APPENDIX G

Soil erosion assessment

Soil erosion assessment

New England Solar Farm

Prepared for UPC Renewables Australia Pty Ltd | 13 November 2018

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Soil erosion assessment

Final

Report J17300RP1 | Prepared for UPC Renewables Australia Pty Ltd | 13 November 2018

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1 Introduction

1.1 Overview

UPC Renewables Australia Pty Ltd (UPC) proposes to develop the New England Solar Farm; a significant grid-connected solar farm and battery energy storage system (BESS) along with associated infrastructure, approximately 6 kilometres (km) east of the township of Uralla, which lies approximately 19 km south of Armidale in the Uralla Shire local government area (LGA) (the project) (Figure 1.1).

The project is a State significant development (SSD) under the State Environmental Planning Policy (State and Regional Development) 2011 (SRD SEPP). A development application (DA) for the project is required to be submitted under Part 4, Division 4.1 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act). The NSW Minister for Planning, or the Minister's delegate, is the consent authority.

An environmental impact statement (EIS) is a requirement of the approval process. This soil erosion assessment report forms part of the EIS. It documents the soil erosion assessment methods and results and the initiatives built into the project design to avoid and minimise erosion associated impacts and the additional mitigation and management measures proposed to address any residual impacts not able to be avoided.

1.2 Site description

The project will be developed within the Uralla Shire LGA. At its closest point, the project boundary is approximately 6 km east of the township of Uralla, and the northern array area starts approximately 8.6 km south of Armidale (refer to Figure 1.1).

The project boundary, which is defined as the entirety of all the involved lots, encompasses a total area of 8,380 ha. The project boundary encompasses 61 lots, the majority of which have been modified by historical land use practices and past disturbances associated with land clearing, cropping and intensive livestock grazing. The properties within the project boundary are currently primarily used for sheep grazing for production of wool and lambs, with some cattle grazing for beef production.

The development footprint is the area within the project boundary on which infrastructure will be located. The development footprint encompasses a total area of 2,787 ha, which includes1,418 ha within the northern array area, 625 ha within the central array area and653 ha within the southern array area. Within the development footprint, approximately 1,000 ha will be required for the rows of PV modules. The remaining area is associated with power conversion units (PCUs), space between the rows, internal access tracks and associated infrastructure (including substations and BESSs). The development footprint also includes land required for connection infrastructure between the three array areas as well as land required for new internal roads to enable access to the three array areas from the surrounding road network. Subject to detailed design and consultation with the project landholders, security fencing and creek crossings may be required on land outside of the development footprint, but within the project boundary.

The land within the project boundary is zoned RU1 Primary Production under the Uralla Local Environmental Plan 2012 (Uralla LEP).

The project is ideally located close to TransGrid's 330 kilovolt (kV) transmission line, which passes through the northern and central array areas (Figure 1.2). It also has access to the regional road network; including the New England Highway and Thunderbolts Way (Figure 1.2).

Source: EMM (2018); DFSI (2017); GA (2015)

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GDA 1994 MGA Zone 56

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KEY

- Development footprint
- Project boundary
- Other SSD solar development
- Airport
- Rail line
- Main road
- Local road
- Watercourse/drainage line
- Waterbody
- Local government area
- NPWS reserve
- State forest

Regional setting

New England Solar Farm
Soil erosion assessment
Figure 1.1

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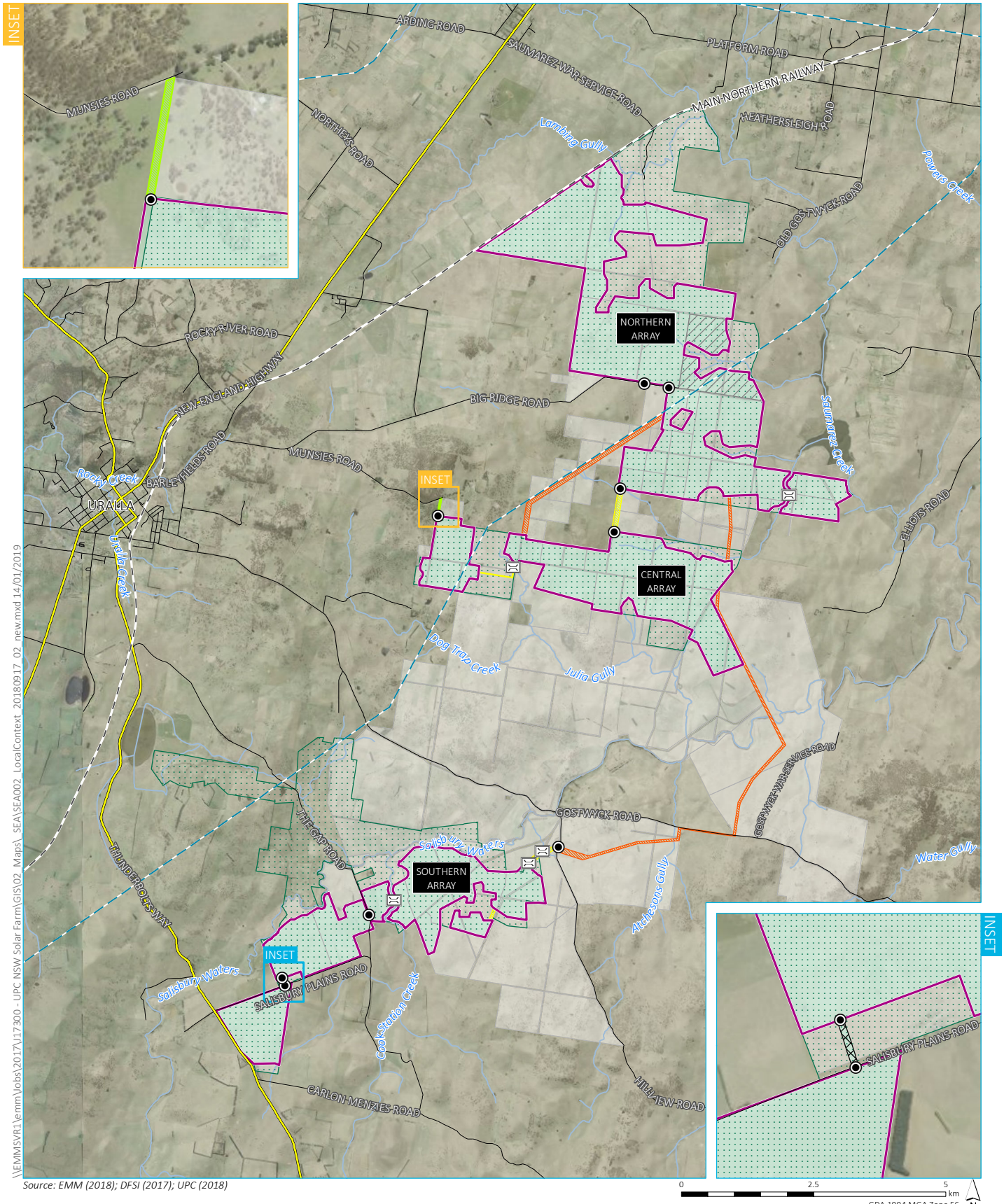

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Source: EMM (2018); DFSI (2017); UPC (2018)

0 2.5 5 km

GDA 1994 MGA Zone 56

N

KEY

- 330 kV transmission line
- Main road
- Local road
- Rail line
- Watercourse/drainage line
- Project boundary
- Study area

Development footprint

- Solar array
- Potential ETL easement
- Potential site access corridor
- Potential site access/ETL easement
- Potential electrical cabling/site access corridor
- Potential site for construction accommodation village
- Potential creek crossing
- Proposed primary site access point

Local context and study area

New England Solar Farm
Soil erosion assessment
Figure 1.2

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A number of local roads traverse the array areas and their surrounds, including Gostwyck Road, Salisbury Plains Road, The Gap Road, Carlon Menzies Road, Munsies Road, Saumarez War Service Road, Hillview Road, Elliots Road and Big Ridge Road, and will provide access to the three array areas from the regional road network throughout the construction and operation of the project (Figure 1.2).

The primary site access points will be from The Gap Road, Salisbury Plains Road, Hillview Road, Munsies Road and Big Ridge Road (Figure 1.2). Emergency access points may also be required.

1.3 Project boundary terms and definitions

The **project boundary** referred to in this report encompasses the 61 Lot/DPs that make up the development footprint. It is shown in Figure 1.2 and includes the involved lots beneath each of the three array areas as well as potential connection infrastructure and access corridors.

The **study area** referenced throughout this report is shown in Figure 1.2. This represents the area presented in the preliminary environment assessment (PEA) that supported the request for the Secretary's Environmental Assessment Requirements (SEARs). The study area encompasses approximately 4,244 ha and is referenced primarily in the upfront chapters of this report as it represents the area considered prior to the commencement of the fieldwork and soil sampling.

The **development footprint** referred to in this report is shown in Figure 1.2 and represents the potential disturbance footprint of the three solar array areas and associated infrastructure. As noted in Section 1.2, the development footprint also includes land required for connection infrastructure between the three array areas (ie electricity transmission line (ETL) easements and underground or overhead cabling), as well as land required for new internal roads to enable access to the three array areas from the surrounding road network (ie site access corridors). Ground disturbance will occur in these areas; however, only discrete areas of disturbance are anticipated, particularly along ETL easements namely to facilitate power pole placement.

1.4 Project description

The project involves the development, construction and operation of a solar PV electricity generation facility and BESS, which consists of PV modules, batteries, inverters, transformers and associated infrastructure.

The development footprint provided on Figure 1.2 incorporates the land required for:

- the three solar array areas;
- up to three internal solar array substations and a single grid substation;
- associated BESS(s);
- operations and maintenance (O&M) infrastructure, including:
    - O&M buildings (namely meeting facilities, a temperature-controlled spare parts storage facility, supervisory control and data acquisition (SCADA) facilities, a workshop and associated infrastructure); and
    - car parking facilities;

- connection infrastructure between the three array areas (including electricity transmission lines (ETLs) and underground or overhead cabling); and

- a new internal road network to enable access from surrounding local roads to the three array areas during construction and operations.

In addition, security fencing and creek crossings (should they be required) will be placed within the project boundary.

O&M buildings and associated infrastructure will likely be constructed within the footprints nominated for the substations and BESSs; however, their exact location will be determined during detailed design (refer Figure 1.2). The locations for the emergency access points will be identified as part of the project's emergency response plan during detailed design.

Temporary infrastructure during the construction stage of the project including laydown and storage areas and a site compound are also likely to be required in each of the three solar array areas. Laydown areas will likely be in close proximity to the primary site access points and will be placed away from environmentally sensitive areas, where possible.

A construction accommodation village for non-local construction employees may be established as part of the early stages of the project's construction. If constructed, the construction accommodation village may accommodate up to 500 workers and would be on part of Lot 2 of DP 174053 in the northern array area (refer to Figure 1.2). To build the construction accommodation village, topsoil will be stripped where necessary, hardstand constructed and walkways and car parks constructed. The construction accommodation village is expected to be dismantled and its footprint rehabilitated once the project is built and it moves into the operational stage.

Construction of the project will take approximately 36 months from the commencement of site establishment works to commissioning of the three array areas.

The project will have a targeted 'sent out' electricity generating capacity of up to 800 MW (AC) and up to 200 MW (AC) two-hour energy storage. The final number of PV modules within the three array areas will be dependent on detailed design, availability and commercial considerations at the time of construction.

Electricity generated by the project will be injected into the grid via a new cut-in to TransGrid's 330 kV transmission line that traverses the northern and central array areas (refer Figure 1.2).

The infrastructure associated with the project will cover an area within the development footprint. During the preparation of the EIS, the development footprint within the project boundary has been refined on the basis of environmental constraints identification, stakeholder engagement, community consultation and design of project infrastructure with the objective of developing an efficient project that avoids and minimises environmental impacts.

1.5 Assessment guidelines and requirements

This soil erosion assessment has been prepared in accordance with the relevant government assessment requirements, guidelines and policies, and in consultation with the relevant government agencies.

The soil erosion assessment was prepared in due regard with:

- *The Land and Soil Capability Assessment Scheme: Second Approximation* (OEH 2012);

- *Australian Soil and Land Survey Book* (NCST 2009);
- *The Australian Soil Classification* (Isbell 2002); and
- *Soil Data Entry Handbook* (DLWC 2001).

The soil erosion assessment was prepared in accordance with the requirements of the NSW Department of Planning and Environment (DPE). These were set out in the Secretary's Environmental Assessment Requirements (SEARs) for the project, issued on 8 May 2018 and updated on 11 October 2018. The SEARs identify matters that must be addressed in the EIS. Table 1.1 lists the individual requirements relevant to the soil erosion assessment and where they are addressed in this report.

Table 1.1 Relevant SEARs

Requirement	Section addressed
Land - including: an assessment of the impact of the development on agricultural land (including possible cumulative impacts on agricultural enterprises and landholders) and flood prone land, an assessment of any impacts to Crown lands (including Crown Reserve 95655), ***a soil survey to consider the potential for erosion to occur,*** and paying particular attention to the compatibility of the development with the existing land uses on the site and adjacent land (e.g. operating mines, extractive industries, mineral or petroleum resources, exploration activities, aerial spraying, dust generation, and biosecurity risk) during operation and after decommissioning, with reference to the zoning provisions applying to the land, including subdivision.	Chapter 4. Note this report addresses the ***italicised*** part.

1.6 Structure of the report

The soil erosion assessment report is structured as follows:

- an outline of the methodologies to assess the study area's soil erosion potential (Chapter 2);
- a desktop review of the study area's soil erosion potential (Chapter 3);
- soil survey results and analysis (Chapter 4);
- discussion of erosion potential and erosion and sediment control (Chapter 4 and Chapter 5); and
- high level discussion of land capability and soil fertility within the development footprint (Section 4.5.1).

2 Method

2.1 Assessment process

The soil erosion assessment comprised the following:

- a desktop review of existing information and the current state of the environment;
- a soil survey (the survey) to characterise soil types within the development footprint, including laboratory analysis;
- assessment of erosion potential using results from the soil survey; and
- a high level description of the fertility and land capability of the soils within the development footprint.

2.2 Desktop review

A desktop assessment was undertaken using existing information on soils and soil environments for the study area (with a focus on the development footprint) sourced from:

- *NSW soil and land information system* (SALIS) (CSIRO 2018);
- *Soil profile attribute data* (eSPADE) online database (OEH 2018);
    - Great soil group mapping of NSW;
    - Land and soil capability classes mapping;
    - Australian soil classification system soil type mapping of NSW; and
    - Hydrologic soil group mapping.

2.3 Soil survey

Surveys were completed by EMM Consulting Pty Ltd (EMM) from Monday 30 July to Friday 3 August 2018 to examine the soil and landform properties of the study area (with a focus on the development footprint) and inform erosion potential. This included taking soil samples for laboratory analysis.

Laboratory analysis of soil samples was guided by *The Land and Soil Capability Assessment Scheme: Second Approximation* (OEH 2012).

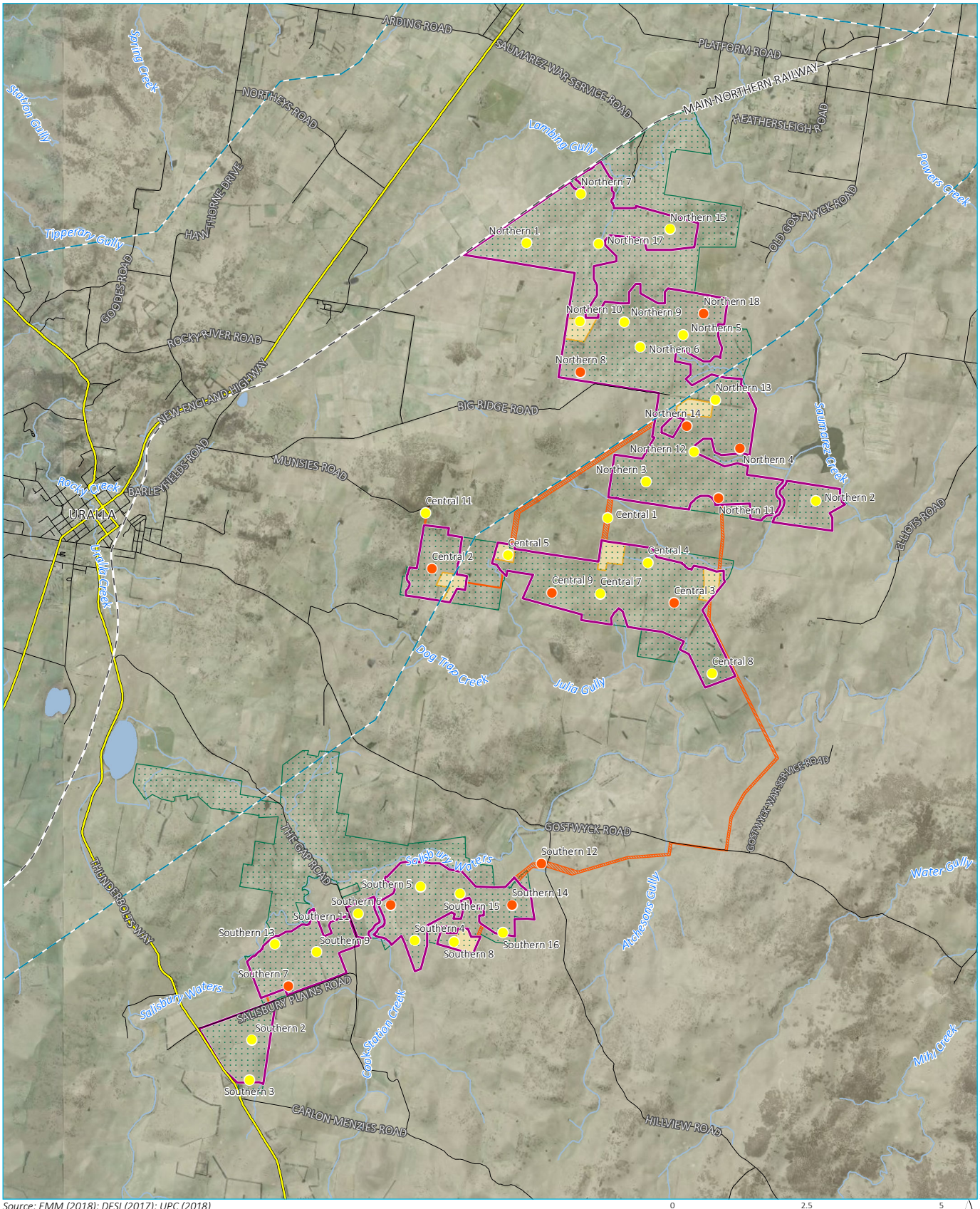
2.3.1 Sample site selection

Positioning of the soil survey sites was based on grid sampling with the intention of providing a relatively even distribution of sites across the development footprint (ie where ground disturbance is expected). The 45 soil survey sites are shown in Figure 2.1 and listed in Table 2.1.

Table 2.1 Soil survey sites

Sample site name	Latitude	Longitude
Northern 1	364254	6614110
Northern 2	369625	6609324
Northern 3	366470	6609685
Northern 4	368209	6610303
Northern 5	367159	6612407
Northern 6	366362	6612185
Northern 7	365257	6615023
Northern 8	365226	6611607
Northern 9	366070	6612648
Northern 10	365172	6612651
Northern 11	367814	6609385
Northern 12	367365	6610238
Northern 13	367761	6611201
Northern 14	367229	6610713
Northern 15	366913	6614368
Northern 17	365589	6614105
Northern 18	367536	6612806
Central 1	365751	6609008
Central 2	362488	6608067
Central 3	366995	6607432
Central 4	366505	6608176
Central 5	363904	6608322
Central 7	365619	6607597
Central 8	367698	6606122
Central 9	364720	6607621
Central 11	362372	6609104
Southern 2	359163	6599334
Southern 3	359098	6598583
Southern 4	362169	6601162
Southern 5	362282	6602163
Southern 6	361722	6601815
Southern 7	359826	6600317
Southern 8	362906	6601139
Southern 9	360341	6600945
Southern 11	361137	6601648
Southern 12	364527	6602593
Southern 13	359569	6601088
Southern 14	363981	6601818
Southern 15	363011	6602026
Southern 16	363811	6601311

Note: MGA Zone 56



Source: EMM (2018); DFSI (2017); UPC (2018)

0 2.5 5 km

GDA 1994 MGA Zone 56

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KEY

- Soil survey location
- Laboratory analysed soil survey location
- 330 kV transmission line
- Main road
- Local road
- Rail line
- Watercourse/drainage line
- Waterbody
- Study area

Development footprint

- Solar array
- Potential site access/ETL easement/electrical cabling
- Potential substation/BESS footprint

Location of soil survey sites

New England Solar Farm
Soil erosion assessment
Figure 2.1

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2.3.2 Sampling method

i Soil extraction

Soil sampling was carried out by an EMM representative with suitable experience in soil classification according to the Australian soil classification system. A total of 40 sites were surveyed and a manual soil auger was used to extract a soil profile down to a depth of at least 0.6 metres below ground level (m bgl). Surface disturbance at each site was limited to approximately 50 millimetres (mm) x 50 mm. Samples were collected from each soil horizon.

ii Profile description

The soil profile was described in the field for the following characteristics:

- vegetation type;
- site condition (signs of erosion, landform, groundcover and vegetation);
- soil surface condition;
- soil water status;
- pedality (including ped shape and size);
- structure (arrangement of soil particles);
- boundaries (shape of the changes between horizons); and
- 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 A (DPI 2015).

iii Laboratory samples

At every site, 400 gram (g) sub-samples of soil were taken from each identified soil horizon. Sub-samples were placed in heavy-duty, sealable plastic bags and labelled. Sub-samples from 12 sites (Figure 2.1) were submitted for laboratory analysis as they best represented soil heterogeneity within the development footprint. A total of 31 samples were analysed with a number of sites having more than two soil horizons submitted for analysis (refer Appendix B).

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;
- $pH_{1:5}$;

- electrical conductivity ($EC_{1:5}$);
- exchangeable cations (calcium (Ca), magnesium (Mg), sodium (Na), potassium (K) and cation exchange capacity (CEC));
- exchangeable sodium percentage (ESP);
- total organic carbon (TOC);
- Emerson aggregate stability; and
- soluble chloride (Cl^-) and sulfate (SO_4^{2-}).

Topsoil samples were subject to the following additional fertility tests:

- Colwell phosphorus (P) and potassium (K);
- total nitrogen, nitrate and nitrite (N); and
- total P.

Representative sample sites were also analysed for particle size distribution (PSD). Four sites were selected to represent soil types and each identified soil horizon was analysed. Detailed laboratory results can be found in Appendix B.

3 Desktop review

3.1 Climate

The climate of Uralla is classified as Cfb (subtropical highland) under the Köppen climate classification system (ISC-Audubon 2018). Climate data for the study area has been obtained from the Australian Bureau of Meteorology's (BoM) station, Uralla (Dumaresq Street) (station number 056034). Mean monthly minimum and maximum temperatures range between 0.4°C-11.8°C in winter and 12.7°C-26.4°C in summer (BoM 2018). The average annual rainfall is 794 mm, with the heaviest of falls occurring in the summer months.

3.2 Topography and landform

The majority of the study area is within the Armidale Plateau subregion, which is characterised by an undulating to hilly plateau at an elevation of approximately 1,100 metres Australian height datum (m AHD). The local topography can be described as a mix of low rolling hills and flatter areas that are frequently dissected by drainage networks and their adjacent floodplains, terraces and foot slopes. Elevation across the study area is variable at approximately 986-1,149 m AHD.

3.3 Surface hydrology

The study area is within the Macleay catchment, in the northern tablelands region of the Great Dividing Range. The Macleay catchment borders the Clarence and Bellinger catchments to the north, Gwydir and Namoi catchments to the west and the Hastings and Manning catchments to the south. The Macleay catchment drains to the Pacific Ocean in the east. Perennial watercourses within the study area and surrounds include Salisbury Waters, Cook Station Creek, Dog Trap Creek and Julia Gully.

3.4 Regional geology

The Dorrigo – Coffs Harbour 1:250,000 Geological series sheet SI/56-10 and SH/56-11 (Leitch et al 1971) shows the study area lies within four geological units. These units are summarised in Table 3.1.

Table 3.1 Geological units in the study area

Geological unit	Description
Ts	Conglomerate, greybilly, sandstone and claystone.
Pag	Gostwyck Adamellite (biotite granitoid commonly with blue quartz, and minor amphibole, garnet and graphite).
Cs	Sandon Beds (greywacke, argillite, chert, jasper and basic volcanics).
Tb	Tholeiitic and alkaline basalts, minor trachytes and dolerite.

3.5 Regional soil mapping

3.5.1 Australian soil classification

The Australian soil classification scheme (Isbell 2016) 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 profile.

State-wide mapping identifies that the study area encompasses seven soil orders, namely Dermosols, Kurosols (natric), Ferrosols, Kurosols, Rudosols, Vertosols and Kandosol (Figure 3.1). These orders are described in Table 3.2.

Table 3.2 Australian soil classification orders in the study area

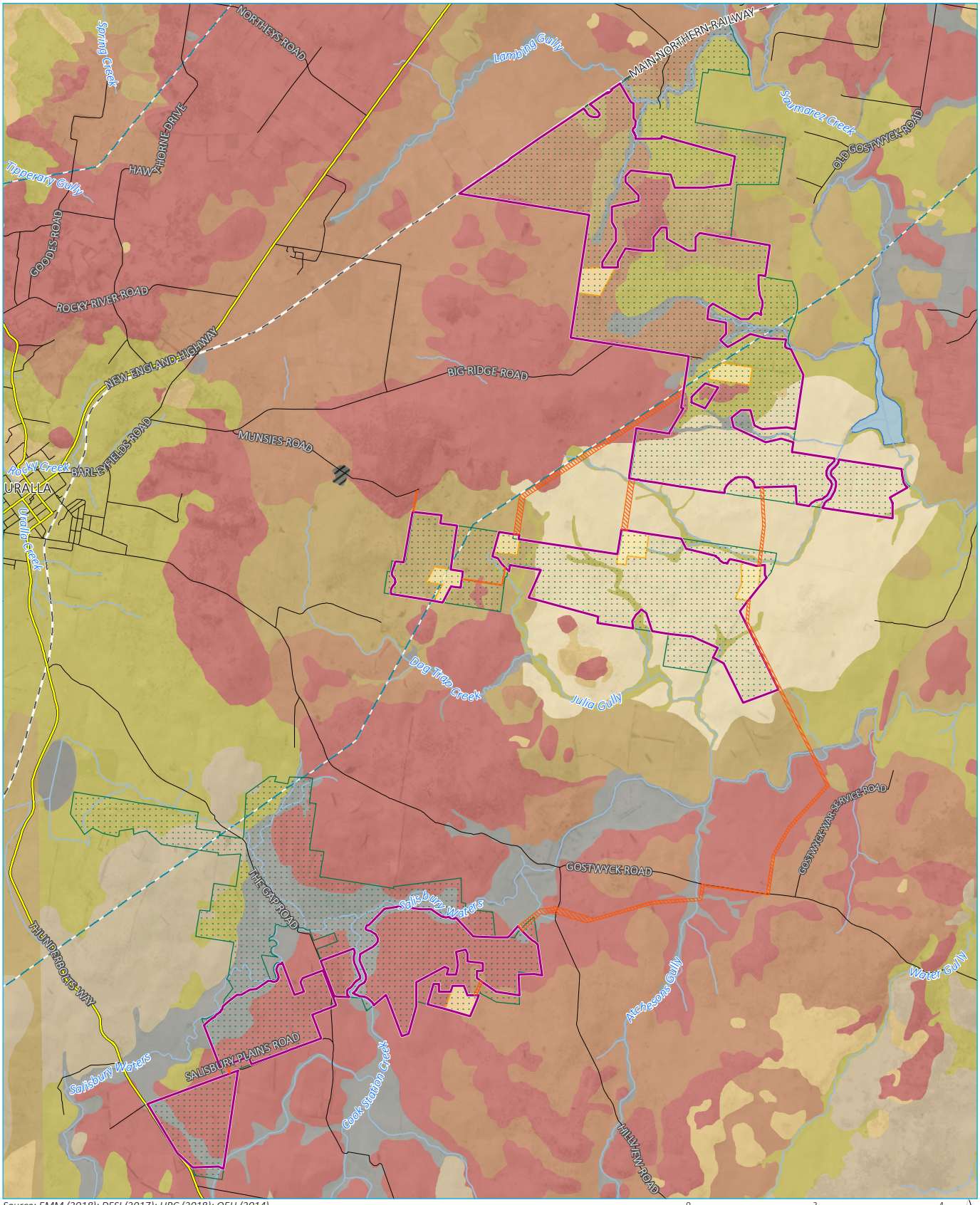
Soil order	Description
Dermosols	Soils with structured B horizons and lacking strong texture contrast between A and B horizons.
Kurosols	Soils with a texture contrast and strongly acid B horizons (pH < 5.5).
Kurosols (natric)	Soils with a texture contrast and strongly acid (pH < 5.5) B horizons. The upper 0.2 m of the B2 horizon is sodic.
Ferrosols	Soils with B2 horizons that are high in free iron oxides (>5%), and which lack strong texture contrast between A and B horizons.
Rudosols	Soils that are weakly structured throughout the profile with the exception of the A horizon. Often shallow ie. bedrock is located near surface.
Vertosols	Clay soils with shrink-swell properties that exhibit strong cracking when dry and at depth have slickenslides and/or lenticular structural aggregates. Although many soils exhibit gilgai microrelief, this feature is not used in their definition.
Kandosols	Soils that lack texture contrast, have massive or only weakly structured B horizons and are not calcareous throughout.

3.5.2 Great soil group

An older soil classification system that provides additional information on soil properties is the Great Soil Groups classification (OEH 2018), which corresponds closely at this location with the Australian soil classification described in Section 3.5.1. The soils within the study area fall under seven soil orders; Siliceous sands (SS), Soloths (SH), Red podzolic soils – less fertile (RPI), Chocolate soils (C), Euchrozems (E), Red podzolic soils – more fertile (RPm) and Black earths (BE). These orders are described in Table 3.3.

Table 3.3 Great Soil Group orders in the study area

Soil order	Description
Siliceous sands (SS)	Soils characterised by their uniform sand to clayey sand texture, deep profiles, massive single-grain structure and the absence of any distinct horizons except for a minimal accumulation of organic matter in the A1 horizon.
Soloths (SH)	Soils with a strong texture contrast and a bleached A2 horizon. The B horizon has medium to coarse blocky peds which may be arranged in a coarse columnar fashion.
Red podzolic soils – less fertile (RPI)	Texture contrast soils with a light to medium textured A1 horizon over a pale or bleached A2 horizon over a reddish, firm to friable B horizon with generally polyhedral structure. These soils are formed over granites and metasediment.
Chocolate soils (C)	Brownish, friable, moderately pedal to fine block structured clay loam soils with weak to moderate horizon differentiation.
Euchrozems (E)	Red, strongly structured clays with a somewhat lower clay content near the surface. They resemble, but are more alkaline than Kraznozems.
Red podzolic soils – more fertile (RPm)	Texture contrast soils with a light to medium textured A1 horizon over a pale or bleached A2 horizon over a reddish, firm to friable B horizon with generally polyhedral structure. These soils are formed of volcanics and granodiorites
Black earths (BE)	Black, clay soils with an alkaline to neutral pH. Wide, deep cracks form when dry.



Source: EMM (2018); DFSI (2017); UPC (2018); OEH (2014)

0 2 4 km

GDA 1994 MGA Zone 56

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KEY

- 330 kV transmission line
- Main road
- Local road
- Rail line
- Watercourse/drainage line
- Study area

Development footprint

- Solar array
- Potential site access/ETL easement/electrical cabling
- Potential substation/BESS footprint

Existing Australian soil classification (ASC)

- Dermosols
- Ferrosols
- Kandosols
- Kurosols
- Kurosols, Natric
- Rudosols
- Rudosols and Tenosols
- Vertosols
- Water
- Disturbed terrain and areas not accessed

Existing Australian soil classification

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Soil erosion assessment
Figure 3.1

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3.5.3 eSPADE soil profiles

The eSPADE soil profile database (OEH 2018) has been used to find soil profiles surveyed in the region that have been submitted to the SALIS database. No profiles occur directly within the study area. Table 3.4 describes a number of eSPADE soil profiles within proximity of the study area. The soils described in Table 3.4 are classified as a Dermosol, Ferrosol and Chromosol.

Table 3.4 eSPADE soil profiles

Survey date	Survey number	Easting	Northing	Zone	Horizons	ASC	Surface pH
13/02/2001	1001020-279	367165	6610888	56	2	Dermosol	6.5
26/08/1999	1001020-139	366454	6613814	56	2	Ferrosol	7
11/01/2001	1001020-249	364995	6615238	56	5	Chromosol	7

3.5.4 Hydrologic soil group

The hydrologic soil groups are defined as follows (OEH 2018):

- 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.

All four soil hydrologic groups occur within the study area (OEH 2018), with soil hydrology ranging from soils with very slow infiltration rates through to high infiltration rates.

3.5.5 Surrounding land uses

The study area is zoned RU1 Primary Production under the Uralla LEP. Land surrounding the study area is predominantly used for agriculture. Cattle and sheep grazing for wool, breeding stock and meat dominate agricultural activities within the study area and its surrounds.

4 Soil survey findings

4.1 Landscape

The development footprint occurs on gently undulating plains with long gentle slopes intersected by drainage lines and depressions. In the northern array area, higher elevations had more evident rocky outcrops and coarse fragments across the soil surface (Photograph 4.1). These were less pronounced or not evident on lower slopes and plains. The northern and central array areas have higher elevation and greater topography when compared to the southern array area. Features of gully erosion (Photograph 4.2) and sheet erosion (Photograph 4.3) were evident in the texture contrast soils of the central array area. These tended to occur along drainage lines.

Similar to the northern array area, in the southern array area, higher elevations had more evident rocky outcrops and coarse fragments across the soil surface. The southern array area had a higher percentage of cultivation (Photograph 4.4) with the majority being pasture crops and improved pastures.

4.2 Vegetation and groundcover

Almost all survey sites were currently being used for grazing pasture. Some had been cultivated with improved pastures. There was generally good vegetative cover in most areas. Relatively recent grazing pressure was obvious in some paddocks with vegetation being very low and some soil surface disturbance from hooves.

Some sites showed obvious signs of erosion, progressive form sheet to rill to gully forms. Figure 4.1 provides an indication of the locations of three areas with existing significant erosion impacts within the central array area. Within the development footprint, an increase in the potential for rill and gully erosion may occur where stripping of the vegetation cover and exposure of soil occurs. Additional working of the soil where construction activity involves some soil extraction may also contribute to an increased risk of dispersion.

Photograph 4.1 Rocky outcrops in the northern array area

Photograph 4.2 **Gully erosion in the central array area**

Photograph 4.3 **Sheet erosion in the central array area**

Photograph 4.4 Cultivated pasture crops in the southern array area

4.3 Soil types

Due to the size and location of the development footprint and the area's underlying geology and topography, there are a variety of soil orders represented across the landscape. The soil orders identified in the soil survey are described below. The main soil types representative of the development footprint are Vertosols, Dermosols, Tenosols and texture contrast soils. The main representative soils were sent for analysis by the laboratory.

The actual surveyed Australian soil classifications within the development footprint are shown on Figure 4.1 overlaid with the current available Australian soil classification mapping.

4.3.1 Vertosol

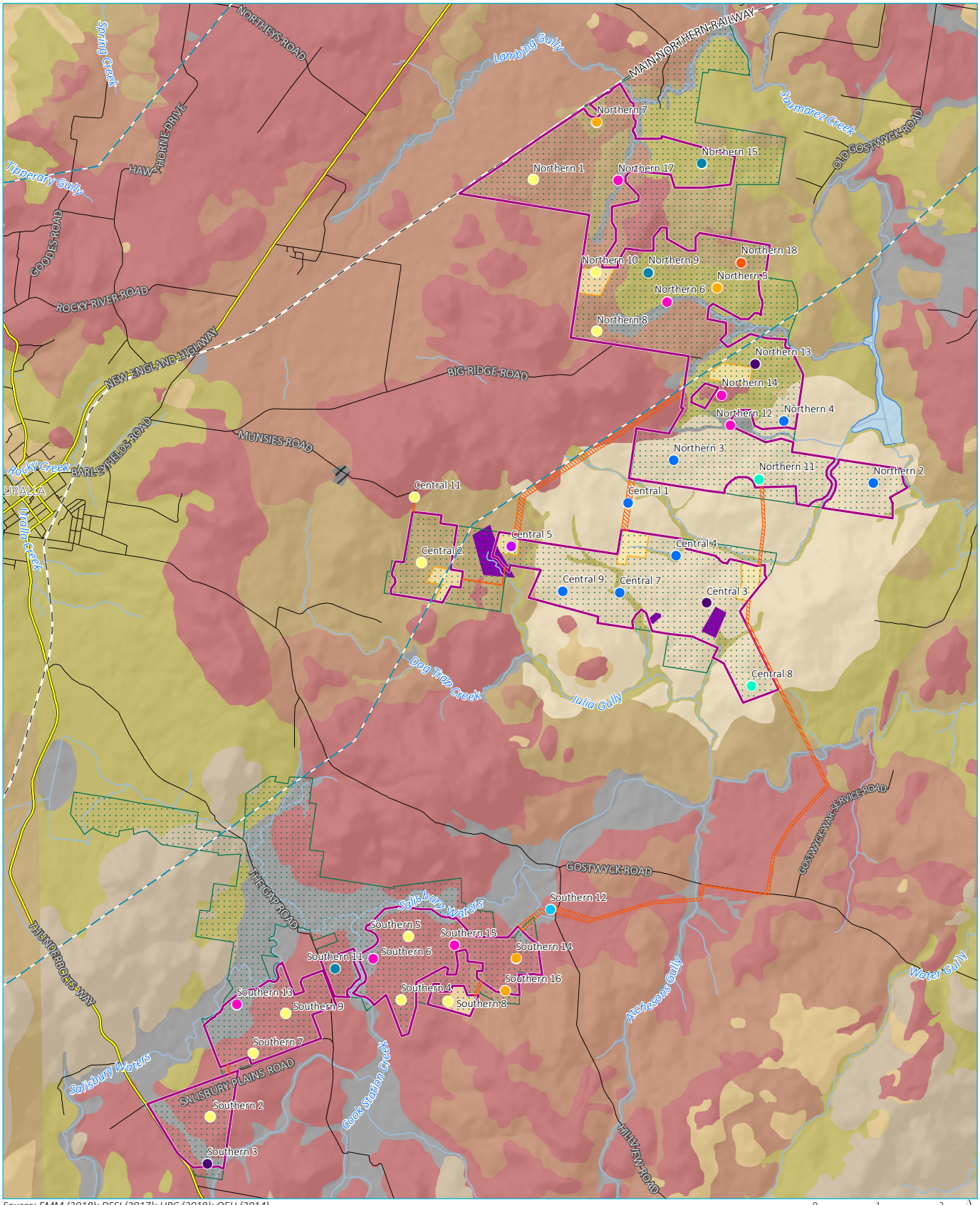
Vertosols are soils that have a clay field texture of 35% or more throughout the entire profile. They experience shrinking and swelling leading to surface cracking at least 5 mm wide, observable at most times of the year. Vertosols also have slickensides and/or lenticular peds within the soil profile.

4.3.2 Tenosol

This soil order incorporates soils with generally weak pedologic organisation apart from the A horizons, encompassing a diverse range of soils. Tenosols generally have poor water retention, almost universal low fertility and occur in regions of low and erratic rainfall. They are mainly used for grazing based on native pastures. In better watered areas limited forestry is supported.

4.3.3 Dermosol

Dermosols are moderately deep and well-drained soils of wetter areas in eastern Australia. They have B2 horizons with structure more developed than weak throughout the major part of the horizon, and do not have clear or abrupt textural B horizons. These soils can support a wide range of land uses including cattle and sheep grazing of native pastures. Cereal crops, especially wheat, are commonly grown on the more fertile Dermosols.



Source: EMM (2018); DFSI (2017); UPC (2018); OEH (2014)

0 1 2 km
GDA 1994 MGA Zone 56

N

KEY

- 330 kV transmission line
- Watercourse/drainage line
- Main road
- Local road
- Rail line
- Existing areas of erosion
- Study area

Development footprint

- Solar array
- Potential site access/ETL easement/electrical cabling
- Potential substation/BESS footprint

Soil survey class

- Tenosol
- Dermosol
- Kandosol
- Vertosol
- Ferrosol
- Chromosol
- Sodosol
- Transition (of texture contrast and tenosol)
- Chromosol (borderline texture contrast)
- Not classified

Existing Australian soil classification (ASC)

- Dermosols
- Ferrosols
- Kandosols
- Kurosols
- Kurosols, Natric
- Rudosols
- Rudosols and Tenosols
- Vertosols
- Water
- Disturbed terrain and areas not accessed

Surveyed Australian soil classification

New England Solar Farm
Soil erosion assessment
Figure 4.1

EMM
creating opportunities

4.3.4 Chromosol

Chromosols have strong texture contrast between the A and B horizons. The upper part of the B horizon is not strongly acid and generally not sodic. These soils have moderate agricultural potential with moderate chemical fertility and water-holding capacity. They can be susceptible to soil acidification and soil structure decline.

4.3.5 Sodosol

Sodosols show strong texture contrast with highly sodic B horizon but they are not highly acidic (pH > 5.5). Sodosols tend to be found in poorly drained sites. Generally, sodosols have very low agricultural potential with high sodicity leading to high erodibility, poor structure and low permeability. These soils have low to moderate chemical fertility and can be associated with soil salinity.

4.3.6 Kandosols

Kandosols are soils which lack strong texture contrast, have massive or only weakly structured B horizons, and are not calcareous throughout. The B2 horizon is generally well developed and has a maximum clay content in some part of the B2 horizon which exceeds 15%.

4.3.7 Ferrosols

Ferrosols do not have a strong texture contrast. They tend to be well structured and their B2 horizon has high free iron oxide (Fe >5%). Ferrosols have high agricultural potential because of their good structure and moderate to high chemical fertility and water-holding capacity. They may suffer nutrient leaching in high rainfall areas and they also have potential for structural decline.

4.4 Soil profile

Table 4.1 provides an overview of the physical characteristics of the representative soils within the development footprint.

Table 4.1 Representative soil profiles

Soil Order	Tenosol	Kandosol	Vertosol	Texture contrast Sodosol	Dermosol
Site	Central 9	Central 8	Northern 6	Northern 18	Northern 8
Profile					
Horizons	A1, B2	A1, B2	A1, B2	A1, A2, B2	A1, B2
A1 pH	5.3	6.2	6.2	5.6	5.8
A structure	Sub-angular blocky	Grainy	Polyhedral	Sub-angular blocky	Sub-angular blocky
B Structure	Sub-angular blocky	Massive	Polyhedral	Polyhedral	Polyhedral

4.5 Soil chemistry

The laboratory analysis results have been compared against soil sufficiency and interpretation data sourced from Baker and Eldershaw (1993), Peverill, Sparrow and Reuter (1999), and Hazelton and Murphy (2016).

The pH of the surface soil ranged from slightly acidic to neutral across the entire development footprint, with a trend of slight acidity in the surface progressing to neutral in the subsoils for all soil types analysed. These values pose no risk to revegetation. The soil salinity values are considered very low. Exchangeable sodium values are considered sufficient and not posing a risk to vegetation growth in most survey sites. A small number of sites had slightly elevated exchangeable sodium values in the subsoil. The calcium to magnesium ratio was considered slightly less than optimal across soils within the development footprint when compared to accepted soil sufficiency values.

The CEC of all soil types surveyed is considered extremely low, indicating the soils may have overall poor fertility. Soil fertility parameters are discussed further below.

4.5.1 Soil fertility and land capability

Soil fertility was assessed against sufficiency and interpretation data sourced from Baker and Eldershaw (1993), Peverill, Sparrow and Reuter (1999), and Hazelton and Murphy (2016). Total nitrogen was sufficient across all soil types analysed within the development footprint; however, nitrate and nitrite values were considered insufficient with some variability across the soils and areas sampled. Exchangeable potassium was generally of moderate sufficiency with very low values in the subsoils. Colwell P was high in all sites except the Tenosol, Kandosol and Sodosol soils in the northern array area. The total P in the northern array area was also low. Organic carbon values were insufficient for most soil types, except the Vertosol.

Micronutrient values were also analysed. Sulfate values were moderate in some surface soils indicating the possible use of fertilisers. Chloride values were higher in the central array area compared to the southern and northern array areas, but were well below any trigger level for soil sufficiency.

The Vertosol and Dermosol soils had moderate fertility. The remaining soil types are insufficient in significant parameters, resulting in poor fertility, which would pose a risk to revegetation if not managed effectively. On an area basis, the central array area has slightly poorer fertility values when compared to the southern and northern array areas.

Nutrient values tended to be variable within and between soil types, most probably due to the large area being surveyed within the development footprint. Based on the macro and micro nutrient levels, on average the soils that were sampled are considered to be moderate to poorly fertile depending on soil type.

i Inherent fertility

Inherent fertility is a relative indicator of the soil's capacity to retain and release nutrients for uptake by plants, and is associated with clay and organic matter content. Existing inherent fertility mapping is based on the soil types presumed to be present in a given area.

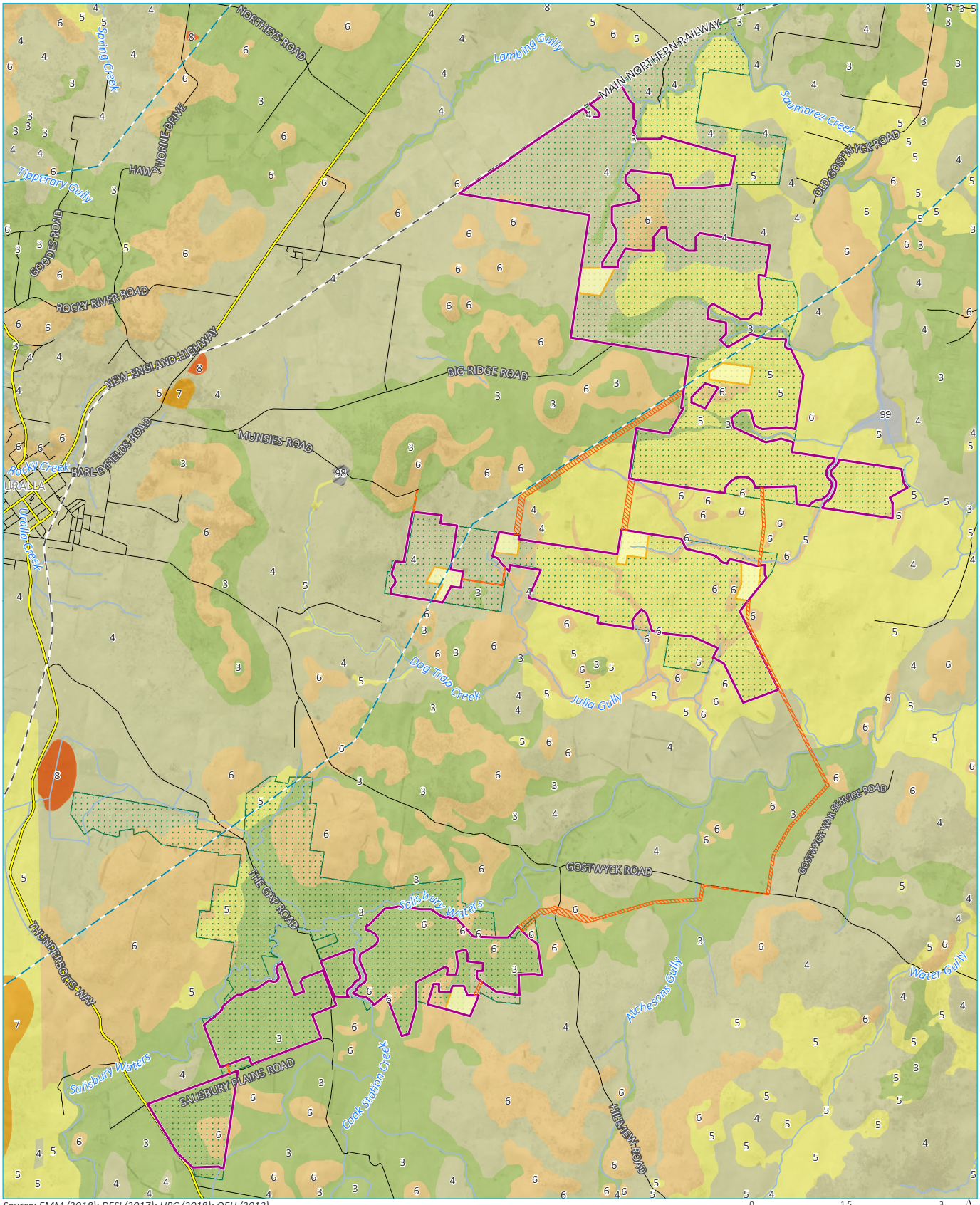
Inherent soil fertility classifications for the development footprint have been mapped by OEH (2018) and range from moderately low through to high. The inherent fertility values may be affected by actual soil type, and chemical and physical characteristics of the soils. Areas of higher elevation were observed to have significant surface rockiness. Drainage lines may experience water logging and poor drainage.

ii Land and soil capability

Land and soil capability is the inherent physical capacity of the land to sustain a range of land uses and management practices in the long term without degradation to soil, land, air and water resources (OEH 2012). The land and soil capability class gives an indication of the land management practices that can be applied to a parcel of land without causing degradation to the land and soil. Failure to manage land in accordance with its capability risks degradation of resources, leading to a decline in natural ecosystem values, agricultural productivity and infrastructure functionality. As land capability decreases, the management of hazards requires an increase in knowledge, expertise and investment.

Figure 4.2 shows the existing land and soil capability class mapping for the development footprint (OEH 2018). Land and soil capability within the development footprint ranges from Class 3 (moderate limitations) through to Class 6 (very severe limitations). Class 6 occurs in isolated patches generally associated with areas of higher elevation within the development footprint.

The analysis undertaken as part of this assessment cannot be used to conclusively verify the inherent fertility or land capability within the development footprint; however, the soil survey and analysis results generally align with the existing broad scale mapping.



Source: EMM (2018); DFSI (2017); UPC (2018); OEH (2013)

0 1.5 3 km

GDA 1994 MGA Zone 56

N

\\EMMSVR1\emm\Jobs\2017\117300 - UPC NSW Solar Farm\GIS\02_Maps_SEA\SEA006_LandandSoilCapability_20180914_01.mxd 14/01/2019

KEY

- 330 kV transmission line
- Watercourse/drainage line
- Main road
- Local road
- Rail line

- Study area

Development footprint

- Solar array
- Potential site access/ETL easement/electrical cabling
- Potential substation/BESS footprint

Land and soil capability

- 2 - Very high capability land
- 3 - High capability land
- 4 - Moderate capability land
- 5 - Moderate-low capability land
- 6 - Low capability land
- 7 - Very low capability land
- 8 - Extremely low capability land
- Disturbed terrain, not assessed
- Water

Land and soil capability

New England Solar Farm
Soil erosion assessment
Figure 4.2

EMM
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4.5.2 Soil erodibility

Dispersion risk was evaluated for all samples analysed. The soil erodibility factor (K) was also evaluated for select samples from the dominant soil types within the development footprint. The main soil types representative of the development footprint were the Vertosols, Dermosols, Tenosols and texture contrast soils, including Chromosols and Sodosols. The Vertosol and Dermosol soils were considered more cohesive, while Tenosol soil was sandier with a massive structure. The texture contrast soils possessed obvious bleached A_2 horizons, indicating poor drainage and lateral movement of infiltrated water.

i Dispersion risk

The soils ranged from slightly acidic to neutral across the development footprint, with a trend of slight acidity in the surface progressing to neutral in the subsoils. Exchangeable aluminium was below detection limits for most sites and therefore not a factor in soil stability. Soil salinity was very low across the development footprint.

A soil with an ESP of >6 is considered sodic. Sodic soils are generally dispersive and are prone to tunnel erosion and severe gully erosion. The exchangeable sodium was very low across the development footprint, with many sites recording below 0.1 cent moles per kilogram (cmol/kg). Three sites were identified as having sodic subsoils. In the northern array area, Site 18 was characterised as a Sodosol due to the total B horizon surveyed exceeding an ESP of 6 (ESP 7.3 to 10.8) and not being strongly acidic. In the central array area, a Dermosol (site 2) and a Tenosol (site 9) had ESP values of 8 and 7.7 respectively in the lower B horizon. These are near the areas of the existing erosion shown in Figure 4.1.

The Emerson class number of the soil, whereby soils are divided into seven classes on the basis of their coherence in water, indicates the dispersion potential of a soil. All surface soils had an Emerson class of 4, which indicates a low risk of significant dispersion. The majority of subsoils were Emerson Class 3, which indicates some risk of dispersion when worked.

On the basis of the parameters discussed above, it is considered that there is a low to moderate risk of dispersion based on soil type if the soil is significantly disturbed or overworked during construction, especially if works occur during or immediately following rain events.

ii Soil erodibility factor - K

Soil erodibility is a measure of the susceptibility of soil particles to detachment and transport by rainfall and runoff. Soil texture is the primary component of soil erodibility. However, soil structure, organic matter and permeability also contribute. Soil erodibility values are shown in Table 4.2 and were calculated using the methodology outlined in Landcom (2004).The soils analysed were chosen as the most representative soil types across the development footprint. It is important to note that this methodology only considers rill and sheet erosion. In accordance with the guidelines, highly dispersive and moderately dispersive soils had their K factor increased by 20% and 10% respectively.

Table 4.2 Soil erodibility results

Analytes	Sample ID			
	South 6- Vertosol	**Central 2 - Dermosol**	**Central 9 - Tenosol**	**North 18 - Sodosol**
Surface soil texture	Clay	Sandy clay	Sandy clay loam	Sandy clay loam
Soil structure	Angular blocky	Angular blocky	Massive	Sub angular blocky
Organic matter	Moderate	Moderate	Moderate	Moderate

Table 4.2 Soil erodibility results

Analytes	Sample ID			
	South 6- Vertosol	Central 2 - Dermosol	Central 9 - Tenosol	North 18 - Sodosol
Profile permeability	4	4	4	4
K value surface	0.019	0.028	0.018	0.031
K value subsoil	0.019	0.017	0.034	0.019

These K values represent moderate soil erodibility. The central array area Tenosol soil type displays a higher subsoil erodibility compared to the southern and northern array areas. This is where existing sheet and gully erosion was observed where the subsoil had been exposed. The Vertosol soils are generally stable while the Dermosol and Sodosol surface soils have moderate erodibility K factors when exposed.

4.6 Erosion hazard assessment

4.6.1 Methodology

The erosion hazard assessment described below acts as an indicator to determine what levels of erosion and sedimentation control measures should be applied to the project. The estimated soil loss from a range of slopes was calculated using the Revised Universal Soil Loss Equation (RUSLE). This equation aims to predict the long term soil loss rate from a given site based on the site characteristics.

The equation is as follows:

$$A = K * R * Ls * P * C$$

Whereby:

A = predicted soil loss per ha per year;

K = soil erodibility factor;

R = rainfall erosivity factor;

Ls = slope length/gradient factor;

P = erosion control factor; and

C = ground cover and management factor.

4.6.2 Soil erodibility factor

As a conservative measure, the highest soil surface erodibility factor presented in Section 4.5.2 was used in the RUSLE equation (ie Tenosol soil with a K factor of 0.034).

4.6.3 Rainfall erosivity factor

The rainfall erosivity factor is a measure of the ability of rainfall to cause erosion. It is the product of the total energy and intensity of the rainfall event.

A rainfall erosivity of 1,500 was used in the calculation. This was based on the project location, which was taken from Map 3, Appendix B of *Managing Urban Stormwater: Soils and Construction: Volume 1 March 2004* (Landcom 2004).

4.6.4 C and P Factors

C and P factors are used to describe the management of sites with respect to reducing soil loss.

The C factor measures the combined effect of all the interrelated cover and management characteristics adopted over a site. It also reflects the covering applied to a site.

The P factor measures the combined effect of all support practices and management variables.

The industry accepted defaults for C and P have been adopted and values of 1.0 and 1.3 will be used respectively.

4.6.5 Ls Factor

The slope length (Ls) factor varies between different slope lengths and slope gradients.

As a conservative measure, an average slope angle and length of 6% and 300 m respectively were used, resulting in an Ls Factor of 3.25 (refer to Table A1 of Appendix A of *Managing Urban Stormwater: Soils and Construction: Volume 1 March 2004* (Landcom 2004)).

4.6.6 Erosion hazard

Using the RUSLE equation:

$$A = K * R * Ls * P * C$$

Where:

- K = The K values for each surface soil type identified in Section 4.5.2
- R = 1500 rainfall erosivity
- Ls = 3.25 slope length factor
- P = 1.0
- C = 1.3

The estimated soil loss is:

- Vertosol = 120.41 t/ha/yr;
- Dermosol = 177.45 t/ha/yr;
- Tenosol = 114.07 t/ha/yr; and
- Sodosol = 196.46 t/ha/yr.

The relationship between qualitative erosion hazard categories and the quantitative soil loss rate is shown in Table 4.3. The table shows that the worst case soil surface erosion loss potential (ie 196.46 t/ha/yr), is considered to be a low erosion hazard risk.

Table 4.3 Erosion hazard categories[1]

Soil loss class	Calculated soil loss	Erosion hazard
Units	**t/ha/yr**	
1	<150	Very low
2	151-225	Low
3	226-350	Low-moderate
4	351-500	Moderate
5	501-750	High
6	751-1,500	Very high
7	>1,501	Extreme

Notes 1. Sourced from Table 3.2 from Managing Urban Stormwater: Soils and Construction: Volume 1 March 2004 (Landcom 2004).

5 Erosion and sediment control

An erosion and sediment control (ESC) plan will be prepared in accordance with *Managing Urban Stormwater: Soils and Construction* (Landcom 2004) prior to commencement of construction. ESC measures will be implemented on a site-specific basis within the development footprint to maximise effectiveness.

Based on the outcomes of the soil survey undertaken, it is considered that implementation of general ESC measures will be suitable within the development footprint. ESC measures will be implemented as far as practicable prior to any soil disturbance and will include:

- site specific ESC plans will be developed for use during site preparation works, construction and operations;
- ESCs will be installed, with priority given to sloped areas and areas adjacent to drainage lines;
- all construction and operational activities will be planned and carried out to ensure that damage to soil and vegetation outside the area designated for clearing (ie the development footprint) is minimised;
- where practicable, consideration will be given to the timing of disturbance and vegetation clearing ahead of project activities to ensure disturbed areas are exposed for the shortest possible time;
- where practicable, UPC will minimise the disturbance of soils (especially subsoil) or stockpiles at times immediately following significant rainfall events (eg 25 mm in 24 hours);
- disturbed areas will be stabilised and progressively rehabilitated as quickly as possible; and
- ameliorants (such as gypsum and fertiliser) will be applied at recommended rates during construction and as part of decommissioning and rehabilitation activities (in consultation with project landholders) and will assist with erosion management.

A summary of potential ESC measures to be implemented are provided in Table 5.1.

Table 5.1 Indicative erosion and sedimentation control measures by disturbance type/area

Area	Erosion and sediment control measures
Areas cleared of vegetation/ground cover (eg array areas, substation/BESS footprints, temporary construction laydown areas, construction accommodation village)	• divert run-off from undisturbed areas away from construction areas and project infrastructure; • windrow vegetation debris along the contours wherever possible; • minimise the length of time that soil is exposed; and • direct run-off from disturbed areas to ESCs such as sediment basins, where relevant.
Exposed subsoils (eg array areas, substation/BESS footprints, construction accommodation village)	• provide controls for areas of existing gully erosion; • minimise the length of time that subsoil is exposed; and • direct run-off from cleared areas to ESCs such as sediment basins, where relevant.

Infrastructure (eg array areas, substation/BESS footprints)	• provide protection in drains (eg rip rap, revegetate) if there is the potential for water velocity to cause scouring; • confine traffic to access roads and tracks within the development footprint; • install sediment traps, silt fences, hay bales and other ESCs, where relevant; and • rehabilitate disturbed areas around construction sites promptly using an ameliorant (such as gypsum and fertilisers).
Access roads and tracks	• optimise surface drainage and stabilise drainage lines.

The operational stage must consider that shading from the PV modules may reduce the amount of vegetation growth. Certain areas within the development footprint with higher erosive potential and poorer fertility may have more unstable soils on a slope. This may be a greater issue in the Sodosol soil types in the northern array area and within proximity of sites with high exchangeable sodium in the central array area. In these areas, additional control measures such as reducing grazing pressures and use of plant species that are known to grow well under reduced light conditions may be considered.

6 Conclusion and recommendations

The landscape and soil characteristics across the development footprint are variable, reflecting the large area and variability in the underlying geology and topography. The soil types varied across the development footprint with the major soil types identified as Vertosols, Dermosols, Tenosols, and texture contrast soils (Sodosols and Chromosols).

The soils generally had slightly acidic A horizons and neutral pH in the B horizon. The CEC of all soils was very low; however, the macronutrients were moderate in the surface soils. The soils were not saline, but had poor calcium to magnesium ratios and some sodicity.

Soil erodibility ranged from low to moderate across the development footprint, while the overall erosion hazard was low once the landscape features were considered. It is recommended to minimise surface disturbance, wherever practicable. Where surface disturbance occurs, the installation of ESC measures is recommended to minimise the risk of dispersion. Should disturbance or stripping of soil be required, an ameliorant, such as gypsum, could be applied to manage erosion and the slight acidity of the topsoil, and provide for more effective future use, along with the seeding of vegetation ground cover post-construction. Existing areas of erosion may require site specific management to stabilise depending on the type and degree of erosion. This can be addressed in site-specific ESC plans prior to the commencement of construction.

This assessment was a preliminary investigation into the existing soils and their potential for erosion as well as a high level review of their fertility status. The results indicate that the Vertosol and Dermosol soils generally have moderate fertility while the texture contrast soils have poorer fertility. The potential for erosion also reflected this pattern, with the texture contrast soils having a moderate dispersion potential when disturbed. Management for erosion potential as well as rehabilitation is recommended as part of the standard management practices.

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Appendix A

Assessing soil texture

Department of Primary Industries

primefact

Determining soil texture using the ribboning technique

December 2014 Primefact 1363 First edition
Agriculture NSW Water Unit

Soil texture refers to how coarse or fine a soil is: that is, how much sand, silt and clay it contains. Texture has a major influence on how much water a soil can hold. Generally, the smaller and finer the soil particles (the more silt and clay), the more water a soil can hold (but this water may not all be available to the crop).

Soil texture can be estimated by hand, using the ribboning technique, but it takes practice to produce a consistent result.

Assessing soil texture

Carry out this ribbon test on a sample from each layer identified in the soil profile.

1. Take a small handful of soil.

2. Add enough water to make a ball. If you can't make a ball, the soil is very sandy.

3. Feel the ball with your fingers to find out if it is gritty (sand), silky (silt) or plastic/sticky (clay).

4. Reroll the ball and with your thumb gently press it out over your forefinger to make a hanging ribbon.

5. If you can make a short ribbon, your soil texture is loamy, a mixture of sand and clay.

6. The longer the ribbon, the more clay is in your soil.

Do this several times for confirmation and compare the average ribbon length with those in Table 1.

Table 1. Soils textures using the ribboning technique

SAND Coherence nil to very slight, cannot be moulded; single grains adhere to fingers; nil to slight turbidity when puddled.
LOAMY SAND Will form a ribbon to 5 mm. Slight coherence; definite turbidity when puddled in palm of hand
CLAYEY SAND Will form a ribbon 5 to 15 mm. Slight coherence, sticky when wet, many sand grains stick to fingers, discolours fingers with clay stain.
SANDY LOAM Will form a ribbon of 15 to 20 mm. Bolus just coherent and very sandy to touch; sand grains visible.
LIGHT SANDY CLAY LOAM Will form a ribbon of 20 to 25 mm. Bolus moderately coherent but sandy to touch; sand grains easily visible.
LOAM Will form a ribbon of about 25 mm. Bolus coherent and spongy; smooth feel and no obvious sandiness; may be somewhat greasy, as organic matter is usually present.
SANDY CLAY LOAM Will form a ribbon 25 to 40 mm. Bolus strongly coherent, sandy to touch; sand grains visible.
CLAY LOAM Will form a ribbon 40 to 50 mm. Bolus strongly coherent and plastic; smooth to manipulate.
SANDY CLAY and LIGHT CLAY Will form a ribbon 50 to 75 mm. Plastic bolus, slight resistance to shearing. sandy clay - can see, feel and hear sand grains. light clay - smooth to touch.
LIGHT MEDIUM CLAY Will form a ribbon 75 to 85 mm. Plastic bolus smooth to touch; moderate resistance to shearing between thumb and forefinger.
MEDIUM CLAY Will form a ribbon 85 to 100 mm. Smooth plastic bolus: handles like plasticine and can be moulded into rods, moderate resistance to ribboning.
HEAVY CLAY Will easily form a ribbon over 100 mm. Smooth plastic bolus; handles like stiff plasticine; can be moulded into rods without fracture; has firm resistance to ribboning shear.

Each soil texture is classified within a ribbon length range (for example, sandy clay loam ribbon length is 25 to 40 mm long). Therefore, once a consistent ribbon length is being produced, you can be reasonably sure that the correct soil texture has been identified.

Glossary

Bolus: handful of moistened soil kneaded into a ball

Clay: plate like mineral particles in soil with a diameter less than 0.002 mm. Also refers to a soil in which the clay particles constitute more than 35% of the mass and more than 40% silt sized particles.

Plastic bolus: handful of moistened soil able to retain its shape after moulding. Usually possible in heavy soil types. Plastic refers to the state where soil is able to be permanently deformed without rebounding or losing volume

Puddled: soil in which the structure has been destroyed by the addition of water and or tillage at high water contents. Porosity, permeability and aggregation are all reduced in puddled soils

Sand: mineral particles in soil with a diameter ranging 0.02 – 2.0 mm. Also refers to a soil in which sand particles constitute more than 85% of the mass

Shearing: The action of applying (tangential) force to material (soil). In the case of texture determination it involves pressing a ribbon out between thumb and forefinger.

Silt: mineral particles in soil with a diameter ranging 0.002 – 0.02 mm

Turbidity: cloudiness or haziness of a fluid caused by large numbers of individual particles. A measure of reduced transparency of water (or air) due to the presence of suspended material.

More information

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How to texture soils and test for salinity: Salinity notes No8

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Jeremy Giddings Irrigation Industry Development Officer (Horticulture)

Based on WaterWise on the Farm Fact Sheet, Series 1: Irrigation Farm Resources 2004

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V14/3395 PUB 14/176 Jobtrack 13288

Appendix B

Laboratory results

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1819289**	Page	: 1 of 15
Client	: **EMM CONSULTING PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MS KYLIE DRAPALA	Contact	: Sepan Mahamad
Address	: 1/4 87 WICKHAM TERRACE SPRING HILL QLD 4000	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: 07 3839 1800	Telephone	: +61-7-3243 7222
Project	: J17300 - New England Solar Farm	Date Samples Received	: 08-Aug-2018 13:15
Order number	:	Date Analysis Commenced	: 10-Aug-2018
C-O-C number	: ----	Issue Date	: 22-Aug-2018 14:12
Sampler	: NICK JAMSON		
Site	: ----		
Quote number	: EN/112/18		
No. of samples received	: 31		
No. of samples analysed	: 31		

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

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

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

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

Signatories

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

Signatories	*Position*	*Accreditation Category*
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Greg Vogel	Laboratory Manager	Brisbane Acid Sulphate Soils, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Satishkumar Trivedi	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Satishkumar Trivedi	Senior Acid Sulfate Soil Chemist	Brisbane Inorganics, Stafford, QLD
Tom Maloney	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD

General Comments

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

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

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

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

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

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

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

- ED006(Exchangeable Cations on Alkaline Soils): Unable to calculate Magnesium/Potassium Ratio for samples EB1819289-020 (Central 2 - 40-60cm) and EB1819289-025 (North 14 - 40-60cm) as the required results for Magnesium/Potassium are below LOR.
- EK057G (Nitrite as N): Sample EB1819289_001 (Southern 12 - 0-14cm) was diluted due to matrix interference. LOR adjusted accordingly.
- ALS is not NATA accredited for the analysis of Exchangeable Aluminium and Exchange Acidity in soils when performed under ALS Method ED005.
- ALS is not NATA accredited for the analysis of Exchangeable Cations on Alkaline Soils when performed under ALS Method ED006.
- ED007 (Exchangeable Cations): Magnesium/Potassium ratio could not be determined as both the Magnesium and Potassium results were less than reportable limits for some samples.
- ED007 (Exchangeable Cations): Calcium/Magnesium ratio could not be determined as both the Calcium and Magnesium results were less than reportable limits for some samples.
- EA058 Emerson: V. = Very, D. = Dark, L. = Light, VD. = Very Dark
- ED007 and ED008: When Exchangeable Al is reported from these methods, it should be noted that Rayment & Lyons (2011) suggests Exchange Acidity by 1M KCl - Method 15G1 (ED005) is a more suitable method for the determination of exchange acidity (H+ + Al3+).

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	Southern 12 - 0-14cm	Southern 7 - 0-15cm	Southern 14 - 0-12cm	Southern 6 - 0-20cm	Central 3 - 0-10cm
			Client sampling date / time	30-Jul-2018 00:00	30-Jul-2018 00:00	31-Jul-2018 00:00	30-Jul-2018 00:00	08-Feb-2018 00:00
Compound	CAS Number	LOR	Unit	EB1819289-001	EB1819289-002	EB1819289-003	EB1819289-004	EB1819289-005
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	5.9	5.0	5.8	5.6	5.1
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	143	51	29	37	84
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	28.7	9.4	12.6	18.4	10.6
EA058: Emerson Aggregate Test								
Color (Munsell)	----	-	-	Very Dark Brown	Very Dark Greyish Brown	Dark Greyish Brown	Very Dark Greyish Brown	Brown
Texture	----	-	-	Sandy Clay Loam	Sandy Clay	Sandy Clay	Clay Loam	Sandy Clay Loam
Emerson Class Number	EC/TC	-	-	4	4	4	3	4
EA150: Particle Sizing								
+75µm	----	1	%	----	----	----	23	----
+150µm	----	1	%	----	----	----	21	----
+300µm	----	1	%	----	----	----	19	----
+425µm	----	1	%	----	----	----	18	----
+600µm	----	1	%	----	----	----	17	----
+1180µm	----	1	%	----	----	----	16	----
+2.36mm	----	1	%	----	----	----	13	----
+4.75mm	----	1	%	----	----	----	8	----
+9.5mm	----	1	%	----	----	----	4	----
+19.0mm	----	1	%	----	----	----	<1	----
+37.5mm	----	1	%	----	----	----	<1	----
+75.0mm	----	1	%	----	----	----	<1	----
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	----	----	----	31	----
Silt (2-60 µm)	----	1	%	----	----	----	44	----
Sand (0.06-2.00 mm)	----	1	%	----	----	----	11	----
Gravel (>2mm)	----	1	%	----	----	----	14	----
Cobbles (>6cm)	----	1	%	----	----	----	<1	----
EA152: Soil Particle Density								
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	----	----	----	2.28	----
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	<0.1	0.4	<0.1	0.1	0.2
Exchangeable Aluminium	----	0.1	meq/100g	<0.1	0.2	<0.1	<0.1	<0.1

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	Southern 12 - 0-14cm	Southern 7 - 0-15cm	Southern 14 - 0-12cm	Southern 6 - 0-20cm	Central 3 - 0-10cm
				Client sampling date / time	30-Jul-2018 00:00	30-Jul-2018 00:00	31-Jul-2018 00:00	30-Jul-2018 00:00	08-Feb-2018 00:00
Compound	CAS Number	LOR	Unit		EB1819289-001	EB1819289-002	EB1819289-003	EB1819289-004	EB1819289-005
					Result	Result	Result	Result	Result
ED007: Exchangeable Cations									
Exchangeable Calcium	----	0.1	meq/100g		10.9	2.2	4.0	9.1	1.2
Exchangeable Magnesium	----	0.1	meq/100g		4.9	0.6	2.4	6.6	0.6
Exchangeable Potassium	----	0.1	meq/100g		2.9	0.3	0.2	0.4	0.3
Exchangeable Sodium	----	0.1	meq/100g		0.1	<0.1	0.2	0.3	<0.1
Cation Exchange Capacity	----	0.1	meq/100g		18.8	3.5	6.8	16.5	2.3
Exchangeable Sodium Percent	----	0.1	%		0.6	2.4	3.4	1.8	3.2
Calcium/Magnesium Ratio	----	0.1	-		2.2	3.7	1.7	1.4	2.0
Magnesium/Potassium Ratio	----	0.1	-		1.7	2.0	13.6	17.7	2.0
ED021: Bicarbonate Extractable Potassium (Colwell)									
Bicarbonate Extractable K (Colwell)	----	100	mg/kg		1650	<200	<200	241	204
ED040S : Soluble Sulfate by ICPAES									
Sulfate as SO4 2-	14808-79-8	10	mg/kg		40	20	<10	20	30
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	10	mg/kg		70	10	20	50	40
EK055: Ammonia as N									
Ammonia as N	7664-41-7	20	mg/kg		<20	<20	<20	<20	<20
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N (Sol.)	14797-65-0	0.1	mg/kg		<0.5	<0.1	0.1	0.3	<0.1
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N (Sol.)	14797-55-8	0.1	mg/kg		61.9	23.2	11.5	6.4	26.4
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg		61.9	23.2	11.6	6.7	26.4
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	20	mg/kg		4980	2890	1710	2100	980
EK062: Total Nitrogen as N (TKN + NOx)									
^ Total Nitrogen as N	----	20	mg/kg		5040	2910	1720	2110	1010
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	2	mg/kg		1210	368	420	465	154
EK080: Bicarbonate Extractable Phosphorus (Colwell)									
Bicarbonate Ext. P (Colwell)	----	5	mg/kg		119	16	8	81	15
EP003: Total Organic Carbon (TOC) in Soil									
Total Organic Carbon	----	0.02	%		3.74	1.08	2.14	1.76	0.72

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	Central 2 - 0-11cm	Central 9 - 0-15cm	North 14 0-8cm	North 11 0-20cm	Northern 4 - 0-20cm
			Client sampling date / time	31-Jul-2018 00:00	08-Aug-2018 00:00	08-Aug-2018 00:00	08-Aug-2018 00:00	08-Aug-2018 00:00
Compound	CAS Number	LOR	Unit	EB1819289-006	EB1819289-007	EB1819289-008	EB1819289-009	EB1819289-010
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	5.7	5.3	6.2	6.2	5.5
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	24	25	74	24	18
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	16.3	8.4	27.6	9.0	7.3
EA058: Emerson Aggregate Test								
Color (Munsell)	----	-	-	Very Dark Greyish Brown	Brown	Very Dark Brown	Dark Grey	Brown
Texture	----	-	-	Sandy Clay	Sandy Clay Loam	Sandy Clay	Sandy Clay Loam	Sandy Clay
Emerson Class Number	EC/TC	-	-	3	4	4	4	4
EA150: Particle Sizing								
+75µm	----	1	%	34	68	----	----	----
+150µm	----	1	%	26	62	----	----	----
+300µm	----	1	%	22	53	----	----	----
+425µm	----	1	%	21	45	----	----	----
+600µm	----	1	%	20	35	----	----	----
+1180µm	----	1	%	17	12	----	----	----
+2.36mm	----	1	%	12	<1	----	----	----
+4.75mm	----	1	%	3	<1	----	----	----
+9.5mm	----	1	%	<1	<1	----	----	----
+19.0mm	----	1	%	<1	<1	----	----	----
+37.5mm	----	1	%	<1	<1	----	----	----
+75.0mm	----	1	%	<1	<1	----	----	----
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	18	7	----	----	----
Silt (2-60 µm)	----	1	%	42	24	----	----	----
Sand (0.06-2.00 mm)	----	1	%	26	65	----	----	----
Gravel (>2mm)	----	1	%	14	4	----	----	----
Cobbles (>6cm)	----	1	%	<1	<1	----	----	----
EA152: Soil Particle Density								
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	2.34	2.42	----	----	----
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	0.2	0.2	----	----	0.2
Exchangeable Aluminium	----	0.1	meq/100g	0.1	<0.1	----	----	0.1

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	Central 2 - 0-11cm	Central 9 - 0-15cm	North 14 0-8cm	North 11 0-20cm	Northern 4 - 0-20cm
			Client sampling date / time	31-Jul-2018 00:00	08-Aug-2018 00:00	08-Aug-2018 00:00	08-Aug-2018 00:00	08-Aug-2018 00:00
Compound	CAS Number	LOR	Unit	EB1819289-006	EB1819289-007	EB1819289-008	EB1819289-009	EB1819289-010
				Result	Result	Result	Result	Result
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	3.9	1.2	27.5	3.1	1.5
Exchangeable Magnesium	----	0.1	meq/100g	3.2	0.4	15.1	0.9	0.6
Exchangeable Potassium	----	0.1	meq/100g	0.2	0.1	2.4	0.4	0.2
Exchangeable Sodium	----	0.1	meq/100g	0.2	<0.1	0.1	<0.1	<0.1
Cation Exchange Capacity	----	0.1	meq/100g	7.7	1.9	45.1	4.6	2.5
Exchangeable Sodium Percent	----	0.1	%	2.7	2.6	0.3	0.3	2.0
Calcium/Magnesium Ratio	----	0.1	-	1.2	3.0	1.8	3.4	2.5
Magnesium/Potassium Ratio	----	0.1	-	13.2	2.9	6.4	2.0	3.1
ED021: Bicarbonate Extractable Potassium (Colwell)								
Bicarbonate Extractable K (Colwell)	----	100	mg/kg	299	240	1360	422	243
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	20	10	40	<10	<10
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	30	10	30	20	20
EK055: Ammonia as N								
Ammonia as N	7664-41-7	20	mg/kg	<20	<20	<20	<20	<20
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N (Sol.)	14797-65-0	0.1	mg/kg	0.3	<0.1	0.3	0.2	<0.1
EK058G: Nitrate as N by Discrete Analyser								
Nitrate as N (Sol.)	14797-55-8	0.1	mg/kg	4.1	5.9	14.4	4.6	1.3
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	4.4	5.9	14.7	4.8	1.3
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	20	mg/kg	1580	860	5910	1280	530
EK062: Total Nitrogen as N (TKN + NOx)								
^ Total Nitrogen as N	----	20	mg/kg	1580	860	5920	1280	530
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	2	mg/kg	322	161	1400	215	99
EK080: Bicarbonate Extractable Phosphorus (Colwell)								
Bicarbonate Ext. P (Colwell)	----	5	mg/kg	38	21	192	<5	<5
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	1.19	0.69	5.40	1.16	0.58

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	Northern 18 - 0-14cm	Northern 8 0-13cm	Southern 14 - 0-20cm	Southern 14 - 40-60cm	Southern 7 - 15-35cm
			Client sampling date / time	08-Aug-2018 00:00	08-Aug-2018 00:00	31-Jul-2018 00:00	31-Jul-2018 00:00	30-Jul-2018 00:00
Compound	CAS Number	LOR	Unit	EB1819289-011	EB1819289-012	EB1819289-013	EB1819289-014	EB1819289-015
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	5.6	5.8	6.3	6.6	5.7
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	15	56	12	9	10
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	14.2	15.1	5.2	9.5	5.6
EA058: Emerson Aggregate Test								
Color (Munsell)	----	-	-	Very Dark Greyish Brown	Very Dark Greyish Brown	Dark Greyish Brown	Dark Yellowish Brown	Dark Greyish Brown
Texture	----	-	-	Sandy Clay Loam	Sandy Clay	Sandy Clay	Sandy Clay	Sandy Clay
Emerson Class Number	EC/TC	-	-	4	4	3	3	3
EA150: Particle Sizing								
+75µm	----	1	%	57	----	----	----	----
+150µm	----	1	%	47	----	----	----	----
+300µm	----	1	%	32	----	----	----	----
+425µm	----	1	%	26	----	----	----	----
+600µm	----	1	%	21	----	----	----	----
+1180µm	----	1	%	13	----	----	----	----
+2.36mm	----	1	%	7	----	----	----	----
+4.75mm	----	1	%	1	----	----	----	----
+9.5mm	----	1	%	<1	----	----	----	----
+19.0mm	----	1	%	<1	----	----	----	----
+37.5mm	----	1	%	<1	----	----	----	----
+75.0mm	----	1	%	<1	----	----	----	----
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	3	----	----	----	----
Silt (2-60 µm)	----	1	%	37	----	----	----	----
Sand (0.06-2.00 mm)	----	1	%	51	----	----	----	----
Gravel (>2mm)	----	1	%	9	----	----	----	----
Cobbles (>6cm)	----	1	%	<1	----	----	----	----
EA152: Soil Particle Density								
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	2.37	----	----	----	----
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	<0.1	<0.1	----	----	0.2
Exchangeable Aluminium	----	0.1	meq/100g	<0.1	<0.1	----	----	0.1

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	Northern 18 - 0-14cm	Northern 8 0-13cm	Southern 14 - 0-20cm	Southern 14 - 40-60cm	Southern 7 - 15-35cm
			Client sampling date / time	08-Aug-2018 00:00	08-Aug-2018 00:00	31-Jul-2018 00:00	31-Jul-2018 00:00	30-Jul-2018 00:00
Compound	CAS Number	LOR	Unit	EB1819289-011	EB1819289-012	EB1819289-013	EB1819289-014	EB1819289-015
				Result	Result	Result	Result	Result
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	2.8	6.2	2.6	4.3	1.6
Exchangeable Magnesium	----	0.1	meq/100g	0.9	4.7	1.9	4.4	0.4
Exchangeable Potassium	----	0.1	meq/100g	0.2	0.2	<0.1	0.2	0.2
Exchangeable Sodium	----	0.1	meq/100g	<0.1	0.2	0.3	0.5	<0.1
Cation Exchange Capacity	----	0.1	meq/100g	3.9	11.3	4.9	9.3	2.4
Exchangeable Sodium Percent	----	0.1	%	2.1	2.2	5.4	5.3	1.7
Calcium/Magnesium Ratio	----	0.1	-	3.1	1.3	1.4	1.0	4.0
Magnesium/Potassium Ratio	----	0.1	-	5.5	21.5	----	26.8	2.6
ED021: Bicarbonate Extractable Potassium (Colwell)								
Bicarbonate Extractable K (Colwell)	----	100	mg/kg	318	325	310	----	----
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	<10	40	<10	<10	<10
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	<10	40	<10	<10	<10
EK055: Ammonia as N								
Ammonia as N	7664-41-7	20	mg/kg	<20	<20	<20	----	----
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N (Sol.)	14797-65-0	0.1	mg/kg	<0.1	<0.1	0.2	----	----
EK058G: Nitrate as N by Discrete Analyser								
Nitrate as N (Sol.)	14797-55-8	0.1	mg/kg	6.6	11.0	2.4	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	6.6	11.0	2.6	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	20	mg/kg	1810	1680	520	----	----
EK062: Total Nitrogen as N (TKN + NOx)								
^ Total Nitrogen as N	----	20	mg/kg	1820	1690	520	----	----
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	2	mg/kg	276	874	284	----	----
EK080: Bicarbonate Extractable Phosphorus (Colwell)								
Bicarbonate Ext. P (Colwell)	----	5	mg/kg	8	24	<5	----	----
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	0.55	1.26	0.35	0.33	0.24

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	Southern 7 - 35-50cm	Southern 6 - 30-50cm	Central 3 - 20-40cm	Central 3 - 43-60cm	Central 2 - 40-60cm
			Client sampling date / time	30-Jul-2018 00:00	30-Jul-2018 00:00	08-Aug-2018 00:00	08-Aug-2018 00:00	31-Jul-2018 00:00
Compound	CAS Number	LOR	Unit	EB1819289-016	EB1819289-017	EB1819289-018	EB1819289-019	EB1819289-020
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	6.4	6.4	5.6	5.8	7.6
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	10	20	8	8	60
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	7.0	16.7	8.1	8.5	17.2
EA058: Emerson Aggregate Test								
Color (Munsell)	----	-	-	Dark Greyish Brown	Very Dark Greyish Brown	Greyish Brown	Light Yellowish Brown	Brown
Texture	----	-	-	Sandy Clay	Sandy Clay	Sandy Clay Loam	Sandy Clay	Clay Loam
Emerson Class Number	EC/TC	-	-	3	3	3	4	3
EA150: Particle Sizing								
+75µm	----	1	%	----	18	----	----	18
+150µm	----	1	%	----	17	----	----	17
+300µm	----	1	%	----	15	----	----	16
+425µm	----	1	%	----	15	----	----	16
+600µm	----	1	%	----	14	----	----	15
+1180µm	----	1	%	----	13	----	----	13
+2.36mm	----	1	%	----	8	----	----	9
+4.75mm	----	1	%	----	1	----	----	5
+9.5mm	----	1	%	----	<1	----	----	<1
+19.0mm	----	1	%	----	<1	----	----	<1
+37.5mm	----	1	%	----	<1	----	----	<1
+75.0mm	----	1	%	----	<1	----	----	<1
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	----	45	----	----	50
Silt (2-60 µm)	----	1	%	----	36	----	----	29
Sand (0.06-2.00 mm)	----	1	%	----	10	----	----	11
Gravel (>2mm)	----	1	%	----	9	----	----	10
Cobbles (>6cm)	----	1	%	----	<1	----	----	<1
EA152: Soil Particle Density								
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	----	2.31	----	----	2.31
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	----	----	0.2	0.2	----
Exchangeable Aluminium	----	0.1	meq/100g	----	----	<0.1	<0.1	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	Southern 7 - 35-50cm	Southern 6 - 30-50cm	Central 3 - 20-40cm	Central 3 - 43-60cm	Central 2 - 40-60cm
				Client sampling date / time	30-Jul-2018 00:00	30-Jul-2018 00:00	08-Aug-2018 00:00	08-Aug-2018 00:00	31-Jul-2018 00:00
Compound	CAS Number	LOR	Unit		EB1819289-016	EB1819289-017	EB1819289-018	EB1819289-019	EB1819289-020
					Result	Result	Result	Result	Result
ED006: Exchangeable Cations on Alkaline Soils									
Exchangeable Calcium	----	0.2	meq/100g		----	----	----	----	7.6
Exchangeable Magnesium	----	0.2	meq/100g		----	----	----	----	13.3
Exchangeable Potassium	----	0.2	meq/100g		----	----	----	----	<0.2
Exchangeable Sodium	----	0.2	meq/100g		----	----	----	----	1.8
Cation Exchange Capacity	----	0.2	meq/100g		----	----	----	----	23.0
Exchangeable Sodium Percent	----	0.2	%		----	----	----	----	8.0
Calcium/Magnesium Ratio	----	0.2	-		----	----	----	----	0.6
ED007: Exchangeable Cations									
Exchangeable Calcium	----	0.1	meq/100g		3.4	8.9	0.6	1.2	----
Exchangeable Magnesium	----	0.1	meq/100g		1.8	7.8	0.2	1.2	----
Exchangeable Potassium	----	0.1	meq/100g		0.2	0.3	<0.1	<0.1	----
Exchangeable Sodium	----	0.1	meq/100g		<0.1	0.9	<0.1	0.1	----
Cation Exchange Capacity	----	0.1	meq/100g		5.5	17.8	1.0	2.7	----
Exchangeable Sodium Percent	----	0.1	%		1.4	5.1	4.6	4.8	----
Calcium/Magnesium Ratio	----	0.1	-		1.9	1.1	3.0	1.0	----
Magnesium/Potassium Ratio	----	0.1	-		11.2	29.8	----	----	----
ED040S : Soluble Sulfate by ICPAES									
Sulfate as SO4 2-	14808-79-8	10	mg/kg		10	<10	<10	10	10
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	10	mg/kg		10	80	<10	<10	20
EP003: Total Organic Carbon (TOC) in Soil									
Total Organic Carbon	----	0.02	%		0.28	0.36	0.19	0.14	0.38

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	Central 2 - 14-34cm	Central 9 - 20-40cm	Central 9 - 54-65cm	North 14 - 10-30cm	North 14 - 40-60cm
			Client sampling date / time	31-Jul-2018 00:00	08-Aug-2018 00:00	08-Aug-2018 00:00	08-Aug-2018 00:00	08-Aug-2018 00:00
Compound	CAS Number	LOR	Unit	EB1819289-021	EB1819289-022	EB1819289-023	EB1819289-024	EB1819289-025
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	6.4	5.6	5.8	7.0	7.4
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	25	9	7	23	22
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	18.4	5.0	4.9	24.0	18.9
EA058: Emerson Aggregate Test								
Color (Munsell)	----	-	-	Brown	Greyish Brown	Light Yellowish Brown	Very Dark Greyish Brown	Very Dark Greyish Brown
Texture	----	-	-	Clay Loam	Gravelly Sand	Sandy Clay Loam	Clay Loam	Clay Loam
Emerson Class Number	EC/TC	-	-	3	8	3	4	4
EA150: Particle Sizing								
+75µm	----	1	%	27	68	60	----	----
+150µm	----	1	%	25	63	55	----	----
+300µm	----	1	%	24	54	45	----	----
+425µm	----	1	%	23	46	38	----	----
+600µm	----	1	%	23	36	29	----	----
+1180µm	----	1	%	21	12	12	----	----
+2.36mm	----	1	%	16	<1	<1	----	----
+4.75mm	----	1	%	7	<1	<1	----	----
+9.5mm	----	1	%	<1	<1	<1	----	----
+19.0mm	----	1	%	<1	<1	<1	----	----
+37.5mm	----	1	%	<1	<1	<1	----	----
+75.0mm	----	1	%	<1	<1	<1	----	----
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	44	2	7	----	----
Silt (2-60 µm)	----	1	%	28	28	30	----	----
Sand (0.06-2.00 mm)	----	1	%	11	66	59	----	----
Gravel (>2mm)	----	1	%	17	4	4	----	----
Cobbles (>6cm)	----	1	%	<1	<1	<1	----	----
EA152: Soil Particle Density								
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	2.31	2.52	2.49	----	----
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	----	<0.1	<0.1	----	----
Exchangeable Aluminium	----	0.1	meq/100g	----	<0.1	<0.1	----	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	Central 2 - 14-34cm	Central 9 - 20-40cm	Central 9 - 54-65cm	North 14 - 10-30cm	North 14 - 40-60cm
			Client sampling date / time	31-Jul-2018 00:00	08-Aug-2018 00:00	08-Aug-2018 00:00	08-Aug-2018 00:00	08-Aug-2018 00:00
Compound	CAS Number	LOR	Unit	EB1819289-021	EB1819289-022	EB1819289-023	EB1819289-024	EB1819289-025
				Result	Result	Result	Result	Result
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.2	meq/100g	----	----	----	----	29.2
Exchangeable Magnesium	----	0.2	meq/100g	----	----	----	----	16.3
Exchangeable Potassium	----	0.2	meq/100g	----	----	----	----	<0.2
Exchangeable Sodium	----	0.2	meq/100g	----	----	----	----	0.3
Cation Exchange Capacity	----	0.2	meq/100g	----	----	----	----	45.8
Exchangeable Sodium Percent	----	0.2	%	----	----	----	----	0.7
Calcium/Magnesium Ratio	----	0.2	-	----	----	----	----	1.8
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	5.8	0.4	0.4	28.1	----
Exchangeable Magnesium	----	0.1	meq/100g	10.8	<0.1	0.1	19.3	----
Exchangeable Potassium	----	0.1	meq/100g	0.2	<0.1	<0.1	0.4	----
Exchangeable Sodium	----	0.1	meq/100g	1.0	<0.1	<0.1	0.3	----
Cation Exchange Capacity	----	0.1	meq/100g	17.9	0.4	0.5	48.1	----
Exchangeable Sodium Percent	----	0.1	%	5.8	4.5	7.7	0.7	----
Calcium/Magnesium Ratio	----	0.1	-	0.5	----	4.0	1.4	----
Magnesium/Potassium Ratio	----	0.1	-	61.0	----	----	54.3	----
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	10	<10	<10	<10	<10
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	10	<10	<10	<10	<10
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	0.51	0.12	0.08	0.88	0.44

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	North 11 - 25-45cm	Northern 4 - 40-60cm	Northern 18 - 40-60cm	Northern 18 - 20-40cm	Northern 8 - 40-60cm
			Client sampling date / time	08-Aug-2018 00:00	08-Aug-2018 00:00	08-Aug-2018 00:00	08-Aug-2018 00:00	08-Aug-2018 00:00
Compound	CAS Number	LOR	Unit	EB1819289-026	EB1819289-027	EB1819289-028	EB1819289-029	EB1819289-030
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	6.5	5.5	6.3	6.3	6.2
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	8	11	21	6	28
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	8.2	6.4	16.2	9.4	21.3
EA058: Emerson Aggregate Test								
Color (Munsell)	----	-	-	Pale Brown	Greyish Brown	Yellowish Red	Brown	Dark Greyish Brown
Texture	----	-	-	Sandy Clay	Sandy Clay	Clay Loam	Sandy Loam	Clay Loam
Emerson Class Number	EC/TC	-	-	4	4	3	3	4
EA150: Particle Sizing								
+75µm	----	1	%	----	----	20	63	----
+150µm	----	1	%	----	----	19	56	----
+300µm	----	1	%	----	----	16	46	----
+425µm	----	1	%	----	----	14	41	----
+600µm	----	1	%	----	----	12	38	----
+1180µm	----	1	%	----	----	8	32	----
+2.36mm	----	1	%	----	----	4	26	----
+4.75mm	----	1	%	----	----	2	19	----
+9.5mm	----	1	%	----	----	<1	<1	----
+19.0mm	----	1	%	----	----	<1	<1	----
+37.5mm	----	1	%	----	----	<1	<1	----
+75.0mm	----	1	%	----	----	<1	<1	----
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	----	----	54	6	----
Silt (2-60 µm)	----	1	%	----	----	25	30	----
Sand (0.06-2.00 mm)	----	1	%	----	----	15	36	----
Gravel (>2mm)	----	1	%	----	----	6	28	----
Cobbles (>6cm)	----	1	%	----	----	<1	<1	----
EA152: Soil Particle Density								
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	----	----	2.21	2.50	----
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	----	0.3	----	----	----
Exchangeable Aluminium	----	0.1	meq/100g	----	0.1	----	----	----
ED007: Exchangeable Cations								

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	North 11 - 25-45cm	Northern 4 - 40-60cm	Northern 18 - 40-60cm	Northern 18 - 20-40cm	Northern 8 - 40-60cm
			Client sampling date / time	08-Aug-2018 00:00	08-Aug-2018 00:00	08-Aug-2018 00:00	08-Aug-2018 00:00	08-Aug-2018 00:00
Compound	CAS Number	LOR	Unit	EB1819289-026	EB1819289-027	EB1819289-028	EB1819289-029	EB1819289-030
				Result	Result	Result	Result	Result
ED007: Exchangeable Cations - Continued								
Exchangeable Calcium	----	0.1	meq/100g	1.7	1.2	3.8	1.0	6.4
Exchangeable Magnesium	----	0.1	meq/100g	0.8	0.8	7.1	0.5	9.0
Exchangeable Potassium	----	0.1	meq/100g	0.2	<0.1	0.1	<0.1	0.2
Exchangeable Sodium	----	0.1	meq/100g	<0.1	<0.1	1.4	0.1	0.6
Cation Exchange Capacity	----	0.1	meq/100g	2.8	2.3	12.5	1.6	16.2
Exchangeable Sodium Percent	----	0.1	%	0.7	2.5	10.8	7.3	3.5
Calcium/Magnesium Ratio	----	0.1	-	2.1	1.5	0.5	2.0	0.7
Magnesium/Potassium Ratio	----	0.1	-	5.1	----	48.1	----	59.9
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	<10	<10	20	<10	20
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	<10	10	<10	<10	30
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	0.23	0.18	0.29	0.32	0.30

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	Northern 8 - 16-36cm	----	----	----	----
			Client sampling date / time	08-Aug-2018 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1819289-031	--------	--------	--------	--------
				Result	----	----	----	----
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	**6.2**	----	----	----	----
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	**9**	----	----	----	----
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	**11.2**	----	----	----	----
EA058: Emerson Aggregate Test								
Color (Munsell)	----	-	-	**Dark Greyish Brown**	----	----	----	----
Texture	----	-	-	**Gravelly Sand**	----	----	----	----
Emerson Class Number	EC/TC	-	-	**8**	----	----	----	----
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	**3.2**	----	----	----	----
Exchangeable Magnesium	----	0.1	meq/100g	**2.7**	----	----	----	----
Exchangeable Potassium	----	0.1	meq/100g	<0.1	----	----	----	----
Exchangeable Sodium	----	0.1	meq/100g	**0.2**	----	----	----	----
Cation Exchange Capacity	----	0.1	meq/100g	**6.1**	----	----	----	----
Exchangeable Sodium Percent	----	0.1	%	**2.9**	----	----	----	----
Calcium/Magnesium Ratio	----	0.1	-	**1.2**	----	----	----	----
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	<10	----	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	<10	----	----	----	----
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	**0.30**	----	----	----	----

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