape and size of the changes between horizons);
- colour (hue and chroma using the Munsell colour chart);
- pedality (including ped shape and size);
- fabric (spatial arrangement and nature of solid particles and associated pores);
- structure (arrangement of soil particles);
- soil texture was determined using the ribboning method. This involved wetting soil in the palm of the hand and kneading for 2-10 minutes into a ball. The soil was then made into a ribbon by pushing the ball between the thumb and index finger. The length at which the ribbon broke is then used to determine field texture by referring to the table in Appendix B (DPI 2015);
- consistence (resistance to deformation or rupture of soil material);
- presence of cracks or macropores;
- soil water status;
- coarse fragments (visual assessment of shape, size and distribution);
- hydrology (profile drainage and permeability);
- site condition (landform, groundcover and vegetation); and
- soil surface condition (crusting, cracking, self-mulching).

iii Laboratory samples

a. Surface sample

Surface soil samples were taken by randomly scoping handfuls of soil from six locations in the immediate surroundings to the site. Sampled soil was placed in heavy-duty, sealable plastic bags and labelled and refrigerated.

b. Profile sample

At every site, 400 grams (g) samples of soil were taken at 10 centimetre (cm) interval down the profile including the first 10 cm of the overburden below the soil layer where applicable. Sampled soil was placed in heavy-duty, sealable plastic bags and labelled and refrigerated. Holes were backfilled with soil not collected for laboratory analysis.

2.4 Laboratory testing

A National Association of Testing Authorities (NATA) accredited laboratory (ALS Global) was used to ensure that laboratory testing was undertaken using scientifically correct methods.

The following tests were completed by ALS Global on all soil samples:

- moisture content;
- $pH_{1:5}$;
- $EC_{1:5}$;
- exchangeable cations (calcium (Ca), magnesium (Mg), sodium (Na) and cation exchange capacity (CEC);
- exchangeable sodium percentage (ESP);
- organic matter (OM) and total organic carbon (TOC);
- potassium (K);
- aluminium (Al);
- soluble sulfate (SO_4); and
- alkalinity as calcium carbonate ($CaCO_3$).

The following tests were completed by ALS Global on the top two 10 cm interval soil samples only:

- bicarbonate extractable phosphorus (P); and
- total phosphorus and nitrogen (N).

Detailed laboratory results can be found in Appendix C.

3 Desktop review

3.1 Climate

The climate of the Muswellbrook LGA is classified as humid subtropical (Cfa) under the Köppen Climate Classification System (Köppen 1918). The area is characterised by hot, humid summers and cool, dry winters. Rainfall predominantly occurs during the summer months but heavy isolated falls can occur during the winter.

The nearest Bureau of Meteorology station (the weather station) with complete weather, climate and temperature information is located approximately 20 km away at Scone (station 061089). Mean annual rainfall across the 50 operational years of the weather station is 643.3 millimetres (mm). Maximum temperatures range from 16.4°C to 31.2°C. Minimum temperatures range from 4.7°C to 16.9°C. Meteorology data for the MCM has been sourced from the principal meteorological measuring station established at MCM. Data from 2015 at this station is shown in Figure 3.1.

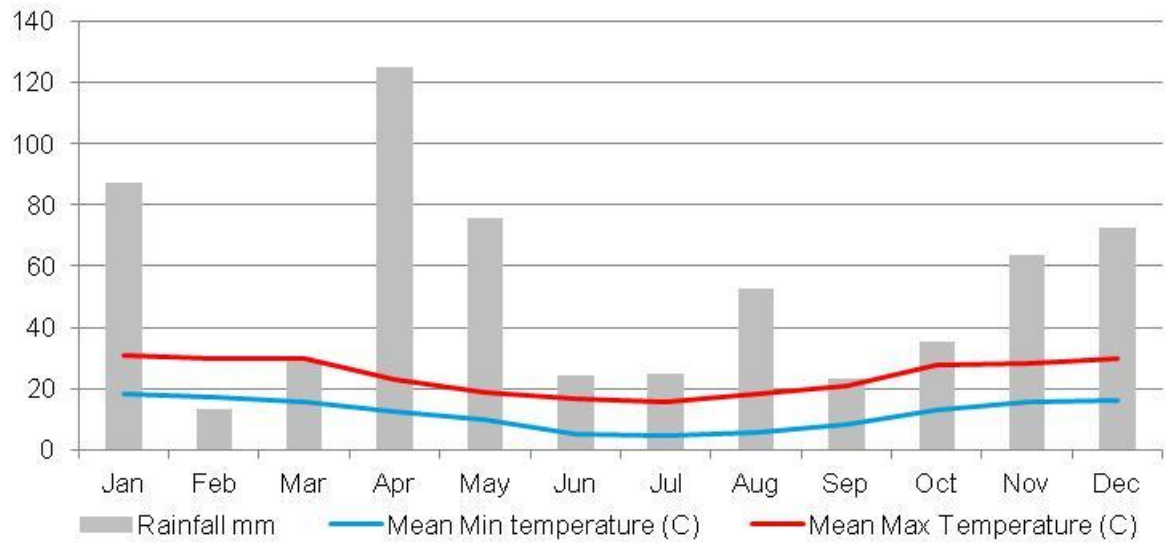


Figure 3.1 Mean temperatures and rainfall

3.2 Topography

Elevation generally declines in a westerly direction from MCM, where the elevation on the flood plain adjacent to the Hunter River is approximately 150 m AHD. Notable topographic features include Skeletar Ridge to the south of MCM (333 m AHD) and the ridge to the east which includes Bells Mountain (690 m AHD). Natural ground elevations within MCM range between 230 and 260 m AHD, while the rehabilitated mining spoil mounds reach over 300 m AHD.

3.3 Surface hydrology

The two main catchments near the site are associated with the Muscle and Sandy Creeks. Both catchments discharge into the Hunter River. The Hunter River flows south and has an average flow of 200 megalitres (ML)/day at the Muswellbrook gauging station. The edge of the Hunter River floodplain is approximately 2.8 km west of MCM. These creeks both flow intermittently, usually during high rainfall events. Surface water runoff from Skeletar Ridge flows into Sandy Creek in a north-westerly direction. The catchment south of Skeletar Ridge flows towards Muscle Creek, which subsequently flows into the Hunter River. The water in both creeks is slightly alkaline and varies in salinity depending on rainfall ie higher EC in drier conditions and lower during rainfall.

3.4 Regional geology

MCM is within the Hunter Coalfield, along the northern edge of the Sydney Basin bordering the Gunnedah Basin. The border with the Sydney Basin is delineated by the Hunter Thrust Fault which brings Carboniferous rocks up against younger Permian rocks. This is a major reverse fault. Based on regional geology mapping (Glenn and Beckett 1993), the coal measures in the region form part of the Muswellbrook Anticline which joins the Aberdeen Thrust Fault. The Aberdeen Thrust Fault dissects the MCM and the modification area.

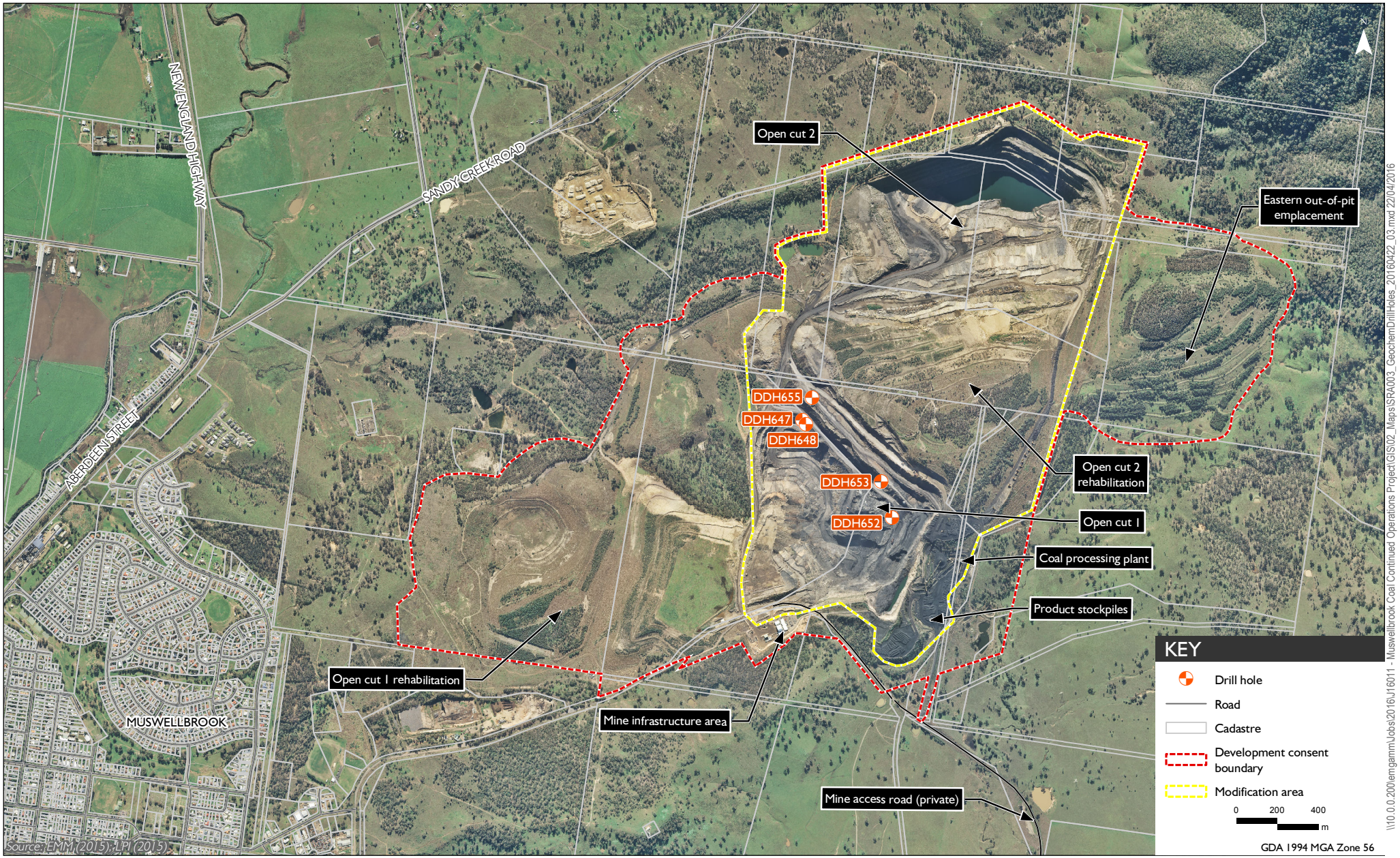
The stratigraphic sequence across the Hunter Coalfield consists of the Permian coal seam sequence with an overburden and interburden comprised of lithic sandstone, interbedded with siltstone, tuffaceous claystone and mudstone. The Permian rocks form a regular layered sedimentary sequence made up of two primary units:

- the Maitland Group which includes the Branxton Formation that consists mostly of siltstone and sandstone; and
- the Greta Coal Measures that contain economic coal seams in the Rowan formation.

The Greta Coal Measures are approximately 110 m thick and early to middle Permian (298.9-252.1 million years ago) age. MCC primarily mines the Fleming, Hallett, Muswellbrook, St Heliers, Loder, Upper and Lower Lewis coal seams. These occur over a 60 m stratigraphic interval.

3.4.1 Acid rock drainage potential

Geochemistry testing to determine the acid rock drainage (ARD) potential has been previously completed for the MCM on 79 composite samples taken from five drill holes. Table 3.1 summarises whether the samples are potentially acid forming (PAF) using the equations presented in Appendix D.



EMM

Geochemistry testing drill holes

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Soils Assessment
Figure 3.2

Table 3.1 Geochemistry testing

Sample number	Drill hole	Geology	Sulfide% [1]	Total sulfur (%)	Maximum potential acidity (kg H_2SO_4/t)	Acid neutralising capacity (kg H_2SO_4/t)	Net acid producing potential (kg H_2SO_4/t)	PAF (Yes /No)
MCC7786	MCC648	Spoil	-	0.02	0.61	32.1	-31.49	N
MCC7787	MCC648	Diamictite	-	0.05	1.53	2.8	-1.27	N
MCC7788	MCC648	Diamictite	-	0.08	2.45	15.4	-12.95	N
MCC7789	MCC648	Conglomerate	0.56	0.58	17.1	5.7	11.40	N
MCC7802	MCC647	Sandstone/Conglomerate	-	0.02	0.61	183	-182.39	N
MCC7803	MCC647	Siltstone/Sandstone	0.11	0.13	3.36	276	-272.64	N
MCC7804	MCC647	Sandstone	-	0.07	2.14	78.5	-76.36	N
MCC7805	MCC647	Carbonaceous Mudstone	-	0.19	5.81	264	-258.19	N
MCC7806	MCC647	Claystone	1.24	1.57	37.81	6.3	31.514	Y
MCC7807	MCC647	Sandstone	-	0.06	1.84	28.6	-26.76	N
MCC7808	MCC647	Siltstone/Sandstone/Mudstone	-	0.04	1.22	69.5	-68.28	N
MCC7809	MCC647	Spoil	-	0.05	1.53	3.2	-1.67	N
MCC7810	MCC647	Diamictite	-	0.04	1.22	3.4	-2.18	N
MCC7811	MCC647	Diamictite	-	0.03	0.92	11.2	-10.28	N
MCC7812	MCC647	Conglomerate	-	0.08	2.45	19.6	-17.15	N
MCC7814	MCC647	Coal/Carbonaceous Mudstone	-	0.05	1.53	2.8	-1.27	N
MCC7815	MCC647	Siltstone/Sandstone	-	0.04	1.22	4.3	-3.08	N
MCC7816	MCC647	Siltstone/Sandstone/Clay	-	0.06	1.84	35.9	-34.06	N
MCC7817	MCC647	Carbonaceous Mudstone	0.17	0.23	5.13	3	2.14	Y
MCC7818	MCC647	Carbonaceous Mudstone/Siltstone/Claystone	-	0.22	6.73	2.6	4.13	Y
MCC7819	MCC647	Carbonaceous Siltstone/Claystone	-	0.05	1.53	11	-9.47	N
MCC7820	MCC647	Siltstone/Sandstone	-	0.05	1.53	3	-1.47	N
MCC7821	MCC653	Conglomerate	-	0.06	18.4	21.9	-3.55	N
MCC7822	MCC653	Sandstone	-	0.31	9.48	20	-10.51	N
MCC7823	MCC653	Sandstone	0.19	0.26	5.93	62.2	-56.27	N
MCC7824	MCC653	Sandstone/Claystone	-	0.23	7.04	33.9	-26.86	N
MCC7825	MCC653	Carbonaceous Siltstone/Sandstone/Claystone	-	0.03	0.92	96.9	-95.98	N
MCC7826	MCC653	Sandstone	-	0.15	4.59	4.8	-0.21	N
MCC7827	MCC653	Sandstone/Siltstone/Coal	-	0.03	0.92	4.8	-3.88	N
MCC7828	MCC653	Siltstone/Sandstone	-	0.07	2.14	4.3	-2.16	N
MCC7829	MCC653	Sandstone	-	0.09	2.75	5.7	-2.95	N
MCC7830	MCC653	Sandstone/Siltstone	-	0.12	3.67	172	-168.33	N
MCC7831	MCC653	Sandstone	-	0.21	6.42	7.8	-1.38	N
MCC7832	MCC653	Carbonaceous Claystone	-	0.02	0.61	3.4	-2.79	N
MCC7833	MCC653	Sandstone	-	0.02	0.61	107	-106.39	N

Table 3.1 Geochemistry testing

Sample number	Drill hole	Geology	Sulfide% [1]	Total sulfur (%)	Maximum potential acidity (kg H_2SO_4/t)	Acid neutralising capacity (kg H_2SO_4/t)	Net acid producing potential (kg H_2SO_4/t)	PAF (Yes /No)
MCC7834	MCC653	Siltstone/Sandstone	-	0.03	0.92	7.2	-6.28	N
MCC7835	MCC653	Claystone/Siltstone	-	0.02	0.61	11.8	-11.19	N
MCC7836	MCC653	Siltstone	-	0.07	2.14	4.2	-2.06	N
MCC7837	MCC653	Siltstone	-	0.05	1.53	91.2	-89.67	N
MCC7838	MCC653	Claystone/Siltstone	0.10	0.13	3.18	109	-105.82	N
MCC7839	MCC653	Claystone/Siltstone	-	0.09	2.75	5.2	-2.45	N
MCC7840	MCC652	Sandstone/Siltstone	-	0.03	0.91	44	-43.08	N
MCC7841	MCC652	Sandstone	-	0.02	0.61	70.5	-69.89	N
MCC7842	MCC652	Sandstone/Siltstone/Claystone	-	0.06	1.84	3.8	-1.96	N
MCC7843	MCC652	Siderite/Siltstone	-	0.06	1.84	35.1	-33.26	N
MCC7844	MCC652	Sandstone	-	0.04	1.22	44.7	-43.48	N
MCC7845	MCC652	Sandstone	-	0.07	2.14	178	-175.86	N
MCC7846	MCC652	Siltstone	-	0.04	1.22	3.8	-2.58	N
MCC7847	MCC652	Sandstone	-	0.02	0.61	229	-228.39	N
MCC7848	MCC652	Siltstone/Sandstone	-	0.09	2.75	224	-221.25	N
MCC7849	MCC652	Siltstone/Coal	-	0.11	3.36	229	-225.64	N
MCC7850	MCC652	Sandstone	-	0.02	0.61	170	-169.39	N
MCC7851	MCC652	Siltstone	-	0.09	2.75	1.8	0.95	Y
MCC7852	MCC652	Sandstone	0.55	0.74	16.89	11.1	5.79	Y
MCC7853	MCC652	Siltstone/Coal/Carbonaceous Claystone	-	0.11	3.36	0.5	2.86	Y
MCC7854	MCC652	Sandstone	-	0.22	6.73	29.6	-22.87	N
MCC7855	MCC652	Siltstone	-	0.1	3.06	6.2	-3.14	N
MCC7856	MCC652	Siltstone	-	0.1	3.06	211	-207.94	N
MCC7857	MCC652	Siltstone	-	0.26	7.95	0.9	7.05	Y
MCC7858	MCC652	Claystone/Siltstone	-	0.13	3.98	216	-212.02	N
MCC7859	MCC655	Conglomerate	-	1.02	31.20	20.8	10.40	Y
MCC7860	MCC655	Conglomerate	-	0.18	5.51	31.8	-26.29	N
MCC7861	MCC655	Siltstone	-	0.05	1.53	217	-215.47	N
MCC7862	MCC655	Sandstone	-	0.22	6.73	165	-158.27	N
MCC7863	MCC655	Siltstone	-	0.12	3.67	6	-2.33	N
MCC7864	MCC655	Siltstone/Claystone	-	0.22	6.73	6.1	0.623	Y
MCC7865	MCC655	Claystone	-	0.09	2.75	3.3	-0.55	N
MCC7866	MCC655	Siltstone/Sandstone	-	0.04	1.22	7.5	-6.28	N
MCC7867	MCC655	Claystone	0.08	0.13	2.51	7.9	-5.39	N
MCC7868	MCC655	Carbonaceous Claystone	-	0.05	1.53	5.5	-3.97	N
MCC7869	MCC655	Claystone	-	0.09	2.75	2.9	-0.15	N
MCC7870	MCC655	Sandstone	-	0.02	0.61	74.3	-73.69	N
MCC7871	MCC655	Claystone/Siltstone/Sandstone	-	0.04	1.22	3.5	-2.28	N

Table 3.1 Geochemistry testing

Sample number	Drill hole	Geology	Sulfide% [1]	Total sulfur (%)	Maximum potential acidity (kg H_2SO_4/t)	Acid neutralising capacity (kg H_2SO_4/t)	Net acid producing potential (kg H_2SO_4/t)	PAF (Yes /No)
MCC7872	MCC655	Siltstone/Sandstone	0.01	0.02	0.28	105	-104.73	N
MCC7873	MCC655	Claystone/Siltstone	-	0.08	2.45	6.7	-4.25	N
MCC7874	MCC655	Carbonaceous Claystone/Siltstone	-	0.07	2.14	3.9	-1.76	N
MCC7875	MCC655	Siltstone/Claystone	-	0.05	1.53	4.3	-2.77	N
MCC7876	MCC655	Siltstone	-	0.12	3.67	2.9	0.77	Y
MCC7877	MCC655	Claystone	0.02	0.04	0.73	6.8	-6.07	N

Notes: 1.Where sulfide % values are missing, total sulfur was used to calculate maximum potential acidity instead (may not be a conservative measure as Total S comprises both unoxidised sulfide and oxidised sulfate salt).

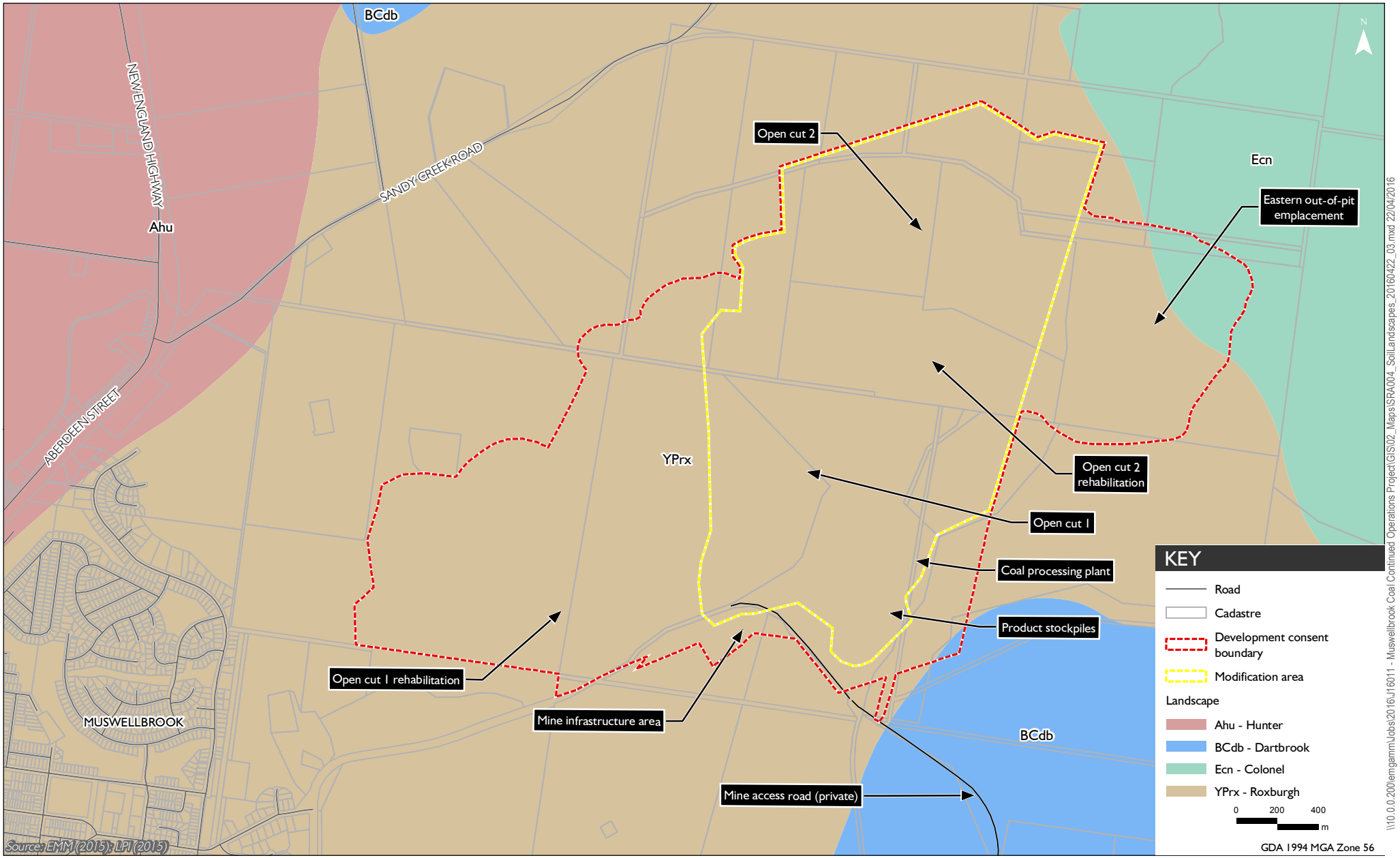
The ALS Global geochemistry test results are attached as Appendix E.

The geochemistry testing summarised in Table 3.1 shows that the vast majority of samples are not acid forming (NAF); further, the majority of samples are acid consuming which is indicated by the negative net acid producing potential (NAPP). Given the overwhelming acid consuming nature of the overburden it is not anticipated that ARD will be produced by the mine during operation or after rehabilitation of the modification area.

3.5 Regional soil mapping

3.5.1 Soil landscapes

Government mapping identifies that the Roxburgh soil landscape encompasses the entire modification area. Details of the Roxburgh soil landscape is provided in Table 3.2.



EMM

Soil landscapes

Muswellbrook Coal Continued Operations Project
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Figure 3.3

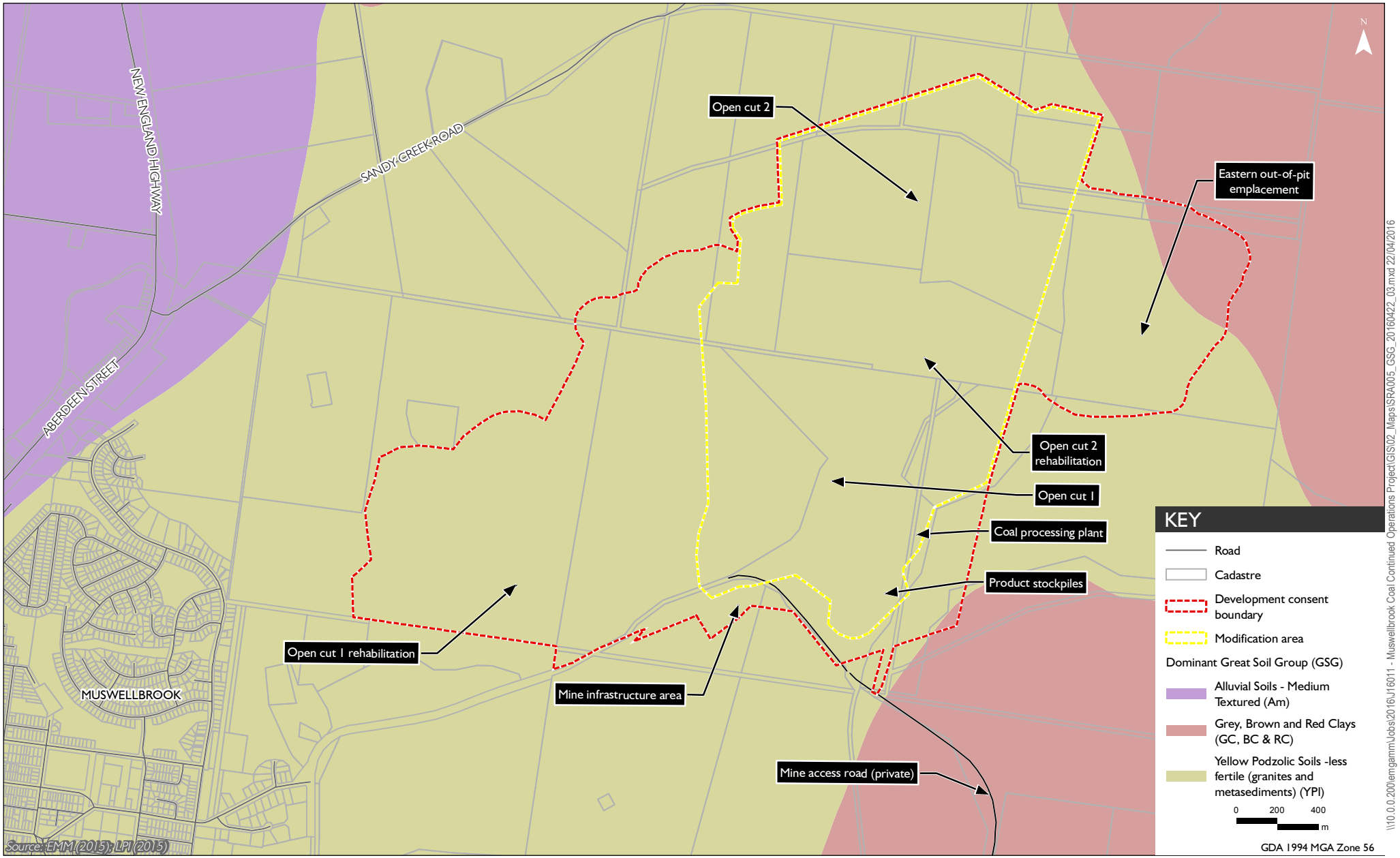
Table 3.2 Roxburgh soil landscape

	Roxburgh[1]
Landform	The Roxburgh soil landscape generally occurs on low and undulating hills. Elevations of 80-370 m a local relief of 60-120 m. Slopes are 0-10% with slope lengths of 800-1,200 m. Drainage lines occur at intervals of 300-1,500 m.
Soils	Yellow Podzolic soils (dominant soil type) mainly occur on the upper to midslopes with Red Solodic soils more likely to occur on more rounded hills. Lithosols occur on crests Brown Podzolic soils can also be found on slopes. Yellow Soloths have been found in some gullies.
Erosion	Minor to moderate sheet erosion is common. Gullies up to 3 m deep are associated with dispersible Soloths and Solodic Soils.
Vegetation	Open woodland of narrow-leaved red ironbark, white box and yellow box with some blakelys red gum, broad-leaved red ironbark, grey gum and grey box. Extensive clearing for grazing has occurred.

Notes: 1. NSW DEH 2016.

3.5.2 Great Soils Group

Great Soil Group information was sourced from the Soil Landscapes of the Singleton 1:250,000 Sheet (Kovac & Lawrie 1991). The parent material has been weathered to form Podzolic Soils. Podzolic soils in the Sydney Basin usually consist of a fine sandy loam A horizon before abruptly progressing into a heavy clay. Podzolic soils often have moderate fertility and good water holding capacity. The dominant Great Soils Group (GSG) found in the modification area is yellow podzolic soils-less fertile (YPI) Figure 3.4. These soils are formed on granite and metasediments giving them a moderately low fertility.



EMM

Great soil groups

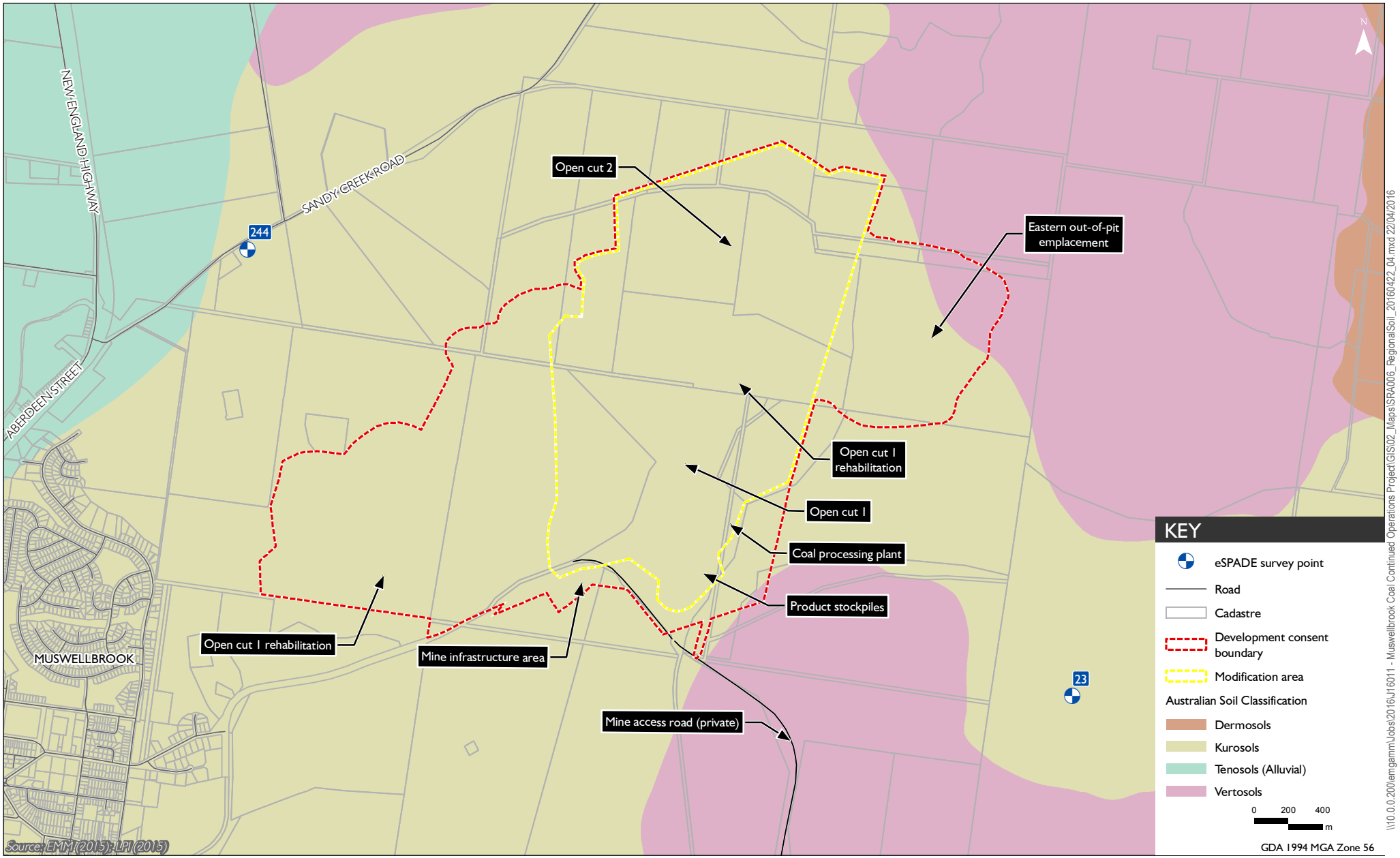
Muswellbrook Coal Continued Operations Project
Soils Assessment
Figure 3.4

3.5.3 Australian Soil Classification

The Australian Soil Classification scheme (Isbell 1996) is a multi-category scheme with soil classes defined on the basis of diagnostic horizons or materials and their arrangement in vertical sequence as seen in an exposed soil profile. The modification area is mapped under the order Kurosol. Vertosols and Tenosols (Alluvial) are also in the land surrounding the MCM (Figure 3.5. Descriptions of these soil orders are given in Table 3.3.

Table 3.3 Soil orders

Order	Location	Description
Kurosol	Sole soil type in the modification area.	Clear texture contrast between A and B horizon. The major upper 0.2 m of the B2 horizon is strongly acidic (pH_w <5.5). Many have unusual subsoil chemical features such as high exchangeable magnesium, sodium and aluminium and very low calcium.
Vertosol	Predominantly to the north and east of the approved open cut mining operation.	Clay soils (>35% clay) with shrink-swell properties which cause deep and wide cracking on drying. Lenticular structure and slickensides are diagnostic features. Vary substantially in colour and pH.
Tenosols (Alluvial)	Predominantly to the west of the approved open cut mining operation.	An intermediate between Rudosols and Kandosols. Weak horizon development and neglible structural organisation except in the A horizon.



EMM

Regional soil

Muswellbrook Coal Continued Operations Project
Soil and Rehabilitation Assessment
Figure 3.5

3.5.4 Inherent soil fertility

The inherent soil fertility (Stace et al 1968) classes (based on GSG, section 3.5.2), range from Low (1) soil fertility through to Moderately High (4) fertility.

The fertility rankings are defined by OEH (2015) as:

- **Moderately high (4):** includes soils with high fertility in their virgin state but fertility can be significantly reduced after a few years of cultivation and amendments and fertilisers are required.
- **Moderate (3):** soils have low to moderate fertilities and usually require fertiliser and/or have some physical restriction for arable use.
- **Moderately low (2):** Includes soils with low fertilities, such that, generally, only plants suited to grazing can be supported. Large inputs of fertiliser are required to make the soils useable for arable purposes.
- **Low (1):** Includes soils which, due to their poor physical and/or chemical status only support plant growth. The maximum agricultural use of these soils is low intensity grazing.

NSW mapping reveals that all soils in the modification area have a moderately low (2) fertility.

3.5.5 Biophysical Strategic Agricultural Land

Biophysical Strategic Agricultural Land (BSAL) is land with high quality soil and water resources capable of sustaining high levels of productivity. As of March 2016, the modification area is not formally recognised by the NSW Government as potential BSAL (NSW DP 2016).

3.5.6 Hydrologic soil group

The hydrologic soil groups are defined as follows (NSW OEH 2016):

- **A:** soils having high infiltration rates, even when thoroughly wetted and consisting chiefly of deep, well to excessively-drained sands or gravels. These soils have a high rate of water transmission.
- **B:** soils having moderate infiltration rates when thoroughly wetted and consisting chiefly of moderately deep to deep, moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission.
- **C:** soils having slow infiltration rates when thoroughly wetted and consisting chiefly of soils with a layer that impedes downward movement of water, or soils with moderately fine to fine texture. These soils have a slow rate of water transmission.
- **D:** soils having very slow infiltration rates when thoroughly wetted and consisting chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very slow rate of water transmission.

The NSW Government has classified the soil as the mine as Hydrologic soil group C. The podzolic nature of the soils means that the strong texture contrast between the A and B horizon is likely to inhibit water flow down the soil profile and will cause waterlogging in the A horizon.

3.5.7 eSPADE soil profiles

The eSPADE soil profile data base has been used to find soil profiles surveyed in the region that have been submitted to the SALIS database by the soil surveyor. No profiles occur directly within the modification area (Figure 3.5). Table 3.4 describes two nearby eSPADE soil profiles.

Table 3.4 eSPADE soil profiles

Survey date	Survey number	Easting	Northing	Zone	Soil type	Horizons	Surface texture	Surface pH
November 3, 1988	244	303305	6431389	56	Soloth (GSG)	4	Loamy sand	6
September 20, 2005	23	308105	6428789	56	Chocolate Soil (GSG)	2	Silty clay	6.5

Notes: 1. X coordinates = easting, Y coordinates = northing (UTM 56).

3.6 Regional land use and land capability

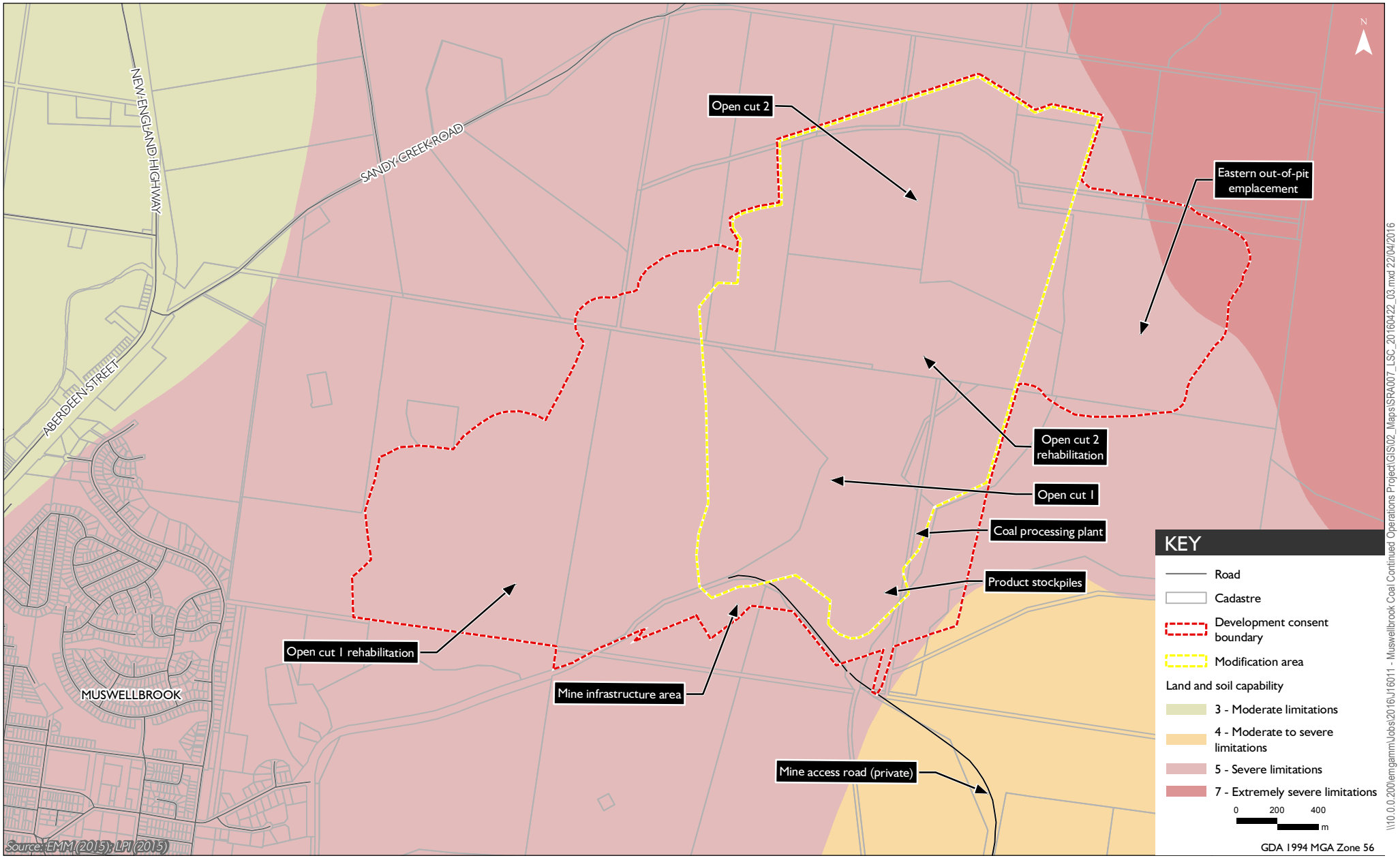
3.6.1 Land use

Land uses surrounding the mine include agricultural activities, light industrial land uses and residential areas. Agricultural activities are located on properties surrounding MCM and primarily include grazing of beef cattle. Light industrial land uses include Muswellbrook Quarry to the north-west, St Heliers correctional centre to the north-west and Muswellbrook waste management facility to the south. Muswellbrook township is to the west, with other notable rural-residential areas along Sandy Creek Road to the north, Woodlands Ridge Estate to the south and along Muscle Creek Road to the south-east.

Other significant features surrounding MCM include the Main Northern Rail Line and the New England Highway, which run to the west through Muswellbrook township and to the south towards Singleton. Numerous other mining operations and power-generating facilities exist between Muswellbrook and Singleton.

3.6.2 LSC classes

LSC of land at the MCM is classified by the NSW Government (NSW OEH 2016) as Class 5 (Figure 3.6). This land has severe limitations for high impact land management uses such as cropping. There are few management practices generally available to overcome these limitations. Class 5 land is generally better suited for grazing with some limitations or very occasional cultivation for pasture establishment.



EMM

LSC regional map

Muswellbrook Coal Continued Operations Project
Soils Assessment
Figure 3.6

3.7 State of the environment

3.7.1 Topography

The modification area is a rehabilitated landscape characterised by steep slopes of between 20-30%. The steep upper slopes gradually wane towards the edge of the rehabilitated area.

3.7.2 Vegetation

Rehabilitation monitoring from Eco Logical (2015) (Table 3.5) has shown that vegetation communities in the modification area are generally of low quality.

Table 3.5 Vegetation communities

Monitoring site	Vegetation composition
RW site 1	(*Corymbia maculata*) and (*Eucalyptus cladocalyx*) stunted canopy with a Coojong (*Acacia saligna*) dominated mid-storey and weedy groundcover. The weed species present is Fireweed (*Senecio madagascariensis)*.
RW site 2	Coojong dominated canopy and weedy groundcover. The weed species present is Fireweed.
RP site 1	Composed primarily of weed species including Rhodes Grass (*Chloris gayana*), Fireweed, Branched Centaury (*Cenatarium tenuiflorum*), Haresfoot Clover (*Trifolium arvense*), Hop Clover (*Trifolium campestre*) and White clover (*Trifolium repens*).
RP site 2	Composed primarily of weed species including Rhodes Grass, Barrel Medic (*Medicago truncatula*), Branched Centaury, Red Natal Grass (*Melinis repens*), Fireweed, Haresfoot Clover and Hop Clover.

Notes: 1.Eco Logical 2015.

2 RW = rehabilitated woodland, RP = rehabilitated pasture.

3.7.3 Soil

The soil profile is a thin layer of soil (mixed topsoil, subsoil and overburden) underlain by overburden. The soil profile has been vegetated with pasture and woodland grasses and trees at various stages of establishment.

Monitoring of the existing rehabilitated area within the modification area during 2015 (Eco Logical 2015) included sampling the soil surface which was tested for soil chemistry. The major findings from soil testing were:

- pH averaged 6.1 at RW and 6.5 at RP;
- salinity was higher than analogue sites but was relatively low averaging 83 microsiemens per centimetre (µS/cm) in RW and 58 µS/cm in RP;
- exchangeable potassium are moderate at 0.6 milliequivalents per 100 grams of soil (meq/100g) at RW and 0.62 meq/100g at RP;
- organic matter levels were moderate but low relative to analogue sites with RW averaging 3.2% and RP averaging 4.3%;
- the majority of sites contained much higher sulfur compared to analogue sites but relatively, are deemed adequate averaging 20 mg/kg in RW and 38 mg/kg in RP;

- nitrite and nitrate was considered very low averaging 1.2 mg/kg in RW and 0.65 mg/kg in RP; and
- total nitrogen levels were considerably lower than analogue sites averaging 2000 mg/kg in RW and 2515 mg/kg in RP.

Eco Logical (2015) determined that the soils in the modification area were of poor quality.

4 Soil survey

The modification area is a rehabilitated landscape, where soil (mixed topsoil (A horizon), subsoil (B Horizon) and Overburden) has been spread over the final landform, followed by seeding with grass and tree species. Because the soil is man-made it is defined as Anthroposol soil type using the Australian Soil Classification (Isbell 2002):

> Anthroposols are soils that result from human activities which have caused profound modification, mixing, truncation or burial of the original soil horizons, or the creation of new soil parent materials. Where burial of a pre-existing soil is involved, the anthropic materials must be 0.3 m or more thick. Pedogenic features may be the result of in situ processes (usually the minimal development of an A1 horizon, sometimes the stronger development of typical soil horizons) or the result of pedogenic processes prior to modification or placement (ie. the presence of identifiable pre-existing soil material).

Spolic Anthroposols were the dominant soil type indentified in the modification area. Spolic Anthroposols are soils that have been moved by earthmoving equipment in mining, highway construction or dam construction. Landscapes are human-formed and hence may present an 'unnatural' geomorphic expression.

The following sections describe the soil survey results for each site shown in Figure 2.1.

4.1 Landscape

4.1.1 Topography

Slopes were moderately inclined at all sites ranging from 20% to 30%. Vegetation composition at each site varied but typically included some trees and grasses.

4.1.2 Vegetation and ground cover

Sites 1, 3 and 5 consisted of rehabilitated woodland communities with a grass understory. The grass was much taller and denser at site 3 than site 1 and site 5 and had a thin layer of leaf litter (approximately 0.5-2 cm) above the soil surface. At site 1 and site 5, leaf litter was generally thicker and formed a larger percentage of ground cover than site 3 and is likely a result of the higher tree density at sites 1 and sites 5. The soil surfaces across all sites were dry and hard-set. All sites other than site 5 had varying densities of gravel covering the soil surface.

Sites 2 and 4 consisted of rehabilitated grassland communities with sporadic patches of tress. The density of grass at site 2 was much higher than site 4. Trees at site 4 were more mature and larger than those at site 2. Leaf litter above the soil surface was absent from the rehabilitated grasslands.

Figure 4.1 and Figure 4.2 demonstrate the two main vegetation communities observed ie rehabilitated woodland and rehabilitated grassland.

Figure 4.1 Rehabilitated woodland (site 3)

Figure 4.2 Rehabilitated grassland (site 2)

4.2 Soil description

Detailed field logs describing soil characteristics were recorded and are provided in Appendix F. Soil profiles were similar at all sites but had some noticeable differences. The following sections describe the soil profile at each site.

4.2.1 Site 1

Soil texture was fine sandy loam across all depths. It was slightly plastic and non-sticky. Segregations and mottling was absent. The soil was highly saline, non sodic and neutral. Salinity and alkalinity increased with depth.

The A_{11} horizon was brown, dry and extended from 0-0.1 m below ground surface (bgs). There was a small amount of dark brown decaying organic matter. Many dispersed coarse fragments were observed with a single grain structure.

The A_{12} horizon was brown, dry and extended from 0.1-0.25 m bgs. Many dispersed coarse fragments were observed (smaller and less frequent than A_{11}) with a single grain structure. There was also a small amount of sub-angular blocky (0.5-1 cm) peds.

The site profile is summarised in Table 4.1.

Table 4.1 Site 1 soil profile

ASC	Horizon name and depth (m bgs)	Colour, mottles and bleach	Moisture, field pH and drainage	Texture and structure	Coarse fragments, segregations and roots
	A_{11} 0-0.1	Brown, 10 YR 4/3, small amount of decaying organic matter (10 YR 3/3).	Dry, field pH of 6.76 and well drained.	Fine sandy loam and single grained (apedal).	Many (20-50%), subangular/rounded, small pebbles (2-6 mm) to medium pebbles (6-20 mm). Many small roots.
	A_{12} 0.1-0.25	Brown, 10 YR 4/3 and no mottles.	Dry, field pH of 6.94 and well drained.	Fine sandy loam and single grained (apedal). Sub-dominant sub-angular blocky (0.5-1 cm).	Many, subangular/rounded, small pebbles to medium pebbles. Less frequent medium pebbles than A_{11}. Very few small roots.

4.2.2 Site 2

Soil texture was fine sandy loam across all depths. It was slightly plastic and non-sticky. Segregations and mottling was absent. The soil was extremely saline, non sodic and neutral to mildly alkaline. Alkalinity and salinity did not correlate with depth.

The A_{11} horizon was brown, dry and extended from 0-0.3 m bgs. Many dispersed coarse fragments were observed with a single grain structure. There was also a small amount of sub-angular blocky (1-3 cm) peds.

The A_{12} horizon was very dark greyish brown, dry and extended from 0.3-0.45 m bgs. Many dispersed coarse fragments were observed (larger and more frequent than A_{11}) with a single grain structure. There was also a small amount of sub-angular blocky (1-3 cm) peds.

The site profile is summarised in Table 4.2.

Table 4.2 Site 2 soil profile

ASC	Horizon name and depth (m bgs)	Colour, mottles and bleach	Moisture, field pH and drainage	Texture and structure	Coarse fragments, segregations and roots
	A_{11} 0-0.3	Brown, 10 YR 4/3 and no mottles.	Dry, field pH of 7.35-7.41 and well drained.	Fine sandy loam and single grained (apedal). Sub-dominant sub-angular blocky (1-3 cm).	Many, subangular/rounded, small pebbles to stones (200-600 mm). Many small roots.
	A_{12} 0.3-0.45	Very dark greyish brown, 10 YR 3/2 and no mottles.	Dry, field pH of 7.47 and well drained.	Fine sandy loam and single grained (apedal). Sub-dominant sub-angular blocky (1-3 cm).	Many, subangular/rounded, small pebbles to stones. Stones more frequent than A_{11}. Few small roots.

4.2.3 Site 3

Soil texture was fine sandy loam across all depths. It was slightly plastic and non-sticky. Segregations and mottling was absent. The soil was highly saline after the first 0.1 m bgs, non sodic and neutral. Salinity increased with depth while alkalinity had no correlation.

There were no visible horizons. The soil was dark yellowish brown, dry and extended down to 0.4 m bgs. Coarse fragments were dispersed and common with a single grain structure. There was also a small amount of sub-angular blocky (0.5-2 cm) peds.

Table 4.3 Site 3 soil profile

ASC	Horizon name and depth (m bgs)	Colour, mottles and bleach	Moisture, field pH and drainage	Texture and structure	Coarse fragments, segregations and roots
	No visible horizons 0-0.4	Brown, 10 YR 4/3 and no mottles.	Dry, field pH of 7.07-7.22 and well drained.	Fine sandy loam and single grained (apedal). Sub-dominant sub-angular blocky (0.5-2 cm).	Common (10-20%), subangular/rounded, small pebbles to large pebbles (20-60 mm). Increase in frequency with depth and many small roots.

4.2.4 Site 4

Soil texture was fine sandy loam across all depths. It was slightly plastic and non-sticky. Segregations and mottling was absent. The soil was extremely saline, non sodic and strongly acidic. Acidity and salinity did not correlate with depth.

There were no visible horizons. The soil was yellowish brown, dry and extended down to 0.35 m bgs. Coarse fragments were dispersed and common with a single grain structure. There was also a small amount of sub-angular blocky (0.5-2 cm) peds.

Table 4.4 Site 4 soil profile

ASC	Horizon name and depth (m bgs)	Colour, mottles and bleach	Moisture, field pH and drainage	Texture and structure	Coarse fragments, segregations and roots
	No visible horizons 0-0.35	Yellowish brown, 10 YR 5/4 and no mottles.	Dry, field pH of 5.09-5.74 and no mottles.	Fine sandy loam and single grained (apedal). Sub-dominant sub-angular blocky (0.5-2 cm).	Common (10-20%), subangular/rounded, small pebbles to large pebbles and very few small roots.

4.2.5 Site 5

Site 5 had a sandy clay loam texture which transitioned to clayey sand at 0.5 m bgs, which was believed to be dispersed overburden.

Soil texture was sandy clay loam transitioning to clayey sand at depth. Segregations and mottling was absent. The soil was saline, non sodic and mildly alkaline or moderately alkaline. Salinity slightly increased with depth while alkalinity had no correlation.

The A_{11} horizon was brown, dry and extended from 0-0.5 m bgs. Many dispersed coarse fragments were observed with a single grain structure. It was slightly plastic and non-sticky. There was also a small amount of sub-angular blocky (0.5-1 cm) peds.

The A_{12} horizon was dark yellowish brown, dry and extended from 0.5-0.7 m bgs. Many dispersed coarse fragments were observed (larger and more frequent than A_{11}) with a single grain structure. Soil was non-plastic and non-sticky. There was also a small amount of sub-angular blocky (0.5-1 cm) peds.

Table 4.5 Site 5 soil profile

ASC	Horizon name and depth (m bgs)	Colour, mottles and bleach	Moisture, field pH and drainage	Texture and structure	Coarse fragments, segregations and roots
	A_{11} 0-0.5	Brown, 10 YR 4/3 and no mottles.	Dry, field pH of 7.04-7.31 and well drained.	Sandy clay loam and single grained (apedal). Sub-dominant sub-angular blocky (0.5-1 cm).	Few (2-10%), subangular/rounded, small pebbles to cobbles (60-200 mm) and many small roots.
	A_{12} 0.5-0.7	Dark yellowish brown, 10 YR 4/4 and no mottles.	Dry, field pH of 7.11-7.28 and well drained.	Clayey sand **(CHECK)** and single grained (apedal). Sub-dominant sub-angular blocky (0.5-1 cm).	Few (2-10%), subangular/rounded, small pebbles to cobbles and few small roots.

4.3 Soil chemistry

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 soil chemistry results presented in the following sections.

Table 4.6 All sites soil chemistry

Constituents	pH	EC_{se}	Organic Carbon (TOC)	Nitrite + Nitrate as N (Sol.)	Total Kjeldahl N	Total N	P (Colwell)	Total P	CEC	Ca	Mg	K	Na	Al	Alkalinity as $CaCO_3$	ESP	Ca/Mg ratio	Sulfate as SO_4^{2-}
Unit	pH units	dS/m	%	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	meq/ 100g	meq/ 100g	meq/ 100g	meq/ 100g	meq/ 100g	meq/ 100g	mg/kg	%	-	mg/kg
Soil Sufficiency[1]	6.0-7.5	<1.9	>1.2	>15		>1500	>10		12-25	>5	>1	<0.7	>0.3	<5% CEC		<6	>2	
Site 1 0-0.1	7.2	11.69	3.14	2.1	1610	1610	82	633	15.4	13.4	1.5	0.2	<0.1	0.65	1140	0.6	8.9	2700
Site 1 0.1-0.25	7.3	23.8	1.63	0.6	910	910	46	532	14.5	12.9	1.3	0.2	<0.1	-	788	-	-	6260
Site 2 0-0.1	7.6	42.7	1.51	0.4	540	540	18	390	7.8	4.8	3.0	<0.2	<0.2	-	1140	<0.2	1.6	12900
Site 2 0.1-0.2	7.3	41.3	1.63	0.3	590	590	15	338	29.9	26.1	3.1	0.2	0.3	0.69	875	1	8.4	13400
Site 2 0.2-0.3	7.4	46.62	1.28	-	-	-	-	-	7.1	4.5	2.6	<0.2	<0.2	-	962	<0.2	1.7	14400
Site 2 0.3-0.45	7.5	44.52	1.05	-	-	-	-	-	6.4	4.0	2.4	<0.2	<0.2	-	1050	<0.2	1.7	14300
Site 3 0-0.1	7.4	1.08	0.87	0.1	440	440	8	237	3.1	3.1	<0.2	<0.2	<0.2	-	306	<0.2	-	80
Site 3 0.1-0.2	7.1	11.54	0.93	<0.1	360	360	9	277	9.4	8.3	0.5	0.1	<0.1	3.19	508	0.9	16.6	2320
Site 3 0.2-0.3	7.1	16.94	0.81	-	-	-	-	-	11.7	10.6	0.6	0.1	0.1	1.71	438	1.1	17.7	4050
Site 3 0.3-0.4	7.2	26.32	1.16	-	-	-	-	-	15	13.5	1.0	0.1	<0.1	2.67	464	0.6	13.5	7240
Site 4 0-0.1	5.5	27.58	0.81	<0.1	240	240	30	420	16.1	14.7	0.8	0.1	<0.1	2.48	88	0.6	18.4	8000
Site 4 0.1-0.2	5.4	28.84	0.7	<0.1	250	250	32	397	18.5	17.2	0.8	0.1	<0.1	1.08	96	0.5	21.5	8360
Site 4 0.2-0.35	5.5	22.68	<0.5	-	-	-	-	-	13.5	12.0	1.0	0.1	<0.1	1.48	122	0.7	12	6210
Site 5 0-0.1	7.6	1.53	1.22	1.3	550	550	9	309	4.0	3.0	1.0	<0.2	<0.2	-	735	<0.2	2.8	230
Site 5 0.1-0.2	7.8	2.72	1.04	0.3	560	560	8	292	4.5	3.3	1.1	<0.2	<0.2	-	700	<0.2	2.9	540
Site 5 0.2-0.3	7.8	3.21	0.93	-	-	-	-	-	2.6	2.6	<0.2	<0.2	<0.2	-	586	<0.2	-	720
Site 5 0.3-0.4	7.8	3.78	0.93	-	-	-	-	-	3.9	3.0	0.9	<0.2	<0.2	-	516	<0.2	3.4	900
Site 5 0.4-0.5	7.9	3.54	1.16	-	-	-	-	-	2.9	2.9	<0.2	<0.2	<0.2	-	464	<0.2	-	830
Site 5 0.5-0.6	7.9	4.23	0.64	-	-	-	-	-	2.0	2.0	<0.2	<0.2	<0.2	-	542	<0.2	-	310
Site 5 0.6-0.7	7.8	4.28	0.64	-	-	-	-	-	1.9	1.9	<0.2	<0.2	<0.2	-	289	<0.2	-	360
Undisturbed site 0-0.1	7.7	0.69	1.57	0.1	860	860	11	223	4.2	3.2	1.0	<0.2	<0.2	-	709	<0.2	3.2	40

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

The following sections summarise the soil chemistry for each site.

4.3.1 Site 1

Site 1 soil chemistry results are summarised in Table 4.7. In summary the soil at site 1 is limited by:

- EC;
- macronutrients (nitrate + nitrite); and
- micronutrients (exchangeable K).

Table 4.7 Site 1 soil chemistry

Elements	Comments
pH_{water}	Neutral across the entire profile. Inside of the desirable range for agriculture throughout the profile. Would not restrict agriculture.
EC	Very high salinity levels that would restrict agriculture. Note: gypsum application and subsequent elevated sulfate levels are responsible for the high soil salinity measurements. Mixing of soil with underlying overburden likely further contributes to this. Gypsum can also make EC measurements erroneously high due to its variable solubility when compared to chloride salts.
Fertility	
Macronutrients	Insufficient nitrate + nitrite but high levels of P (whole profile) and total N (topsoil). Nitrate +nitrite levels may restrict agriculture.
Micronutrients	Adequate levels of all exchangeable cations except for K. Al and Na are below harmful levels. Low K may present some fertility issues.
CEC	Moderate CEC, indicating adequate fertility.
Erosion potential	
ESP	Low ESP indicating a non-sodic soil, which would not restrict agriculture.
Ca:Mg ratio	A stable Ca:Mg ratio in the topsoil, but inconclusive in the subsoil.
Organic Carbon	High to moderate levels of organic carbon in A11 and A12 horizons which is indicative of structural stability.

4.3.2 Site 2

Site 2 soil chemistry results are summarised in Table 4.8. In summary the soil at site 2 is limited by:

- EC;
- CEC;
- macronutrients (nitrate + nitrite);
- micronutrients (exchangeable K); and
- Ca:Mg ratio.

Table 4.8 Site 2 soil chemistry

Elements	Comments
pH_{water}	Mostly mildly alkaline. Inside of the desirable range for agriculture except for 0-0.1 m. Unlikely to restrict agriculture.
EC	Very high salinity levels that would restrict agriculture. Note: gypsum application and subsequent elevated sulfate levels are responsible for the high soil salinity measurements. Mixing of soil with underlying overburden likely further contributes to this. Gypsum can also make EC measurements erroneously high due to its variable solubility when compared to chloride salts.
Fertility	
Macronutrients	Insufficient nitrate + nitrite and total N but adequate levels of P. Nitrate +nitrite levels may restrict agriculture.
Micronutrients	Adequate levels of all exchangeable cations except for K. Al and Na are below harmful levels. Low K may present some fertility issues.
CEC	Low CEC except for 0.1-0.2 m, may present fertility issues.
Erosion potential	
ESP	Low ESP indicating a non-sodic soil, which would not restrict agriculture.
Ca:Mg ratio	An unstable Ca:Mg ratio except for 0.1-0.2 m, indicating soil instability.
Organic Carbon	Moderate to low levels of organic carbon. This is indicative of structural stability throughout most the profile.

4.3.3 Site 3

Site 3 soil chemistry results are summarised in Table 4.9. In summary the soil at site 3 is limited by:

- EC;
- CEC;
- macronutrients (nitrate + nitrite and P);
- micronutrients (exchangeable K and Mg); and
- organic carbon.

Table 4.9 Site 3 soil chemistry

Elements	Comments
pH_{water}	Mostly neutral. Inside of the desirable range for agriculture. Would not restrict agriculture.
EC	Very high salinity levels except for 0-0.1 m that would restrict agriculture. Note: gypsum application and subsequent elevated sulfate levels are responsible for the high soil salinity measurements. Mixing of soil with underlying overburden likely further contributes to this. Gypsum can also make EC measurements erroneously high due to its variable solubility when compared to chloride salts.

Table 4.9 Site 3 soil chemistry

Elements	Comments
Fertility	
Macronutrients	Insufficient nitrate + nitrite, total N and P. Will restrict agriculture.
Micronutrients	Mostly insufficient levels of all exchangeable cations except for Ca. Al and Na are below harmful levels. Low Mg and K may present fertility issues.
CEC	Low CEC except for 0.3-0.4 m, may present fertility issues.
Erosion potential	
ESP	Low ESP indicating a non-sodic soil, which would not restrict agriculture.
Ca:Mg ratio	Stable Ca:Mg ratios, indicating soil stability.
Organic Carbon	Low levels of organic carbon. This is indicative of structural instability.

4.3.4 Site 4

Site 4 soil chemistry results are summarised in Table 4.10. In summary the soil at site 4 is limited by:

- pH;
- EC;
- macronutrients (nitrate + nitrite);
- micronutrients (Exchangeable K and Mg); and
- organic carbon.

Table 4.10 Site 4 soil chemistry

Elements	Comments
pH_{water}	Strongly acid. Outside of the desirable range for agriculture. Would restrict agriculture.
EC	Very high salinity levels that would restrict agriculture. Note: gypsum application and subsequent elevated sulfate levels are responsible for the high soil salinity measurements. Mixing of soil with underlying overburden likely further contributes to this. Gypsum can also make EC measurements erroneously high due to its variable solubility when compared to chloride salts.
Fertility	
Macronutrients	Insufficient nitrate + nitrite and total N but adeqaute P. Will likely restrict agriculture.
Micronutrients	Insufficient levels of all exchangeable cations except for Ca. Al and Na are below harmful levels. Low Mg and K may present fertility issues.
CEC	Moderate CEC, indicating adequate fertility.
Erosion potential	
ESP	Low ESP indicating a non-sodic soil, which would not restrict agriculture.
Ca:Mg ratio	Stable Ca:Mg ratios, indicating soil stability.
Organic Carbon	Low levels of organic carbon. This is indicative of structural instability.

4.3.5 Site 5

Site 5 soil chemistry results are summarised in Table 4.11. In summary the soil at site 5 is limited by:

- EC;
- CEC;
- macronutrients (nitrate + nitrite and P);
- micronutrients (Exchangeable Ca, K and Mg); and
- organic carbon.

Table 4.11 Site 5 soil chemistry

Elements	Comments
pH_{water}	Mildly alkaline to moderately alkaline. Slightly outside of the desirable range for agriculture. May restrict alkaline sensitive plant growth.
EC	High salinity levels except for 0-0.1 m that would restrict agriculture. Note: gypsum application and subsequent elevated sulfate levels are responsible for the high soil salinity measurements. Mixing of soil with underlying overburden likely further contributes to this. Gypsum can also make EC measurements erroneously high due to its variable solubility in water when compared to chloride salts.
Fertility	
Macronutrients	Insufficient nitrate + nitrite, total N and P. Will restrict agriculture.
Micronutrients	Mostly insufficient levels of all exchangeable cations. Na is below harmful levels. Low Ca, Mg and K may present fertility issues.
CEC	Low CEC, may present fertility issues.
Erosion potential	
ESP	Low ESP indicating a non-sodic soil, which would not restrict agriculture.
Ca:Mg ratio	Stable Ca:Mg ratios, indicating potential soil stability.
Organic Carbon	Mostly low levels of organic carbon. This is indicative of structural instability.

5 Land and soil capability assessment

5.1 LSC classification system

The assessment of LSC classes for MCM was conducted in accordance with the requirements of the *Land and soil capability assessment scheme* (OEH 2012). The LSC class definitions are presented in Table 5.1. The assessment was carried out using the information collected during the survey and supplemented with information gathered during the desktop review.

The assessment process involves determination of soils and landscape characteristics against eight decision tables. The decision tables use landscape, soils and climate data on the various hazards or limitations to allocate land to a LSC class based on each hazard or limitation (OEH 2012). Each hazard is assigned one of eight LSC classes where Class 1 represents the least hazard and Class 8 represents the greatest hazard and each is assessed individually ensuring a profile of hazards is developed for the land being assessed. The final hazard assessment for the land is based on the highest hazard (OEH 2012). Data for the assessment was sourced from the survey, desktop review and laboratory tests. A summary of the results for each site assessed is presented in Table 5.2. Appendix A presents the detailed LSC assessment.

Table 5.1 LSC classes - general definitions (OEH 2012)

LSC class	General definition
Land capable of a wide variety of land uses (cropping, grazing, horticulture, forestry, nature conservation)	
1	**Extremely high capability land**: Land has no limitations. No special land management practices required. Land capable of all rural land uses and land management practices.
2	**Very high capability land**: Land has slight limitations. These can be managed by readily available, easily implemented management practices. Land is capable of most land uses and land management practices, including intensive cropping with cultivation.
3	**High capability land**: Land has moderate limitations and is capable of sustaining high-impact land uses, such as cropping with cultivation, using more intensive, readily available and widely accepted management practices. However, careful management of limitations is required for cropping and intensive grazing to avoid land and environmental degradation.
Land capable of a variety of land uses (cropping with restricted cultivation, pasture cropping, grazing, some horticulture, forestry, nature conservation)	
4	**Moderate capability land**: Land has moderate to high limitations for high-impact land uses. Will restrict land management options for regular high-impact land uses such as cropping, high-intensity grazing and horticulture. These limitations can only be managed by specialised management practices with a high level of knowledge, expertise, inputs, investment and technology.
5	**Moderate–low capability land**: Land has high limitations for high-impact land uses. Will largely restrict land use to grazing, some horticulture (orchards), forestry and nature conservation. The limitations need to be carefully managed to prevent long-term degradation.
Land capable for a limited set of land uses (grazing, forestry and nature conservation	
6	**Low capability land**: Land has very high limitations for high-impact land uses. Land use restricted to low-impact land uses such as grazing, forestry and nature conservation. Careful management of limitations is required to prevent severe land and environmental degradation.
Land generally incapable of agricultural land use (selective forestry and nature conservation)	
7	**Very low capability land**: Land has severe limitations that restrict most land uses and generally cannot be overcome. On-site and off-site impacts of land management practices can be extremely severe if limitations not managed. There should be minimal disturbance of native vegetation.
8	**Extremely low capability land**: Limitations are so severe that the land is incapable of sustaining any land use apart from nature conservation. There should be no disturbance of native vegetation.

Table 5.2 LSC classes for each site

Site	LSC hazards								
	Water Erosion	Wind Erosion	Soil structural decline	Soil acidification	Salinity	Waterlogging	Shallow soils and rockiness	Mass movement	LSC class
1	6	2	3	3	4	1	6	1	6
2	6	2	3	3	4	1	6	1	6
3	6	2	3	3	4	1	6	1	6
4	6	3	3	5	4	1	6	1	6
5	6	2	3	3	3	2	4	1	6

5.2 Conclusions

The assessment of the LSC classes for the modification area at each site was conducted in accordance with the requirements of the *Land and soil capability assessment scheme* (OEH 2012). The assessment found that the modification area is identified as Class 6 LSC (Table 5.3). These soils are most suited for grazing, forestry and nature conservation:

- sites 1-4 received the Class 6 LSC rating based on the water erosion and rockiness and/or shallowness of the soils classification; and
- site 5 received the Class 6 LSC rating solely due to the water erosion classification.

Table 5.3 Modification area LSC classes

Class	Capability	Land in the modification area
Land capable of a wide variety of land uses (cropping, grazing, horticulture, forestry, nature conservation)		
1	Extremely high	None
2	Very high	None
3	High	None
Land capable of a variety of land uses (cropping with restricted cultivation, pasture cropping, grazing, some horticulture, forestry, nature conservation)		
4	Moderate	None None
5	Moderate-low	None
Land capable for a limited set of land uses (grazing, forestry and nature conservation)		
6	Low	Anthroposols
Land generally incapable of agricultural land use (selective forestry and nature conservation)		
7	Very low	None
8	Extremely low	None

6 Conclusions

Landscape and soil characteristics were similar across the modification area with all soils being classified as Spolic Anthroposols. Despite this, there were noticeable variations between the soils at each sample site in terms of profile depth, colour and horizons. Soils were neutral to moderately alkaline (except site 4), had moderate to low levels of organic carbon, high salinity and moderately low fertility. The high levels of salinity observed were likely due to the influence of gypsum application and mixing with underlying overburden.

The LSC assessment revealed that the entire modification area is categorised as class 6. This is based on the water erosion potential and/or the shallowness of the soils. Class 6 areas are restricted to low impact land uses such as grazing, forestry and nature conservation.

References

Australasian Groundwater & Environmental Consultants 2010, *Muswellbrook Coal Mine Development Consent Modification – Groundwater Impact Assessment*, report prepared by Australasian Groundwater & Environmental Consultants for Hansen Bailey Pty Ltd.

Baker DE & Eldershaw VJ 1993, *Interpreting soil analyses*, Department of Primary Industries, Queensland Department of Environment and Resource Management (DERM) 2011, *Guidelines for applying the proposed strategic cropping land criteria*, accessed 29 October 2015, http://www.nrm.qld.gov.au/land/planning/pdf/strategic-cropping/scl-guidelines.pdf.

Department of Primary Industries (DPI) 2015, *Quick reference guide: assessing soil texture*, accessed 27 January 2016, http://vro.agriculture.vic.gov.au/dpi/vro/vrosite.nsf/pages/soilhealth_texture_pdf/$FILE/QRG_Texture.pdf

Department of Land and Water Conservation (DLWC) 2001, 3rd Edition, *Soil data entry handbook*.

Eco Logical 2015, *2015 Rehabilitation monitoring report*. Report prepared by Eco Logical for Muswellbrook Coal Company.

Glen RA, Beckett J 1993, *Hunter coalfield regional geology 1:100 000*, 2nd Ed., NSW Department of Industry; Resources & Energy, accessed 25 February 2016, http://www.resourcesandenergy.nsw.gov.au/geoproducts/details?editionid=412&productid=337

Gray, J., Murphy, C., Chapman, G., and Noble, R. 1997, 2nd edition, *Soil and Landscape Issues in Environmental Impact Assessment*, NSW Department of Land and Water Conservation, Sydney.

Isbell RF 2002, *The Australian soil classification, CSIRO Publishing, Melbourne.*

Köppen, W. P. 1918. Klassification der Klimate nach Temperatur, Niederschlag und Jahreslauf. Petermanns Geog. Mitt.. 64. 193–203; 243–248.Kovac, M & Lawrie, J 1991, *Soil Landscapes of the Singleton 1:250,000 Sheet*, Soil Conservation Service of NSW, Sydney.

Muswellbrook Coal Company (MCC) 2002, *Muswellbrook Coal Company Limited, No. 1 Open Cut Extension Environmental Impact Statement 2002*. Report prepared by HLA-Envirosciences Pty Limited.

National Committee on Soil and Terrain (NCST) 2009, 3rd edition, *Australian soil and land survey handbook*, *CSIRO Publishing, Melbourne*.

New South Wales Office of Environment and Heritage (NSW OEH) 2016, *NSW soil and land information maps*, accessed 25 February 2016, http://www.environment.nsw.gov.au/eSpadeWebApp/

New South Wales Office of Environment and Heritage (NSW OEH) 2012a, *The land and soil capability scheme; second approximation*. Prepared by NSW OEH.

New South Wales Office of Environment and Heritage (NSW OEH) 2012b, *Interim protocol for site verification and mapping of biophysical strategic agricultural land*. prepared by NSW OEH.

New South Wales Department of Planning and Environment (NSW DP) 2016, *Biophysical strategic agricultural land maps*, accessed 25 February 2016, http://www.planning.nsw.gov.au/Policy-and-Legislation/Mining-and-Resources/Safeguarding-our-Agricultural-Land.

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

Appendix A

LSC assessment

Land and Soil Capability Assessment Report

Decision Tables

Prepared for Muswellbrook Coal Company | 1 April 2016

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Land and Soil Capability Assessment Report

Draft Report

Report J16011RP1 | Prepared for Muswellbrook Coal Company | 1 April 2016

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1 Introduction

This report is focused on meeting the requirements of *The land and soil capability assessment scheme* (OEH 2012). The land and soil capability assessment scheme (OEH 2012) outlines the process to assess the limitations of land-use based on the biophysical characteristics of the land. It should be noted that the tables enclosed within this report are either directly replicated or adapted from OEH 2012.

The land and soil capability (LSC) classes present on a property are determined at the farm scale for each soil management unit (SMU). This is done using the information collected during the field survey and supplemented with information gathered during the desktop assessment. Table 1.1 outlines the information required to make an assessment of land and soil capability classes and their definitions (OEH 2012). Table 1.2 provides definitions of the land and soil capability classes.

Table 1.1 Data requirements for determining LSC classes (OEH 2012)

	Water erosion	Wind erosion	Soil structure decline	Soil acidification	Salinity	Water-logging	Shallow soils and rock	Mass movement
NSW Division	✓							
Sand dune or mobile sand body	✓							
Slope %	✓							✓
Scree or talus slope								✓
Footslope or drainage plain receiving high run-on	✓							
Gully erosion or sodic dispersible subsoils	✓							
Annual rainfall		✓		✓				✓
Wind erosive power		✓						
Exposure to wind		✓						
Surface soil texture		✓	✓	✓				
Surface soil texture modifier			✓					
Great Soil Group				✓				
pH of surface soil				✓				
Surface soil modifier				✓				
Parent material				✓				
Recharge potential of landscape					✓			
Discharge potential of landscape					✓			
Salt store of landscape					✓			
Waterlogging duration						✓		
Return period of waterlogging						✓		
Rocky outcrop							✓	
Soil depth							✓	
Presence of existing mass movement								✓

Table 1.2 Land and soil capability classes - general definitions (EOH 2012)

LSC class	General definition
Land capable of a wide variety of land uses (cropping, grazing, horticulture, forestry, nature conservation)	
1	**Extremely high capability land**: Land has no limitations. No special land management practices required. Land capable of all rural land uses and land management practices.
2	**Very high capability land**: Land has slight limitations. These can be managed by readily available, easily implemented management practices. Land is capable of most land uses and land management practices, including intensive cropping with cultivation.
3	**High capability land**: Land has moderate limitations and is capable of sustaining high-impact land uses, such as cropping with cultivation, using more intensive, readily available and widely accepted management practices. However, careful management of limitations is required for cropping and intensive grazing to avoid land and environmental degradation.
Land capable of a variety of land uses (cropping with restricted cultivation, pasture cropping, grazing, some horticulture, forestry, nature conservation)	
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5	**Moderate–low capability land**: Land has high limitations for high-impact land uses. Will largely restrict land use to grazing, some horticulture (orchards), forestry and nature conservation. The limitations need to be carefully managed to prevent long-term degradation.
Land capable for a limited set of land uses (grazing, forestry and nature conservation	
6	**Low capability land**: Land has very high limitations for high-impact land uses. Land use restricted to low-impact land uses such as grazing, forestry and nature conservation. Careful management of limitations is required to prevent severe land and environmental degradation
Land generally incapable of agricultural land use (selective forestry and nature conservation)	
7	**Very low capability land**: Land has severe limitations that restrict most land uses and generally cannot be overcome. On-site and off-site impacts of land management practices can be extremely severe if limitations not managed. There should be minimal disturbance of native vegetation.
8	**Extremely low capability land**: Limitations are so severe that the land is incapable of sustaining any land use apart from nature conservation. There should be no disturbance of native vegetation.

The land and soil capability assessment scheme (OEH 2012) applies different criteria to properties depending on their location in New South Wales (NSW). Under The Crown Lands Act of 1884 NSW was divided into the three land division zones of Western, Central and Eastern. The first step in the assessment process is to determine which zone the property exists in. This can be determined by locating the property on the map in Figure 1.1.

Figure 1.1 Map of NSW land divisions

This can accurately be achieved through examination of the 1907 Map of New South Wales. Table 1.3 provides the result of looking up the project on the 1907 map.

Table 1.3 NSW Land Division of the project

	Division
Muswellbrook Coal Mine	Eastern Division

Source: http://www.nla.gov.au/apps/cdview/?pi=nla.map-rm2795-sd

2 Assessment of water erosion LSC classes

Table 2.1 outlines the assessment table for determining water erosion LSC classes. Assessment has been based on the criteria applicable to the Eastern Land Division. Table 2.2 outlines the results table for water erosion LSC classes for each of the detailed sites.

Table 2.1 Water erosion LSC class assessment table (OEH 2012)

NSW division	Slope class (%) for each LSC class							
	Class 1	**Class 2**	**Class 3**	**Class 4[1]**	**Class 5[2]**	**Class 6**	**Class 7**	**Class 8**
Eastern and Central divisions	<1	1 to <3	3 to <10 or 1 to <3 with slopes >500m length	10 to <20	10 to <20	20 to <33	33 to <50	>50
Western division[3]	<1	1 to <3 or <1 for hardsetting red soils	1 to 3	3 to 5	3 to 5	5 to 33	33 to 50	>50

Notes: *1.No gully erosion or sodic/dispersible soils are present.*

2. Gully erosion and/or sodic/dispersible soils are present.

3. Western CMA provided advice on slope classes.

Table 2.2 Water erosion LSC classes for the SMUs within the project area

Soil type	Slope class (%)[1]	Water Erosion LSC class
Anthroposols		
Sample Site 1	30	6
Sample Site 2	20	6
Sample Site 3	25	6
Sample Site 4	25	6
Sample Site 5	30	6

3 Assessment of wind erosion LSC classes

The wind erosion LSC class requires the assessment of four hazards:

1. wind erodibility class of surface soil;
2. wind erosion power;
3. exposure to wind; and
4. average yearly rainfall.

3.1 Wind erodibility hazard

Table 3.1 outlines the assessment figure for determining wind erodibility hazard

Table 3.1 Wind erodibility hazard of surface soils (OEH 2012)

Wind erodibility class of surface soil	Surface soil texture
Low	Loams, clay loams or clays (all with >13% clay)
Moderate	Fine sandy loams or sandy loams (all with 6–13% clay); also includes organic peats
High	Loamy sands or loose sands (all with <6% clay).

3.2 Exposure to Wind

Table 3.2 outlines the assessment figure for determining exposure to wind

Table 3.2 Exposure to wind (OEH 2012)

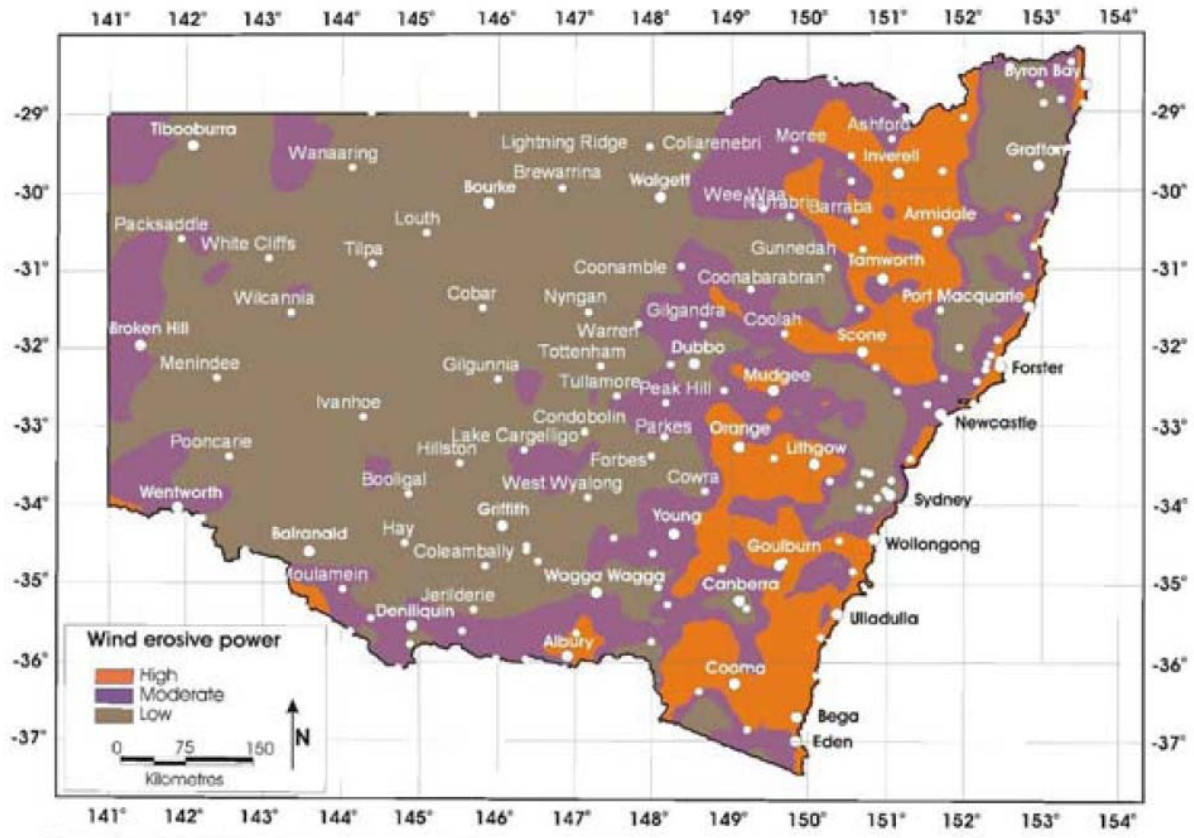
Exposure to wind class of surface soil	Site exposure to prevailing winds
Low	Sheltered locations in valleys or in the lee of hills
Moderate	Intermediate situations – not low or high exposure locations
High	Hilltops, cols or saddles, open plains or exposed coastal locations

3.3 Average yearly Rainfall

Average yearly rainfall for the project area is 643.3 mm. http://www.bom.gov.au/climate/data/ (March 2016)

3.4 Wind erosion power

Figure 3.1 outlines the assessment figure for determining wind erosion power.



Source: NSW Department of Trade and Investment (undated).

Figure 3.1 Wind erosive power (NSW Department of Trade and Investment in OEH 2012)

3.5 Wind erosion LSC classes

Table 3.3 outlines the assessment table for determining wind erosion LSC classes. Table 3.4 outlines the results table for water erosion LSC classes.

Table 3.3 Wind erosion LSC class assessment table (OEH 2012)

Wind erodibility class of surface soil	Wind erosive power	Exposure to wind	Average annual rainfall (mm)			
			>500	300–500	200 to <300	<200
Low	Low	Low	1	2	3	6
		Moderate	1	2	3	6
		High	2	3	4	7
	Moderate	Low	1	2	3	6
		Moderate	2	3	4	6
		High	3	4	5	7
	High	Low	2	3	4	6
		Moderate	3	4	5	7
		High	4	5	6	7

Table 3.3 Wind erosion LSC class assessment table (OEH 2012)

Wind erodibility class of surface soil	Wind erosive power	Exposure to wind	Average annual rainfall (mm)			
			>500	300–500	200 to <300	<200
Moderate	Low	Low	2	3	4	7
		Moderate	3	4	5	7
		High	4	5	6	8
	Moderate	Low	2	3	4	6
		Moderate	3	4	5	7
		High	4	5	6	8
	High	Low	3	4	5	7
		Moderate	4	5	6	8
		High	5	6	7	8
High	Low	Low	3	4	5	7
		Moderate	4	5	6	8
		High	5	6	7	8
	Moderate	Low	4	5	6	8
		Moderate	5	6	7	8
		High	6	7	8	8
	High	Low	5	6	7	8
		Moderate	6	7	8	8
		High	7 (8*)	8	8	8

*Note: * Mobile sand bodies such as coastal beaches, foredunes and blowouts are Class 8.*

Table 3.4 Wind erosion LSC classes for the SMUs within the project area

SMUs	Surface soil texture	Wind erodibility class	Wind erosive power	Site exposure	Exposure to wind	Average annual rainfall[1]	Wind Erosion LSC class
Anthroposols							
Sample Site 1	Fine sandy loam	Moderate	Moderate	Lower slope	Low	643.3	2
Sample Site 2	Fine sandy loam	Moderate	Moderate	Lower slope	Low	643.3	2
Sample Site 3	Fine sandy loam	Moderate	Moderate	Lower slope	Low	643.3	2
Sample Site 4	Fine sandy loam	Moderate	Moderate	Mid-slope	Moderate	643.3	3
Sample Site 5	Sandy clay loam	Low	Moderate	Mid-slope	Moderate	643.3	2

4 Assessment of soil structural decline LSC classes

Table 4.1 outlines the assessment table for determining soil structural decline LSC classes. Table 4.2 provides further information on the surface soil properties of clays to be used in collaboration with Table 4.1. Table 4.3 outlines the results table for soil structural decline LSC classes.

Table 4.1 Soil structural decline LSC class assessment table (OEH 2012)

Field texture (surface soils)	Modifier	Outcome - surface soil type	LCS class
Loose sand	Nil	Loose sand	1
Sandy loam	Nil	Fragile light textured surface soil	3
Fine sandy loam	Normal	Fragile light textured soil	3
	High levels of silt and very fine sand (>60%)	Fragile light textured soil – very hardsetting	4
Loam	Normal	Fragile medium textured soil	3
	Friable/ferric[1]	Friable medium textured soils – includes dark, friable loam soils	1
	High levels of silt and very fine sand	Fragile medium textured soil – very hardsetting	4
	Mildly sodic	Mildly sodic loam surface soil	4
	Moderately sodic	Moderately sodic loam surface soil	6
Clay loam	Normal	Fragile medium textured soil	3
	Friable/ferric[1]	Friable clay loam surface soil – includes dark, friable clay loam soils	1
	High levels of silt and very fine sand (>60%)	Fragile medium textured soil – very hardsetting	4
	Mildly sodic	Mildly sodic clay loam surface soil	4
	Moderately sodic	Moderately sodic clay loam surface soil	6
Clay	Friable/ferric[1]	Friable clay surface soil	2
	Strongly self-mulching	Strongly self-mulching surface soil	1
	Weakly self-mulching	Weakly self-mulching surface soil	3
	Mildly sodic	Mildly sodic/coarsely structured clay surface soil	4
	Moderately sodic	Moderately sodic/coarsely structured clay surface soil	6
	Strongly sodic	Strongly sodic surface soil	7
Highly organic soils	Mineral soils with high organic matter[2]	Mineral soils with high organic matter	-[2]
	Organosol/peat soils[3]	Organic/peat soils	7

Notes: *1. The occurrence of friable or ferric surface soils is associated with (a) basaltic or basic parent materials and soils of the Ferrosols groups in the Australian Soil Classification or the Krasnozems and Euchrozem Great Soil Groups, and (b) the dark loam surface soils of the Chernozems and Prairie Soils on alluvial flats.*

2 Loosely defined here as soils with over 8% organic carbon. These soils revert to the LSC class determined by the mineral component of the soils.

3 Organosols have organic material layers over 0.4 m thick with minimum organic carbon of 12% if sands or 18% if clays (Isbell 2002).

Table 4.2 Guidelines for evaluating some surface soil properties of clays

Sodicity/size of soil structural units	Character of surface soil
Very low exchangeable sodium (<3%), high exchangeable calcium, strongly swelling clays (smectitic) as in Vertosols (GSG Black Earths) Peds/aggregates 2–5 mm in an air dry condition	Strongly self-mulching surface soil
Low exchangeable sodium (3–5%), moderate exchangeable calcium, moderately swelling clays (illitic, interstratified, kaolinitic) as in many Dermosols and fertile Chromosols (GSG, Krasnozems, Euchrozems and others) Peds/aggregates 5–10 mm in an air dry condition	Weakly self-mulching surface soil
Moderate levels of exchangeable sodium (5–8%), often moderately low exchangeable calcium relative to exchangeable magnesium (ratio <2:1) Peds/aggregates 10–20 mm in an air dry condition	Mildly sodic surface soils
High levels of exchangeable sodium (8–15%), often low exchangeable calcium relative to exchangeable magnesium (ratio <1:1) Peds/aggregates 20–50 mm in an air dry condition	Moderately sodic surface soils
Very high levels of exchangeable sodium (>15%), often very low exchangeable calcium relative to exchangeable magnesium (ratio <0.5:1) Peds/aggregates >50 mm in an air dry condition	Strongly sodic surface soils

Table 4.3 Soil structural decline LSC classes for the SMU's within the project area

SMU's	Field texture (surface soils)	Modifier	Outcome - surface soil type	Soil structural decline LSC class
Anthroposols				
Sample Site 1	Fine sandy loam	Normal	Fragile light textured surface soil	3
Sample Site 2	Fine sandy loam	Normal	Fragile light textured surface soil	3
Sample Site 3	Fine sandy loam	Normal	Fragile light textured surface soil	3
Sample Site 4	Fine sandy loam	Normal	Fragile light textured surface soil	3
Sample Site 5	Sandy clay loam	Normal	Fragile medium textured surface soil	3

5 Assessment of soil acidification LSC classes

Soil acidification is determined through a combination of buffering capacity of the soil surface, mean annual rainfall and pH of the natural soil surface. Buffering capacity of the soil surface can be determined through three different processes. Using either the Great Soil Group (Table 5.1), the soil surface texture (Table 5.2) or the geology of the area (Table 5.3). Table 5.4 is the assessment table that uses the buffering capacity information to determine the LSC class. Table 5.5 outlines the results table for soil acidification LSC classes.

Table 5.1 Estimating buffering capacity of the soil surface by Great Soil Group (OEH 2012)

Great Soil Group	Buffering capacity of surface soil	Great Soil Group	Buffering capacity of surface soil
Acid Peats	VL	Non-calcic Brown soils	M
Alluvial Soils – Light sandy textured (Sands to Sandy Loams)	L	Peaty Podzols	L
Alluvial Soils – Medium textured (Loams clay loams)	M	Podzols	VL
Alpine Humus soils	M	Prairie Soils	H
Black Earths	VH	Red and Brown Hardpan Soils	H
Brown Earths	M	Red-brown Earths	M
Brown Podzolic Soils	M	Red Earths – less fertile (granites and metasediments)	L
Calcareous Red Earths	H	Red Earths – more fertile (volcanics, granodiorites) or highly structured	M
Calcareous Sands	M	Red Podzolic Soils – less fertile (granites and metasediments)	L
Chernozems	H	Red Podzolic Soils – more fertile (volcanics, granodiorites) or highly structured	M
Chocolate soils	M	Rendzinas	H
Desert Loams	M	Siliceous Sands	VL
Earthy Sands	VL	Solodic soils	L
Euchrozems	H	Solonchaks	H
Gleyed Podzolic Soils	L	Solonetz	M
Grey-brown and Red Calcareous Soils	H	Solonized Brown Soils	M
Grey-brown Podzolic soils	L	Solonized Solonetz	L
Grey, Brown and Red Clays	VH	Soloths	L
Humic Gleys	L	Terra Rossa Soils	M
Humus Podzols	L	Wiesenboden	H
Krasnozems	M	Xanthozems	M
Lateritic Podzolic Soils	L	Yellow Earths	L
Lithosols	VL	Yellow Podzolic Soils – less fertile (granites and metasediments)	L
Neutral to Alkaline Peats	M	Yellow Podzolic Soils – more fertile (volcanics, granodiorites) or highly structured	M

Table 5.2 Estimating buffering capacity of the soil surface by surface soil texture (OEH 2012)

Surface soil texture	Buffering capacity of surface soil
Sands and sandy loams – no calcium carbonate	VL
Sands and sandy loams – with calcium carbonate	M
Fine sandy loams – no calcium carbonate	L
Fine sandy loams – with calcium carbonate	M
Loams and clay loams – no calcium carbonate	M
Loams and clay loams – with calcium carbonate	H
Dark loams and clay loams (e.g. topsoils in Chernozems and Prairie Soils)	H
Clays – no calcium carbonate	H
Clays – with calcium carbonate	VH
Clays – with high shrink–swell	VH

The following textures described in the field survey were not specifically listed in Table 5.2, so the buffering capacity was assumed by using the equivalent clay percentages (as per the standard soil texture triangle). Silty clay loam, sandy clay loam, silty loam, clay loam sandy were assumed to be medium buffering capacity. Loamy sand, clayey sand were assumed to be low buffering capacity.

Table 5.3 Estimating buffering capacity of the soil surface by geology (OEH 2012)

Nature of parent material	Buffering capacity of surface soil
Highly weathered shales and metamorphic rocks, quartzose sandstones – highly siliceous	VL
Siliceous granites, sandstones	VL to L
Intermediate parent materials – granodiorites, less weathered shales and metamorphic rocks, andesites	M
Intermediate to basic rocks and parent materials – basalts, some andesites, gabbros, dolerites	H
Basic to ultrabasic rocks and parent materials – highly mafic or carbonates present, e.g. limestones	VH
Alluvium with high levels of carbonates and clays	H
Alluvium – sandy light textured	L
Alluvium – medium textured	M

Table 5.4 Soil acidification LSC class assessment table (OEH 2012)

Texture/ buffering capacity	pH of the natural surface soil				
	<4.0 (CaCl2) <4.7 (water)	4.0–4.7 (CaCl2) 4.7–5.5 (water)	4.7–6.0 (CaCl2) 5.5–6.7 (water)	6.0–7.5 (CaCl2) 6.7–8.0 (water)	>7.5 (CaCl2) >8.0 (water)
Mean annual rainfall <550 mm					
Very low	6*	5	4	3	n/a
Low	5	5	3	3	n/a
Moderate	5	4	3	2	1
High	4	3	2	1	1
Very high	n/a	n/a	1	1	1
Mean annual rainfall 550–700 mm					
Very low	6*	5	5	4	n/a
Low	5	5	4	3	n/a
Moderate	5	4	3	3	1
High	n/a	n/a	2	2	1
Very high	n/a	n/a	1	1	1
Mean annual rainfall 700–900 mm					
Very low	6*	5	5	4	n/a
Low	6*	5	4	4	n/a
Moderate	5	4	3	3	2
High	n/a	n/a	2	2	1
Very high	n/a	n/a	2	1	1
Mean annual rainfall >900 mm or irrigation					
Very low	6*	5	5*	4	n/a
Low	6*	4	4	3*	n/a
Moderate	5	4	3	3	2
High	5	3	2	2	1
Very high	5	3	2	1	1

Table 5.5 Soil acidification LSC classes for the SMUs within the project area

SMUs	Great Soil Group	Surface soil texture	Geology	Buffering capacity of surface soil	Average annual rainfall[1]	pH of the natural surface soil	Soil acidification LSC class
Anthroposols							
Sample site 1		Fine sandy loam		L	643.3	7.2	3
Sample site 2		Fine sandy loam		L	643.3	7.6	3
Sample site 3		Fine sandy loam		L	643.3	7.4	3
Sample site 4		Fine sandy loam		L	643.3	5.5	5
Sample site 5		Sandy clay loam		L	643.3	7.6	3

6 Assessment of salinity LSC classes

Salinity hazard is determined as a result of recharge potential, discharge potential and salt store. Table 6.1 and Figure 6.1 Table 6.1 summarises the supporting information for decision making, while Table 6.2 is the assessment table for salinity LSC classes. Table 6.3 outlines the results table for salinity LSC classes.

Table 6.1 A summary of salinity LSC notes from OEH 2012

Factor	Notes	Example	Information Source
Recharge potential	Recharge potential is the potential for water from rainfall, irrigation or streams to infiltrate past the plant root zone into the underlying groundwater system. This can occur over a whole landscape, or a component of the landscape, where water readily infiltrates soil, sediment or rock. Typically recharge areas have permeable, shallow and/or stony soils and fractured and/or weathered rock.	Recharge potential is highest where there is high rainfall relative to evaporation, low leaf area and plant water use, low water-holding capacity, and high permeability of the soils, regolith and rocks. Under natural conditions it relates to the climate, land use and hydrological characteristics of the catchment. It is exacerbated by land-use practices that disturb the vegetation cover or soil surface.	The value assigned for recharge potential is a qualitative assessment based on aerial photography, field observation and/or available literature, in particular soil landscape maps and reports.
Discharge potential	Discharge potential is the potential for groundwater to flow from the saturated zone to the land surface. It is a function of position in the landscape, depth to water table, groundwater pressure, soil type, substrate permeability and evapotranspiration. Discharge may occur as leakage to streams, evaporation from shallow water tables, or as springs and wet areas where water tables intersect the land surface or where narrow breaks occur in low permeability layers above confined aquifers.	Discharge potential is highest when recharge rates are greater than the amount of water that leaves the groundwater system through base flow and evapotranspiration. Typical discharge areas are low in the landscape and have high water tables, or higher in the landscape if sub-surface barriers impede groundwater flow.	The value assigned for discharge potential is a qualitative assessment based on aerial photography, field observation and/or available literature, in particular soil landscape maps and reports.
Salt store	**Salt stores** are high for many soils, regolith materials and rock types. This will depend on weathering characteristics, geological structures, rock and soil type, depth of the various materials and salt flux.	It is possible to have areas of low salt store and still have a salinity hazard due to evaporative concentration of salts at the soil surface. Conversely, areas of high salt store can have a lower hazard due to low rainfall. For example, in areas of low rainfall and low slope, salinity hazard can be low.	Figure 7.1 provides a broad indication of salt stores throughout NSW. This map is generalised and local information should be used where available.

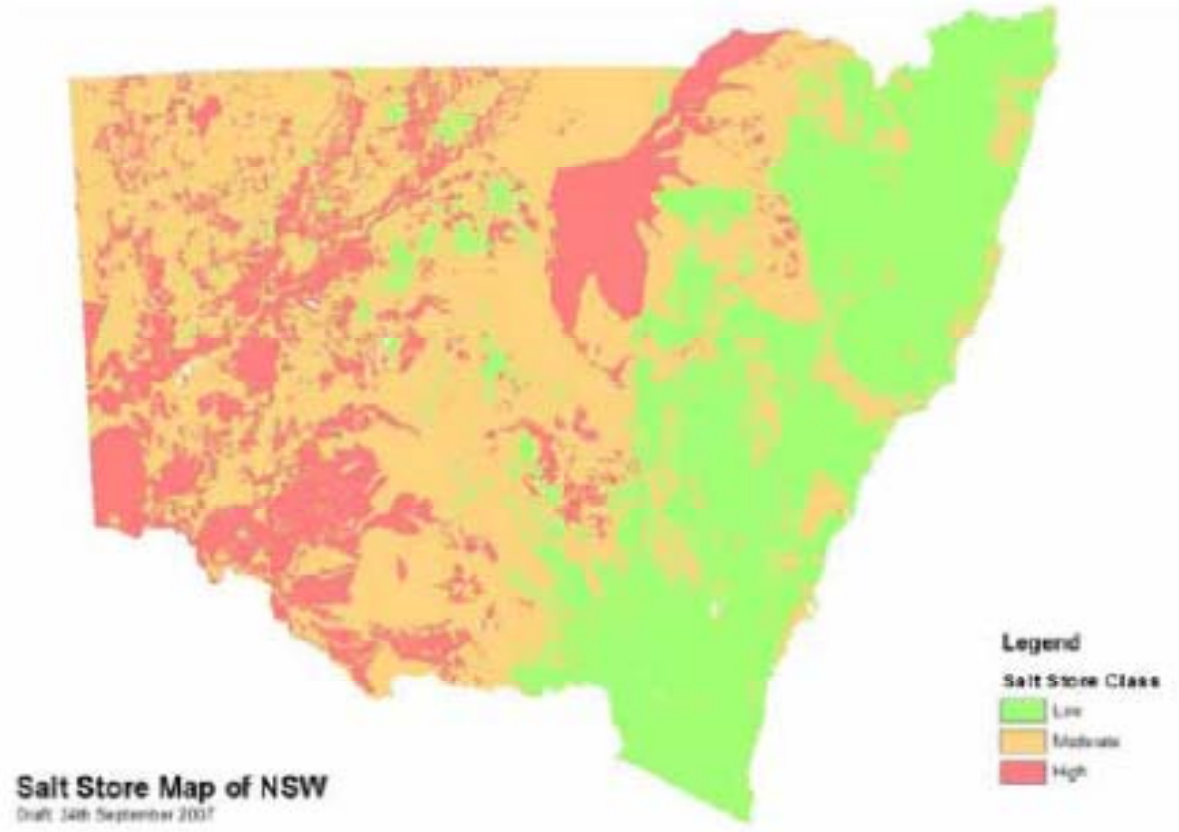


Figure 6.1 Salt store map of NSW (OEH 2012)

Table 6.2 Salinity LSC class assessment table (OEH 2012)

Recharge potential	Discharge potential	Salt store	LSC class
Low	Low	Low	1
		Moderate	3
		High	4
	Moderate	Low	1
		Moderate	4
		High	4
	High	Low	1
		Moderate	4
		High	5
Moderate	Low	Low	1
		Moderate	3
		High	4
	Moderate	Low	2
		Moderate	5
		High	6
	High	Low	1 (3) *
		Moderate	6
		High	6
High	Low	Low	1
		Moderate	4
		High	5
	Moderate	Low	3 (2) *
		Moderate	4
		High	7
	High	Low	2 (3) *
		Moderate	6
		High	7

Note: ** The values in brackets are more accurate and should be used in preference to the original*

Table 6.3 Salinity LSC classes for the SMUs within the project area

SMU	Recharge Potential	Discharge Potential	Salt store	Information sources	Salinity LSC class
Sample site 1	Moderate	Low	High	Salis data cards, lab data, BOM	4
Sample site 2	Moderate	Low	High	Salis data cards, lab data, BOM	4
Sample site 3	Moderate	Low	High	Salis data cards, lab data, BOM	4
Sample site 4	Moderate	Low	High	Salis data cards, lab data, BOM	4
Sample site 5	Moderate	Low	Moderate	Salis data cards, lab data, BOM	3

7 Assessment of waterlogging LSC classes

Table 7.1 outlines the assessment table for determining waterlogging LSC classes and Table 7.2 provides the results.

Table 7.1 Waterlogging LSC class assessment table (OEH 2012)

Typical waterlogging duration (months)	Return period	Typical soil drainage*	LSC class**
0	every year	rapidly drained and well drained	1
0–0.25	every year	moderately well drained	2
0.25–2	every year	imperfectly drained	3
2–3	every 2 to 3 years	imperfectly drained	4
2–3	every year	imperfectly drained	5
>3	every year	poorly drained	6
Almost permanently	every year	very poorly drained	8

Notes: ** NCST (2009, p.202–4).*

*** Based on slope position, climate and length of time soils are wet.*

Table 7.2 Waterlogging LSC classes for the SMUs within the project area

SMUs	Typical waterlogging duration(months)	Return period	Typical soil drainage	Waterlogging LSC class
Anthroposols				
Sample site 1	0	every year	Well drained	1
Sample site 2	0	every year	Well drained	1
Sample site 3	0	every year	Well drained	1
Sample site 4	0	every year	Well drained	1
Sample site 5	0-0.25	every year	Moderately well drained	2

8 Assessment of shallow soils and rockiness LSC classes

Table 8.1 outlines the assessment table for determining shallow soils and rockiness LSC classes and Table 8.2 provides the results.

Table 8.1 Shallow soils and rockiness LSC class assessment table (OEH 2012)

Rocky outcrop (% coverage)*	Soil depth (cm)	LSC class**
Nil	>100	1
<30 (localised*)	>100	2
	75– <100	3
	50– <75	4
	25– <50	6
	0– <25	7
30–50 (widespread*)	>100	4
	75–100	5
	25–75	6
	<25	7
50–70 (widespread*)	>100	6
	50–100	6
	25– <50	7
	<25	7
>70	n/a	8

Notes: ** Rock outcrop limitation from soil landscape report.*

*** Based on rocky outcrop and soil depth*

Table 8.2 Shallow soils and rockiness LSC classes for each soil type

SMUs	Rocky outcrop (% coverage)	Soil depth (cm)	Shallow soils and rockiness LSC class
Anthroposols			
Sample site 1	Nil	25-<50	6
Sample site 2	Nil	25-<50	6
Sample site 3	Nil	25-<50	6
Sample site 4	Nil	25-<50	6
Sample site 5	Nil	50-<75	4

9 Assessment of mass movement LSC classes

Table 9.1 outlines the assessment table for determining mass movement LSC classes and Table 9.2 provides the results.

Table 9.1 Mass movement LSC class assessment table (OEH 2012)

Mean annual rainfall (mm)	Mass movement present	Slope class (%)	LSC class
<500	No	n/a	1
	Yes	n/a	8
>500	No	n/a	1
	Yes	<20	6
		>20–50	7
		50 or any scree or talus slope	8

Note: scree or talus slopes go automatically into Class 8

Table 9.2 Mass movement LSC classes for the SMUs within the project area

SMUs	Mean annual rainfall (mm)	Mass movement present	Slope class (%)	Mass movement LSC class
Anthroposols				
Sample site 1	643.3	No	n/a	1
Sample site 2	643.3	No	n/a	1
Sample site 3	643.3	No	n/a	1
Sample site 4	643.3	No	n/a	1
Sample site 5	643.3	No	n/a	1

10 Assessment of LSC classes for soil management units

Table 10.1 below is a summary table of soil management units (SMU), LSC classes of each element and the overall LSC classes for each SMU. The Anthroposols all fall into a land and soil classification of 6. Table 10.1 shows the coverage of LSC classes across the project area in accordance with the spatial distribution of the SMUs.

Table 10.1 Summary of LSC classes across the project area

SMUs	Water Erosion LSC class	Wind Erosion LSC class	Soil structural decline LSC class	Soil acidification LSC class	Salinity LSC class	Waterlogging LSC class	Shallow soils and rockiness LSC class	Mass movement LSC class	SMULSC class
Anthroposols									
Sample site 1	6	2	3	3	4	1	6	1	6
Sample site 2	6	2	3	3	4	1	6	1	6
Sample site 3	6	2	3	3	4	1	6	1	6
Sample site 4	6	3	3	5	4	1	6	1	6
Sample site 5	6	2	3	3	3	2	4	1	6

11 Conclusion

The assessment of the land and soil capability classes for the project and each soil management unit was conducted in accordance with the requirements of the *Land and soil capability assessment scheme* (OEH 2012). The assessment found that the project area is identified as Class 6 capability land. These soils are most suited for grazing, forestry and nature conservation. Sites 1-4 received the Class 6 rating based on the water erosion and the rockiness and/or shallowness of the soils classification. Site 5 received the Class 6 rating solely due to the water erosion classification.

Table 11.1 Land and soil capability classes in the project area

Class	Capability	General definition[1]	Land in the project area
Land capable of a wide variety of land uses (cropping, grazing, horticulture, forestry, nature conservation)			
1	Extremely high	Land has no limitations. No special land management practices required. Capable of all rural land uses and land management practices.	None
2	Very high	Land has slight limitations. Land is capable of most land uses and land management practices, including intensive cropping with cultivation.	None
3	High	Land has moderate limitations and is capable of sustaining high-impact land uses, such as cropping with cultivation. However, careful management of limitations is required for cropping and intensive grazing to avoid land and environmental degradation.	None
Land capable of a variety of land uses (cropping with restricted cultivation, pasture cropping, grazing, some horticulture, forestry, nature conservation)			
4	Moderate	Moderate to high limitations for high-impact land uses. It will restrict land management options for regular high-impact land uses such as cropping, high-intensity grazing and horticulture; and the limitations can only be managed by specialised management practices with a high level of knowledge, expertise, inputs, investment and technology	None
5	Moderate-low	High limitations for high-impact land uses. Will largely restrict land use to grazing, some horticulture (orchards), forestry and nature conservation. The limitations need to be carefully managed to prevent long-term degradation.	None
Land capable for a limited set of land uses (grazing, forestry and nature conservation)			
6	Low	Very high limitations for high-impact land uses and is generally suitable for limited land uses such as grazing, forestry and nature conservation. Careful management of limitations is required to prevent severe land and environmental degradation.	Anthroposols
Land generally incapable of agricultural land use (selective forestry and nature conservation)			
7	Very low	Severe limitations that restrict most land uses and generally cannot be overcome. Generally suitable only for selective forestry and nature conservation.	None
8	Extremely low	Limitations are so severe that the land is incapable of sustaining any land use apart from nature conservation.	None

Notes: 1.modified description from OEH 2012.

References

Australian Bureau of Meteorology http://www.bom.gov.au/climate/data/ (visited 07 March 2016)

Department of Environment and Heritage (2012) *Land and soil capability assessment scheme.* NSW government.

Appendix B

Assessing soil texture

Texture	Behaviour of moist bolus	Approx clay %
SAND	Coherence nil to very slight; cannot be moulded; single sand grains adhere to fingers.	less than 5 %
LOAMY SAND	Slight coherence; can be sheared between thumb and forefinger to give minimal ribbon of about 5mm.	about 5 %
CLAYEY SAND	Slight coherence; sticky when wet; many sand grains stick to fingers; will form minimal ribbon of 5 - 15 mm. Discolours fingers with clay stain.	5-10 %
SANDY LOAM	Bolus just coherent but very sandy to touch; will form ribbon 15-25 mm; dominant sand grains are medium size and readily visible.	10-20 %
FINE SANDY LOAM	Bolus coherent; fine sand can be felt and heard when manipulated; will form ribbon of 15-25 mm; sand grains are clearly evident under a hand lens.	10-20 %
LIGHT SANDY CLAY LOAM	Bolus strongly coherent but sandy to touch; sand grains dominantly medium size and easily visible; will form ribbon of 20-25 mm.	15-20 %
LOAM	Bolus coherent and rather spongy; smooth feel when manipulated but with no obvious sandiness or 'silkiness'; may be somewhat greasy to the touch if much organic matter present; will form ribbon about 25 mm	about 25 %
LOAM, FINE SANDY	Bolus coherent and slightly spongy; fine sand can be felt and heard when manipulated; will form ribbon about 25 mm.	about 25 %
SILTY LOAM	Coherent bolus, very smooth and silky; will form ribbon about 25 mm	about 25 % & silt >25 %
SANDY CLAY LOAM	Strongly coherent bolus sandy to touch; medium size sand grains visible in a finer matrix; will form ribbon of 25-40 mm.	20-30 %
CLAY LOAM	Coherent plastic bolus; will form ribbon of 40-50 mm.	30-35 %
CLAY LOAM, SANDY	Coherent plastic bolus; medium size sand grains visible in finer matrix; will form ribbon of 40-50 mm.	30-35 %
SILTY CLAY LOAM	Coherent smooth bolus; plastic and often silky to the touch; will form ribbon of 40-50 mm.	30-35 % & silt >25 %
FINE SANDY CLAY LOAM	Coherent bolus; fine sand can be felt and heard when manipulated; will form ribbon of 40-50 mm.	30-35 %
SANDY CLAY	Plastic bolus; fine to medium sand can be seen, felt or heard in clayey matrix; will form ribbon of 50-75 mm.	35-40 %
SILTY CLAY	Plastic bolus; smooth and silky to manipulate; ribbon 50-75 mm	35-40 % & silt >25 %
LIGHT CLAY	Plastic bolus; smooth to touch; slight resistance to ribbon shearing between thumb and forefinger; will form ribbon of 50-75 mm	35-40 %
LIGHT MEDIUM CLAY	Plastic bolus; smooth to touch; slight to moderate resistance to ribboning shear (greater than for light clay); will form ribbon of about 75 mm.	40-45 %
MEDIUM CLAY	Smooth plastic bolus; handles like plasticine; can be moulded into rods without fracture; has moderate resistance to ribboning shear; will form ribbon of 75 mm or more.	45-55 %
MEDIUM HEAVY CLAY	Smooth plastic bolus; handles like plasticine; can be moulded into rods without fracture; has moderate to firm resistance to ribboning shear; will form ribbon of 75 mm or more.	>50 %
HEAVY CLAY	Smooth plastic bolus; handles like stiff plasticine; can be moulded into rods without fracture; has firm resistance to ribboning shear; will form ribbon of 75 mm or more.	>50 %

(DPI 2015)

Appendix C

Soil test results

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1604773**	Page	: 1 of 12
Amendment	: **1**		
Client	: **EMGA MITCHELL MCLENNAN**	Laboratory	: Environmental Division Brisbane
Contact	: NICOLE ARMIT	Contact	: Customer Services EB
Address	: 1/4 87 WICKHAM TERRACE SPRING HILL QLD 4000	Address	: 2 Byth Street Stafford QLD Australia 4053
E-mail	: narmit@emmconsulting.com.au	E-mail	: ALSEnviro.Brisbane@alsglobal.com
Telephone	: 07 4927 0506	Telephone	: +61-7-3243 7222
Facsimile	: 07 3839 1866	Facsimile	: +61-7-3243 7218
Project	: Muswellbrook Coal Continuation Project	QC Level	: NEPM 2013 B3 & ALS QC Standard
Order number	: ----	Date Samples Received	: 23-Feb-2016 14:45
C-O-C number	: ----	Date Analysis Commenced	: 24-Feb-2016
Sampler	: N JAMSON	Issue Date	: 07-Mar-2016 15:50
Site	: ----		
		No. of samples received	: 21
Quote number	: ----	No. of samples analysed	: 21

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

NATA Accredited Laboratory 825

Accredited for compliance with ISO/IEC 17025.

Signatories

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

Signatories	*Position*	*Accreditation Category*
Greg Vogel	Laboratory Manager	Brisbane Acid Sulphate Soils, Stafford, QLD
Greg Vogel	Laboratory Manager	Brisbane Inorganics, 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.

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.

- ED006 Exchangeable Cations (Calcium/Magnesium Ratio): Results could not be calculated for samples EB1604773-007, 016, 018, 019 and 020 as the required Calcium or Magnesium analytes were less than reportable limits.
- AMENDMENT 7/3/16: This report has been amended following the identification of an error in the LIMS quoting or reporting setup for this test. The quality system is being utilised to resolve this issue. ED008 (Exchangeable Cations) results have now been reported for sample 'Site 1 - 10-25cm'.
- 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	Site 1 - 0.10cm	Site 1 - 10-25cm	Site 2 - 0-10cm	Site 2 10-20cm	Site 2 20.30cm
			Client sampling date / time	[18-Feb-2016]	[18-Feb-2016]	[18-Feb-2016]	[18-Feb-2016]	[18-Feb-2016]
Compound	CAS Number	LOR	Unit	EB1604773-001	EB1604773-002	EB1604773-003	EB1604773-004	EB1604773-005
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	7.2	7.3	7.6	7.3	7.4
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	835	1700	3050	2950	3330
EA055: Moisture Content								
Moisture Content (dried @ 103°C)	----	1	%	2.0	2.8	4.7	6.8	6.2
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	----	----	----	----	----
Exchangeable Aluminium	----	0.1	meq/100g	----	----	----	----	----
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.2	meq/100g	----	----	4.8	----	4.5
Exchangeable Magnesium	----	0.2	meq/100g	----	----	3.0	----	2.6
Exchangeable Potassium	----	0.2	meq/100g	----	----	<0.2	----	<0.2
Exchangeable Sodium	----	0.2	meq/100g	----	----	<0.2	----	<0.2
Cation Exchange Capacity	----	0.2	meq/100g	----	----	7.8	----	7.1
Exchangeable Sodium Percent	----	0.2	%	----	----	<0.2	----	<0.2
Calcium/Magnesium Ratio	----	0.2	-	----	----	1.6	----	1.7
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	13.4	12.9	----	26.1	----
Exchangeable Magnesium	----	0.1	meq/100g	1.5	1.3	----	3.1	----
Exchangeable Potassium	----	0.1	meq/100g	0.2	0.2	----	0.2	----
Exchangeable Sodium	----	0.1	meq/100g	<0.1	<0.1	----	0.3	----
Exchangeable Aluminium	----	0.1	meq/100g	0.1	<0.1	----	0.2	----
Cation Exchange Capacity	----	0.1	meq/100g	15.4	14.5	----	29.9	----
Exchangeable Sodium Percent	----	0.1	%	0.6	0.6	----	1.0	----
Calcium/Magnesium Ratio	----	0.1	-	8.9	9.9	----	8.4	----
ED037: Alkalinity								
Total Alkalinity as CaCO3	----	1	mg/kg	1140	788	1140	875	962
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/kg	1140	788	1140	875	962
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	2700	6260	12900	13400	14400
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	2.1	0.6	0.4	0.3	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	Site 1 - 0.10cm	Site 1 - 10-25cm	Site 2 - 0-10cm	Site 2 10-20cm	Site 2 20.30cm
				Client sampling date / time	[18-Feb-2016]	[18-Feb-2016]	[18-Feb-2016]	[18-Feb-2016]	[18-Feb-2016]
Compound	CAS Number	LOR	Unit		EB1604773-001	EB1604773-002	EB1604773-003	EB1604773-004	EB1604773-005
					Result	Result	Result	Result	Result
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser - Continued									
Total Kjeldahl Nitrogen as N	----	20	mg/kg		1610	910	540	590	----
EK062: Total Nitrogen as N (TKN + NOx)									
^ Total Nitrogen as N	----	20	mg/kg		1610	910	540	590	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	2	mg/kg		633	532	390	338	----
EK080: Bicarbonate Extractable Phosphorus (Colwell)									
Bicarbonate Ext. P (Colwell)	----	5	mg/kg		82	46	18	15	----
EP004: Organic Matter									
Organic Matter	----	0.5	%		5.4	2.8	2.6	2.8	2.2

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	Site 3 30-45cm	Site 3 - 0.10cm	Site 3 - 10.20cm	Site 3 - 20.30cm	Site 3 - 30.40cm
			Client sampling date / time	[18-Feb-2016]	[18-Feb-2016]	[18-Feb-2016]	[18-Feb-2016]	[18-Feb-2016]
Compound	CAS Number	LOR	Unit	EB1604773-006	EB1604773-007	EB1604773-008	EB1604773-009	EB1604773-010
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	7.5	7.4	7.1	7.1	7.2
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	3180	77	824	1210	1880
EA055: Moisture Content								
Moisture Content (dried @ 103°C)	----	1	%	7.7	2.2	3.3	4.8	4.1
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	----	----	----	----	----
Exchangeable Aluminium	----	0.1	meq/100g	----	----	----	----	----
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.2	meq/100g	4.0	3.1	----	----	----
Exchangeable Magnesium	----	0.2	meq/100g	2.4	<0.2	----	----	----
Exchangeable Potassium	----	0.2	meq/100g	<0.2	<0.2	----	----	----
Exchangeable Sodium	----	0.2	meq/100g	<0.2	<0.2	----	----	----
Cation Exchange Capacity	----	0.2	meq/100g	6.4	3.1	----	----	----
Exchangeable Sodium Percent	----	0.2	%	<0.2	<0.2	----	----	----
Calcium/Magnesium Ratio	----	0.2	-	1.7	----	----	----	----
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	----	----	8.3	10.6	13.5
Exchangeable Magnesium	----	0.1	meq/100g	----	----	0.5	0.6	1.0
Exchangeable Potassium	----	0.1	meq/100g	----	----	0.1	0.1	0.1
Exchangeable Sodium	----	0.1	meq/100g	----	----	<0.1	0.1	<0.1
Exchangeable Aluminium	----	0.1	meq/100g	----	----	0.3	0.2	0.4
Cation Exchange Capacity	----	0.1	meq/100g	----	----	9.4	11.7	15.0
Exchangeable Sodium Percent	----	0.1	%	----	----	0.9	1.1	0.6
Calcium/Magnesium Ratio	----	0.1	-	----	----	16.6	17.7	13.5
ED037: Alkalinity								
Total Alkalinity as CaCO3	----	1	mg/kg	1050	306	508	438	464
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/kg	1050	306	508	438	464
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	14300	80	2320	4050	7240
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	----	0.1	<0.1	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	Site 3 30-45cm	Site 3 - 0.10cm	Site 3 - 10.20cm	Site 3 - 20.30cm	Site 3 - 30.40cm
				Client sampling date / time	[18-Feb-2016]	[18-Feb-2016]	[18-Feb-2016]	[18-Feb-2016]	[18-Feb-2016]
Compound	CAS Number	LOR	Unit		EB1604773-006	EB1604773-007	EB1604773-008	EB1604773-009	EB1604773-010
					Result	Result	Result	Result	Result
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser - Continued									
Total Kjeldahl Nitrogen as N	----	20	mg/kg		----	440	360	----	----
EK062: Total Nitrogen as N (TKN + NOx)									
^ Total Nitrogen as N	----	20	mg/kg		----	440	360	----	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	2	mg/kg		----	237	277	----	----
EK080: Bicarbonate Extractable Phosphorus (Colwell)									
Bicarbonate Ext. P (Colwell)	----	5	mg/kg		----	8	9	----	----
EP004: Organic Matter									
Organic Matter	----	0.5	%		1.8	1.5	1.6	1.4	2.0

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	Site 4 - 0.10cm	Site 4 - 10-20cm	Site 4 - 20.35cm	Site 5 - 0.10cm	Site 5 - 10-20cm
			Client sampling date / time	[18-Feb-2016]	[18-Feb-2016]	[18-Feb-2016]	[18-Feb-2016]	[18-Feb-2016]
Compound	CAS Number	LOR	Unit	EB1604773-011	EB1604773-012	EB1604773-013	EB1604773-014	EB1604773-015
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	5.5	5.4	5.5	7.6	7.8
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	1970	2060	1620	161	286
EA055: Moisture Content								
Moisture Content (dried @ 103°C)	----	1	%	4.6	3.6	4.0	3.2	3.6
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	<0.1	<0.1	<0.1	----	----
Exchangeable Aluminium	----	0.1	meq/100g	<0.1	<0.1	<0.1	----	----
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.2	meq/100g	----	----	----	3.0	3.3
Exchangeable Magnesium	----	0.2	meq/100g	----	----	----	1.0	1.1
Exchangeable Potassium	----	0.2	meq/100g	----	----	----	<0.2	<0.2
Exchangeable Sodium	----	0.2	meq/100g	----	----	----	<0.2	<0.2
Cation Exchange Capacity	----	0.2	meq/100g	----	----	----	4.0	4.5
Exchangeable Sodium Percent	----	0.2	%	----	----	----	<0.2	<0.2
Calcium/Magnesium Ratio	----	0.2	-	----	----	----	2.8	2.9
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	14.7	17.2	12.0	----	----
Exchangeable Magnesium	----	0.1	meq/100g	0.8	0.8	1.0	----	----
Exchangeable Potassium	----	0.1	meq/100g	0.1	0.1	0.1	----	----
Exchangeable Sodium	----	0.1	meq/100g	<0.1	<0.1	<0.1	----	----
Exchangeable Aluminium	----	0.1	meq/100g	0.4	0.2	0.2	----	----
Cation Exchange Capacity	----	0.1	meq/100g	16.1	18.5	13.5	----	----
Exchangeable Sodium Percent	----	0.1	%	0.6	0.5	0.7	----	----
Calcium/Magnesium Ratio	----	0.1	-	18.4	21.5	12.0	----	----
ED037: Alkalinity								
Total Alkalinity as CaCO3	----	1	mg/kg	88	96	122	735	700
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/kg	88	96	122	735	700
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	8000	8360	6210	230	540
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	<0.1	<0.1	----	1.3	0.3
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	Site 4 - 0.10cm	Site 4 - 10-20cm	Site 4 - 20.35cm	Site 5 - 0.10cm	Site 5 - 10-20cm
				Client sampling date / time	[18-Feb-2016]	[18-Feb-2016]	[18-Feb-2016]	[18-Feb-2016]	[18-Feb-2016]
Compound	CAS Number	LOR	Unit		EB1604773-011	EB1604773-012	EB1604773-013	EB1604773-014	EB1604773-015
					Result	Result	Result	Result	Result
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser - Continued									
Total Kjeldahl Nitrogen as N	----	20	mg/kg		240	250	----	550	560
EK062: Total Nitrogen as N (TKN + NOx)									
^ Total Nitrogen as N	----	20	mg/kg		240	250	----	550	560
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	2	mg/kg		420	397	----	309	292
EK080: Bicarbonate Extractable Phosphorus (Colwell)									
Bicarbonate Ext. P (Colwell)	----	5	mg/kg		30	32	----	9	8
EP004: Organic Matter									
Organic Matter	----	0.5	%		1.4	1.2	<0.5	2.1	1.8

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	Site - 20-30cm	Site 5 - 30-40cm	Site 5 - 40-50cm	Site 5 - 50-60cm	Site 5 - 60-70cm
			Client sampling date / time	[18-Feb-2016]	[18-Feb-2016]	[18-Feb-2016]	[18-Feb-2016]	[18-Feb-2016]
Compound	CAS Number	LOR	Unit	EB1604773-016	EB1604773-017	EB1604773-018	EB1604773-019	EB1604773-020
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	7.8	7.8	7.9	7.9	7.8
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	338	398	373	184	186
EA055: Moisture Content								
Moisture Content (dried @ 103°C)	----	1	%	2.5	2.6	2.8	1.8	1.8
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	----	----	----	----	----
Exchangeable Aluminium	----	0.1	meq/100g	----	----	----	----	----
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.2	meq/100g	2.6	3.0	2.9	2.0	1.9
Exchangeable Magnesium	----	0.2	meq/100g	<0.2	0.9	<0.2	<0.2	<0.2
Exchangeable Potassium	----	0.2	meq/100g	<0.2	<0.2	<0.2	<0.2	<0.2
Exchangeable Sodium	----	0.2	meq/100g	<0.2	<0.2	<0.2	<0.2	<0.2
Cation Exchange Capacity	----	0.2	meq/100g	2.6	3.9	2.9	2.0	1.9
Exchangeable Sodium Percent	----	0.2	%	<0.2	<0.2	<0.2	<0.2	<0.2
Calcium/Magnesium Ratio	----	0.2	-	----	3.4	----	----	----
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	----	----	----	----	----
Exchangeable Magnesium	----	0.1	meq/100g	----	----	----	----	----
Exchangeable Potassium	----	0.1	meq/100g	----	----	----	----	----
Exchangeable Sodium	----	0.1	meq/100g	----	----	----	----	----
Exchangeable Aluminium	----	0.1	meq/100g	----	----	----	----	----
Cation Exchange Capacity	----	0.1	meq/100g	----	----	----	----	----
Exchangeable Sodium Percent	----	0.1	%	----	----	----	----	----
Calcium/Magnesium Ratio	----	0.1	-	----	----	----	----	----
ED037: Alkalinity								
Total Alkalinity as CaCO3	----	1	mg/kg	586	516	464	542	289
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/kg	586	516	464	542	289
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	720	900	830	310	360
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	----	----	----	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	Site - 20-30cm	Site 5 - 30-40cm	Site 5 - 40-50cm	Site 5 - 50-60cm	Site 5 - 60-70cm
				Client sampling date / time	[18-Feb-2016]	[18-Feb-2016]	[18-Feb-2016]	[18-Feb-2016]	[18-Feb-2016]
Compound	CAS Number	LOR	Unit		EB1604773-016	EB1604773-017	EB1604773-018	EB1604773-019	EB1604773-020
					Result	Result	Result	Result	Result
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser - Continued									
Total Kjeldahl Nitrogen as N	----	20	mg/kg		----	----	----	----	----
EK062: Total Nitrogen as N (TKN + NOx)									
^ Total Nitrogen as N	----	20	mg/kg		----	----	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	2	mg/kg		----	----	----	----	----
EK080: Bicarbonate Extractable Phosphorus (Colwell)									
Bicarbonate Ext. P (Colwell)	----	5	mg/kg		----	----	----	----	----
EP004: Organic Matter									
Organic Matter	----	0.5	%		1.6	1.6	2.0	1.1	1.1

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	UNDIST Site - 0-10cm	----	----	----	----
			Client sampling date / time	[18-Feb-2016]	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1604773-021	--------	--------	--------	--------
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	**7.7**	----	----	----	----
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	**49**	----	----	----	----
EA055: Moisture Content								
Moisture Content (dried @ 103°C)	----	1	%	**3.5**	----	----	----	----
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	----	----	----	----	----
Exchangeable Aluminium	----	0.1	meq/100g	----	----	----	----	----
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.2	meq/100g	**3.2**	----	----	----	----
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	**4.2**	----	----	----	----
Exchangeable Sodium Percent	----	0.2	%	<0.2	----	----	----	----
Calcium/Magnesium Ratio	----	0.2	-	**3.2**	----	----	----	----
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	----	----	----	----	----
Exchangeable Magnesium	----	0.1	meq/100g	----	----	----	----	----
Exchangeable Potassium	----	0.1	meq/100g	----	----	----	----	----
Exchangeable Sodium	----	0.1	meq/100g	----	----	----	----	----
Exchangeable Aluminium	----	0.1	meq/100g	----	----	----	----	----
Cation Exchange Capacity	----	0.1	meq/100g	----	----	----	----	----
Exchangeable Sodium Percent	----	0.1	%	----	----	----	----	----
Calcium/Magnesium Ratio	----	0.1	-	----	----	----	----	----
ED037: Alkalinity								
Total Alkalinity as CaCO3	----	1	mg/kg	**709**	----	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/kg	**709**	----	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/kg	<5	----	----	----	----
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	**40**	----	----	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	**0.1**	----	----	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	UNDIST Site - 0-10cm	----	----	----	----
				Client sampling date / time	[18-Feb-2016]	----	----	----	----
Compound	CAS Number	LOR	Unit		EB1604773-021	--------	--------	--------	--------
					Result	Result	Result	Result	Result
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser - Continued									
Total Kjeldahl Nitrogen as N	----	20	mg/kg		**860**	----	----	----	----
EK062: Total Nitrogen as N (TKN + NOx)									
^ **Total Nitrogen as N**	----	20	mg/kg		**860**	----	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	2	mg/kg		**223**	----	----	----	----
EK080: Bicarbonate Extractable Phosphorus (Colwell)									
Bicarbonate Ext. P (Colwell)	----	5	mg/kg		**11**	----	----	----	----
EP004: Organic Matter									
Organic Matter	----	0.5	%		**2.7**	----	----	----	----

Appendix D

Interpreting geochemistry

D.1 Acid base accounting

The acid base account involves static laboratory procedures that evaluate the balance between acid generating processes (oxidation of sulfide minerals) and acid neutralising processes (dissolution of alkaline carbonates, displacement of exchangeable bases, and weathering of silicates).

The values arising from the acid base account are referred to as the maximum potential acidity (MPA) and the acid neutralising potential (ANP). The difference between the MPA and the ANC is referred to as the net acid producing potential (NAPP).

Table D.1 summarises the main static tests used to calculate the acid base account and their reason for inclusion in the EGi (1998) study.

Table D.1 Acid base account testing

Test	Reason for inclusion
Total sulfur	Used to calculate maximum potential acidity.
Acid neutralising capacity (ANC)	Potential neutralising agents such as carbonates that maybe available to reduce the total acid balance.

The use of Total Sulfur as a measure of maximum potential acidity (MPA) may not be a conservative measure as Total S comprises both unoxidised sulfide and oxidised sulfate salt.

D.2 Calculations

$$\%Sulfate\ Sulfur = \frac{Sulfate\ sulfur\ (mg/kg)}{10{,}000} \quad [1]$$

$$Sulfide\ sulfur = Total\ sulfur(\%) - Sulfate\ sulfur\ (\%) \quad [2]$$

$$MPA\ (tH2\ \ SO_4) = Sulfide(\%) \times 30.59 \quad [3]$$

$$MPA\ (tCaCCO_3) = Sulfide(\%) \times 31.25 \quad [4]$$

Appendix E

Geochemistry test results

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1600423**	Page	: 1 of 18
Client	: **CARBON BASED ENVIRONMENTAL**	Laboratory	: Environmental Division Brisbane
Contact	: MR COLIN DAVIES (cbased)	Contact	: Customer Services EB
Address	: 47 BOOMERANG ST CESSNOCK NSW, AUSTRALIA 2325	Address	: 2 Byth Street Stafford QLD Australia 4053
E-mail	: cbased@bigpond.com	E-mail	: ALSEnviro.Brisbane@alsglobal.com
Telephone	: +61 49904443	Telephone	: +61-7-3243 7222
Facsimile	: +61 02 49904442	Facsimile	: +61-7-3243 7218
Project	: MCC Geochemical	QC Level	: NEPM 2013 B3 & ALS QC Standard
Order number	: ----	Date Samples Received	: 12-Jan-2016 12:25
C-O-C number	: ----	Date Analysis Commenced	: 20-Jan-2016
Sampler	: ----	Issue Date	: 28-Jan-2016 07:34
Site	:		
		No. of samples received	: 79
Quote number	: ----	No. of samples analysed	: 79

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

NATA Accredited Laboratory 825

Accredited for compliance with ISO/IEC 17025.

WORLD RECOGNISED ACCREDITATION

Signatories

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

Signatories	*Position*	*Accreditation Category*
Ben Felgendrejeris		Brisbane Acid Sulphate Soils, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

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

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

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

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

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.

- ASS: EA013 (ANC) Fizz Rating: 0- None; 1- Slight; 2- Moderate; 3- Strong; 4- Very Strong; 5- Lime.

Analytical Results

Sub-Matrix: ROCK (Matrix: SOIL)			Client sample ID	MCC7786	MCC7787	MCC7788	MCC7789	MCC7802
			Client sampling date / time	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]
Compound	CAS Number	LOR	Unit	EB1600423-001	EB1600423-002	EB1600423-003	EB1600423-004	EB1600423-005
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	**7.9**	**7.4**	**5.9**	**7.5**	**8.4**
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	**200**	**260**	**993**	**214**	**189**
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	**32.1**	**2.8**	**15.4**	**5.7**	**183**
ANC as CaCO3	----	0.1	% CaCO3	**3.3**	**0.3**	**1.6**	**0.6**	**18.6**
Fizz Rating	----	0	Fizz Unit	**1**	**0**	**1**	**0**	**3**
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	**0.02**	**0.05**	**0.08**	**0.58**	**0.02**

Analytical Results

Sub-Matrix: ROCK (Matrix: SOIL)			Client sample ID	MCC7803	MCC7804	MCC7805	MCC7806	MCC7807
			Client sampling date / time	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]
Compound	CAS Number	LOR	Unit	EB1600423-006	EB1600423-007	EB1600423-008	EB1600423-009	EB1600423-010
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	7.8	8.3	8.7	4.9	8.0
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	1090	638	413	1400	278
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	276	78.5	264	6.3	28.6
ANC as CaCO3	----	0.1	% CaCO3	28.2	8.0	27.0	0.6	2.9
Fizz Rating	----	0	Fizz Unit	4	2	3	0	1
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.13	0.07	0.19	1.57	0.06

Analytical Results

Sub-Matrix: ROCK (Matrix: SOIL)			Client sample ID	MCC7808	MCC7809	MCC7810	MCC7811	MCC7812
			Client sampling date / time	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]
Compound	CAS Number	LOR	Unit	EB1600423-011	EB1600423-012	EB1600423-013	EB1600423-014	EB1600423-015
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	7.8	7.6	7.6	7.9	6.7
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	242	233	192	360	671
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	69.5	3.2	3.4	11.2	19.6
ANC as CaCO3	----	0.1	% CaCO3	7.1	0.3	0.4	1.1	2.0
Fizz Rating	----	0	Fizz Unit	2	0	0	1	1
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.04	0.05	0.04	0.03	0.08

Analytical Results

Sub-Matrix: ROCK (Matrix: SOIL)			Client sample ID	MCC7814	MCC7815	MCC7816	MCC7817	MCC7818
			Client sampling date / time	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]
Compound	CAS Number	LOR	Unit	EB1600423-016	EB1600423-017	EB1600423-018	EB1600423-019	EB1600423-020
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	7.8	7.2	8.1	6.8	3.4
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	130	166	283	567	1560
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	2.8	4.3	35.9	3.0	2.6
ANC as CaCO3	----	0.1	% CaCO3	0.3	0.4	3.6	0.3	0.3
Fizz Rating	----	0	Fizz Unit	0	0	1	0	0
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.05	0.04	0.06	0.23	0.22

Analytical Results

Sub-Matrix: ROCK (Matrix: SOIL)			Client sample ID	MCC7819	MCC7820	MCC7821	MCC7822	MCC7823
			Client sampling date / time	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]
Compound	CAS Number	LOR	Unit	EB1600423-021	EB1600423-022	EB1600423-023	EB1600423-024	EB1600423-025
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	**7.0**	**7.2**	**5.8**	**7.1**	**8.0**
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	**199**	**166**	**2180**	**1350**	**343**
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	**11.0**	**3.0**	**21.9**	**20.0**	**62.2**
ANC as CaCO3	----	0.1	% CaCO3	**1.1**	**0.3**	**2.2**	**2.0**	**6.3**
Fizz Rating	----	0	Fizz Unit	**1**	**0**	**1**	**1**	**2**
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	**0.05**	**0.05**	**0.60**	**0.31**	**0.26**

Analytical Results

Sub-Matrix: ROCK (Matrix: SOIL)			Client sample ID	MCC7824	MCC7825	MCC7826	MCC7827	MCC7828
			Client sampling date / time	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]
Compound	CAS Number	LOR	Unit	EB1600423-026	EB1600423-027	EB1600423-028	EB1600423-029	EB1600423-030
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	**7.8**	**8.3**	**7.0**	**7.9**	**7.2**
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	**748**	**407**	**565**	**204**	**559**
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	**33.9**	**96.9**	**4.8**	**4.8**	**4.3**
ANC as CaCO3	----	0.1	% CaCO3	**3.4**	**9.9**	**0.5**	**0.5**	**0.4**
Fizz Rating	----	0	Fizz Unit	**1**	**2**	**0**	**0**	**0**
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	**0.23**	**0.03**	**0.15**	**0.03**	**0.07**

Analytical Results

Sub-Matrix: ROCK (Matrix: SOIL)			Client sample ID	MCC7829	MCC7830	MCC7831	MCC7832	MCC7833
			Client sampling date / time	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]
Compound	CAS Number	LOR	Unit	EB1600423-031	EB1600423-032	EB1600423-033	EB1600423-034	EB1600423-035
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	**7.4**	**7.9**	**7.5**	**7.8**	**8.3**
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	**220**	**209**	**305**	**140**	**150**
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	**5.7**	**172**	**7.8**	**3.4**	**107**
ANC as CaCO3	----	0.1	% CaCO3	**0.6**	**17.5**	**0.8**	**0.3**	**10.9**
Fizz Rating	----	0	Fizz Unit	**1**	**3**	**0**	**0**	**2**
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	**0.09**	**0.12**	**0.21**	**0.02**	**0.02**

Analytical Results

Sub-Matrix: ROCK (Matrix: SOIL)			Client sample ID	MCC7834	MCC7835	MCC7836	MCC7837	MCC7838
			Client sampling date / time	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]
Compound	CAS Number	LOR	Unit	EB1600423-036	EB1600423-037	EB1600423-038	EB1600423-039	EB1600423-040
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	**8.0**	**8.0**	**7.8**	**7.9**	**7.7**
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	**168**	**297**	**108**	**155**	**701**
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	**7.2**	**11.8**	**4.2**	**91.2**	**109**
ANC as CaCO3	----	0.1	% CaCO3	**0.7**	**1.2**	**0.4**	**9.3**	**11.2**
Fizz Rating	----	0	Fizz Unit	**1**	**1**	**0**	**2**	**2**
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	**0.03**	**0.02**	**0.07**	**0.05**	**0.13**

Analytical Results

Sub-Matrix: ROCK (Matrix: SOIL)			Client sample ID	MCC7839	MCC7840	MCC7841	MCC7842	MCC7843
			Client sampling date / time	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]
Compound	CAS Number	LOR	Unit	EB1600423-041	EB1600423-042	EB1600423-043	EB1600423-044	EB1600423-045
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	**7.2**	**8.3**	**8.5**	**7.4**	**6.8**
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	**220**	**288**	**291**	**291**	**276**
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	**5.2**	**44.0**	**70.5**	**3.8**	**35.1**
ANC as CaCO3	----	0.1	% CaCO3	**0.5**	**4.5**	**7.2**	**0.4**	**3.6**
Fizz Rating	----	0	Fizz Unit	**0**	**2**	**2**	**0**	**2**
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	**0.09**	**0.03**	**0.02**	**0.06**	**0.06**

Analytical Results

Sub-Matrix: ROCK (Matrix: SOIL)			Client sample ID	MCC7844	MCC7845	MCC7846	MCC7847	MCC7848
			Client sampling date / time	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]
Compound	CAS Number	LOR	Unit	EB1600423-046	EB1600423-047	EB1600423-048	EB1600423-049	EB1600423-050
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	**8.0**	**8.0**	**7.6**	**8.2**	**6.8**
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	**281**	**452**	**299**	**101**	**455**
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	**44.7**	**178**	**3.8**	**229**	**224**
ANC as CaCO3	----	0.1	% CaCO3	**4.6**	**18.2**	**0.4**	**23.3**	**22.8**
Fizz Rating	----	0	Fizz Unit	**2**	**3**	**0**	**3**	**3**
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	**0.04**	**0.07**	**0.04**	**0.02**	**0.09**

Analytical Results

Sub-Matrix: ROCK (Matrix: SOIL)			Client sample ID	MCC7849	MCC7850	MCC7851	MCC7852	MCC7853
			Client sampling date / time	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]
Compound	CAS Number	LOR	Unit	EB1600423-051	EB1600423-052	EB1600423-053	EB1600423-054	EB1600423-055
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	**5.7**	**7.9**	**7.2**	**5.4**	**3.9**
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	**427**	**161**	**168**	**871**	**865**
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	**229**	**170**	**1.8**	**11.1**	**0.5**
ANC as CaCO3	----	0.1	% CaCO3	**23.4**	**17.3**	**0.2**	**1.1**	<0.1
Fizz Rating	----	0	Fizz Unit	**3**	**3**	**0**	**1**	**0**
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	**0.11**	**0.02**	**0.09**	**0.74**	**0.11**

Analytical Results

Sub-Matrix: ROCK (Matrix: SOIL)			Client sample ID	MCC7854	MCC7855	MCC7856	MCC7857	MCC7858
			Client sampling date / time	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]
Compound	CAS Number	LOR	Unit	EB1600423-056	EB1600423-057	EB1600423-058	EB1600423-059	EB1600423-060
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	**6.2**	**5.6**	**7.1**	**4.3**	**5.3**
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	**1240**	**513**	**570**	**819**	**475**
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	**29.6**	**6.2**	**211**	**0.9**	**216**
ANC as CaCO3	----	0.1	% CaCO3	**3.0**	**0.6**	**21.5**	<0.1	**22.1**
Fizz Rating	----	0	Fizz Unit	**1**	**1**	**3**	**0**	**3**
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	**0.22**	**0.10**	**0.10**	**0.26**	**0.13**

Analytical Results

Sub-Matrix: ROCK (Matrix: SOIL)			Client sample ID	MCC7859	MCC7860	MCC7861	MCC7862	MCC7863
			Client sampling date / time	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]
Compound	CAS Number	LOR	Unit	EB1600423-061	EB1600423-062	EB1600423-063	EB1600423-064	EB1600423-065
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	**5.6**	**6.8**	**8.7**	**8.2**	**8.2**
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	**2680**	**394**	**364**	**756**	**287**
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	**20.8**	**31.8**	**217**	**165**	**6.0**
ANC as CaCO3	----	0.1	% CaCO3	**2.1**	**3.2**	**22.1**	**16.8**	**0.6**
Fizz Rating	----	0	Fizz Unit	**1**	**1**	**3**	**3**	**1**
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	**1.02**	**0.18**	**0.05**	**0.22**	**0.12**

Analytical Results

Sub-Matrix: ROCK (Matrix: SOIL)			Client sample ID	MCC7864	MCC7865	MCC7866	MCC7867	MCC7868
			Client sampling date / time	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]
Compound	CAS Number	LOR	Unit	EB1600423-066	EB1600423-067	EB1600423-068	EB1600423-069	EB1600423-070
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	**7.3**	**7.5**	**7.8**	**7.3**	**7.6**
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	**164**	**253**	**189**	**363**	**195**
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	**6.1**	**3.3**	**7.5**	**7.9**	**5.5**
ANC as CaCO3	----	0.1	% CaCO3	**0.6**	**0.3**	**0.8**	**0.8**	**0.6**
Fizz Rating	----	0	Fizz Unit	**0**	**0**	**0**	**1**	**0**
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	**0.22**	**0.09**	**0.04**	**0.13**	**0.05**

Analytical Results

Sub-Matrix: ROCK (Matrix: SOIL)			Client sample ID	MCC7869	MCC7870	MCC7871	MCC7872	MCC7873
			Client sampling date / time	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]
Compound	CAS Number	LOR	Unit	EB1600423-071	EB1600423-072	EB1600423-073	EB1600423-074	EB1600423-075
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	6.0	7.6	7.6	8.2	7.5
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	575	142	146	171	184
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	2.9	74.3	3.5	105	6.7
ANC as CaCO3	----	0.1	% CaCO3	0.3	7.6	0.4	10.7	0.7
Fizz Rating	----	0	Fizz Unit	0	2	0	2	1
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.09	0.02	0.04	0.02	0.08

Analytical Results

Sub-Matrix: ROCK (Matrix: SOIL)			Client sample ID	MCC7874	MCC7875	MCC7876	MCC7877	----
			Client sampling date / time	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	----
Compound	CAS Number	LOR	Unit	EB1600423-076	EB1600423-077	EB1600423-078	EB1600423-079	--------
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	**6.0**	**7.6**	**7.7**	**7.2**	**----**
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	**354**	**134**	**82**	**132**	**----**
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	**3.9**	**4.3**	**2.9**	**6.8**	**----**
ANC as CaCO3	----	0.1	% CaCO3	**0.4**	**0.4**	**0.3**	**0.7**	**----**
Fizz Rating	----	0	Fizz Unit	**0**	**0**	**0**	**0**	**----**
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	**0.07**	**0.05**	**0.12**	**0.04**	**----**

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1603958**	Page	: 1 of 23
Client	: **CARBON BASED ENVIRONMENTAL**	Laboratory	: Environmental Division Brisbane
Contact	: MR COLIN DAVIES (cbased)	Contact	: Customer Services EB
Address	: 47 BOOMERANG ST CESSNOCK NSW, AUSTRALIA 2325	Address	: 2 Byth Street Stafford QLD Australia 4053
E-mail	: cbased@bigpond.com	E-mail	: ALSEnviro.Brisbane@alsglobal.com
Telephone	: +61 49904443	Telephone	: +61-7-3243 7222
Facsimile	: +61 02 49904442	Facsimile	: +61-7-3243 7218
Project	: MCC Geochemical	QC Level	: NEPM 2013 B3 & ALS QC Standard
Order number	: ----	Date Samples Received	: 16-Feb-2016 06:04
C-O-C number	: ----	Date Analysis Commenced	: 18-Feb-2016
Sampler	: ----	Issue Date	: 24-Feb-2016 15:55
Site	:		
		No. of samples received	: 33
Quote number	: ----	No. of samples analysed	: 33

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

NATA Accredited Laboratory 825

Accredited for compliance with ISO/IEC 17025.

Signatories

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

Signatories	*Position*	*Accreditation Category*
Ben Felgendrejeris		Brisbane Acid Sulphate Soils, Stafford, QLD
Greg Vogel	Laboratory Manager	Brisbane Inorganics, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Matt Frost	Senior Organic 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.

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.

- EG005T (Total Metals) Sample EB163958-003 shows poor matrix spike recovery due to sample heterogeneity. Confirmed by visual inspection
- EG005T (Total Metals) Sample EB1603958-001 shows poor duplicate results due to sample heterogeneity. Confirmed by re-extraction and re-analysis.
- ED093T (Total Cations) Sample EB1603958-031 shows poor duplicate results due to sample heterogeneity. Confirmed by visual inspection.
- ED093T(Total Cations) Sample EB1603958-001 shows poor duplicate results due to sample heterogeneity. Confirmed by re-extraction and re-analysis.
- **This work order has been created to rebatch samples from previous ALS workorder EB1600423.**
- EA046 ABCC: NATA Acreditation does not cover the performance of this service.
- 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	MCC7789 EB1600423-004	MCC7802 EB1600423-005	MCC7803 EB1600423-006	MCC7805 EB1600423-008	MCC7806 EB1600423-009
				Client sampling date / time	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]
Compound	CAS Number	LOR	Unit		EB1603958-001	EB1603958-002	EB1603958-003	EB1603958-004	EB1603958-005
					Result	Result	Result	Result	Result
EA026 : Chromium Reducible Sulfur									
Chromium Reducible Sulphur	----	0.005	%		<0.005	----	0.121	0.120	1.26
EA055: Moisture Content									
Moisture Content (dried @ 103°C)	----	1	%		<1.0	----	2.4	----	<1.0
ED005: Exchange Acidity									
Exchange Acidity	----	0.1	meq/100g		----	----	----	----	----
ED006: Exchangeable Cations on Alkaline Soils									
Exchangeable Calcium	----	0.2	meq/100g		----	6.5	11.8	2.3	----
Exchangeable Magnesium	----	0.2	meq/100g		----	7.8	13.2	5.4	----
Exchangeable Potassium	----	0.2	meq/100g		----	0.6	0.5	<0.2	----
Exchangeable Sodium	----	0.2	meq/100g		----	0.5	1.1	0.7	----
Cation Exchange Capacity	----	0.2	meq/100g		----	15.4	26.7	8.4	----
Exchangeable Sodium Percent	----	0.2	%		----	3.4	4.2	8.0	----
ED008: Exchangeable Cations									
Exchangeable Calcium	----	0.1	meq/100g		----	----	----	----	----
Exchangeable Magnesium	----	0.1	meq/100g		----	----	----	----	----
Exchangeable Potassium	----	0.1	meq/100g		----	----	----	----	----
Exchangeable Sodium	----	0.1	meq/100g		----	----	----	----	----
Cation Exchange Capacity	----	0.1	meq/100g		----	----	----	----	----
Cation Exchange Capacity	----	0.1	meq/100g		----	----	----	----	----
Exchangeable Sodium Percent	----	0.1	%		----	----	----	----	----
ED037: Alkalinity									
Total Alkalinity as CaCO3	----	1	mg/kg		614	----	71300	----	104
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/kg		614	----	71000	----	104
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/kg		<5	----	262	----	<5
ED038A: Acidity									
Acidity	----	1	mg/kg		93	----	<5	----	2550
ED040S : Soluble Sulfate by ICPAES									
Sulfate as SO4 2-	14808-79-8	10	mg/kg		210	----	200	----	3440
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	10	mg/kg		20	----	20	----	20
ED093S: Soluble Major Cations									
Calcium	7440-70-2	10	mg/kg		140	----	30	----	300
Magnesium	7439-95-4	10	mg/kg		30	----	30	----	610

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	MCC7789 EB1600423-004	MCC7802 EB1600423-005	MCC7803 EB1600423-006	MCC7805 EB1600423-008	MCC7806 EB1600423-009
				Client sampling date / time	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]
Compound	CAS Number	LOR	Unit		EB1603958-001	EB1603958-002	EB1603958-003	EB1603958-004	EB1603958-005
					Result	Result	Result	Result	Result
ED093S: Soluble Major Cations - Continued									
Sodium	7440-23-5	10	mg/kg		30	----	220	----	160
Potassium	7440-09-7	10	mg/kg		10	----	30	----	60
ED093T: Total Major Cations									
Calcium	7440-70-2	50	mg/kg		1450	----	65600	----	1260
Magnesium	7439-95-4	50	mg/kg		830	----	53400	----	1680
Sodium	7440-23-5	50	mg/kg		<50	----	1120	----	430
Potassium	7440-09-7	50	mg/kg		<50	----	2400	----	910
EG005S : Soluble Metals by ICPAES									
Aluminium	7429-90-5	1	mg/kg		<1	----	<1	----	<1
Antimony	7440-36-0	0.1	mg/kg		<0.1	----	<0.1	----	<0.1
Arsenic	7440-38-2	0.1	mg/kg		<0.1	----	<0.1	----	<0.1
Boron	7440-42-8	1	mg/kg		<1	----	<1	----	<1
Cadmium	7440-43-9	0.1	mg/kg		<0.1	----	<0.1	----	<0.1
Chromium	7440-47-3	0.1	mg/kg		<0.1	----	<0.1	----	<0.1
Cobalt	7440-48-4	0.1	mg/kg		<0.1	----	<0.1	----	4.8
Copper	7440-50-8	0.1	mg/kg		<0.1	----	<0.1	----	<0.1
Iron	7439-89-6	1	mg/kg		<1	----	<1	----	7
Lead	7439-92-1	0.1	mg/kg		0.1	----	<0.1	----	<0.1
Manganese	7439-96-5	0.1	mg/kg		0.1	----	<0.1	----	26.2
Molybdenum	7439-98-7	0.1	mg/kg		<0.1	----	<0.1	----	<0.1
Nickel	7440-02-0	0.1	mg/kg		<0.1	----	<0.1	----	7.9
Selenium	7782-49-2	0.1	mg/kg		<0.1	----	0.3	----	0.1
Zinc	7440-66-6	0.1	mg/kg		<0.1	----	<0.1	----	2.9
EG005T: Total Metals by ICP-AES									
Aluminium	7429-90-5	50	mg/kg		180	----	22400	----	3830
Antimony	7440-36-0	5	mg/kg		<5	----	<5	----	<5
Arsenic	7440-38-2	5	mg/kg		<5	----	<5	----	7
Boron	7440-42-8	50	mg/kg		<50	----	<50	----	<50
Cadmium	7440-43-9	1	mg/kg		<1	----	<1	----	<1
Chromium	7440-47-3	2	mg/kg		<2	----	111	----	9
Cobalt	7440-48-4	2	mg/kg		<2	----	32	----	33
Copper	7440-50-8	5	mg/kg		<5	----	40	----	30
Iron	7439-89-6	50	mg/kg		1480	----	73100	----	19200
Lead	7439-92-1	5	mg/kg		<5	----	<5	----	19

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	MCC7789 EB1600423-004	MCC7802 EB1600423-005	MCC7803 EB1600423-006	MCC7805 EB1600423-008	MCC7806 EB1600423-009
				Client sampling date / time	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]
Compound	CAS Number	LOR	Unit		EB1603958-001	EB1603958-002	EB1603958-003	EB1603958-004	EB1603958-005
					Result	Result	Result	Result	Result
EG005T: Total Metals by ICP-AES - Continued									
Manganese	7439-96-5	5	mg/kg		**9**	**----**	**685**	**----**	**164**
Molybdenum	7439-98-7	2	mg/kg		<2	**----**	<2	**----**	<2
Nickel	7440-02-0	2	mg/kg		<2	**----**	**433**	**----**	**70**
Selenium	7782-49-2	5	mg/kg		<5	**----**	**8**	**----**	<5
Zinc	7440-66-6	5	mg/kg		**6**	**----**	**192**	**----**	**76**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	MCC7808 EB1600423-011	MCC7817 EB1600423-019	MCC7818 EB1600423-020	MCC7821 EB1600423-023	MCC7822 EB1600423-024
				Client sampling date / time	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]
Compound	CAS Number	LOR	Unit		EB1603958-006	EB1603958-007	EB1603958-008	EB1603958-009	EB1603958-010
					Result	Result	Result	Result	Result
EA026 : Chromium Reducible Sulfur									
Chromium Reducible Sulphur	----	0.005	%		----	0.110	0.030	0.239	----
EA055: Moisture Content									
Moisture Content (dried @ 103°C)	----	1	%		----	<1.0	----	----	----
ED005: Exchange Acidity									
Exchange Acidity	----	0.1	meq/100g		----	----	----	0.5	----
ED006: Exchangeable Cations on Alkaline Soils									
Exchangeable Calcium	----	0.2	meq/100g		1.1	----	----	----	----
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		1.1	----	----	----	----
Exchangeable Sodium Percent	----	0.2	%		<0.2	----	----	----	----
ED008: Exchangeable Cations									
Exchangeable Calcium	----	0.1	meq/100g		----	----	----	6.3	5.3
Exchangeable Magnesium	----	0.1	meq/100g		----	----	----	1.9	2.2
Exchangeable Potassium	----	0.1	meq/100g		----	----	----	0.1	0.1
Exchangeable Sodium	----	0.1	meq/100g		----	----	----	0.1	0.1
Cation Exchange Capacity	----	0.1	meq/100g		----	----	----	8.9	----
Cation Exchange Capacity	----	0.1	meq/100g		----	----	----	----	7.8
Exchangeable Sodium Percent	----	0.1	%		----	----	----	1.2	1.4
ED037: Alkalinity									
Total Alkalinity as CaCO3	----	1	mg/kg		----	569	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/kg		----	569	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/kg		----	<5	----	----	----
ED038A: Acidity									
Acidity	----	1	mg/kg		----	522	----	----	----
ED040S : Soluble Sulfate by ICPAES									
Sulfate as SO4 2-	14808-79-8	10	mg/kg		----	620	----	----	----
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	10	mg/kg		----	<10	----	----	----
ED093S: Soluble Major Cations									
Calcium	7440-70-2	10	mg/kg		----	170	----	----	----
Magnesium	7439-95-4	10	mg/kg		----	50	----	----	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	MCC7808 EB1600423-011	MCC7817 EB1600423-019	MCC7818 EB1600423-020	MCC7821 EB1600423-023	MCC7822 EB1600423-024
				Client sampling date / time	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]
Compound	CAS Number	LOR	Unit		EB1603958-006	EB1603958-007	EB1603958-008	EB1603958-009	EB1603958-010
					Result	Result	Result	Result	Result
ED093S: Soluble Major Cations - Continued									
Sodium	7440-23-5	10	mg/kg		----	**60**	----	----	----
Potassium	7440-09-7	10	mg/kg		----	**30**	----	----	----
ED093T: Total Major Cations									
Calcium	7440-70-2	50	mg/kg		----	**1000**	----	----	----
Magnesium	7439-95-4	50	mg/kg		----	**330**	----	----	----
Sodium	7440-23-5	50	mg/kg		----	**80**	----	----	----
Potassium	7440-09-7	50	mg/kg		----	**230**	----	----	----
EG005S : Soluble Metals by ICPAES									
Aluminium	7429-90-5	1	mg/kg		----	<1	----	----	----
Antimony	7440-36-0	0.1	mg/kg		----	<0.1	----	----	----
Arsenic	7440-38-2	0.1	mg/kg		----	<0.1	----	----	----
Boron	7440-42-8	1	mg/kg		----	<1	----	----	----
Cadmium	7440-43-9	0.1	mg/kg		----	<0.1	----	----	----
Chromium	7440-47-3	0.1	mg/kg		----	<0.1	----	----	----
Cobalt	7440-48-4	0.1	mg/kg		----	<0.1	----	----	----
Copper	7440-50-8	0.1	mg/kg		----	<0.1	----	----	----
Iron	7439-89-6	1	mg/kg		----	<1	----	----	----
Lead	7439-92-1	0.1	mg/kg		----	<0.1	----	----	----
Manganese	7439-96-5	0.1	mg/kg		----	**0.2**	----	----	----
Molybdenum	7439-98-7	0.1	mg/kg		----	<0.1	----	----	----
Nickel	7440-02-0	0.1	mg/kg		----	**0.2**	----	----	----
Selenium	7782-49-2	0.1	mg/kg		----	**0.3**	----	----	----
Zinc	7440-66-6	0.1	mg/kg		----	<0.1	----	----	----
EG005T: Total Metals by ICP-AES									
Aluminium	7429-90-5	50	mg/kg		----	**6870**	----	----	----
Antimony	7440-36-0	5	mg/kg		----	<5	----	----	----
Arsenic	7440-38-2	5	mg/kg		----	<5	----	----	----
Boron	7440-42-8	50	mg/kg		----	<50	----	----	----
Cadmium	7440-43-9	1	mg/kg		----	<1	----	----	----
Chromium	7440-47-3	2	mg/kg		----	**44**	----	----	----
Cobalt	7440-48-4	2	mg/kg		----	**17**	----	----	----
Copper	7440-50-8	5	mg/kg		----	**62**	----	----	----
Iron	7439-89-6	50	mg/kg		----	**1960**	----	----	----
Lead	7439-92-1	5	mg/kg		----	**10**	----	----	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	MCC7808 EB1600423-011	MCC7817 EB1600423-019	MCC7818 EB1600423-020	MCC7821 EB1600423-023	MCC7822 EB1600423-024
				Client sampling date / time	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]
Compound	CAS Number	LOR	Unit		EB1603958-006	EB1603958-007	EB1603958-008	EB1603958-009	EB1603958-010
					Result	Result	Result	Result	Result
EG005T: Total Metals by ICP-AES - Continued									
Manganese	7439-96-5	5	mg/kg		----	<5	----	----	----
Molybdenum	7439-98-7	2	mg/kg		----	<2	----	----	----
Nickel	7440-02-0	2	mg/kg		----	**62**	----	----	----
Selenium	7782-49-2	5	mg/kg		----	<5	----	----	----
Zinc	7440-66-6	5	mg/kg		----	**17**	----	----	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	MCC7823 EB1600423-025	MCC7824 EB1600423-026	MCC7826 EB1600423-028	MCC7830 EB1600423-032	MCC7831 EB1600423-033
			Client sampling date / time	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]
Compound	CAS Number	LOR	Unit	EB1603958-011	EB1603958-012	EB1603958-013	EB1603958-014	EB1603958-015
				Result	Result	Result	Result	Result
EA026 : Chromium Reducible Sulfur								
Chromium Reducible Sulphur	----	0.005	%	**0.207**	**0.106**	**0.034**	**0.023**	**0.022**
EA055: Moisture Content								
Moisture Content (dried @ 103°C)	----	1	%	<1.0	----	----	----	----
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	----	----	----	----	----
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.2	meq/100g	**1.6**	----	----	----	----
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	**2.7**	----	----	----	----
Exchangeable Sodium Percent	----	0.2	%	<0.2	----	----	----	----
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	----	----	----	----	----
Exchangeable Magnesium	----	0.1	meq/100g	----	----	----	----	----
Exchangeable Potassium	----	0.1	meq/100g	----	----	----	----	----
Exchangeable Sodium	----	0.1	meq/100g	----	----	----	----	----
Cation Exchange Capacity	----	0.1	meq/100g	----	----	----	----	----
Cation Exchange Capacity	----	0.1	meq/100g	----	----	----	----	----
Exchangeable Sodium Percent	----	0.1	%	----	----	----	----	----
ED037: Alkalinity								
Total Alkalinity as CaCO3	----	1	mg/kg	**6340**	----	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/kg	**6260**	----	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/kg	**88**	----	----	----	----
ED038A: Acidity								
Acidity	----	1	mg/kg	<5	----	----	----	----
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	**660**	----	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	**50**	----	----	----	----
ED093S: Soluble Major Cations								
Calcium	7440-70-2	10	mg/kg	**120**	----	----	----	----
Magnesium	7439-95-4	10	mg/kg	**60**	----	----	----	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	MCC7823 EB1600423-025	MCC7824 EB1600423-026	MCC7826 EB1600423-028	MCC7830 EB1600423-032	MCC7831 EB1600423-033
				Client sampling date / time	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]
Compound	CAS Number	LOR	Unit		EB1603958-011	EB1603958-012	EB1603958-013	EB1603958-014	EB1603958-015
					Result	Result	Result	Result	Result
ED093S: Soluble Major Cations - Continued									
Sodium	7440-23-5	10	mg/kg		**150**	----	----	----	----
Potassium	7440-09-7	10	mg/kg		**60**	----	----	----	----
ED093T: Total Major Cations									
Calcium	7440-70-2	50	mg/kg		**17200**	----	----	----	----
Magnesium	7439-95-4	50	mg/kg		**6270**	----	----	----	----
Sodium	7440-23-5	50	mg/kg		**270**	----	----	----	----
Potassium	7440-09-7	50	mg/kg		**720**	----	----	----	----
EG005S : Soluble Metals by ICPAES									
Aluminium	7429-90-5	1	mg/kg		<1	----	----	----	----
Antimony	7440-36-0	0.1	mg/kg		<0.1	----	----	----	----
Arsenic	7440-38-2	0.1	mg/kg		<0.1	----	----	----	----
Boron	7440-42-8	1	mg/kg		<1	----	----	----	----
Cadmium	7440-43-9	0.1	mg/kg		<0.1	----	----	----	----
Chromium	7440-47-3	0.1	mg/kg		<0.1	----	----	----	----
Cobalt	7440-48-4	0.1	mg/kg		<0.1	----	----	----	----
Copper	7440-50-8	0.1	mg/kg		<0.1	----	----	----	----
Iron	7439-89-6	1	mg/kg		<1	----	----	----	----
Lead	7439-92-1	0.1	mg/kg		**0.1**	----	----	----	----
Manganese	7439-96-5	0.1	mg/kg		**0.2**	----	----	----	----
Molybdenum	7439-98-7	0.1	mg/kg		<0.1	----	----	----	----
Nickel	7440-02-0	0.1	mg/kg		<0.1	----	----	----	----
Selenium	7782-49-2	0.1	mg/kg		<0.1	----	----	----	----
Zinc	7440-66-6	0.1	mg/kg		<0.1	----	----	----	----
EG005T: Total Metals by ICP-AES									
Aluminium	7429-90-5	50	mg/kg		**2530**	----	----	----	----
Antimony	7440-36-0	5	mg/kg		<5	----	----	----	----
Arsenic	7440-38-2	5	mg/kg		<5	----	----	----	----
Boron	7440-42-8	50	mg/kg		<50	----	----	----	----
Cadmium	7440-43-9	1	mg/kg		<1	----	----	----	----
Chromium	7440-47-3	2	mg/kg		**8**	----	----	----	----
Cobalt	7440-48-4	2	mg/kg		**7**	----	----	----	----
Copper	7440-50-8	5	mg/kg		**8**	----	----	----	----
Iron	7439-89-6	50	mg/kg		**8560**	----	----	----	----
Lead	7439-92-1	5	mg/kg		**10**	----	----	----	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	MCC7823 EB1600423-025	MCC7824 EB1600423-026	MCC7826 EB1600423-028	MCC7830 EB1600423-032	MCC7831 EB1600423-033
				Client sampling date / time	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]
Compound	CAS Number	LOR	Unit		EB1603958-011	EB1603958-012	EB1603958-013	EB1603958-014	EB1603958-015
					Result	Result	Result	Result	Result
EG005T: Total Metals by ICP-AES - Continued									
Manganese	7439-96-5	5	mg/kg		**80**	----	----	----	----
Molybdenum	7439-98-7	2	mg/kg		<2	----	----	----	----
Nickel	7440-02-0	2	mg/kg		**29**	----	----	----	----
Selenium	7782-49-2	5	mg/kg		<5	----	----	----	----
Zinc	7440-66-6	5	mg/kg		**49**	----	----	----	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	MCC7838 EB1600423-040	MCC7840 EB1600423-042	MCC7841 EB1600423-043	MCC7849 EB1600423-051	MCC7852 EB1600423-054
				Client sampling date / time	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]
Compound	CAS Number	LOR	Unit		EB1603958-016	EB1603958-017	EB1603958-018	EB1603958-019	EB1603958-020
					Result	Result	Result	Result	Result
EA026 : Chromium Reducible Sulfur									
Chromium Reducible Sulphur	----	0.005	%		**0.073**	----	----	**0.031**	**0.544**
EA055: Moisture Content									
Moisture Content (dried @ 103°C)	----	1	%		<1.0	----	----	----	<1.0
ED005: Exchange Acidity									
Exchange Acidity	----	0.1	meq/100g		----	----	----	----	----
ED006: Exchangeable Cations on Alkaline Soils									
Exchangeable Calcium	----	0.2	meq/100g		----	**2.7**	**2.2**	----	----
Exchangeable Magnesium	----	0.2	meq/100g		----	**2.0**	**1.4**	----	----
Exchangeable Potassium	----	0.2	meq/100g		----	<0.2	<0.2	----	----
Exchangeable Sodium	----	0.2	meq/100g		----	<0.2	<0.2	----	----
Cation Exchange Capacity	----	0.2	meq/100g		----	**4.7**	**3.5**	----	----
Exchangeable Sodium Percent	----	0.2	%		----	<0.2	<0.2	----	----
ED008: Exchangeable Cations									
Exchangeable Calcium	----	0.1	meq/100g		----	----	----	----	----
Exchangeable Magnesium	----	0.1	meq/100g		----	----	----	----	----
Exchangeable Potassium	----	0.1	meq/100g		----	----	----	----	----
Exchangeable Sodium	----	0.1	meq/100g		----	----	----	----	----
Cation Exchange Capacity	----	0.1	meq/100g		----	----	----	----	----
Cation Exchange Capacity	----	0.1	meq/100g		----	----	----	----	----
Exchangeable Sodium Percent	----	0.1	%		----	----	----	----	----
ED037: Alkalinity									
Total Alkalinity as CaCO3	----	1	mg/kg		**56700**	----	----	----	**788**
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/kg		**56700**	----	----	----	**788**
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/kg		<5	----	----	----	<5
ED038A: Acidity									
Acidity	----	1	mg/kg		**52**	----	----	----	**565**
ED040S : Soluble Sulfate by ICPAES									
Sulfate as SO4 2-	14808-79-8	10	mg/kg		**260**	----	----	----	**1880**
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	10	mg/kg		**10**	----	----	----	**20**
ED093S: Soluble Major Cations									
Calcium	7440-70-2	10	mg/kg		**160**	----	----	----	**530**
Magnesium	7439-95-4	10	mg/kg		**30**	----	----	----	**160**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	MCC7838 EB1600423-040	MCC7840 EB1600423-042	MCC7841 EB1600423-043	MCC7849 EB1600423-051	MCC7852 EB1600423-054
				Client sampling date / time	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]
Compound	CAS Number	LOR	Unit		EB1603958-016	EB1603958-017	EB1603958-018	EB1603958-019	EB1603958-020
					Result	Result	Result	Result	Result
ED093S: Soluble Major Cations - Continued									
Sodium	7440-23-5	10	mg/kg		**30**	----	----	----	**40**
Potassium	7440-09-7	10	mg/kg		**20**	----	----	----	**50**
ED093T: Total Major Cations									
Calcium	7440-70-2	50	mg/kg		**26000**	----	----	----	**4660**
Magnesium	7439-95-4	50	mg/kg		**4130**	----	----	----	**1950**
Sodium	7440-23-5	50	mg/kg		**60**	----	----	----	**110**
Potassium	7440-09-7	50	mg/kg		**120**	----	----	----	**540**
EG005S : Soluble Metals by ICPAES									
Aluminium	7429-90-5	1	mg/kg		<1	----	----	----	<1
Antimony	7440-36-0	0.1	mg/kg		<0.1	----	----	----	<0.1
Arsenic	7440-38-2	0.1	mg/kg		<0.1	----	----	----	<0.1
Boron	7440-42-8	1	mg/kg		<1	----	----	----	<1
Cadmium	7440-43-9	0.1	mg/kg		<0.1	----	----	----	<0.1
Chromium	7440-47-3	0.1	mg/kg		<0.1	----	----	----	<0.1
Cobalt	7440-48-4	0.1	mg/kg		<0.1	----	----	----	**0.3**
Copper	7440-50-8	0.1	mg/kg		<0.1	----	----	----	<0.1
Iron	7439-89-6	1	mg/kg		<1	----	----	----	<1
Lead	7439-92-1	0.1	mg/kg		<0.1	----	----	----	<0.1
Manganese	7439-96-5	0.1	mg/kg		**0.1**	----	----	----	**0.7**
Molybdenum	7439-98-7	0.1	mg/kg		<0.1	----	----	----	<0.1
Nickel	7440-02-0	0.1	mg/kg		<0.1	----	----	----	**1.8**
Selenium	7782-49-2	0.1	mg/kg		<0.1	----	----	----	**0.2**
Zinc	7440-66-6	0.1	mg/kg		<0.1	----	----	----	<0.1
EG005T: Total Metals by ICP-AES									
Aluminium	7429-90-5	50	mg/kg		**7130**	----	----	----	**5780**
Antimony	7440-36-0	5	mg/kg		<5	----	----	----	<5
Arsenic	7440-38-2	5	mg/kg		<5	----	----	----	**42**
Boron	7440-42-8	50	mg/kg		<50	----	----	----	<50
Cadmium	7440-43-9	1	mg/kg		<1	----	----	----	<1
Chromium	7440-47-3	2	mg/kg		**35**	----	----	----	**18**
Cobalt	7440-48-4	2	mg/kg		**7**	----	----	----	**23**
Copper	7440-50-8	5	mg/kg		**39**	----	----	----	**28**
Iron	7439-89-6	50	mg/kg		**37700**	----	----	----	**13800**
Lead	7439-92-1	5	mg/kg		**7**	----	----	----	**14**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	MCC7838 EB1600423-040	MCC7840 EB1600423-042	MCC7841 EB1600423-043	MCC7849 EB1600423-051	MCC7852 EB1600423-054
				Client sampling date / time	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]
Compound	CAS Number	LOR	Unit		EB1603958-016	EB1603958-017	EB1603958-018	EB1603958-019	EB1603958-020
					Result	Result	Result	Result	Result
EG005T: Total Metals by ICP-AES - Continued									
Manganese	7439-96-5	5	mg/kg		**162**	----	----	----	**38**
Molybdenum	7439-98-7	2	mg/kg		<2	----	----	----	<2
Nickel	7440-02-0	2	mg/kg		**42**	----	----	----	**162**
Selenium	7782-49-2	5	mg/kg		<5	----	----	----	<5
Zinc	7440-66-6	5	mg/kg		**202**	----	----	----	**116**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	MCC7853 EB1600423-055	MCC7855 EB1600423-057	MCC7857 EB1600423-059	MCC7859 EB1600423-061	MCC7860 EB1600423-062
			Client sampling date / time	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]
Compound	CAS Number	LOR	Unit	EB1603958-021	EB1603958-022	EB1603958-024	EB1603958-025	EB1603958-026
				Result	Result	Result	Result	Result
EA026 : Chromium Reducible Sulfur								
Chromium Reducible Sulphur	----	0.005	%	0.033	0.022	0.114	0.496	0.080
EA055: Moisture Content								
Moisture Content (dried @ 103°C)	----	1	%	----	----	----	----	----
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	----	----	----	----	----
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.2	meq/100g	----	----	----	----	----
Exchangeable Magnesium	----	0.2	meq/100g	----	----	----	----	----
Exchangeable Potassium	----	0.2	meq/100g	----	----	----	----	----
Exchangeable Sodium	----	0.2	meq/100g	----	----	----	----	----
Cation Exchange Capacity	----	0.2	meq/100g	----	----	----	----	----
Exchangeable Sodium Percent	----	0.2	%	----	----	----	----	----
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	----	----	----	----	4.0
Exchangeable Magnesium	----	0.1	meq/100g	----	----	----	----	3.1
Exchangeable Potassium	----	0.1	meq/100g	----	----	----	----	0.2
Exchangeable Sodium	----	0.1	meq/100g	----	----	----	----	0.1
Cation Exchange Capacity	----	0.1	meq/100g	----	----	----	----	----
Cation Exchange Capacity	----	0.1	meq/100g	----	----	----	----	7.4
Exchangeable Sodium Percent	----	0.1	%	----	----	----	----	1.5
ED037: Alkalinity								
Total Alkalinity as CaCO3	----	1	mg/kg	----	----	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/kg	----	----	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/kg	----	----	----	----	----
ED038A: Acidity								
Acidity	----	1	mg/kg	----	----	----	----	----
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	----	----	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	----	----	----	----	----
ED093S: Soluble Major Cations								
Calcium	7440-70-2	10	mg/kg	----	----	----	----	----
Magnesium	7439-95-4	10	mg/kg	----	----	----	----	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	MCC7853 EB1600423-055	MCC7855 EB1600423-057	MCC7857 EB1600423-059	MCC7859 EB1600423-061	MCC7860 EB1600423-062
				Client sampling date / time	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]
Compound	CAS Number	LOR	Unit		EB1603958-021	EB1603958-022	EB1603958-024	EB1603958-025	EB1603958-026
					Result	Result	Result	Result	Result
ED093S: Soluble Major Cations - Continued									
Sodium	7440-23-5	10	mg/kg		----	----	----	----	----
Potassium	7440-09-7	10	mg/kg		----	----	----	----	----
ED093T: Total Major Cations									
Calcium	7440-70-2	50	mg/kg		----	----	----	----	----
Magnesium	7439-95-4	50	mg/kg		----	----	----	----	----
Sodium	7440-23-5	50	mg/kg		----	----	----	----	----
Potassium	7440-09-7	50	mg/kg		----	----	----	----	----
EG005S : Soluble Metals by ICPAES									
Aluminium	7429-90-5	1	mg/kg		----	----	----	----	----
Antimony	7440-36-0	0.1	mg/kg		----	----	----	----	----
Arsenic	7440-38-2	0.1	mg/kg		----	----	----	----	----
Boron	7440-42-8	1	mg/kg		----	----	----	----	----
Cadmium	7440-43-9	0.1	mg/kg		----	----	----	----	----
Chromium	7440-47-3	0.1	mg/kg		----	----	----	----	----
Cobalt	7440-48-4	0.1	mg/kg		----	----	----	----	----
Copper	7440-50-8	0.1	mg/kg		----	----	----	----	----
Iron	7439-89-6	1	mg/kg		----	----	----	----	----
Lead	7439-92-1	0.1	mg/kg		----	----	----	----	----
Manganese	7439-96-5	0.1	mg/kg		----	----	----	----	----
Molybdenum	7439-98-7	0.1	mg/kg		----	----	----	----	----
Nickel	7440-02-0	0.1	mg/kg		----	----	----	----	----
Selenium	7782-49-2	0.1	mg/kg		----	----	----	----	----
Zinc	7440-66-6	0.1	mg/kg		----	----	----	----	----
EG005T: Total Metals by ICP-AES									
Aluminium	7429-90-5	50	mg/kg		----	----	----	----	----
Antimony	7440-36-0	5	mg/kg		----	----	----	----	----
Arsenic	7440-38-2	5	mg/kg		----	----	----	----	----
Boron	7440-42-8	50	mg/kg		----	----	----	----	----
Cadmium	7440-43-9	1	mg/kg		----	----	----	----	----
Chromium	7440-47-3	2	mg/kg		----	----	----	----	----
Cobalt	7440-48-4	2	mg/kg		----	----	----	----	----
Copper	7440-50-8	5	mg/kg		----	----	----	----	----
Iron	7439-89-6	50	mg/kg		----	----	----	----	----
Lead	7439-92-1	5	mg/kg		----	----	----	----	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	MCC7853 EB1600423-055	MCC7855 EB1600423-057	MCC7857 EB1600423-059	MCC7859 EB1600423-061	MCC7860 EB1600423-062
				Client sampling date / time	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]
Compound	CAS Number	LOR	Unit		EB1603958-021	EB1603958-022	EB1603958-024	EB1603958-025	EB1603958-026
					Result	Result	Result	Result	Result
EG005T: Total Metals by ICP-AES - Continued									
Manganese	7439-96-5	5	mg/kg		----	----	----	----	----
Molybdenum	7439-98-7	2	mg/kg		----	----	----	----	----
Nickel	7440-02-0	2	mg/kg		----	----	----	----	----
Selenium	7782-49-2	5	mg/kg		----	----	----	----	----
Zinc	7440-66-6	5	mg/kg		----	----	----	----	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	MCC7862 EB1600423-064	MCC7863 EB1600423-065	MCC7864 EB1600423-066	MCC7867 EB1600423-069	MCC7872 EB1600423-074
				Client sampling date / time	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]
Compound	CAS Number	LOR	Unit		EB1603958-027	EB1603958-028	EB1603958-029	EB1603958-030	EB1603958-031
					Result	Result	Result	Result	Result
EA026 : Chromium Reducible Sulfur									
Chromium Reducible Sulphur	----	0.005	%		0.107	0.059	0.149	0.112	----
EA055: Moisture Content									
Moisture Content (dried @ 103°C)	----	1	%		----	----	----	<1.0	<1.0
ED005: Exchange Acidity									
Exchange Acidity	----	0.1	meq/100g		----	----	----	----	----
ED006: Exchangeable Cations on Alkaline Soils									
Exchangeable Calcium	----	0.2	meq/100g		----	----	----	----	----
Exchangeable Magnesium	----	0.2	meq/100g		----	----	----	----	----
Exchangeable Potassium	----	0.2	meq/100g		----	----	----	----	----
Exchangeable Sodium	----	0.2	meq/100g		----	----	----	----	----
Cation Exchange Capacity	----	0.2	meq/100g		----	----	----	----	----
Exchangeable Sodium Percent	----	0.2	%		----	----	----	----	----
ED008: Exchangeable Cations									
Exchangeable Calcium	----	0.1	meq/100g		----	----	----	----	----
Exchangeable Magnesium	----	0.1	meq/100g		----	----	----	----	----
Exchangeable Potassium	----	0.1	meq/100g		----	----	----	----	----
Exchangeable Sodium	----	0.1	meq/100g		----	----	----	----	----
Cation Exchange Capacity	----	0.1	meq/100g		----	----	----	----	----
Cation Exchange Capacity	----	0.1	meq/100g		----	----	----	----	----
Exchangeable Sodium Percent	----	0.1	%		----	----	----	----	----
ED037: Alkalinity									
Total Alkalinity as CaCO3	----	1	mg/kg		----	----	----	788	719
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/kg		----	----	----	788	719
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/kg		----	----	----	<5	<5
ED038A: Acidity									
Acidity	----	1	mg/kg		----	----	----	190	<5
ED040S : Soluble Sulfate by ICPAES									
Sulfate as SO4 2-	14808-79-8	10	mg/kg		----	----	----	480	110
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	10	mg/kg		----	----	----	20	10
ED093S: Soluble Major Cations									
Calcium	7440-70-2	10	mg/kg		----	----	----	50	40
Magnesium	7439-95-4	10	mg/kg		----	----	----	20	20

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	MCC7862 EB1600423-064	MCC7863 EB1600423-065	MCC7864 EB1600423-066	MCC7867 EB1600423-069	MCC7872 EB1600423-074
				Client sampling date / time	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]
Compound	CAS Number	LOR	Unit		EB1603958-027	EB1603958-028	EB1603958-029	EB1603958-030	EB1603958-031
					Result	Result	Result	Result	Result
ED093S: Soluble Major Cations - Continued									
Sodium	7440-23-5	10	mg/kg		----	----	----	120	60
Potassium	7440-09-7	10	mg/kg		----	----	----	70	20
ED093T: Total Major Cations									
Calcium	7440-70-2	50	mg/kg		----	----	----	2890	17100
Magnesium	7439-95-4	50	mg/kg		----	----	----	3730	3530
Sodium	7440-23-5	50	mg/kg		----	----	----	280	100
Potassium	7440-09-7	50	mg/kg		----	----	----	1970	400
EG005S : Soluble Metals by ICPAES									
Aluminium	7429-90-5	1	mg/kg		----	----	----	<1	<1
Antimony	7440-36-0	0.1	mg/kg		----	----	----	<0.1	<0.1
Arsenic	7440-38-2	0.1	mg/kg		----	----	----	<0.1	<0.1
Boron	7440-42-8	1	mg/kg		----	----	----	<1	<1
Cadmium	7440-43-9	0.1	mg/kg		----	----	----	<0.1	<0.1
Chromium	7440-47-3	0.1	mg/kg		----	----	----	<0.1	<0.1
Cobalt	7440-48-4	0.1	mg/kg		----	----	----	<0.1	<0.1
Copper	7440-50-8	0.1	mg/kg		----	----	----	<0.1	<0.1
Iron	7439-89-6	1	mg/kg		----	----	----	<1	<1
Lead	7439-92-1	0.1	mg/kg		----	----	----	<0.1	<0.1
Manganese	7439-96-5	0.1	mg/kg		----	----	----	<0.1	0.2
Molybdenum	7439-98-7	0.1	mg/kg		----	----	----	<0.1	<0.1
Nickel	7440-02-0	0.1	mg/kg		----	----	----	0.1	<0.1
Selenium	7782-49-2	0.1	mg/kg		----	----	----	1.2	0.2
Zinc	7440-66-6	0.1	mg/kg		----	----	----	<0.1	<0.1
EG005T: Total Metals by ICP-AES									
Aluminium	7429-90-5	50	mg/kg		----	----	----	4950	4830
Antimony	7440-36-0	5	mg/kg		----	----	----	<5	<5
Arsenic	7440-38-2	5	mg/kg		----	----	----	12	<5
Boron	7440-42-8	50	mg/kg		----	----	----	<50	<50
Cadmium	7440-43-9	1	mg/kg		----	----	----	<1	<1
Chromium	7440-47-3	2	mg/kg		----	----	----	18	28
Cobalt	7440-48-4	2	mg/kg		----	----	----	21	7
Copper	7440-50-8	5	mg/kg		----	----	----	44	28
Iron	7439-89-6	50	mg/kg		----	----	----	39000	15700
Lead	7439-92-1	5	mg/kg		----	----	----	23	9

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	MCC7862 EB1600423-064	MCC7863 EB1600423-065	MCC7864 EB1600423-066	MCC7867 EB1600423-069	MCC7872 EB1600423-074
				Client sampling date / time	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]	[07-Jan-2016]
Compound	CAS Number	LOR	Unit		EB1603958-027	EB1603958-028	EB1603958-029	EB1603958-030	EB1603958-031
					Result	Result	Result	Result	Result
EG005T: Total Metals by ICP-AES - Continued									
Manganese	7439-96-5	5	mg/kg		----	----	----	**204**	**81**
Molybdenum	7439-98-7	2	mg/kg		----	----	----	<2	<2
Nickel	7440-02-0	2	mg/kg		----	----	----	**234**	**51**
Selenium	7782-49-2	5	mg/kg		----	----	----	**7**	<5
Zinc	7440-66-6	5	mg/kg		----	----	----	**113**	**45**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	MCC7876 EB1600423-078	MCC7877 EB1600423-079	----	----	----
			Client sampling date / time	[07-Jan-2016]	[07-Jan-2016]	----	----	----
Compound	CAS Number	LOR	Unit	EB1603958-032	EB1603958-033	--------	--------	--------
				Result	Result	Result	Result	Result
EA026 : Chromium Reducible Sulfur								
Chromium Reducible Sulphur	----	0.005	%	**0.012**	----	----	----	----
EA055: Moisture Content								
Moisture Content (dried @ 103°C)	----	1	%	----	<1.0	----	----	----
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	----	----	----	----	----
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.2	meq/100g	----	----	----	----	----
Exchangeable Magnesium	----	0.2	meq/100g	----	----	----	----	----
Exchangeable Potassium	----	0.2	meq/100g	----	----	----	----	----
Exchangeable Sodium	----	0.2	meq/100g	----	----	----	----	----
Cation Exchange Capacity	----	0.2	meq/100g	----	----	----	----	----
Exchangeable Sodium Percent	----	0.2	%	----	----	----	----	----
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	----	----	----	----	----
Exchangeable Magnesium	----	0.1	meq/100g	----	----	----	----	----
Exchangeable Potassium	----	0.1	meq/100g	----	----	----	----	----
Exchangeable Sodium	----	0.1	meq/100g	----	----	----	----	----
Cation Exchange Capacity	----	0.1	meq/100g	----	----	----	----	----
Cation Exchange Capacity	----	0.1	meq/100g	----	----	----	----	----
Exchangeable Sodium Percent	----	0.1	%	----	----	----	----	----
ED037: Alkalinity								
Total Alkalinity as CaCO3	----	1	mg/kg	----	**177**	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/kg	----	<5	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/kg	----	<5	----	----	----
ED038A: Acidity								
Acidity	----	1	mg/kg	----	**24**	----	----	----
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	----	**160**	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	----	<10	----	----	----
ED093S: Soluble Major Cations								
Calcium	7440-70-2	10	mg/kg	----	**30**	----	----	----
Magnesium	7439-95-4	10	mg/kg	----	**10**	----	----	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	MCC7876 EB1600423-078	MCC7877 EB1600423-079	----	----	----
				Client sampling date / time	[07-Jan-2016]	[07-Jan-2016]	----	----	----
Compound	CAS Number	LOR	Unit		EB1603958-032	EB1603958-033	--------	--------	--------
					Result	Result	Result	Result	Result
ED093S: Soluble Major Cations - Continued									
Sodium	7440-23-5	10	mg/kg		----	**50**	----	----	----
Potassium	7440-09-7	10	mg/kg		----	**10**	----	----	----
ED093T: Total Major Cations									
Calcium	7440-70-2	50	mg/kg		----	**1870**	----	----	----
Magnesium	7439-95-4	50	mg/kg		----	**1130**	----	----	----
Sodium	7440-23-5	50	mg/kg		----	**90**	----	----	----
Potassium	7440-09-7	50	mg/kg		----	**130**	----	----	----
EG005S : Soluble Metals by ICPAES									
Aluminium	7429-90-5	1	mg/kg		----	<1	----	----	----
Antimony	7440-36-0	0.1	mg/kg		----	<0.1	----	----	----
Arsenic	7440-38-2	0.1	mg/kg		----	<0.1	----	----	----
Boron	7440-42-8	1	mg/kg		----	<1	----	----	----
Cadmium	7440-43-9	0.1	mg/kg		----	<0.1	----	----	----
Chromium	7440-47-3	0.1	mg/kg		----	<0.1	----	----	----
Cobalt	7440-48-4	0.1	mg/kg		----	<0.1	----	----	----
Copper	7440-50-8	0.1	mg/kg		----	<0.1	----	----	----
Iron	7439-89-6	1	mg/kg		----	<1	----	----	----
Lead	7439-92-1	0.1	mg/kg		----	<0.1	----	----	----
Manganese	7439-96-5	0.1	mg/kg		----	<0.1	----	----	----
Molybdenum	7439-98-7	0.1	mg/kg		----	<0.1	----	----	----
Nickel	7440-02-0	0.1	mg/kg		----	<0.1	----	----	----
Selenium	7782-49-2	0.1	mg/kg		----	<0.1	----	----	----
Zinc	7440-66-6	0.1	mg/kg		----	<0.1	----	----	----
EG005T: Total Metals by ICP-AES									
Aluminium	7429-90-5	50	mg/kg		----	**10300**	----	----	----
Antimony	7440-36-0	5	mg/kg		----	<5	----	----	----
Arsenic	7440-38-2	5	mg/kg		----	<5	----	----	----
Boron	7440-42-8	50	mg/kg		----	<50	----	----	----
Cadmium	7440-43-9	1	mg/kg		----	<1	----	----	----
Chromium	7440-47-3	2	mg/kg		----	**32**	----	----	----
Cobalt	7440-48-4	2	mg/kg		----	**14**	----	----	----
Copper	7440-50-8	5	mg/kg		----	**42**	----	----	----
Iron	7439-89-6	50	mg/kg		----	**11600**	----	----	----
Lead	7439-92-1	5	mg/kg		----	**10**	----	----	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	MCC7876 EB1600423-078	MCC7877 EB1600423-079	----	----	----
				Client sampling date / time	[07-Jan-2016]	[07-Jan-2016]	----	----	----
Compound	CAS Number	LOR	Unit		EB1603958-032	EB1603958-033	--------	--------	--------
					Result	Result	Result	Result	Result
EG005T: Total Metals by ICP-AES - Continued									
Manganese	7439-96-5	5	mg/kg		----	**48**	----	----	----
Molybdenum	7439-98-7	2	mg/kg		----	<2	----	----	----
Nickel	7440-02-0	2	mg/kg		----	**105**	----	----	----
Selenium	7782-49-2	5	mg/kg		----	<5	----	----	----
Zinc	7440-66-6	5	mg/kg		----	**140**	----	----	----

Appendix F

Soil field logs

Date	18/02/16	**Site Description** Vegetation - Mature rehab open woodland – trees native trees with small grass patches. Very rocky terrain, some surrounding areas have blackish crust.								
Profile	Sample site 1									
Elevation	249 m									
Site morphology	Wanning lower slope, 30%									
Location UTM 56 0305511 6430793	**Soil classification** Spolic Anthroposol		**Segregations** -			**Coarse fragments** Dispersed, many (20-50%), subangular/rounded and small pebbles (2-6 mm) to medium pebbles (6-20 mm). Size and frequency decrease with depth.		**Surface condition** 100% ground cover (leaf litter/gravel), dry, hardsetting		**Permeability and drainage** Moderately permeable, well drained
Depth/Horizon	**Texture**	**Structure**	**Mottles**	**Colour**	**Soil water status**	**Fabric**	**Roots**	**pH**	**EC (µS)**	**Photograph**
0-10cm A_{11} Sharp (<5 mm), smooth boundary	Fine sandy loam	Apedal (single-grained)	-	Brown (10YR 4/3), Specks of organic matter (dark brown, 10 YR 3/3)	Dry	Sandy	Many small roots	6.76	1088	
10-25cm A_{12}	Fine sandy loam	Apedal (single-grained) with few sub-angular blocky (0.5-1 cm)	-	Brown (10YR 4/3)	Dry	Sandy	Very few small roots	6.94	1774	

Date	18/02/16	**Site Description** Undulating contour drains down slope. Newer rehab area with immature trees and patches of grass. Gravelly area scattered with 10-15cm (diameter) surface rocks. 								
Profile	Sample site 2									
Elevation	259 m									
Site morphology	Waning, lower slope, 20%									
Location UTM 56 0305869 6430858	**Soil classification** Spolic Anthroposol		**Segregations** -			**Coarse fragments** Dispersed, many (20-50%) subangular/rounded, small pebbles (2-6 mm) to stones (200-600 mm). Increase with size and frequency with depth		**Surface condition** Hardsetting, dry, 50% ground cover (patchy grass, gravel)		**Permeability and drainage** Moderately permeable, well drained
Depth/Horizon	**Texture**	**Structure**	**Mottles**	**Colour**	**Soil water status**	**Fabric**	**Roots**	**pH**	**EC (µS)**	**Photograph**
0-10 cm A_{11}	Fine sandy loam	Apedal (single grained) with few sub-angular blocky (1-3 cm)	-	Brown (10 YR 4/3)	Dry	Sandy	Many small roots	7.35	3300	
10-20 cm A_{11}	Fine sandy loam	Apedal (single grained) With few sub-angular blocky (1-3 cm)	-	Brown (10 YR 4/3)	Dry	Sandy	Many small roots	7.4	3320	

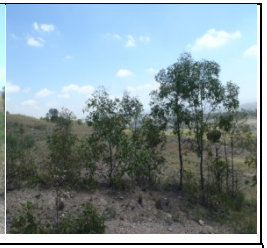
20-30 cm A_{11} Clear (20-50 mm), smooth boundary	Fine sandy loam	Apedal (single grained) with few sub-angular blocky (1-2 cm)	-	Brown (10 YR 4/3)	Dry	Sandy	Few small roots	7.41	3450	
30-45 cm A_{12}	Fine sandy loam	Apedal (single grained) with few sub-angular blocky (1-3 cm)	-	Very dark greyish brown (10 YR 3/2)	Dry (slightly damper)	Sandy	Few small roots	7.47	3390	

Date	18/02/16	**Site Description** Vegetation – Native open woodland with patchy grass. Rill erosion present around site. Gravelly area with scattered rocks (10-15cm) embedded in soil.	
Profile	Sample site 3		
Elevation	300 m		
Site morphology	Lower slope, waning, 25%		

Location	**Soil classification**	**Segregations**	**Coarse fragments**	**Surface condition**	**Permeability and drainage**
UTM 56 0305886 6430634	Spolic Anthroposol	-	Dispersed, common (10-20%) (increase with depth), Subangular/rounded, small pebbles to large pebbles (2-6 mm to 20-60 mm)	80% ground cover (gravel, some grass), dry, hardsetting	Moderately permeable, well drained

Depth/Horizon	**Texture**	**Structure**	**Mottles**	**Colour**	**Soil water status**	**Fabric**	**Roots**	**pH**	**EC (µS)**	**Photograph**
0-10 cm A_1	Fine sandy loam	Apedal (single-grained), with few sub-angular blocky (0.5-2 cm)	-	Dark yellowish brown (10 YR 4/4)	Dry	Sandy	Many small roots	7.07	76.9	
10-20 cm A_1	Fine sandy loam	Apedal (single-grained), with few sub-angular blocky (0.5-2 cm)	-	Dark yellowish brown (10 YR 4/4)	Dry	Sandy	Many small roots	7.03	1025	

20-30 cm A_1	Fine sandy loam	Apedal (massive) Sub-dominant: sub-angular blocky (0.5-2 cm)	-	Dark yellowish brown (10 YR 4/4)	Dry	Sandy	Few small roots	7.09	814	
30-40 cm A_1	Fine sandy loam	Apedal (massive) Sub-dominant: sub-angular blocky (0.5-2 cm)	-	Dark yellowish brown (10 YR 4/4)	Dry	Sandy	Few small roots	7.22	1826	

Date	18/02/16	**Site Description** series of slopes with flat contour drains. Immature trees with patchy grass. Surface is largely covered by gravel and rocks. Rill erosion present.								
Profile	Site 4									
Elevation	251 m									
Site morphology	Midslope, wanning, 25%.									
Location UTM 56 0306419 6430856	**Soil classification** Spolic Anthroposol		**Segregations** -			**Coarse fragments** Dispersed, common (10-20%) subangular/rounded, small pebbles to large pebbles (2-6 mm to 20-60 mm)		**Surface condition** Hardsetting, dry, 75% ground cover (gravel/rocks)		**Permeability and drainage** Moderately permeable, well drained
Depth/Horizon	**Texture**	**Structure**	**Mottles**	**Colour**	**Soil water status**	**Fabric**	**Roots**	**pH**	**EC (µS)**	**Photograph**
0-10 cm A_1	Fine sandy loam	Apedal (single grained) with few sub-angular blocky (0.5-2cm)	-	Yellowish brown (10 YR 5/4)	Dry	Sandy	Very few small roots	5.09	1786	
10-20 cm A_1	Fine sandy loam	Apedal (single grained) with few sub-angular blocky (0.5-2cm)	-	Yellowish brown (10 YR 5/4)	Dry	Sandy	Very few small roots	5.42	2021	

20-35 cm A_1	Fine sandy loam	Dominant: Apedal (massive) Sub-dominant: sub-angular blocky (0.5-2cm)	-	Yellowish brown (10 YR 5/4)	Dry	Sandy	-	5.74	1853	

Date	18/02/16	**Site Description** No observable erosion. No visible rocks on surface. More mature rehab forest with dense grass and infested with weeds. Likely soil deposition area.								
Profile	Site 5									
Elevation	302 m									
Site morphology	Midslope, wanning, 30%									
Location UTM 56 0306175 6430280	**Soil classification** Spolic Anthroposol		**Segregations** -			**Coarse fragments** Dispersed, few (2-10%), small pebbles (2-6 mm) to cobbles (60-200 mm), subangular/rounded		**Surface condition** 100% ground cover (leaf litter, grass/weeds), hardsetting surface, dry		**Permeability and drainage** Moderately permeable, moderately well drained
Depth/Horizon	**Texture**	**Structure**	**Mottles**	**Colour**	**Soil water status**	**Fabric**	**Roots**	**pH**	**EC (µS)**	**Photograph**
0-10 cm A_{11}	Sandy clay loam	Apedal (single grained) With few sub-angular blocky (0.5-1cm)	-	Brown (10 YR 4/3)	Dry	Sandy	Many small roots	7.04	165.3	
10-20 cm A_{11}	Sandy clay loam	Apedal (single grained) With few sub-angular blocky (0.5-1cm)	-	Brown (10 YR 4/3)	Dry	Sandy	Many small roots	7.43	267.9	

20-30 cm A_{11}	Sandy clay loam	Apedal (single grained) With few sub-angular blocky (0.5-1cm)	-	Brown (10 YR 4/3)	Dry	Sandy	Many small roots	7.38	316	
30-40 cm A_{11}	Sandy clay loam	Apedal (single grained) With few sub-angular blocky (0.5-1cm)	-	Brown (10 YR 4/3)	Dry	Sandy	Few small roots	7.34	341	
40-50 cm A_{11}	Sandy clay loam	Apedal (single grained) With few sub-angular blocky (0.5-1cm)	-	Brown (10 YR 4/3)	Dry	Sandy	Few small roots	7.31	282	

50-60 cm A_{12} Clear (20-50 mm), smooth boundary	Clayey sand/loamy sand?	Apedal (single grained) With few sub-angular blocky (0.5-1cm)	-	Dark yellowish brown (10 YR 4/4)	Dry	Sandy	Few small roots	7.28	199.7	
60-70 cm A_{12}	Clayey sand/loamy sand?	Apedal (single grained) With few sub-angular blocky (0.5-1cm)		Dark yellowish brown (10 YR 4/4)	Dry	Sandy	Few small roots	7.11	162.3	

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