APPENDIX G SOIL SURVEY AND ASSESSMENT

Soil Survey

MAXWELL SOLAR FARM

JULY 2019

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EXECUTIVE SUMMARY

NGH Environmental Pty Ltd (NGH) have been engaged by Maxwell Solar Pty Ltd to prepare a soil survey for the proposed Maxwell Solar Farm (the Proposal). The soil survey is required to address the Department of Planning & Environment (DoPE) Secretary's Environmental Assessment Requirements (SEARs). The SEARs include a requirement for *'a soil survey to determine the soil characteristics and consider the potential for erosion to occur'*.

The Proposal includes the construction, operation and decommissioning of a ground-mounted PV solar array which would generate approximately 25 megawatts (MW) (alternating current (AC)) to supply electricity to the Maxwell Infrastructure site and/or the Maxwell Underground site and/or the National Energy Market (NEM). The solar farm would be constructed on rehabilitated mining overburden.

The soil survey includes a desktop assessment of available data and a soil investigation including test pitting and laboratory analysis of collected soil samples.

The desktop assessment indicates that the pre-mining subsoil and topsoil may include one, or a combination of, the Bayswater, Liddell and/or Roxburgh soil landscape/s. Without suitable erosion and sediment control measures these soil landscapes have the potential for sheet erosion, rill erosion and gully erosion. Based on site observations and laboratory results, it is likely that the pre-mining subsoil soil landscapes now comprise the mining overburden (fill). Similarly, the topsoil observed onsite is similar to the topsoil properties of the Bayswater, Liddell and Roxburgh soil landscapes data sheets (Appendix A). It is expected that the topsoil and subsoil (fill) observed on site would respond to erosion and sedimentation in a similar manner to the Bayswater, Liddell and/or Roxburgh soil landscapes.

The results of the laboratory analysis indicate that topsoil and subsoil (fill) includes non-dispersive fines that are susceptible to erosion. The laboratory analysis also indicates sodic soils that may have structural problems that lead to dispersive fines.

As a result of the desktop assessment and the laboratory analysis the topsoil and subsoil (fill) is considered to have a high erosion potential if not stabilised. However, with the implementation of mitigation measures recommended in section 4 the potential risk of erosion and sedimentation would be minimised.

ACRONYMS AND ABBREVIATIONS

AC	Alternating current
ARENA	Australian Renewable Energy Agency
Ca	Calcium
CEC	Cation exchange capacity
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DOI - L&W	Department of Industry – Lands & Water
DoPE	Department of Planning & Environment
DPI	Department of Primary Industries
EC	Electrical conductivity
ECEC	Effective cation exchange capacity
EIS	Environmental Impact Statement
ESCP	Erosion and sediment control plan
ESP	Exchangeable sodium percentage
ha	Hectares
K	Potassium
kV	Kilovolt
m	Metre
Mg	Magnesium
mm	Millimetre
MW	Megawatts
N	Nitrogen
Na	Sodium
NATA	National Association of Testing Authorities (Australia)
NEM	National Energy Market

OEH	Office of Environment & Heritage
P	Phosphorus
pH	Power of hydrogen
PV	Photovoltaic
S	Sulfur
SEARs	Secretary's Environmental Assessment Requirements
TP	Test pit
%	Percent

1 INTRODUCTION

This Soil Survey (the Report) describes the soil characteristics at the site of the proposed Maxwell Solar Farm (the Proposal) and assesses the potential for erosion during construction. The solar farm would be located on rehabilitated open cut mine land within the Maxwell Infrastructure site at Muswellbrook, NSW. The proposed solar farm would have the potential to generate approximately 25MW (AC) for the supply of electricity to the Maxwell Infrastructure site and/or the Maxwell Underground site and/or the National Energy Market (NEM).

Maxwell Solar Pty Ltd have received the Department of Planning & Environment (DoPE) Secretary's Environmental Assessment Requirements (SEARs) for the preparation of an Environmental Impact Statement (EIS) for the Maxwell Solar project.

The SEARs include a requirement for *'a soil survey to determine the soil characteristics and consider the potential for erosion to occur'*. Attachment 1 of the SEARs indicates that the land requirements must be prepared in accordance with:

- Primefact 1063: Infrastructure proposals on rural land (Department of Primary Industries (DPI), 2013)
- Establishing the social licence to operate large scale solar facilities in Australia: insights from social research for industry (Australian Renewable Energy Agency (ARENA), 2015)
- *Local Land Services Act 2013*
- Australian Soil and Land Survey Handbook (Commonwealth Scientific and Industrial Research Organisation (CSIRO), 2009)
- Guidelines for Surveying Soil and Land Resources (CSIRO, 2008)
- The land and soil capability assessment scheme: second approximation (Office of Environment and Heritage (OEH), 2012)
- Land Use Conflict Risk Assessment Guide (Department of Industry – Lands and Water (DoI – L&W), 2011).

No further details are provided in the SEARs.

1.1 PURPOSE

The purpose of the Report is to address the SEARs requirement to determine the soil characteristics and consider the potential for erosion. The soil survey focusses on areas and strata that are likely to be disturbed during construction of the Proposal. The Report recommends mitigation measures to minimise the erosion and sedimentation risks during construction.

1.2 KEY COMPONENTS OF THE PROPOSAL

The Proposal includes the construction, operation and decommissioning of a ground-mounted PV solar array which would generate approximately 25 megawatts (MW) (alternating current (AC)) to be supply electricity to the Maxwell Infrastructure site and/or the Maxwell Underground site and/or the NEM.

The Maxwell Solar project, as presented in Figure 1-1, includes a project boundary of about 145 hectares including a solar array/pad of about 105 hectares (ha) and about 1.2 kilometres (km) of above ground linear infrastructure. The linear infrastructure includes above ground transmission line easements to connect to

the existing Maxwell Infrastructure (nee Drayton Mine) substation (33 kilovolt (kV) option) or proposed switchyard (66kV option).

Construction of the Proposal would take approximately 12 to 18 months, with a shorter peak construction period of approximately six months, during which time the main construction works would take place.

The Maxwell Solar Farm would be expected to operate for approximately 30 years. After this initial operating period, the solar farm would either be decommissioned, removing all above ground infrastructure and returning the site to its existing land capability, or repowered with new photovoltaic (PV) equipment to continue operations as a solar plant. It is noted that an indefinite planning approval is being sought.

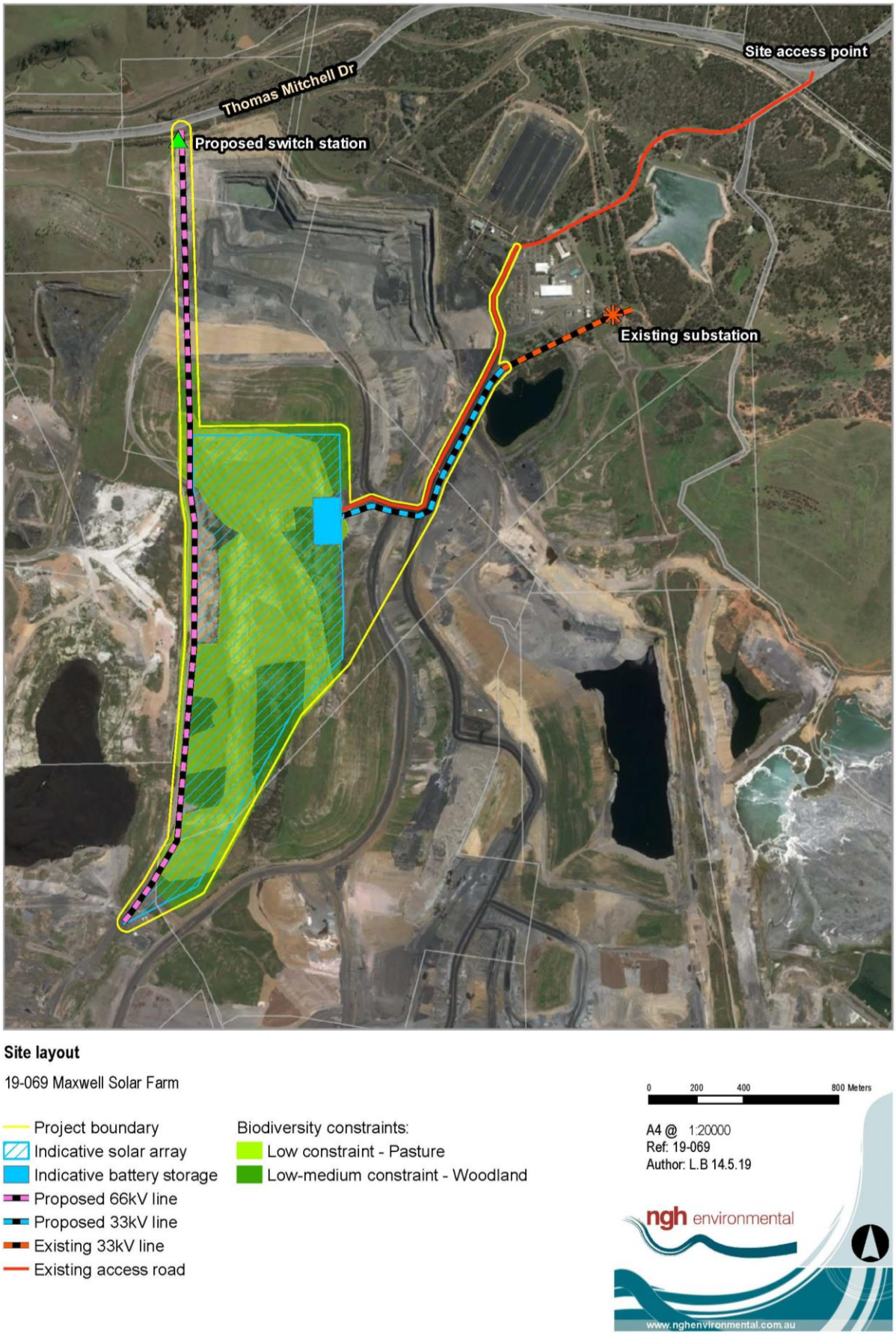


Figure 1-1 Maxwell Solar Farm proposed design and constraints

2 SOIL SURVEY

2.1 DESKTOP ASSESSMENT

2.1.1 Existing environment

The proposed location for the Proposal is a rehabilitated portion of a heavily disturbed former open cut mining operation. The Proposal would be constructed on rehabilitated overburden.

The topography of the Proposal area has been heavily modified by mining and rehabilitation activities.

The solar array area of the Proposal would be constructed on an area known as the 'North Tip', as described in the Rehabilitation and Offset Management Plan (Anglo American, 2013). Rehabilitation of the North Tip was undertaken prior to 2013.

2.1.2 Regional soil landscapes

The pre-mining regional soil landscapes are presented on Figure 2-1. The soil landscape maps are managed by the The Department of Planning, Industry and Environment (formally OEH) and describe the properties of soils and the landscapes in which they occur. Descriptions of these soil landscapes are attached as Appendix A and key points are summarised in Table 2-1 below.

Overburden used at the Proposal site is likely to have been sourced from the Bayswater and / or Liddell soil landscapes (refer to Figure 2-1). The overburden may also include a small proportion of the Roxburgh soil landscape.

Table 2-1 Soil landscapes data (Source: OEH eSpade, 2019)

Soil landscape	Geology	Typical Soil erosion (pre-mining environment)
BAYSWATER	Geological Unit as described in the Soil Landscape: Singleton Coal Measures Parent Rock: Sandstone, shale, mudstone, conglomerate and coal. Parent Material: In situ weathered parent rock with alluvium in the drainage lines.	Moderate sheet and gully erosion is common on slopes. Gullies (to 3 metres (m)) are associated with the highly erodible yellow solodic soils. Salt scalds and associated erosion are common in some areas.
LIDDELL	Geological Unit as described in the Soil Landscape: Singleton Coal Measures Parent Rock: Lithic sandstone, shale, mudstone, conglomerate, siltstone and coal seams. Parent Material: In situ weathered parent rock and some derived colluvium.	Minor to severe sheet erosion is common, with some minor rill erosion. Moderate gully erosion (to 1.5m) in drainage line where salting may be a feature.
ROXBURGH	Geological Unit as described in the Soil Landscape: Singleton Coal Measures	Minor to moderate sheet erosion is common. Some gullies up to 3m

Soil landscape	Geology	Typical Soil erosion (pre-mining environment)
	Parent Rock: Sandstone, shale, mudstone, conglomerate and coal. Parent Material: In situ weathered parent rock and derived colluvium.	deep are associated with the dispersible soloths and solodic soils.

2.1.3 Design and construction

Factors of the design and construction that may contribute to the erosion potential are presented in Table 2-2.

Table 2-2 Design and construction elements that contribute to the erosion potential

Factor	Input
Duration of disturbance	6 months (peak disturbance)
Area of disturbance	The area of disturbance has been estimated as 26,000 m^2. Calculated as 25% disturbance of the 105 ha solar array area. Depending on the construction methodology implemented by the construction contractor the disturbance of existing ground cover may be more or less.
Slopes	The solar arrays would be located on flat areas with slopes up to 10%. The power lines would be located on steeper slopes up to 30%.

Without the implementation of erosion and sediment controls projects with a similar duration and area of disturbance would be considered high risk. However, with the implementation of mitigation measures recommended in section 4 the potential risk of erosion and sedimentation would be minimised.

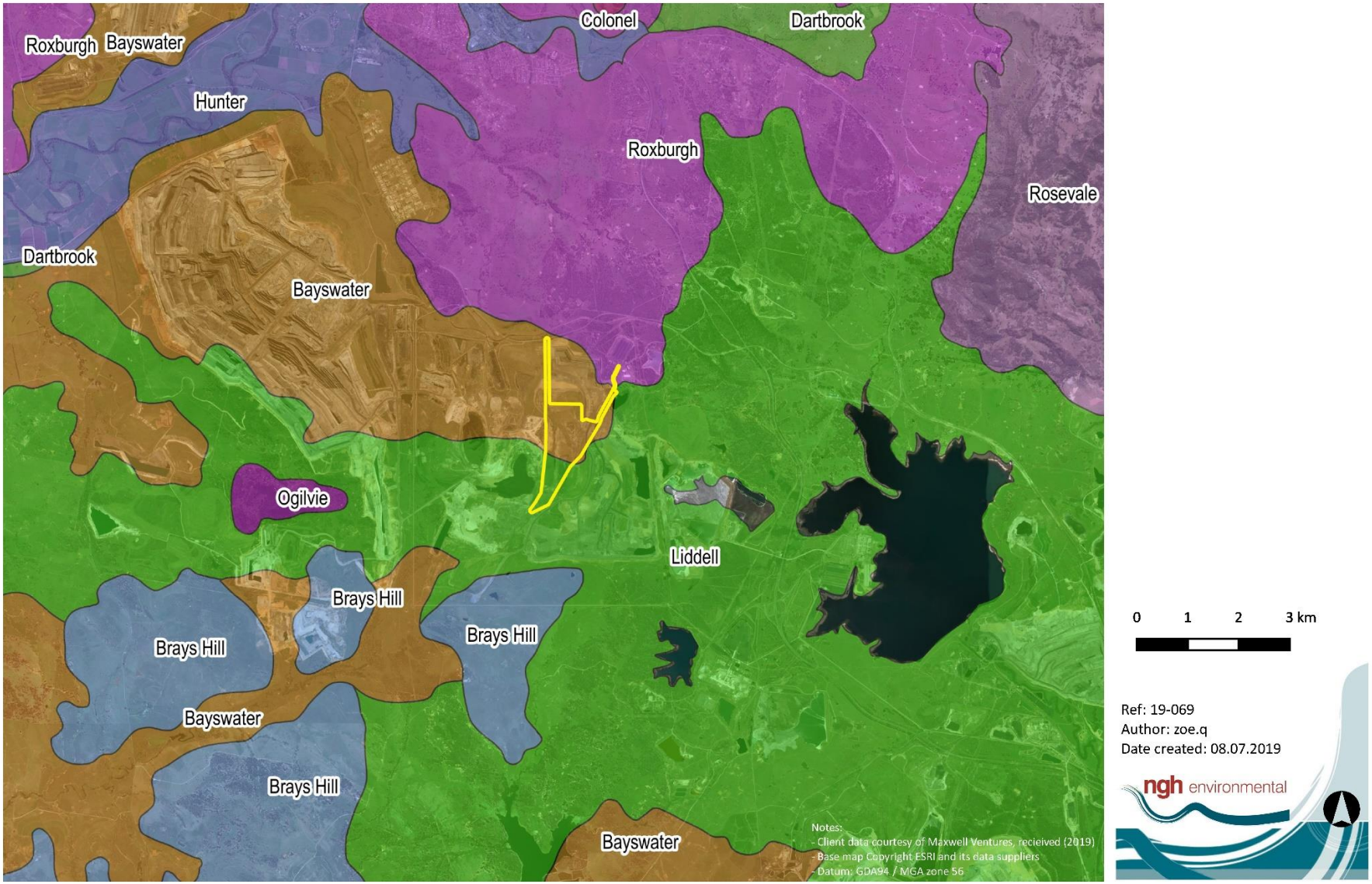


Figure 2-1 Pre-mining soil landscapes (The Proposal site is shown in yellow) (Source: OEH, 2017 and eSpade, 2019)

2.2 SOIL INVESTIGATION, SAMPLING AND ANALYSIS

2.2.1 Site observations

Site observations recorded during the soil investigation indicate that the rehabilitated area comprises sown grasses along with weeds. The topsoil utilised was ameliorated in places with biosolids prior to seeding. Negligible erosion was observed on the rehabilitated areas of the site. Gravel, cobbles and boulders present in the material at the surface act to reduce sediment detachment.

The site also included unrehabilitated areas for both the powerline corridor and solar farm access. The access is to be rehabilitated as part of the mine rehabilitation programme during 2019 and 2020.

2.2.2 Soil investigation

The soil investigation included a test pitting program utilising an excavator supplied by Maxwell Solar Pty Ltd. The program included eight test pits (TP1 to TP8) Figure 2-2 (TP7 was not undertaken as it was located on an active internal road and the proposed work in this area would be the overhead transmission lines and so unlikely to disturb soils).

The investigation was carried out in accordance with the *Guidelines for Surveying Soil and Land Resources* (CSIRO, 2008) for a moderately high (detailed) intensity level (refer to Table 2-3).

Table 2-3 Recommended soil survey intensity

Intensity level	Inspection density	Publication scale	Objectives
Moderately high (detailed)	1 per 5 ha to 25 ha i.e. 4 to 20 per km^2	1:25 000	Moderately intensive uses at 'field' level, detailed project planning

Test pit logs were recorded during the soil investigation and are attached as Appendix B. Photos from the soil survey are attached as Appendix C.

Test pits TP1, TP2, TP4 and TP8 had topsoil ranging from 50 millimetre (mm) to 300mm depth. The topsoil was underlain by fill consisting of clay (with silt or sand) or gravel (with sand and/or silt) to the maximum depth of the test pit investigation. Topsoil was described as well graded silty sand. Little topsoil was observed in three test pits (TP3, TP5 and TP6).

Table 2-4 details the subsoil material observed during test pitting. All test pits comprised fill with some proportion of fine sediments.

Table 2-4 Fill descriptions

Test pit	Depth (m)	Material
1	0.3 – 1.5	FILL, Silty CLAY, medium to high plasticity, brown with mottled grey, with sand, gravel and boulders
2	0.2 – 1.4	FILL, Silty CLAY, low to medium plasticity, brown with mottled grey, yellow and red, with fine to medium grained sand, some boulders and cobbles
3	0.0 – 0.5	FILL, Gravelly Sandy CLAY, medium plasticity, brown, with roots to 0.2 m
	0.5 – 1.4	FILL, Sandy GRAVEL, coarse grained, grey, fine to coarse sand
4	0.05 – 0.5	FILL, Sandy CLAY, low to medium plasticity, brown with mottled grey, dark grey and yellow
	0.5 – 1.4	FILL, Sandy CLAY, low plasticity, dark grey and grey, some coal and boulders
5	0.0 – 1.3	FILL, Silty Sandy GRAVEL, course grained gravel, fine to medium grained sand, light brown and brown, with cobbles
6	0.0 – 1.25	FILL, Silty Sandy GRAVEL, fine to course gravel, fine to coarse sand, dark grey, with coal fragments, cobbles and boulders
8	0.3 – 1.3	FILL, Silty CLAY, low to medium plasticity, mottled grey, brown and red

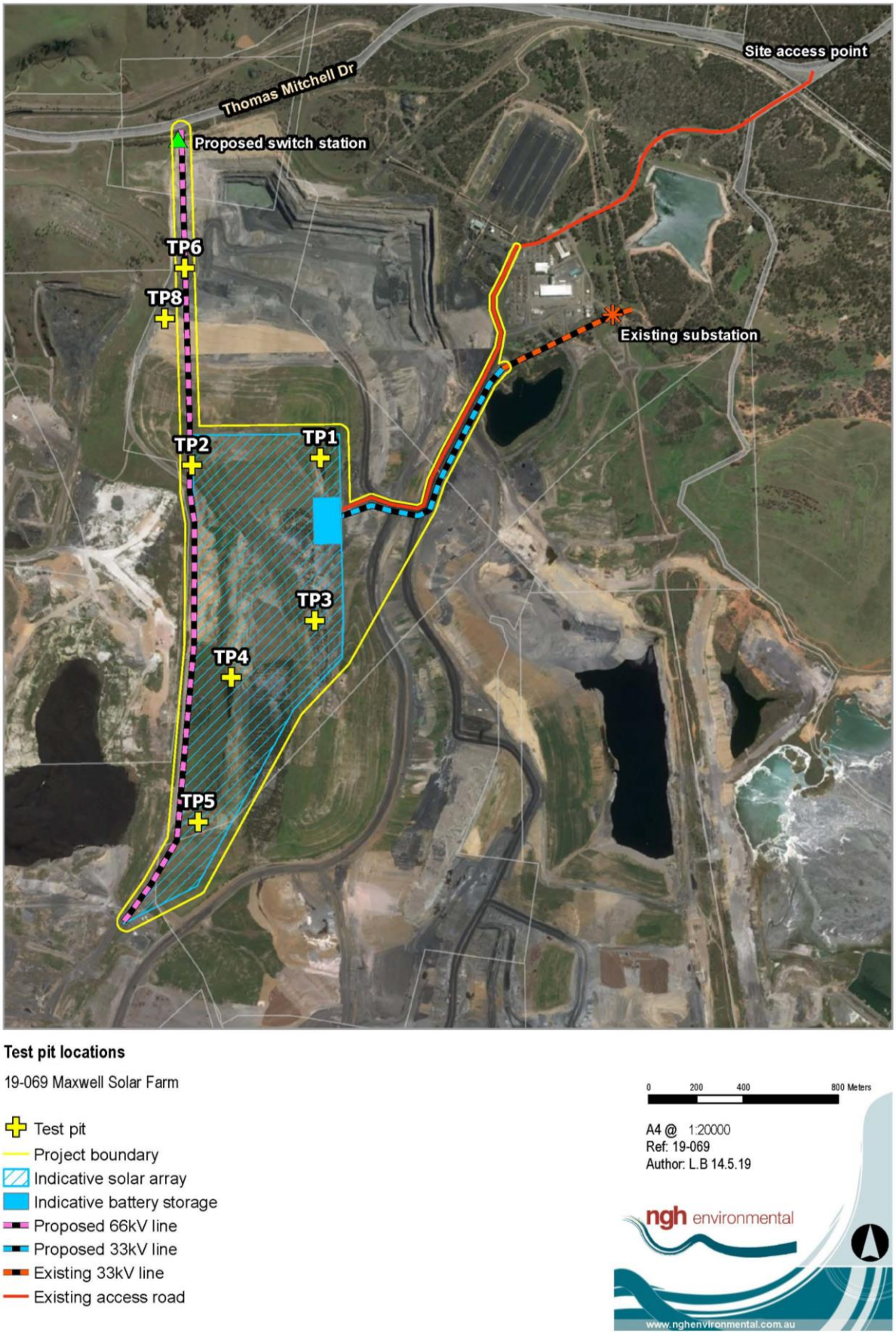


Figure 2-2 Test pit locations

2.2.3 Laboratory analysis

Topsoil

Three topsoil samples (TP1 0.0-0.2, TP2 0.0-0.2 and TP8 0.0-0.3) were dispatched to a National Association of Testing Authorities (NATA) accredited laboratory for testing. The topsoil suite of analytes included:

- pH
- Electrical conductivity (EC)
- Chloride
- Exchangeable Cations (Calcium (Ca), Magnesium (Mg), Sodium (Na), Potassium (K)) plus effective cation exchange capacity (CEC) and exchangeable sodium percentage (ESP)
- Nitrogen - Total Nitrogen as N
- Phosphorous - Total Phosphorus as P
- Sizings - Particle Sizing to 75µm (Sieve) (excluding TP8 0.0-0.3)
- Sulfur - Total as S
- Organic Matter Content plus Organic Carbon by Calc' (Walkley Black)
- Emerson Aggregate Test.

The laboratory results are attached as Appendix D. A summary of the topsoil analysis is included in Table 2-5.

Subsoil

Nine subsoil samples (all comprising fill) (TP1 0.5-0.6, TP2 0.3-0.4, TP3 0.0-0.3, TP3 0.6-0.7, TP4 0.1-0.3, TP4 0.6-0.7, TP5 0.0-0.3, TP6 0.0-0.5 and TP8 0.5-0.6) were dispatched to a NATA accredited laboratory for testing. The subsoil suite of analytes included:

- pH plus EC (1:5)
- Chloride (requires 1:5 soil water leach)
- Exchangeable Cations (Ca, Mg, Na, K) plus CEC & ESP
- Emerson Aggregate Test.

Sizings - Particle Sizing to 75µm (Sieve) was carried out on seven samples (TP1 0.5-0.6, TP2 0.0-0.2, TP2 0.3-0.4, TP3 0.0-0.3, TP3 0.6-0.7, TP4 0.1-0.3 and TP4 0.6-0.7). Three subsoil samples were excluded from particle sizing analysis as gravel, cobbles and/or boulders were present in the soil profile (TP3 0.6-0.7, TP5 0.0-0.3 and TP6 0.0-0.5).

The laboratory results are attached as Appendix D. A summary of the subsoil analysis is included in Table 2-6.

Table 2-5 Topsoil soil analysis results

Sample ID	pH	EC	Chloride	Exchangeable Calcium	Exchangeable Magnesium	Exchangeable Potassium	Exchangeable Sodium	Cation Exchange Capacity	Exchangeable Sodium Percent	Nitrogen - Total Nitrogen as N	Phosphorous - Total Phosphorus as P	PSA - % fines (<0.075 mm)	Sulfur - Total as S	Organic Matter	Total Organic Carbon	Emerson Aggregate Test
Unit	pH	µS/cm	mg/kg	meq/100g	meq/100g	meq/100g	meq/100g	meq/100g	%	mg/kg	mg/kg	%	%	%	%	
TP1 0.0-0.2	8	69	50	3.2	2.6	0.3	<0.2	6.2	<0.2	880	177	41	0.06	3	1.7	4
TP2 0.0-0.2	8.4	123	30	5.8	3.5	0.3	<0.2	9.6	<0.2	820	293	60	0.05	2.6	1.5	4
TP8 0.0-0.3	8.8	335	110	3.3	4.4	<0.2	1.3	9	15	560	393	----	0.03	1.5	0.9	3

Table 2-6 Subsoil soil analysis results

Sample ID	pH	EC	Chloride	Exchangeable Calcium	Exchangeable Magnesium	Exchangeable Potassium	Exchangeable Sodium	Cation Exchange Capacity	Exchangeable Sodium Percent	Nitrogen - Total Nitrogen as N	Phosphorous - Total Phosphorus as P	PSA - % fines (<0.075 mm)	Sulfur - Total as S	Organic Matter	Total Organic Carbon	Emerson Aggregate Test
Unit	pH	µS/cm	mg/kg	meq/100g	meq/100g	meq/100g	meq/100g	meq/100g	%	mg/kg	mg/kg	%	%	%	%	
TP1 0.5-0.6	8.4	226	60	2.2	1.7	<0.2	<0.2	3.9	<0.2	----	----	56	----	----	----	4
TP2 0.3-0.4	8.4	91	<10	4.7	3.1	<0.2	<0.2	7.8	<0.2	----	----	55	----	----	----	4
TP3 0.0-0.3	8.8	92	80	2.1	3.6	<0.2	0.9	6.6	13.4	----	----	57	----	----	----	3
TP3 0.6-0.7	8.7	216	70	2.2	3.8	<0.2	1.1	7.1	15.6	----	----	----	----	----	----	3
TP4 0.1-0.3	8.8	71	10	4.4	3.1	<0.2	<0.2	7.5	<0.2	----	----	46	----	----	----	4
TP4 0.6-0.7	8.5	69	<10	5.4	4.1	<0.2	<0.2	9.7	<0.2	----	----	56	----	----	----	4
TP5 0.0-0.3	9	90	20	4	2.2	<0.2	<0.2	6.3	<0.2	----	----	----	----	----	----	4
TP6 0.0-0.5	9	287	30	1	9.3	0.4	1.2	11.9	10	----	----	----	----	----	----	3
TP8 0.5-0.6	8.3	555	140	1.5	3	<0.2	0.8	5.3	15.1	----	----	----	----	----	----	4

3 CONCLUSION

3.1 DESKTOP ASSESSMENT AND SITE OBSERVATIONS

The desktop assessment indicates that the pre-mining subsoil and topsoil may include one, or a combination of, the Bayswater, Liddell and/or Roxburgh soil landscape/s. Without suitable erosion and sediment control measures these soil landscapes have the potential for sheet erosion, rill erosion and gully erosion.

Based on site observations and laboratory results, it is likely that the pre-mining subsoil soil landscapes described above comprise the mining overburden (fill). Similarly, the topsoil observed onsite is similar to the topsoil properties of the Bayswater, Liddell and Roxburgh soil landscapes data sheets (Appendix A). It is expected that the topsoil and subsoil (fill) observed on site would respond to erosion and sedimentation in a similar manner to the Bayswater, Liddell and/or Roxburgh soil landscapes.

3.2 LABORATORY ANALYSIS

The results of topsoil laboratory analysis indicates that the topsoil has similar properties and is consistent across the site. The topsoil analysis results indicate:

- Slightly alkaline soil with pH ranging from pH 8 to pH 8.8. Increasing soil alkalinity leads to some plant nutrients becoming unavailable. The observed pH range is unlikely to impact rehabilitation using this topsoil.
- Very low to low salinity. Increased salinity can adversely affect the growth of most plants.
- Cation analysis indicates that the topsoil may be deficient in Calcium, Magnesium and Potassium. The CEC ranges from 6.2 to 9.6 meq/100g. CEC is the soil's ability to hold cations by electrical attraction and is a useful indicator of soil fertility because it shows the soil's ability to supply three important plant nutrients: Calcium, Magnesium and Potassium.
- Topsoil at TP1 and TP2 recorded 41% and 60% passing 0.075 mm particle size respectively. This indicates the topsoil contains 39% and 40% clays and silts. Clays and silts are more susceptible to erosion.
- The Exchangeable Sodium Percentage (ESP) was <0.2 in two of three topsoil samples (TP1 and TP2). This is due to a non-detection of sodium. Topsoil from TP8 recorded an ESP of 15. Soil material with an ESP of 15 is strongly sodic. Sodic soils can have structural problems that lead to clay particles being dispersive (and increasing the risk of erosion).
- Emerson aggregate test results indicate a range from 3 to 4 and is slightly to non-dispersible soils. The Emerson aggregate test classifies the behaviour of soil aggregates, when immersed, on their coherence in water. The results are categorised 1 (extremely dispersive) to 8 (non-dispersive).
- The topsoil organic carbon content (0.9-1.7%) was below average for dryland soils (0.7-4.0%). Total organic carbon is a measure of the carbon contained within soil organic matter. Total organic carbon is a good indicator of topsoil quality.

The results of subsoil laboratory analysis indicates that the subsoil has similar properties and is consistent across the site. The sub soil analysis results indicate:

- Slightly alkaline sub soil with a pH range of pH 8.3 to pH 9.
- Very low to low salinity.

- Cation analysis indicates that the subsoil may be deficient in Calcium, Magnesium and Potassium. The CEC ranges from 3.9 to 11.9 meq/100g.
- The particle size analysis indicates that the subsoil contains 46% to 57% particles less than 0.075 mm. This indicates that the subsoil has a significant proportion of clays and silts that are more susceptible to erosion.
- The ESP is less than <0.2% at five of nine subsoil samples. This is due to a non-detection of sodium. The remaining subsoil samples recorded an ESP of 10% to 15.6%. Soil material with an ESP in this range is considered sodic. Clay particles can be dispersive in sodic soils.
- Emerson aggregate test results indicate slightly to non dispersible soils.

The results of the laboratory analysis indicate that topsoil and subsoil is consistent with the Bayswater, Liddell and/or Roxburgh soil landscapes and include non-dispersive fines that are susceptible to erosion. The laboratory analysis also indicates sodic soils that may contributeto dispersive fines.

In Conclusionthe topsoil and subsoil (fill) have erosion potential if not stabilised. Therefore the mitigation measures recommended below whould be implemented to minimise the risk of erosion and sedimentation.

4 RECOMMENDATIONS

The following mitigation measures should be implemented to minimise soil erosion and sedimentation during construction of the Proposal:

- A construction Erosion and Sediment Control Plan (ESCP) be prepared for in accordance with Landcom Soils and Construction: Managing Urban Stormwater (2004).
- The design and construction to minimise ground disturbance and avoid disturbing steep slopes.
- Where ground disturbance is required, the vegetation (organic matter) is retained and reused during rehabilitation.
- Topsoil stockpiled separately and treated with ameliorants as soon as practicable to encourage topsoil quality for reuse during rehabilitation.
- A rehabilitation and revegetation plan be prepared and include stabilisation and topsoil amelioration.
- Soils disturbed during construction and with an exchangeable sodium percentage above 6% treated with gypsum to increase the levels of calcium and magnesium, and thus lowering the exchangeable sodium percentage.
- Unrehabilitated areas on the powerline easement and access road rehabilitated in accordance with the conditions of the current mining approval.

5 REFERENCES

Anglo American. (2013). *Drayton Mine Rehabilitation and Offset Management Plan* .

ARENA. (2015). • *Establishing the social licence to operate large scale solar facilities in Australia: insights from social research for industry.* Australian Renewable Energy Agency.

CSIRO. (2008). *Guideline for Surveying Soil and Land Resources.* CSIRO.

CSIRO. (2009). *Australian Soil and Land Survey Handbook.* CSIRO.

DoI - L&W. (2011). *Land Use Conflict Risk Assessment Guide.* Department of Industry - Lands and Water.

DPI. (2013). *Primefact 1060: Infrastructure proposals on rural land* . Department of Primary Industries .

Landcom. (2004). *Managing Urban Stormwater, Soils & Construction.* (Volume 1) NSW Government.

OEH. (2012). *The land and soil capability assessment scheme: second approximation.* Office of Environment and Heritage.

OEH. (2017). *Soil Landscapes of Central and Eastern NSW*. Retrieved from Data NSW: https://data.nsw.gov.au/data/dataset/published-soil-landscapes-of-central-and-eastern-nsw37d37

OEH. (2019). *eSPADE*. Retrieved from Office of Environment and Heritage - Soil profile and soil map information: https://www.environment.nsw.gov.au/espade2webapp

APPENDIX A SOIL LANDSCAPE DATA SHEETS

SC-bz BAYSWATER SOIL LANDSCAPE

GENERAL

This soil landscape covers undulating low hills south-west of Muswellbrook. The main soils are Yellow Solodic Soils (Dy3.43, Dy3.33) on slopes with Alluvial Soils in drainage lines. There are Brown and Yellow Earths (Gn2.41, Gn2.21, Gn2.61) and Prairie Soils (Gn3.91, Gn3.41, Gn4.41) in some drainage lines. Red and Yellow podzolic soils (Dr2.11, Dr1.11, Dr2.21, Dy2.11) and Brown Podzolic Soils (Db1.11, Db0.11, Db1.21) occur on slopes. There are also yellow Solodic Soil - Red-brown Earth intergrades (Dy2.13).

ASSOCIATED SOIL LANDSCAPES: Liddell and Roxburgh

CLIMATIC ZONE: 3B

LANDFORM

Undulating low hills, ranging in elevation from 140 - 220 m. Slopes are 3 - 10%, with slope lengths averaging 1,200 m. Local relief is 40 - 60 m. Drainage lines occur at 700 – 1,000 m intervals.

NATIVE VEGETATION:

Much of the area has been cleared out of woodland for grazing on unimproved pastures. Remnants of forest red gum and forest oak occur. Broad - leaved red ironbark, narrow-leaved red ironbark, bull oak, grey box and swamp oak may also be found in some areas.

GEOLOGY

Geological Unit: Singleton Coal Measures
Parent Rock: Sandstone, shale, mudstone, conglomerate and coal.
Parent Material: *In situ* weathered parent rock with alluvium in the drainage lines.

SOIL EROSION

Moderate sheet and gully erosion is common on slopes. Gullies (to 3 m) are associated with the highly erodible yellow solodic soils. Salt scalds and associated erosion are common in some areas.

GENERAL SOIL DESCRIPTIONS

Yellow Solodic Soils (Dy3.43, Dy3.33)

Topsoil: Brown fine sandy loam to loam with weak structure; pH 6.0 - 6.5. Overlies bleached dull brown or light grey light sandy clay loam to loam fine sandy; and massive or with weak structure; pH 6.5 - 7.0; depth to 20 cm.

Subsoil: Clear change to bright yellowish brown medium clay with strong structure; yellow, orange or grey mottles (up to 50%); pH 6.5 - 9.0, increasing with depth.

Alluvial Soils

Topsoil: Brown loamy sandy to sandy clay which is single-grained to massive.

Yellow Solodic Soil – Red-brown Earth intergrades (Dy2.13)

Topsoil: Dark reddish brown sandy clay loam that has weak structure; pH 6.5 - 7.90; depth to 18 cm.

Subsoil: Gradual or diffuse change to bright brown sandy clay loam to sandy, light, or light - medium clay; weak structure.

Prairie Soils (Gn3.91, Gn3.41, Gn4.41)

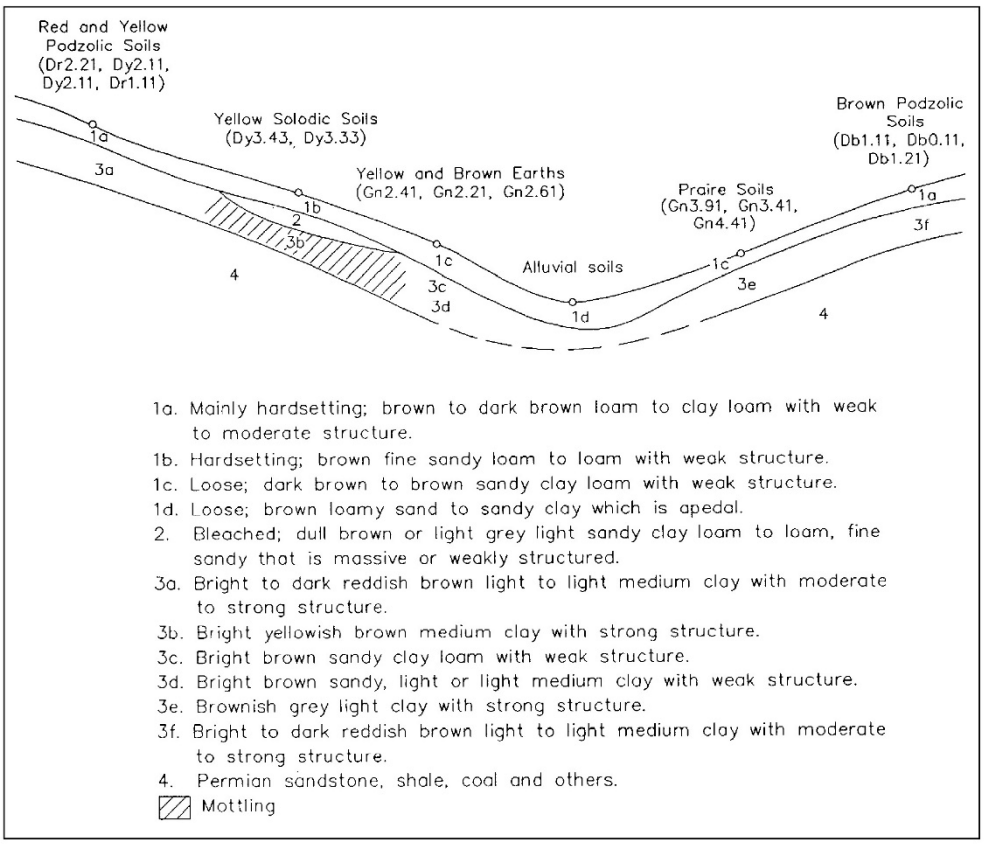
Topsoil: Brown sandy clay loam; massive or with weak structure; depth to 65 cm.
Subsoil: Brownish grey light clay; strong structure; pH 6.0.

Red and Yellow Podzolic Soils (Dr2.11, Dr1.11, Dr2.21, Dy2.11)

Topsoil: Brown to dark brown loam to clay loam with weak to moderate structure; pH 6.0; depth to 12 cm.
Subsoil: Clear change to bright reddish brown to dark reddish brown light to light medium clay; moderate to strong structure; pH 5.5.

Brown Podzolic Soils (Db1.11, Db0.11, Db1.21)

Topsoil: Brown to dark brown loam to clay loam with weak to moderate structure; pH 5.5; depth to 7 cm.
Subsoil: Clear change to brown light medium clay with moderate to strong structure; pH 5.5.



	Yellow Solodic Soils	Red and Yellow Podzolic Soils
Northcote code	Dy3.43, Dy3.33	Dr2.11, Dr1.11, Dr2.1, Dy2.11
Dominance	Common	Common
Landform element	Lower slope	Slopes
Surface condition	Hardsetting	Hardsetting
Drainage	Poorly to imperfectly drained	Well-drained
Soil permeability	Moderately to slowly permeable	Moderately permeable
Watertable depth	-	-
Available water-holding capacity	Moderate	Moderate to high
Depth to bedrock	+90 cm	40 - 300 cm
Flood hazard	Low to moderate	Low
pH (topsoil)	6.0 - 6.5	6.0
Fertility (chemical)	Low	Low
Known nutrient deficiencies	N, P	N, P, Mo, S
Soil salinity	High	Low
Erodibility (topsoil)	Moderate to high	High
Erodibility (subsoil)	High	Moderate
Erosion hazard	Very high to extreme	Moderate
Structural degradation hazard	High	High
Land capability classification	V	V
USCS (subsoil)	CL	CL, CH
Shrink-swell potential	-	Low
Mass movement hazard	Low	Low

	Brown and Yellow Earths	Prairie Soils
Northcote code	Gn2.41, Gn2.21, Gn2.61	Gn3.91, Gn3.41, Dn4.41
Dominance	Minor	Minor
Landform element	Depositional sites near creeks	Depositional sites near creeks
Surface condition	Loose	-
Drainage	Well-drained	Moderately well-drained to poorly drained
Soil permeability	Highly permeable	Moderately permeable
Watertable depth	-	-
Available water-holding capacity	Low to moderate	Moderate
Depth to bedrock	70 cm	200 cm
Flood hazard	Moderate	Moderate
pH (topsoil)	6.0	6.0
Fertility (chemical)	Low	Low
Known nutrient deficiencies	N, P, Mo, S	N, P
Soil salinity	Low	Low
Erodibility (topsoil)	High	Low to high
Erodibility (subsoil)	Moderate to high	Moderate to high
Erosion hazard	Moderate	Moderate
Structural degradation hazard	High	Low to high
Land capability classification	IV	IV
USCS (subsoil)	CL	-
Shrink-swell potential	Low	-
Mass movement hazard	Low	Low

	Alluvial Soils	Yellow Solodic Soils – Red-brown Earth intergrades
Northcote code	-	Dy2.13
Dominance	Minor	Minor
Landform element	Lower slopes and drainage depressions	Upper slope
Surface condition	Loose	Hardsetting
Drainage	Moderately well-drained	Well-drained
Soil permeability	Moderately permeable	Moderately permeable
Watertable depth	70 cm	-
Available water-holding capacity	Moderate	Moderate
Depth to bedrock	+80 cm	+50 cm
Flood hazard	High	Low
pH (topsoil)	6.0	6.5
Fertility (chemical)	Low	Low
Known nutrient deficiencies	N,P	N,P
Soil salinity	High	High
Erodibility (topsoil)	Moderate	Moderate
Erodibility (subsoil)	Low	Moderate
Erosion hazard	Very high	Very high
Structural degradation hazard	Moderate	High
Land capability classification	IV, V	V
USCS (subsoil)	-	-
Shrink-swell potential	Low	-
Mass movement hazard	Low	Low

	Brown Podzolic Soils
Northcote code	Db1.11, Db0.11, Db1.21
Dominance	Minor
Landform element	Slopes
Surface condition	Crusting or hardsetting
Drainage	Moderately well-drained
Soil permeability	Moderately permeable
Watertable depth	-
Available water-holding capacity	Low to moderate
Depth to bedrock	40 - 250 cm
Flood hazard	Low
pH (topsoil)	5.5
Fertility (chemical)	Low
Known nutrient deficiencies	N, P, Mo, S
Soil salinity	Low
Erodibility (topsoil)	High
Erodibility (subsoil)	Moderate
Erosion hazard	Moderate
Structural degradation hazard	Moderate
Land capability classification	V
USCS (subsoil)	CH, CL
Shrink-swell potential	Low
Mass movement hazard	Low

SH-ld LIDDELL SOIL LANDSCAPE

GENERAL

This soil landscape covers undulating low hills and undulating hills in the Liddell Power Station area. The main soils are Yellow Soloths (Dy2.41, Dy3.81) on slopes with some Yellow Solodic Soils (Dy3.32, Dy2.42, Dy3.42) on concave slopes. There are Earthy and Siliceous Sands (Uc5.22, Uc5.11) on mid to lower slopes where the parent material is more sandy. There are some Red Soloths (Dr2.41), Red Solodic Soils (Dr2.41) and Red Podzolic Soils (Dr5.11).

ASSOCIATED SOIL LANDSCAPE: Bayswater

CLIMATIC ZONE: 3B

LANDFORM

Undulating low hills with a few undulating hills, ranging in elevation from 140 – 220 m. Slopes are 4 - 7%, with long slope lengths (1200 – 2000 m). Local relief is 60 – 120 m. Drainage lines occur at 300 – 1000 m intervals.

NATIVE VEGETATION

An open-woodland of narrow-leaved red ironbark, yellow box, white box and spotted gum with some blakelys red gum, rough-barked apple and kurrajong. Bull oak and swamp oak are also common. There is some smooth-barked apple.

GEOLOGY

Geological Unit: Singleton Coal Measures
Parent Rock: Lithic sandstone, shale, mudstone, conglomerate, siltstone and coal seams.
Parent Material: *In situ* weathered parent rock and some derived colluvium.

SOIL EROSION

Minor to severe sheet erosion is common, with some minor rill erosion. Moderate gully erosion (to 1.5m) in drainage line where salting may be a feature.

GENERAL SOIL DESCRIPTIONS:

Yellow Soloths (Dy2.41, Dy3.81)

Topsoil: Brown loamy sand to sandy loam; single-grained at the surface and massive below; pH 6.0.
Overlies A2 horizon or pan. Bleached; light grey or dull yellow orange sandy loam or sandy clay loam; massive; pH 6.0 - 6.5; depth to 25 cm.

Subsoil: Sharp or clear change to bright brown or dull orange sandy clay with weak or strong structure; distinct brown or orange mottles (to 20%); pH 6.0 - 6.5.

Yellow Solodic Soils (Dy3.32)

Topsoil: Dark brown loam; weak structure; pH 6.5.
Overlies A2 horizon. Bleached; dull orange clay loam with weak structure; pH 6.0; depth to 20 cm.

Subsoil: Clear change to bright reddish brown light clay; strong angular blocky structure; pH 6.5.
Becomes more yellowish brown with depth; orange and grey mottles (to 30%).

Earthy Sands (Uc5.22)

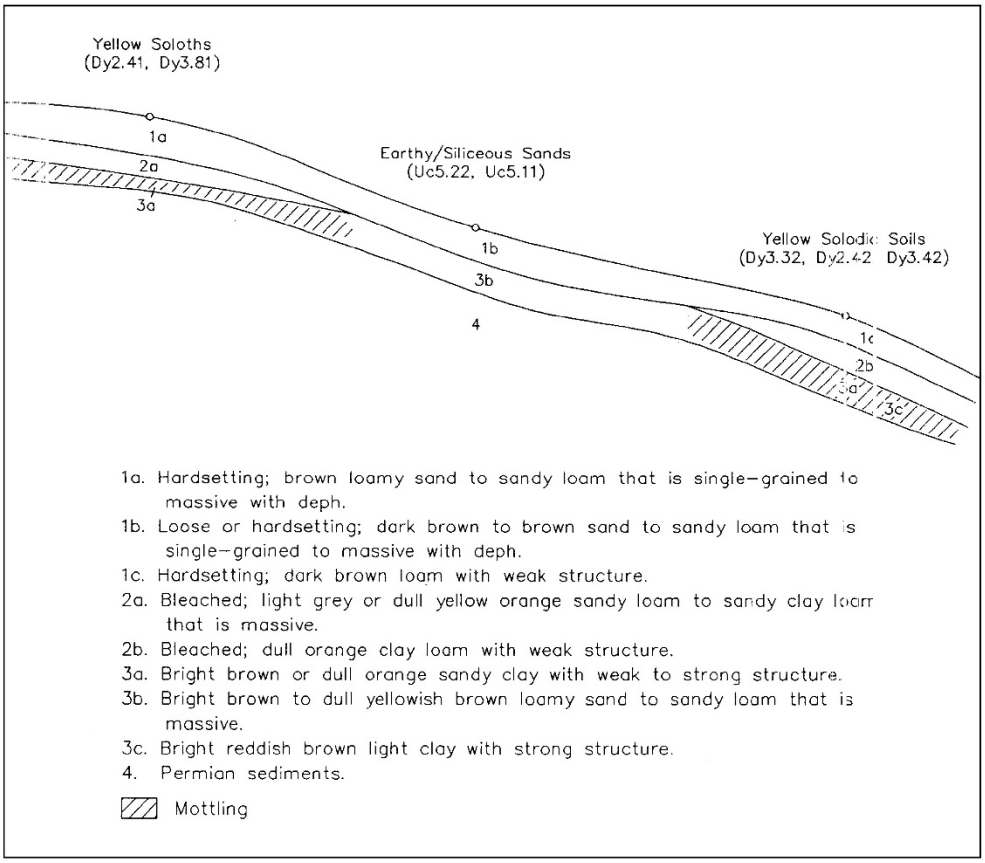
Topsoil: Dark brown sandy loam; single-grained at surface; massive below; pH 6.0 - 6.5; depth to 40 cm.

Subsoil: Gradual change to dull yellowish brown sandy loam; massive; earthy fabric; pH 7.0.

Siliceous Sands (Uc5.1)

Topsoil: Brown sand to loamy sand; single-grained; massive below surface; pH 6.0; depth to 40 cm.

Subsoil: Gradual change to bright brown loamy sand; massive; sandy fabric.



	Yellow Soloths	Yellow Solodic Soils
Northcote code	Dy2.41, Dy3.81	Dy3.32
Dominance	common	minor
Landform element	upper to lower slopes	midslope
Surface condition	hardsetting	hardsetting
Drainage	poorly to well drained	imperfectly drained
Soil permeability	moderately permeable	moderately permeable
Watertable depth	variable	variable
Available water-holding capacity	Moderate	Moderate
Depth to bedrock	+50 cm	+110 cm
Flood hazard	Low to moderate	Low
pH (topsoil)	6.0	6.5
Fertility (chemical)	Low	Low
Known nutrient deficiencies	-	-
Soil salinity	High	High
Erodibility (topsoil)	Moderate to high	Moderate
Erodibility (subsoil)	Moderate to high	Moderate
Erosion hazard	High to very high	High
Structural degradation hazard	High	High
Land capability classification	V, VI	V
USCS (subsoil)	-	-
Shrink-swell potential	-	-
Mass movement hazard	Low	Low

	Earthy Sands	Siliceous Sands
Northcote code	Uc5.22	Uc5.11
Dominance	Minor	Minor
Landform element	Midslope	Lower slope
Surface condition	Hardsetting and gravelly	Loose
Drainage	Well drained	Well drained
Soil permeability	Highly permeable	Highly permeable
Watertable depth	-	-
Available water-holding capacity	Low	Low
Depth to bedrock	+55 cm	+100 cm
Flood hazard	Low	Moderate
pH (topsoil)	6.0	6.0
Fertility (chemical)	Low	Low
Known nutrient deficiencies	-	-
Soil salinity	Low	Low
Erodibility (topsoil)	Low	Low
Erodibility (subsoil)	Low	Low
Erosion hazard	High	High
Structural degradation hazard	Moderate	Moderate
Land capability classification	V	V
USCS (subsoil)	-	-
Shrink-swell potential	Low	Low
Mass movement hazard	Low	Low

YP-rx ROXBURGH SOIL LANDSCAPE

GENERAL

This soil landscape covers undulating low hills and undulating hills. yellow podzolic soils (Dy3.11, Dy2.41) occur on upper to midslopes with red solodic soils (Dr2.43) on more rounded hills. Lithosols (Um5.21) occur on crests. Brown podzolic soils (Db2.21) occur on slopes on conglomerate with associated flat pavements. Yellow soloths (Dy3.41) have been recorded in some gullies.

CLIMATIC ZONE: 3B

LANDFORM

Undulating low hills and undulating hills with elevations of 80 – 370 m. Slopes are 0 – 10%, with slope lengths of 800 – 1200 m. Local relief is 60 – 120 m. Drainage lines occur at intervals of 300 – 1500 m.

NATIVE VEGETATION

An 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.

GEOLOGY

Geological Unit: Singleton Coal Measures
Parent Rock: Sandstone, shale, mudstone, conglomerate and coal.
Parent Material: *In situ* weathered parent rock and derived colluvium.

SOIL EROSION

Minor to moderate sheet erosion is common. Some gullies up to 3m deep are associated with the dispersible soloths and solodic soils.

GENERAL SOIL DESCRIPTIONS:

Yellow Podzolic Soils (Dy3.11, Dy2.41)

Topsoil: Brown fine sandy loam to silt loam; weak sub-angular blocky structure or massive; pH 6.0 - 6.5.
There may be an A2 horizon. Bleached; light brownish grey fine sandy loam; massive; pH 6.5; depth to 40 cm.

Subsoil: Sharp change to bright brown or bright reddish brown sandy clay to heavy clay; moderate to strong structure; porous rough-faced peds; may be mottled brown, yellow and red (to 30%); pH 6.0.

Red Solodic Soils (Dr2.43)

Topsoil: Dark reddish brown fine sandy loam with weak structure; pH 6.5.
Overlies A2 horizon. Massive; pH 6.0; depth to 20 cm.

Subsoil: Clear change to reddish brown light to light medium clay that has strong structure; pH 7.0 - 8.0.
Becomes brighter with depth with distinct orange mottles (to 20%); pH 8.0 - 9.0.

Lithosols (Um5.21)

Topsoil: Dark reddish brown light sandy clay loam; single-grained; pH 7.5.
Becomes a loam fine sandy at 10 cm depth; pH 8.0.
Bedrock at 35 cm.

Brown Podzolic Soils (Db2.21)

Topsoil: Very dark brown loam fine sandy with weak structure; pH 5.5.
Overlies dark brown A2 horizon. Loam fine sandy with weak structure; depth to 20 cm.

Subsoil: Clear change to brown sandy clay with strong sub-angular blocky structure; faint yellow and brown mottles (to 20%); pH 6.0.
Becomes brighter with depth.

Yellow Soloths (Dy3.41)

Not described.

	Yellow Podzolic Soils	Brown Podzolic Soils
Northcote code	Dy3.11, Dy2.41	Db2.21
Dominance	Common	Minor
Landform element	Upper to midslopes	Upper to midslopes
Surface condition	Hardsetting, sometimes gravelly	Hardsetting
Drainage	Imperfectly drained to moderately well drained	Moderately well drained
Soil permeability	Moderately permeable	Moderately permeable
Watertable depth	-	-
Available water-holding capacity	Moderate	Moderate
Depth to bedrock	+80 cm	+60 cm
Flood hazard	Low	Low
pH (topsoil)	6.0-6.5	5.5
Fertility (chemical)	Low	Low
Known nutrient deficiencies	P	P
Soil salinity	Low	Low
Erodibility (topsoil)	Moderate	Moderate
Erodibility (subsoil)	Low to moderate	Low
Erosion hazard	Moderate to very high	High
Structural degradation hazard	High	High
Land capability classification	V	V
USCS (subsoil)	-	-
Shrink-swell potential	-	-
Mass movement hazard	Low	Low

	Red Solodic Soils	Lithosols
Northcote code	Dr2.43	Um5.21
Dominance	Minor	Minor
Landform element	Upper concave slopes	Crest
Surface condition	Hardsetting	Hardsetting
Drainage	Moderately well drained	Well drained
Soil permeability	Moderately permeable	Highly permeable
Watertable depth	-	-
Available water-holding capacity	Moderate	Low
Depth to bedrock	+140 cm	35 cm
Flood hazard	Low	Low
pH (topsoil)	6.5	7.5
Fertility (chemical)	Low	Low
Known nutrient deficiencies	P	P
Soil salinity	High	Low
Erodibility (topsoil)	Moderate	Moderate
Erodibility (subsoil)	Moderate	-
Erosion hazard	High	High
Structural degradation hazard	High	High
Land capability classification	V	V
USCS (subsoil)	-	-
Shrink-swell potential	-	Low
Mass movement hazard	Low	Low

APPENDIX B TEST PIT LOGS

ngh environmental

TESTPIT No. 1

PROJECT NUMBER 19-069	**DATE** 12/04/2019	**COORDINATES** 56H 0304 068
PROJECT NAME Maxwell Solar	**COMPANY** Client provided	**COORDINATES** UTM 6419 110
	PLANT Excavator	**LOGGED BY** SM
	METHOD Test pit	
	TOTAL DEPTH 1.5 m	

COMMENTS

Depth (m)	Samples	Graphic Log	Material Description	Additional Observations
0	DS 0.0 - 0.2		TOPSOIL, Silty SAND, fine to medium grained, dark brown, with low plasticity clay and fine to medium grained gravel	TOPSOIL
0.5	DS 0.5 - 0.6		FILL, Silty CLAY, medium to high plasticity, brown with mottled grey, with sand, gravel and boulders	FILL
1				
1.5			Discontinued at 1.5 m	
2				
2.5				
3				
3.5				
4				
4.5				
5				
5.5				

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TESTPIT No. 2

PROJECT NUMBER 19-069	**DATE** 11/04/2019	**COORDINATES** 56H 0303 525
PROJECT NAME Maxwell Solar	**COMPANY** Client provided	**COORDINATES** UTM 6419 078
	PLANT Excavator	**LOGGED BY** SM
	METHOD Test pit	
	TOTAL DEPTH 1.4 m	

COMMENTS

Depth (m)	Samples	Graphic Log	Material Description	Additional Observations
0	DS 0.0 - 0.2		TOPSOIL, Silty SAND, fine to medium grained, dark brown, with roots	TOPSOIL with cobbles and boulders observed at the surface
	DS 0.3.0.4		FILL, Silty CLAY, low to medium plasticity, brown with mottled grey, yellow and red, with fine to medium grained sand, some boulders and cobbles	FILL
0.5				
1				
1.5			Discontinued at 1.4 m	
2				
2.5				
3				
3.5				
4				
4.5				
5				
5.5				

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TESTPIT No. 3

PROJECT NUMBER 19-069	**DATE** 11/04/2019	**COORDINATES** 56H 0304 045
PROJECT NAME Maxwell Solar	**COMPANY** Client provided	**COORDINATES** UTM 6418 421
	PLANT Excavator	**LOGGED BY** SM
	METHOD Test pit	
	TOTAL DEPTH 1.4 m	

COMMENTS

Depth (m)	Samples	Graphic Log	Material Description	Additional Observations
0	DS 0.0 - 0.3		FILL, Gravelly Sandy CLAY, medium plasticity, brown, with roots to 0.2 m	FILL
0.5	DS 0.6-0.7		FILL, Sandy GRAVEL, course grained, grey, fine to course sand	FILL
1				
1.5			Discontinued at 1.4 m on rock	
2				
2.5				
3				
3.5				
4				
4.5				
5				
5.5				

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TESTPIT No. 4

PROJECT NUMBER 19-069	**DATE** 11/04/2019	**COORDINATES** 56H 0303 692
PROJECT NAME Maxwell Solar	**COMPANY** Client provided	**COORDINATES** UTM 6418 178
	PLANT Excavator	**LOGGED BY** SM
	METHOD Test pit	
	TOTAL DEPTH 1.4 m	

COMMENTS

Depth (m)	Samples	Graphic Log	Material Description	Additional Observations
0	DS 0.1 - 0.3		TOPSOIL, Silty SAND, fine to medium grained, dark grey, with roots	TOPSOIL
			FILL, Sandy CLAY, low to medium plasticity, brown with mottled grey, dark grey and yellow	FILL
0.5	DS 0.8-0.7		FILL, Sandy Clay, low plasticity, dark grey and grey, some coal and boulders	
1				
1.5			Discontinued at 1.4 m on rock	
2				
2.5				
3				
3.5				
4				
4.5				
5				
5.5				

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TESTPIT No. 5

PROJECT NUMBER 19-069 **PROJECT NAME** Maxwell Solar	**DATE** 11/04/2019 **COMPANY** Client provided **PLANT** Excavator **METHOD** Test pit **TOTAL DEPTH** 1.3 m	**COORDINATES** 56H 0303 692 **COORDINATES** UTM 6418 178 **LOGGED BY** SM

COMMENTS

Depth (m)	Samples	Graphic Log	Material Description	Additional Observations
0.5 1	DS 0.0 - 0.3		FILL, Silty Sandy GRAVEL, course grained gravel, fine to medium grained sand, light brown and brown, with cobbles	FILL
1.5 2 2.5 3 3.5 4 4.5 5 5.5			Discontinued at 1.3 m	

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TESTPIT No. 6

PROJECT NUMBER 19-069	**DATE** 11/04/2019	**COORDINATES** 56H 0303 493
PROJECT NAME Maxwell Solar	**COMPANY** Client provided	**COORDINATES** UTM 6419 912
	PLANT Excavator	**LOGGED BY** SM
	METHOD Test pit	
	TOTAL DEPTH 1.25 m	

COMMENTS

Depth (m)	Samples	Graphic Log	Material Description	Additional Observations
0.5	DS 0.0-0.5		FILL, Silty Sandy GRAVEL, fine to course gravel, fine to course sand, dark grey, with coal fragments, cobbles and boulders	FILL
1				
1.5			Discontinued at 1.25 m	
2				
2.5				
3				
3.5				
4				
4.5				
5				
5.5				

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TESTPIT No. 8

PROJECT NUMBER 19-069	**DATE** 11/04/2019	**COORDINATES** 56H 0303 410
PROJECT NAME Maxwell Solar	**COMPANY** Client provided	**COORDINATES** UTM 6419 898
	PLANT Excavator	**LOGGED BY** SM
	METHOD Test pit	
	TOTAL DEPTH 1.3 m	

COMMENTS

Depth (m)	Samples	Graphic Log	Material Description	Additional Observations
0	DS 0.0-0.3		TOPSOIL, Silty SAND, fine to medium grained, dark brown with roots	TOPSOIL
0.5	DS 0.5-0.6		FILL, Silty CLAY, low to medium plasticity, mottled grey, brown and red	FILL
1				
1.3			Discontinued at 1.3 m	
1.5				
2				
2.5				
3				
3.5				
4				
4.5				
5				
5.5				

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APPENDIX C SOIL SURVEY PHOTOS

TP1

TP2

TP3

TP4

TP5

TP6

TP8

APPENDIX D LABORATORY RESULTS

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **ES1911764**	Page	: 1 of 7
Client	: **NGH Environmental**	Laboratory	: Environmental Division Sydney
Contact	: SCOTT MCGRATH	Contact	: Customer Services ES
Address	: 7/11 Union Street Newcastle West NSW 2302	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone	: ----	Telephone	: +61-2-8784 8555
Project	: 19-069	Date Samples Received	: 15-Apr-2019 14:30
Order number	: PO1323	Date Analysis Commenced	: 17-Apr-2019
C-O-C number	: ----	Issue Date	: 30-Apr-2019 13:59
Sampler	: SCOTT MCGRATH		
Site	: ----		
Quote number	: EN/333		
No. of samples received	: 12		
No. of samples analysed	: 12		

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

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

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

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

Signatories

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

Signatories	*Position*	*Accreditation Category*
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Celine Conceicao	Senior Spectroscopist	Sydney Inorganics, Smithfield, NSW
Dian Dao		Sydney Inorganics, Smithfield, NSW
Dianne Blane	Laboratory Coordinator (2IC)	Newcastle - Inorganics, Mayfield West, NSW
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.

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

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

- ALS is not NATA accredited for the analysis of Exchangeable Cations on Alkaline Soils when performed under ALS Method ED006.
- EK061G/EK067G: Poor matrix spike recovery for TKN & Total P due to sample heterogeneity. Confirmed by re-digestion and re-analysis.
- EA058 Emerson: V. = Very, D. = Dark, L. = Light, VD. = Very Dark
- ED007 and ED008: When Exchangeable Al is reported from these methods, it should be noted that Rayment & Lyons (2011) suggests Exchange Acidity by 1M KCl - Method 15G1 (ED005) is a more suitable method for the determination of exchange acidity (H+ + Al3+).

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	TP1 0.0-0.2	TP1 0.5-0.6	TP2 0.0-0.2	TP2 0.3-0.4	TP3 0.0-0.3
			Client sampling date / time	12-Apr-2019 00:00	12-Apr-2019 00:00	11-Apr-2019 00:00	11-Apr-2019 00:00	11-Apr-2019 00:00
Compound	CAS Number	LOR	Unit	ES1911764-001	ES1911764-002	ES1911764-003	ES1911764-004	ES1911764-005
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	8.0	8.4	8.4	8.4	8.8
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	69	226	123	91	92
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	0.1	%	----	10.5	----	10.7	12.2
Moisture Content	----	1.0	%	11.4	----	11.6	----	----
EA058: Emerson Aggregate Test								
Color (Munsell)	----	-	-	Very Dark Grayish Brown (2.5Y 3/2)	Brown (10YR 5/3)	Dark Gray (10YR 4/1)	Grayish Brown (10YR 5/2)	Grayish Brown (10YR 5/2)
Texture	----	-	-	Clay Loam, Sandy	Silty Clay Loam	Sandy Clay	Sandy Clay Loam	Sandy Clay
Emerson Class Number	EC/TC	-	-	4	4	4	4	3
EA150: Particle Sizing								
+75µm	----	1	%	59	44	40	45	43
+150µm	----	1	%	49	23	29	29	33
+300µm	----	1	%	43	19	22	23	23
+425µm	----	1	%	41	18	19	20	19
+600µm	----	1	%	39	17	17	19	17
+1180µm	----	1	%	37	16	15	17	16
+2.36mm	----	1	%	34	14	13	16	14
+4.75mm	----	1	%	31	13	11	15	13
+9.5mm	----	1	%	28	13	8	13	12
+19.0mm	----	1	%	28	13	8	13	5
+37.5mm	----	1	%	<1	<1	<1	<1	<1
+75.0mm	----	1	%	<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size								
Fines (<75 µm)	----	1	%	41	56	60	55	57
Sand (>75 µm)	----	1	%	24	29	26	29	29
Gravel (>2mm)	----	1	%	35	15	14	16	14
Cobbles (>6cm)	----	1	%	<1	<1	<1	<1	<1
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.2	meq/100g	3.2	2.2	5.8	4.7	2.1
Exchangeable Magnesium	----	0.2	meq/100g	2.6	1.7	3.5	3.1	3.6
Exchangeable Potassium	----	0.2	meq/100g	0.3	<0.2	0.3	<0.2	<0.2
Exchangeable Sodium	----	0.2	meq/100g	<0.2	<0.2	<0.2	<0.2	0.9

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	TP1 0.0-0.2	TP1 0.5-0.6	TP2 0.0-0.2	TP2 0.3-0.4	TP3 0.0-0.3
				Client sampling date / time	12-Apr-2019 00:00	12-Apr-2019 00:00	11-Apr-2019 00:00	11-Apr-2019 00:00	11-Apr-2019 00:00
Compound	CAS Number	LOR	Unit		ES1911764-001	ES1911764-002	ES1911764-003	ES1911764-004	ES1911764-005
					Result	Result	Result	Result	Result
ED006: Exchangeable Cations on Alkaline Soils - Continued									
Cation Exchange Capacity	----	0.2	meq/100g		6.2	3.9	9.6	7.8	6.6
Exchangeable Sodium Percent	----	0.2	%		<0.2	<0.2	<0.2	<0.2	13.4
ED042T: Total Sulfur by LECO									
Sulfur - Total as S (LECO)	----	0.01	%		0.06	----	0.05	----	----
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	10	mg/kg		50	60	30	<10	80
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg		2.7	----	0.5	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	20	mg/kg		880	----	820	----	----
EK062: Total Nitrogen as N (TKN + NOx)									
^ Total Nitrogen as N	----	20	mg/kg		880	----	820	----	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	2	mg/kg		177	----	293	----	----
EP004: Organic Matter									
Organic Matter	----	0.5	%		3.0	----	----	----	----
Organic Matter	----	0.5	%		----	----	2.6	----	----
Total Organic Carbon	----	0.5	%		1.7	----	----	----	----
Total Organic Carbon	----	0.5	%		----	----	1.5	----	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	TP3 0.6-0.7	TP4 0.1-0.3	TP4 0.6-0.7	TP5 0.0-0.3	TP6 0.0-0.5
			Client sampling date / time	11-Apr-2019 00:00	11-Apr-2019 00:00	11-Apr-2019 00:00	11-Apr-2019 00:00	11-Apr-2019 00:00
Compound	CAS Number	LOR	Unit	ES1911764-006	ES1911764-007	ES1911764-008	ES1911764-009	ES1911764-010
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	8.7	8.8	8.5	9.0	9.0
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	216	71	69	90	287
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	0.1	%	7.3	15.9	13.3	5.4	10.7
EA058: Emerson Aggregate Test								
Color (Munsell)	----	-	-	Very Dark Gray (N 3/)	Dark Grayish Brown (10YR 4/2)	Grayish Brown (10YR 5/2)	Brown (10YR 5/3)	Black (2.5Y 2.5/1)
Texture	----	-	-	Clay Loam, Sandy	Clay Loam, Sandy	Sandy Clay	Sandy Clay	Clay Loam, Sandy
Emerson Class Number	EC/TC	-	-	3	4	4	4	3
EA150: Particle Sizing								
+75µm	----	1	%	----	54	44	----	----
+150µm	----	1	%	----	43	34	----	----
+300µm	----	1	%	----	27	23	----	----
+425µm	----	1	%	----	18	19	----	----
+600µm	----	1	%	----	12	16	----	----
+1180µm	----	1	%	----	6	14	----	----
+2.36mm	----	1	%	----	3	13	----	----
+4.75mm	----	1	%	----	<1	11	----	----
+9.5mm	----	1	%	----	<1	11	----	----
+19.0mm	----	1	%	----	<1	10	----	----
+37.5mm	----	1	%	----	<1	<1	----	----
+75.0mm	----	1	%	----	<1	<1	----	----
EA150: Soil Classification based on Particle Size								
Fines (<75 µm)	----	1	%	----	46	56	----	----
Sand (>75 µm)	----	1	%	----	50	32	----	----
Gravel (>2mm)	----	1	%	----	4	13	----	----
Cobbles (>6cm)	----	1	%	----	<1	<1	----	----
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.2	meq/100g	2.2	4.4	5.4	4.0	1.0
Exchangeable Magnesium	----	0.2	meq/100g	3.8	3.1	4.1	2.2	9.3
Exchangeable Potassium	----	0.2	meq/100g	<0.2	<0.2	<0.2	<0.2	0.4
Exchangeable Sodium	----	0.2	meq/100g	1.1	<0.2	<0.2	<0.2	1.2
Cation Exchange Capacity	----	0.2	meq/100g	7.1	7.5	9.7	6.3	11.9

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	TP3 0.6-0.7	TP4 0.1-0.3	TP4 0.6-0.7	TP5 0.0-0.3	TP6 0.0-0.5
				Client sampling date / time	11-Apr-2019 00:00	11-Apr-2019 00:00	11-Apr-2019 00:00	11-Apr-2019 00:00	11-Apr-2019 00:00
Compound	CAS Number	LOR	Unit		ES1911764-006	ES1911764-007	ES1911764-008	ES1911764-009	ES1911764-010
					Result	Result	Result	Result	Result
ED006: Exchangeable Cations on Alkaline Soils - Continued									
Exchangeable Sodium Percent	----	0.2	%		**15.6**	<0.2	<0.2	<0.2	**10.0**
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	10	mg/kg		**70**	**10**	<10	**20**	**30**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	TP8 0.0-0.3	TP8 0.5-0.6	----	----	----
			Client sampling date / time	11-Apr-2019 00:00	11-Apr-2019 00:00	----	----	----
Compound	CAS Number	LOR	Unit	ES1911764-011	ES1911764-012	--------	--------	--------
				Result	Result	----	----	----
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	8.8	8.3	----	----	----
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	335	555	----	----	----
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	0.1	%	----	8.6	----	----	----
Moisture Content	----	1.0	%	10.9	----	----	----	----
EA058: Emerson Aggregate Test								
Color (Munsell)	----	-	-	Dark Grayish Brown (10YR 4/2)	Light Olive Brown (2.5Y 5/3)	----	----	----
Texture	----	-	-	Sandy Clay	Sandy Clay	----	----	----
Emerson Class Number	EC/TC	-	-	3	4	----	----	----
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.2	meq/100g	3.3	1.5	----	----	----
Exchangeable Magnesium	----	0.2	meq/100g	4.4	3.0	----	----	----
Exchangeable Potassium	----	0.2	meq/100g	<0.2	<0.2	----	----	----
Exchangeable Sodium	----	0.2	meq/100g	1.3	0.8	----	----	----
Cation Exchange Capacity	----	0.2	meq/100g	9.0	5.3	----	----	----
Exchangeable Sodium Percent	----	0.2	%	15.0	15.1	----	----	----
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.03	----	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	110	140	----	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	0.8	----	----	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	20	mg/kg	560	----	----	----	----
EK062: Total Nitrogen as N (TKN + NOx)								
^ Total Nitrogen as N	----	20	mg/kg	560	----	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	2	mg/kg	393	----	----	----	----
EP004: Organic Matter								
Organic Matter	----	0.5	%	1.5	----	----	----	----
Total Organic Carbon	----	0.5	%	0.9	----	----	----	----