Appendix E

Soil erosion assessment

Orange Grove
Sun Farm

Overland Sun Farming

Orange Grove Sun Farm

Soil erosion assessment

Prepared for Orange Grove Sun Farm Pty Ltd | 11 May 2018

Orange Grove Sun Farm

Soil erosion assessment

Prepared for Orange Grove Sun Farm Pty Ltd |11 May 2018

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Orange Grove Sun Farm

Final

Report J17210RP1 | Prepared for Orange Grove Sun Farm Pty Ltd| 11 May 2018

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Date	11 May 2018	Date	11 May 2018

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Table of contents

Table of contents *(Cont'd)*

Appendices

Tables

Figures

1 Introduction

1.1 Overview

OVERLAND Sun Farming Pty Ltd (OVERLAND) on behalf of Orange Grove Sun Farm Pty Ltd (the proponent) proposes to develop the Orange Grove Sun Farm, a large-scale solar photovoltaic (PV) generation facility and associated building and electrical infrastructure including grid connection works near the township of Gunnedah, in the Brigalow Belt South Bioregion of northern NSW (Figure 1.1) (the project). The proponent proposes to develop the project on a site within the Gunnedah Shire local government area (LGA), approximately 12 kilometres (km) east of the township of Gunnedah.

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 site is approximately 12 km east of the township of Gunnedah (Figure 1.1). The site is divided by Orange Grove Road in to two portions and encompasses an area of approximately 817 hectares (ha). The legal property description is given in Table 1.1. The site is zoned RU1 Primary Production under the Gunnedah Local Environmental Plan (LEP) 2012.

Table 1.1 Property description

Portion	Site		Development footprint	
	Lot description	**Area (ha)**	**Lot description**	**Area (ha)**
Northern	DP 945590 (Lots 1 and 2) DP 754928 (Lots 27 and 30) DP 1068520 (Lots 1 and 2) DP 1068518 (Lot 3)	463	DP 945590 (Lot 1 and part Lot 2) DP 754928 (Lot 30) DP 1068520 (part lot 1) DP 1068518 (Lot 3)	239
Southern	DP 945590 (Lot 2) DP 126183 (Lots 1, 2 and 3)	354	DP 945590 (part Lot 2) DP 126183 (part Lot 1)	14
Total area (ha)		**817**		**253**

The development footprint is defined as the land area within the site where project infrastructure will be constructed and operate for the project life. The development footprint encompasses an area of 253 ha, which has been refined through the project design process to avoid identified environmental constraints.

The site is within the:

- Brigalow Belt South Interim Biogeographic Regionalisation for Australia (IBRA) region;
- Liverpool Plains IBRA subregion;
- Namoi Catchment Management Area; and
- Gunnedah Shire LGA.

1.3 Assessment 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* (NSW Office of Environment and Heritage (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 20 December 2017. The SEARs identify matters that must be addressed in the EIS. Table 1.2 lists the individual requirements relevant to the soil erosion assessment and where they are addressed in this report.

Table 1.2 Relevant SEARs

Requirement	Section addressed
Land -	Section 5.
including an assessment of the impact of the development on agricultural land (including impacts to Biophysical Strategic Agricultural Land) and flood prone land; ***a soil survey to consider the potential for erosion to occur (including impacts associated with sodic soils),*** and paying particular attention to cumulative impacts and compatibility of the development with the existing land uses on the site and adjacent land (eg Gunnedah Solar Farm, operating mines, extractive industries, mineral or petroleum resources, exploration activities, aerial spraying, dust generation, and risk of weed and pest infestation) during operation and after decommissioning, with reference to the zoning provisions applying to the land.	Note this report addresses the ***italicised*** part.

1.4 Structure of the report

The soil erosion assessment is structured as follows:

- an outline of the methodologies to assess the development footprint's soil erosion potential;
- a desktop review of the development footprint's soil erosion potential;
- soil survey results and analysis; and
- erosion potential and erosion and sediment control.

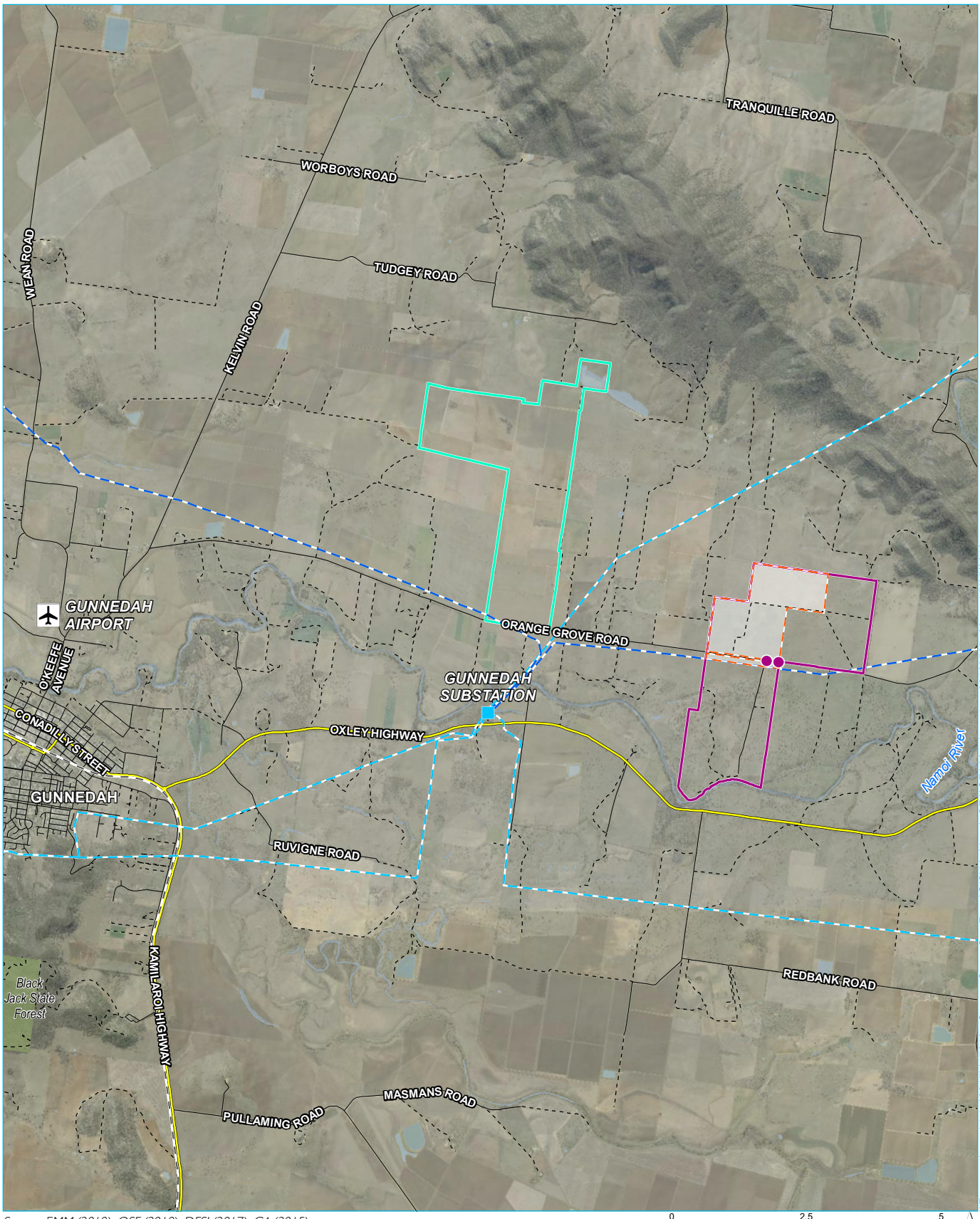
1.5 Project description

The project includes the development, construction and operation of a solar PV electricity generation facility, which comprises the installation of PV solar panels, electrical cabling, electrical switch yard / substation, electrical connection to the TransGrid network and other associated infrastructure within the development footprint. The project comprises the following key components:

- a network of PV solar panel arrays including supporting structures and tracker system;
- an internal network of electrical collection and distribution systems including electrical inverters;
- an internal network of communications and control cabling and systems;
- switchyard including electrical switching, control and monitoring equipment, electrical transformation system and operational control room;
- electrical connection and communications cabling from the on-site switchyard and transformation area to the TransGrid 132 kV electrical network;
- a management hub, including material storage areas, demountable offices, amenities and equipment sheds;
- provision of land area within the development footprint for possible future energy storage and network support devices; and
- fencing, access roads from adjacent public roadways, on-site parking and internal access roads.

The project may include the installation of battery and energy storage devices within a secure compound within the development footprint. The rated capacity of future battery and energy storage devices has not been determined at this stage of project development. The inclusion of such energy storage devices will be determined during the detailed design stage of the project, and will be dependent on network integration and commercial considerations at such time. A modification to the consent would be sought to permit installation of this infrastructure within the development footprint if required.

Access to the development footprint will be direct from Orange Grove Road (Figure 1.1). Limited site preparation and civil works will be required primarily due to the type of infrastructure being developed and also the site's predominantly flat terrain and cleared landscape.



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

0 2.5 5 km

GDA 1994 MGA Zone 56

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KEY

- Orange Grove Sun Farm site boundary
- Development footprint
- Indicative site access point
- Gunnedah Solar Farm (SSD 8658 - proposed by Photon Energy Generation Pty Ltd)*
- 132 kV transmission line
- 66 kV transmission line
- Rail line
- Main road
- Local road
- Vehicular track
- Waterbody
- State forest

* DPE 2017, Gunnedah Solar Farm, viewed 11 October 2017, http://majorprojects.planning.nsw.gov.au/index.pl?action=view_job&job_id=8658

Location of the Orange Grove Sun Farm

Orange Grove Sun Farm
Soil erosion assessment
Figure 1.1

EMM

2 Method

2.1 Assessment process

The assessment comprised the following:

- a desktop review of existing information and the current state of the environment (Section 3);
- a soil survey (the survey) to characterise soil types of the development footprint, including laboratory analysis (Section 4); and
- assessment of erosion potential using results from the soil survey (Section 5).

2.2 Desktop review

A desktop assessment was undertaken using existing information on soils and soil environments for the development footprint sourced from:

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

2.3 Soil survey

A survey was completed by EMM Consulting Pty Ltd (EMM) on 21 March 2018 to examine the soil and landform properties of the site (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).

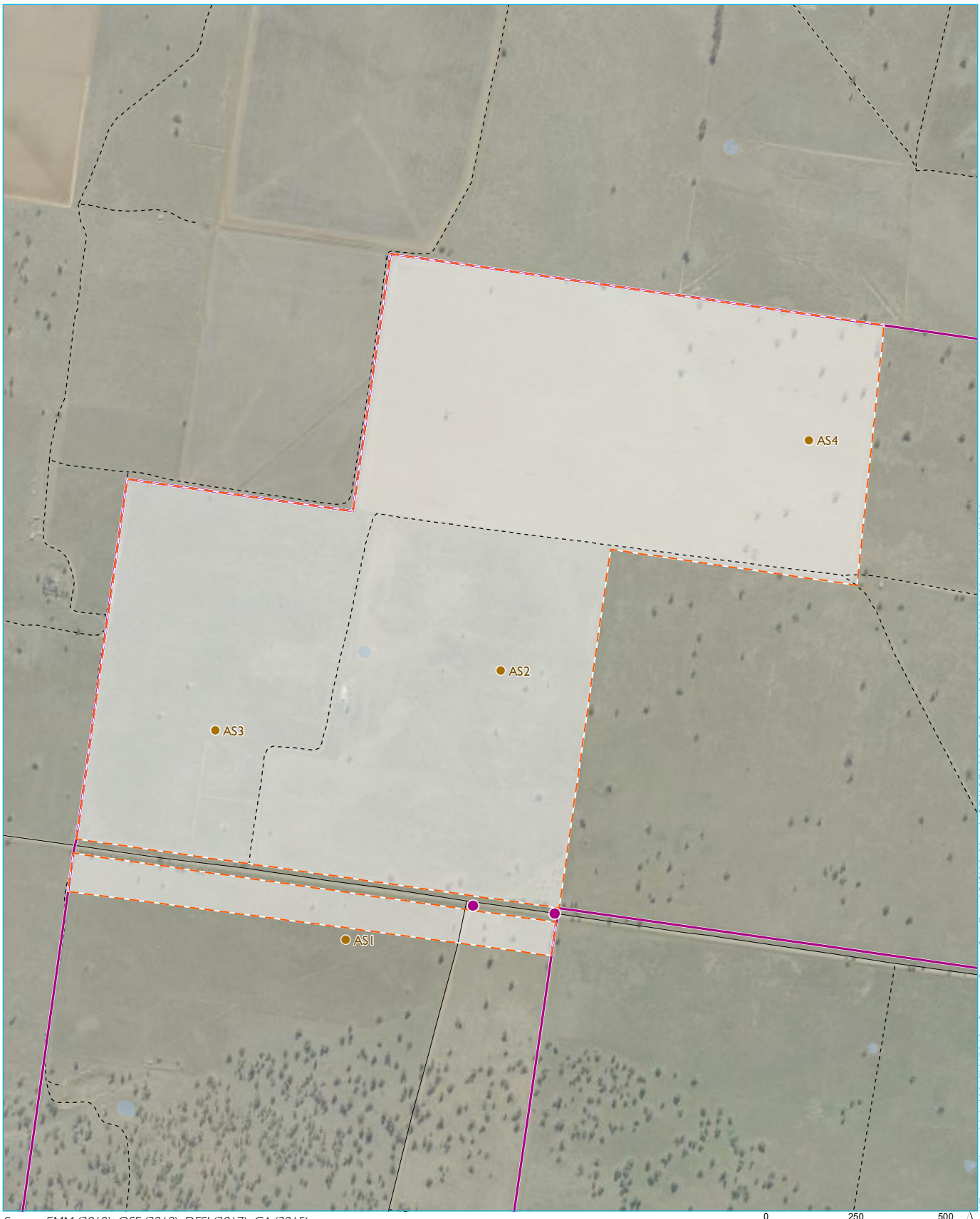
2.3.1 Sample site selection

i Selection

Positioning of the sample 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 sites are shown in Figure 2.1 and Table 2.1.

Table 2.1 Soil sample sites

Site	Latitude	Longitude
AS1	-30.97055	150.39030
AS2	-30.96388	150.39500
AS3	-30.96522	150.38664
AS4	-30.95827	150.40414



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

0 250 500 m
GDA 1994 MGA Zone 56
N

KEY

- Orange Grove Sun Farm site boundary
- Development footprint
- Indicative site access point
- Soil sample sites
- Local road
- Vehicular track
- Waterbody

Location of soil sample sites

Orange Grove Sun Farm
Soil erosion assessment
Figure 2.1

EMM

2.3.2 Sampling method

i Soil extraction

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).

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, two, 400 gram (g) sub-samples of soil were taken. Sub-samples were placed in heavy-duty, sealable plastic bags and labelled. Sub-samples from sites AS1, AS2 and AS4 were submitted for laboratory analysis as they best represented soil heterogeneity at the site. The remaining sub-samples were stored in case further analysis is requested by the NSW Government at a later time.

2.4 Laboratory testing

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

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

- moisture content;
- $pH_{1:5}$;
- $EC_{1:5}$;
- exchangeable cations (calcium (Ca), magnesium (Mg), sodium (Na), potassium (K) and cation exchange capacity (CEC));

- exchangeable sodium percentage (ESP);
- total organic carbon (TOC); and
- Emerson aggregate stability.

Detailed laboratory results can be found in Appendix B.

3 Desktop review

3.1 Climate

Gunnedah has a harsh climate with temperatures rising above 40°C in summer and dropping below 0°C in winter. Climate data for the site has been obtained from the Australian Bureau of Meteorology's (BoM) station, Gunnedah Pool (Station number 055023). Mean monthly minimum and maximum temperatures range between 19°C to 32.1°C in summer and 4.8°C to 16.2°C in winter (BoM 2018). The average annual rainfall is 637 mm. Severe thunderstorms in the summer months often cause heavy downpours.

3.2 Topography and landform

Local topography is generally flat with some gentle rises and with slopes on-site generally less than 1%. However, there are several highpoints in the area including the township of Gunnedah, which is located on a hilly region, Black Jack Mountain located south of the township of Gunnedah, and a large forested area located 2.7 km north of the site.

3.3 Surface hydrology

The site is within the Namoi catchment, in northern NSW and west of the Great Dividing Range. The Namoi catchment borders the Gwydir River catchment to the north, Macleay River catchment to the east, Castlereagh catchment to the west and Hunter catchment to the south. An unnamed first order tributary is mapped in the northern portion of the development footprint.

3.4 Regional geology

The Manilla 1:250,000 Geological series sheet SH 56-9 (NSW Department of Mines 1973) shows the development footprint is within quaternary alluvium deposits that are comprised of stream alluvium deposits including the riverine plain deposits. These deposits consist of unconsolidated sandy to silty minor gravels and form extensive flat alluvial plains.

3.5 Regional soil mapping

3.5.1 Australian soil classification

The Australian Soil Classification scheme (Isbell 1996) is a multi-category scheme with soil classes defined on the basis of diagnostic horizons or materials and their arrangement in vertical sequence as seen in an exposed profile. State-wide mapping identifies that the development footprint falls under the order of Vertosols (Figure 3.1). Vertosol soils are clay soils with shrink-swell properties that exhibit strong cracking when dry and at depth have slickensides and/or lenticular structural aggregates. Although many soils exhibit gilgai microrelief, this feature is not used in their definition.

3.5.2 Great soil group soil type

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 soil within the development footprint is classified as Grey, Brown and Red Clays under this mapping system.

Grey, Brown and Red Clays are mainly found on volcanic rocks and are typically red, deep, well-structured, acidic, porous soils. They have relatively high clay contents and tend to display a gradual increase in clay with depth (Stace et al 1968).

3.5.3 eSPADE soil profiles

The eSPADE soil profile data base (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 development footprint. Table 3.1 describes a number of eSPADE soil profiles within proximity of the development footprint. The soils described in Table 3.1 are classified as a Grey Vertosol and Black Chromosol.

Table 3.1 eSPADE soil profiles

Survey date	Survey number	Easting	Northing	Zone	Horizons	ASC classification	Surface pH
02/07/2001	1004239-11	253659	6572149	56	2	Unclassified	6.0
15/02/2000	1000935-86	250120	6574451	56	4	Chromosol	6.5
15/02/2000	1000935-83	249767	6574544	56	5	Vertosol	6
15/02/2000	1000935-85	249601	6574662	56	6	Vertosol	7
02/07/2001	1004239-24	250881	6568759	56	2	Unclassified	7.5

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.

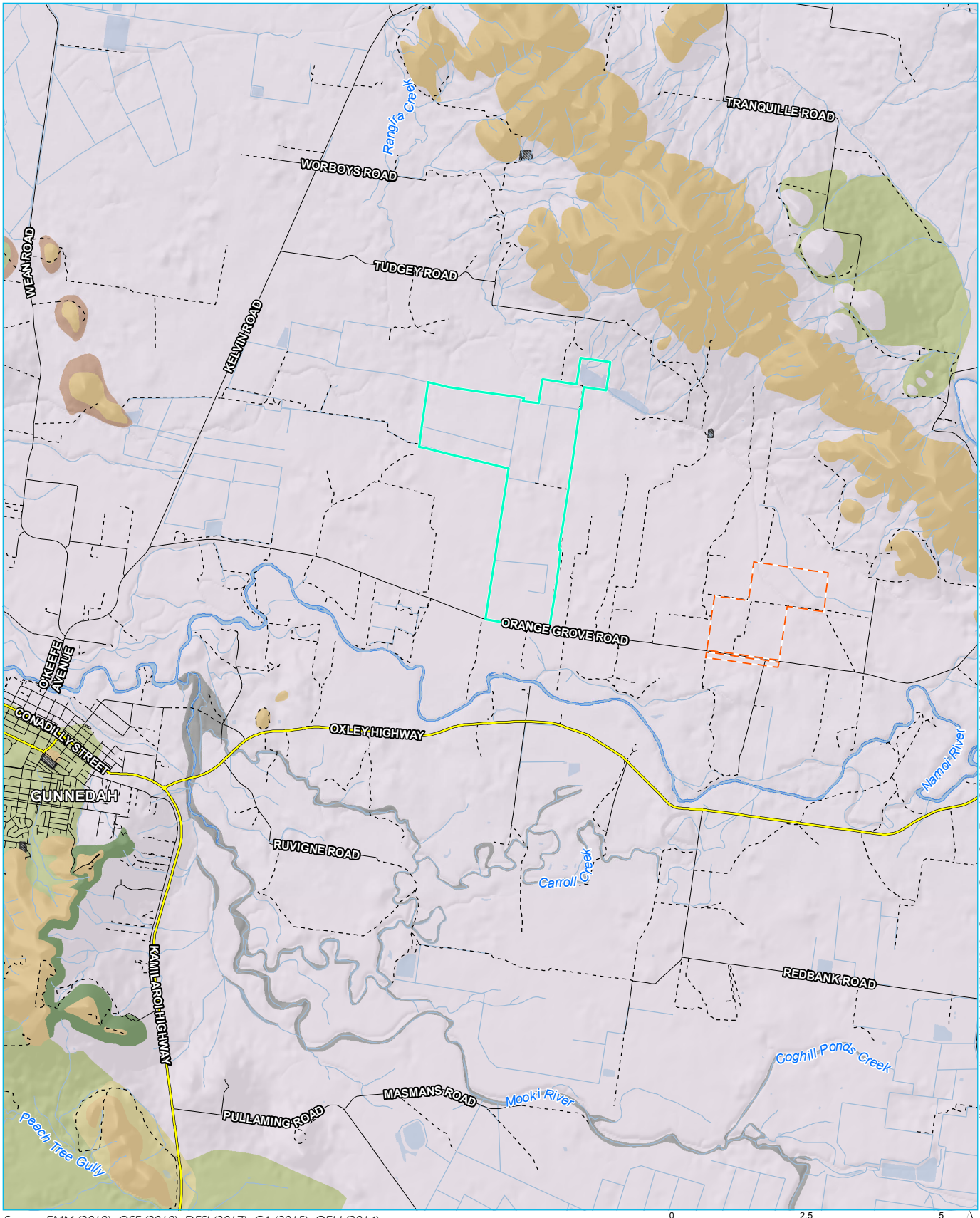
The NSW Government (OEH 2018) has classified the soil within the development footprint as Hydrologic soil group D, ie very slow infiltration.

3.5.5 Surrounding land use

The majority of land surrounding the site is zoned RU1 primary production under the Gunnedah LEP. Land uses surrounding the site are predominantly agricultural and include both dryland and irrigated broadacre crop production and livestock grazing.

At its closest point, the development footprint is approximately 4.2 km north-east of TransGrid's Gunnedah Substation. TransGrid's 132 kilovolt (kV) transmission line runs parallel to the southern boundary of the southern portion of the development footprint (refer Figure 1.1).

The site has access to the local and regional road network including the Kamilaroi and Oxley Highways, Orange Grove Road and Kelvin Road (refer Figure 1.1).



Source: EMM (2018); OSF (2018); DFSI (2017); GA (2015); OEH (2014)

0 2.5 5 km

GDA 1994 MGA Zone 56

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KEY

- Development footprint
- Gunnedah Solar Farm (SSD 8658 - proposed by Photon Energy Generation Pty Ltd)*
- Main road
- Local road
- Vehicular track
- Watercourse / drainage line

Dominant Australian Soil Classification (ASC) - Order (OEH, 2014)

- Calcarosols
- Chromosols
- Kandosols
- Rudosols and Tenosols
- Sodosols
- Tenosols (Alluvial)
- Vertosols
- Water
- Disturbed Terrain and areas not accessed

Australian soil classification

Orange Grove Sun Farm

Soil erosion assessment

Figure 3.1

EMM

** DPE 2017, Gunnedah Solar Farm, viewed 11 October 2017, http://majorprojects.planning.nsw.gov.au/index.pl?action=view_job&job_id=8658*

4 Soil survey findings

4.1 Landscape

4.1.1 Topography

The topography was very low with slopes generally under 1%. Vegetation composition at each sample site was largely composed of pasture grasses and sporadic trees or fallow cropping area.

4.1.2 Vegetation and ground cover

Three sample sites, AS1, AS2 and AS3, consisted of dryland pasture grassland communities. AS4 was located in a cultivated area. Ground cover differed between sites: AS1 and AS2 had 70% ground cover; while AS3 had only 40%. All of these consisted of grass. AS4 in the cultivated area had only 20% ground cover consisting of the remains of the previous crop.

4.2 Soil description

Detailed field logs describing erosion relevant soil characteristics were recorded and are provided in Appendix C. The following sections describe the physical and chemical characteristics of the sample sites.

4.2.1 Soil profile

Soil texture was clay loam sandy in the A horizon and medium clay in the B horizon across all sample sites. Mottling and gleying was not observed. No gilgai microrelief were observed at any site.

The A_1 horizon generally extended from 0-0.2 m bgl. Pedality in the A_1 varied across sample sites including apedal, weakly pedal and moderately pedal. Where peds were present, they were generally sub-angular blocky and ranged in size from 2-20 mm. The A_1 horizon was dry and hard in all locations.

The B_{21} horizon extended from approximately 0.2 m bgl to below the depth of soil sample extraction. Pedality in the B_{21} was strongly pedal in all sites, with the possibility of peds being larger than the auger head. Where peds were present, they were generally sub-angular blocky or polyhedral and ranged in size, with most 10-20 mm due to auger shearing. Soil was moist at AS4 in the cultivated area. Soils under pasture were dry throughout the profile.

4.2.2 Soil chemistry

Three sites were sent for analysis, AS1, AS2 and AS4. The pH was neutral to mildly acidic on the surface and neutral to alkaline at depth. The cultivated area (AS4) had a wider range of pH comparing the surface and subsoil. The EC is considered very low in all soil profiles. The soils were not saline or sodic and would be considered relatively stable.

Soil erodibility was found to be low to moderate overall. 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. The Emerson class number of all samples, both surface and subsoil, was 3. Hazelton and Murphy (2007) describe this class as aggregate being generally stable and indicating a more desirable material for conservation earthworks. Crusting may become a problem with these soils under cultivation. Table 4.1 provides the laboratory results for the three sites sent for analysis

Table 4.1 Laboratory results

Analyte	Unit	AS1 - surface	AS1 - subsoil	AS2 - surface	AS2 - subsoil	AS4 - surface	AS4 - subsoil
pH Value	pH Unit	6.2	7.3	5.9	7.8	5.1	8.4
Electrical Conductivity @ 25°C	µS/cm	100	25	78	32	105	56
Moisture Content (dried @ 103°C)	%	6	8.3	3.5	11.2	6.3	15.5
Emerson Class Number		3	3	3	3	3	3
Exchangeable Calcium	meq/100g	6.8	4.5	7	4.6	5.8	6.5
Exchangeable Magnesium	meq/100g	2.7	1.7	3.8	2.8	3.3	5.1
Exchangeable Potassium	meq/100g	1.6	0.4	0.9	<0.2	0.4	<0.2
Exchangeable Sodium	meq/100g	<0.1	<0.2	0.1	0.3	0.4	1
Cation Exchange Capacity	meq/100g	11.1	6.6	11.8	7.6	10.2	12.7
Exchangeable Sodium Percent	%	0.4	<0.2	1	3.5	3.9	7.7
Calcium/Magnesium Ratio		2.5	2.6	1.8	1.6	1.8	1.3
Magnesium/Potassium Ratio		1.7	4.3	4.2	-	8.3	-
Total Organic Carbon	%	1.2	0.45	1.37	0.6	0.99	0.56

5 Erosion and sediment control

5.1 Erosion potential

Soil erosion is the loss of soil from the landscape through water and wind leading to a reduction in land productivity and ecosystem services. Soil chemistry results (Appendix B) and the *Australian Soil Classification* indicate that the soils have low erosion potential. The erosion potential of the soil, among other physical and chemical attributes, will influence the suitability of management practices.

None of the sites sampled showed any signs of erosion, with good vegetative cover and very shallow slopes likely to have been contributing factors. Within the development footprint, an increase in the potential for rill and gully erosion due to the removal of vegetation during construction is unlikely. Additional working of the soil through construction activities may also contribute to an increased risk of dispersion.

The Emerson aggregate test showed that the soil profiles are prone to dispersion following working. Site AS1 had a moderate Ca:Mg ratio which may provide some additional control for erosion and sites AS2 and AS4 had a low (<2) Ca:Mg ratio, a factor that contributes to soil erosion potential.

5.2 Management

An erosion and sediment control (ESC) plan will be prepared in accordance with *Managing Urban Stormwater: Soils and Construction – Volume 2A Installation of Services* (DECC 2008) prior to commencement of construction. ESC measures will be implemented on an area-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 vegetation clearing and will include:

- 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 there is no damage to soil and vegetation outside the area designated for clearing;
- 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;
- disturbed areas will be stabilised and progressively rehabilitated as quickly as possible; and
- the use of ameliorants (such as lime) will assist with erosion management.

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

Table 5.1 Erosion and sedimentation control measures by area

Area	Erosion and sediment control measures
Areas cleared of vegetation/ground cover	• divert run-off from undisturbed areas away from operations; • windrow vegetation debris along the contour; • minimise the length of time that soil is exposed; and • direct run-off from cleared areas to ESCs such as sediment basins.
Exposed subsoils	• minimise the length of time that subsoil is exposed; and • direct run-off from cleared areas to ESCs such as sediment basins.
Infrastructure	• provide protection in drains (eg rip rap, revegetate) if there is the potential for water velocity to cause scouring; • confine traffic to maintained tracks and roads; • install sediment traps, silt fences, hay bales and other ESCs; and • rehabilitate disturbed areas around construction sites promptly using an ameliorant (such as lime).
Access roads and tracks	• optimise surface drainage and stabilise drainage lines.

6 Conclusion and recommendation

The landscape and soil characteristics were similar across the development footprint with the soils showing properties of Vertosol type soils. Minor variations in the soils were evident in each test location. The soils generally had slightly acidic A horizons and neutral to alkaline pH in the B horizon and low organic matter with depth. The soils were not saline or sodic and would be considered relatively stable.

Soil erodibility was found to be low to moderate overall. It is recommended to minimise disturbance where ever possible. Where 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 lime, could be applied to manage erosion and the slight acidity of the topsoil, and provide for more effective future use.

The current study was a preliminary investigation into the existing soils and their potential for erosion. The results indicate that the soils have a low to moderate potential for erosion. Management for erosion potential is still 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

Primefact 1362. *Determining readily available water (RAW) to assist with irrigation management.*

NSW Agriculture, 2002. *Irrigation for Horticulture in the Mallee*, NSW Department of Primary Industries

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

http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0008/168866/texture-salinity.pdf

Acknowledgments

Jeremy Giddings Irrigation Industry Development Officer (Horticulture)

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

Published by the NSW Department of Primary Industries.

V14/3395 PUB 14/176 Jobtrack 13288

Appendix B

Laboratory results

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1807594**	Page	: 1 of 4
Client	: **EMM CONSULTING PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MS KYLIE DRAPALA	Contact	: Customer Services EB
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	: J17210 Orange grove	Date Samples Received	: 23-Mar-2018 13:45
Order number	:	Date Analysis Commenced	: 26-Mar-2018
C-O-C number	: ----	Issue Date	: 05-Apr-2018 12:17
Sampler	: KYLIE DRAPALA		
Site	: ----		
Quote number	: EN/222/17		
No. of samples received	: 6		
No. of samples analysed	: 6		

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

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

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

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

Signatories

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

Signatories	*Position*	*Accreditation Category*
Andrew Epps	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Satishkumar Trivedi	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Satishkumar Trivedi	Senior Acid Sulfate Soil Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

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

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

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

Where the LOR of a reported result differs from standard LOR, this may be due to high 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): Sample EB1807463-001 shows poor duplicate results due to sample heterogeneity. Confirmed by visual inspection.
- 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	AS1. 0-20	AS1. 35-48	AS2. 0-20	AS2. 30-50	AS4. 0-15
			Client sampling date / time	21-Mar-2018 00:00	21-Mar-2018 00:00	21-Mar-2018 00:00	21-Mar-2018 00:00	21-Mar-2018 00:00
Compound	CAS Number	LOR	Unit	EB1807594-001	EB1807594-002	EB1807594-003	EB1807594-004	EB1807594-005
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	6.2	7.3	5.9	7.8	5.1
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	100	25	78	32	105
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	6.0	8.3	3.5	11.2	6.3
EA058: Emerson Aggregate Test								
Color (Munsell)	----	-	-	Dark Brown	Brown	Dark Brown	Brown	Dark Brown
Texture	----	-	-	Sandy Clay Loam	Sandy Clay Loam	Sandy Clay Loam	Clay Loam	Sandy Clay Loam
Emerson Class Number	EC/TC	-	-	3	3	3	3	3
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	----	----	<0.1	----	0.3
Exchangeable Aluminium	----	0.1	meq/100g	----	----	<0.1	----	0.2
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.2	meq/100g	----	4.5	----	4.6	----
Exchangeable Magnesium	----	0.2	meq/100g	----	1.7	----	2.8	----
Exchangeable Potassium	----	0.2	meq/100g	----	0.4	----	<0.2	----
Exchangeable Sodium	----	0.2	meq/100g	----	<0.2	----	0.3	----
Cation Exchange Capacity	----	0.2	meq/100g	----	6.6	----	7.6	----
Exchangeable Sodium Percent	----	0.2	%	----	<0.2	----	3.5	----
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	6.8	----	7.0	----	5.8
Exchangeable Magnesium	----	0.1	meq/100g	2.7	----	3.8	----	3.3
Exchangeable Potassium	----	0.1	meq/100g	1.6	----	0.9	----	0.4
Exchangeable Sodium	----	0.1	meq/100g	<0.1	----	0.1	----	0.4
Cation Exchange Capacity	----	0.1	meq/100g	----	----	----	----	10.2
Cation Exchange Capacity	----	0.1	meq/100g	11.1	----	11.8	----	----
Exchangeable Sodium Percent	----	0.1	%	0.4	----	1.0	----	3.9
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	1.20	0.45	1.37	0.60	0.99

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	AS4. 40-60	----	----	----	----
				Client sampling date / time	21-Mar-2018 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit		EB1807594-006	--------	--------	--------	--------
					Result	----	----	----	----
EA002 : pH (Soils)									
pH Value	----	0.1	pH Unit		**8.4**	----	----	----	----
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm		**56**	----	----	----	----
EA055: Moisture Content (Dried @ 105-110°C)									
Moisture Content	----	1.0	%		**15.5**	----	----	----	----
EA058: Emerson Aggregate Test									
Color (Munsell)	----	-	-		**Dark Brown**	----	----	----	----
Texture	----	-	-		**Clay Loam**	----	----	----	----
Emerson Class Number	EC/TC	-	-		**3**	----	----	----	----
ED006: Exchangeable Cations on Alkaline Soils									
Exchangeable Calcium	----	0.2	meq/100g		**6.5**	----	----	----	----
Exchangeable Magnesium	----	0.2	meq/100g		**5.1**	----	----	----	----
Exchangeable Potassium	----	0.2	meq/100g		<0.2	----	----	----	----
Exchangeable Sodium	----	0.2	meq/100g		**1.0**	----	----	----	----
Cation Exchange Capacity	----	0.2	meq/100g		**12.7**	----	----	----	----
Exchangeable Sodium Percent	----	0.2	%		**7.7**	----	----	----	----
EP003: Total Organic Carbon (TOC) in Soil									
Total Organic Carbon	----	0.02	%		**0.56**	----	----	----	----

Appendix C

Soil field logs

J17210 ORANGE GROVE Soil survey - data sheet

Site: AS1 Easting: 30.97055 Northing; 150.39030 Date: 21-3-18 Name K Drapalac.

Vegetation types grazed pasture. <3cm high. OM on surface	Slope <1%. -0
Ground cover % 70 - mostly grass dead matter.	Bare ground % 30
Surface condition: Firmness ~~Hard~~ firm Cracks None. Soil crust ? self mulch.	Presence of free water No.
Surface condition notes: maybe a self mulch. OM helping reduce hardness	Signs of erosion: Scalding No Tunnelling No Rills No
A and B horizon properties	
A horizon depth and boundary: 0 - ~~30~~ 25 very gradual	B horizon boundaries 25 - >48
Structure: Weak to massive. Size/shape of peds earthy. ~2-5mm blocky.	Structure: Weak. Size/shape of peds 6mm. bit earthy. /boundary area.
Texture: pH 5	Texture: pH 7
Signs of water logging - colour No mottles.	Signs of water logging - colour No No mottles
Presence of sodosol? No	Presence of sodosol? No.

Notes: So dry - cant auger past 48cm.

J17210 ORANGE GROVE Soil survey - data sheet

Site: AS2. Easting: 30.96388 Northing; 150.39500 Date: 21-3-18 Name K Drapala.

Very Dry condition.

Vegetation types Pasture. Grazed. Veg <3cm.	Slope <1%. - 0.
Ground cover % 70.	Bare ground % 30.
Surface condition: Firmness / Cracks / Soil crust hard. None. fine OM.	Presence of free water No.
Surface condition notes: Very hard. Very fine cracks in surface.	Signs of erosion: Scalding / Tunnelling / Rills No No No.
A and B horizon properties	
A horizon depth and boundary: ~~sub ang~~. 0-25. Very gradual boundary.	B horizon boundaries 25- >60.
Structure: / Size/shape of peds + fine sandy like. Mod. ped. subang. blocky. 6mm. 10%. 20mm.	Structure: / Size/shape of peds angular blocky. Strong ped. 10%. ave >20mm. 30%. 10-20 60%. 6-10mm
Texture: 45mm. Clay.	Texture: M-H clay. too hard to ribbon.
Signs of water logging - colour No mottles. pH 6	Signs of water logging - colour No mottles. pH 7.5
Presence of sodosol? No.	Presence of sodosol? No.

Notes: degraded surface soil. hard & compact.

J17210 ORANGE GROVE Soil survey - data sheet

Site: AS3. Easting: 30.96522 Northing: 150. 38664 Date: 21-3-18 Name Kylie Drapala.

Vegetation types: pasture. grazed currently. <3cm high.	Slope: <1 %.
Ground cover %: 40	Bare ground %: 60
Surface condition: Firmness: hard. Cracks: none. Soil crust: solid.	Presence of free water: None
Surface condition notes: very hard.	Signs of erosion: Scalding: No Tunnelling: No Rills: No.
A and B horizon properties	
A horizon depth and boundary: 0-25cm.	B horizon boundaries
Structure: mod ~~blocky~~ pedal. Size/shape of peds: 6mm. subang blocky.	Structure: strong pedal. Size/shape of peds: 10-20mm. angular ~~blocky~~.
Texture: 40mm.	Texture: Med-heavy clay - can't get a riblon too hard.
Signs of water logging - colour: no mottles. pH 5-5.5	Signs of water logging - colour: no mottling. pH 8.
Presence of sodosol? No?	Presence of sodosol? No?

Notes:

possible brown Vertosol? - no cracking at surface?

~~Chromo~~ Dermosol.

possible manganese nodules in B. 1-2mm. no other segregations or coarse frags

suspect B peds are larger.

J17210 ORANGE GROVE Soil survey - data sheet

Site: AS4 Easting: 30.95827 Northing: 150.40414 Date: 21-3-18 Name K Drapala

Vegetation types Fallow cropping land.	Slope <1%. -0
Ground cover % 20	Bare ground % 80
Surface condition: Firmness Hard. Cracks Surface cracks Soil crust 5mm crust ~10cm plates	Presence of free water None.
Surface condition notes: cultivated.	Signs of erosion: Scalding No Tunnelling No Rills No.
A and B horizon properties	
A horizon depth and boundary: 0-15 gradual.	B horizon boundaries 15- >70.
Structure: massive. Size/shape of peds ~<5mm. or earthy.	Structure: strong >auger? Size/shape of peds moist. angular blocky. breaks down to ~6mm.
Texture: 45mm.	Texture: heavy clay.
Signs of water logging - colour No mottles. pH 5.5	Signs of water logging - colour No strong mottles. pH 8.
Presence of sodosol? No.	Presence of sodosol? No

Notes:

No alosion segregations.

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