APPENDIX H

Land, soil and erosion assessment

AMPYR Shell ENERGY EMM creating opportunities

Wellington South Battery Energy Storage System

Land, Soils and Erosion Assessment

Prepared for AMPYR Australia Pty Ltd

October 2022

Wellington South Battery Energy Storage System

Land, Soils and Erosion Assessment

AMPYR Australia Pty Ltd

J210534 RP10

October 2022

Version	Date	Prepared by	Approved by	Comments
V1	28 April 2022	Harry Savage	Michael Frankcombe	
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Executive Summary

ES1 Introduction

AMPYR Australia Pty Ltd (AMPYR) and Shell Energy (Shell) propose to develop and operate the Wellington Battery Energy Storage System (the project). This involves the development of a large-scale battery energy storage system (BESS) with a discharge capacity of 500 megawatts (MW) and a storage capacity of 1,000 megawatt hours (MWh). The project also incorporates an on-site substation and connection infrastructure to facilitate transfer of energy to and from the electrical grid, upgrades to the TransGrid Wellington Substation and ancillary infrastructure.

EMM Consulting Pty Limited (EMM) has been engaged by AMPYR to prepare a development application for the project under Part 4, Division 4.7 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act). This Land, Soils and Erosion Assessment (LSEA) has been prepared by EMM to support an Environmental Impact Statement (EIS) for the project.

ES2 Existing conditions

A summary of the available land and soil mapping available from eSPADE (DPIE 2020a) characteristics and their associations is presented in Table ES1.

Table ES1 Regional soil mapping summary

Soil landscapes	GSG	ASC	Inherent soil fertility	LSC class	Area (ha)
Nanima (na)	Euchrozems (E)	Ferrosols	Moderately high	6	15.1
Bodangora (bz)	Euchrozems (E)	Ferrosols	Moderately high	3	4.2

The Nanima (na) and Bodangora (ba) soil landscapes are the most extensive land system present at the site. It is modelled as host to Ferrosol soils. The erosion hazards discussed for both soil landscapes highlight:

- soils are slightly to moderately erodible but slopes are steep (3–20%) and long (300–3,000 m);
- erosion hazard is high when surface cover is low, especially under cropping;
- important that soil conservation earthworks or farming practices are utilised to control erosion; and
- severe erosion has occurred in the past.

The project is mapped predominantly as land and soil capability (LSC) class 6, indicating very high limitations for high-impact land uses which should be restricted to low-impact land uses such as grazing, forestry and nature conservation.

ES3 Assessment of impacts

ES3.1 Soil impacts

Impacts to soils and erosion arising from the project primarily relate to construction activities potentially exacerbating erosion, and loss or degradation of existing soil resources. The soil disturbance during construction has the potential to result in the following impacts:

- reduction in soil stability and increased susceptibility to erosion due to vegetation removal or soil exposure, especially as the subsoil is sodic and dispersive in areas;
- erosion of soil due to exposing soils, disturbing dispersive subsoils and concentration of flow;
- loss of structure and water holding capacity due to mechanical compaction;
- loss or degradation of topsoil material viable for use in rehabilitation;
- introduction of salinity or sodicity into the topsoil material if soil is inadequately managed;
- risk of exposing buried contaminants (pesticides and hydrocarbons); and
- introduction of contaminants into soil material (eg hydrocarbons from plant).

ES3.2 Erosion and sediment impacts

Potential project erosion and sediment control impacts include:

- downstream or offsite discharge of sediment and turbid run-off from the erosion of exposed soils, particularly dispersive subsoils and discharge of sediment and turbid run-off from on-going erosion from drainage, landform and infrastructure design not cognisant of dispersive subsoils;
- erosion and subsequent sedimentation of creeks and waterways due to an inappropriately designed and constructed watercourse crossing;
- mud tracking from vehicles and machinery to public roads;
- increased potential for rill and gully erosion due to modification of flow conditions from sheet flow to concentrated flow from constructed land forms (roads, tracks, hardstands) and drains;
- incision and widening of downstream drainage lines due to modification of the run-off hydrograph due to an increase in impermeable surface such as roads, hardstands, roofs and other infrastructure;
- increased maintenance costs for on-going stabilisation of landforms, roads, drains and cable trenches;
- operation and maintenance of sediment control structures due to on-going erosion;
- tunnel erosion under or beside foundations for towers, light poles etc and along cable trenches due to dispersive soils; and
- dust emissions from unsealed roads, hardstands and exposed soils.

ES4 Evaluation of the project

ES4.1 Soil assessment

Most of the site footprint is located on Ferrosol soil types. Ferrosols generally have high agricultural potential due to good structure and moderate to high chemical fertility and water holding capacity. The soil landscapes present both have noted soil erosion risks, particularly where surface cover is low or under cultivation. Soil management practices will be key to maintain suitable soil cover and minimise exposure of erosion-prone subsoils.

With reference to the eSPADE database (DPIE 2020a) and DPIE (2020c), the project site is mapped at the state scale as LSC Classes 3 and 6, predominantly Class 6. These LSC classes represent land with high (Class 3) to low (Class 6) capability for productive use without resulting in land degradation. The site suitability with respect to agriculture considers the inherent LSC class in addition to the extensive amount of land utilised for agriculture within the LGA, of which the project is a very minor area.

Whilst the land and soil capability of agricultural lands in the project site are unlikely to change from their current capability, provided appropriate management and mitigation measures are implemented, the lands will be effectively unavailable for agricultural use during the life of the project.

Impacts to adjacent land relevant to agriculture are expected to be minimal, with the primary potential impact being associated with sediment deposition or erosion from the project site, which can be suitably managed and mitigated.

ES4.2 Erosion and sediment control

Site subsoils have a high erosion potential due to their sodic and/or magnesic properties. The project civil design needs to include the recommended management and mitigation measures for dispersive soils detailed in Chapter 6 otherwise erosion and associated sedimentation in the construction and operational phases can be anticipated. If the recommended measures are implemented, then the erosion and subsequent sedimentation risk will be low with minimal residual impacts.

Both the substation/BESS and TransGrid substation upgrade works area will require the construction of sediment basins during the construction phase, whilst the construction laydown area could require a sediment basin as discussed in Sections 4.2 and 6.1.2v. Type B sediment basins with flow activated dosing systems are recommended for the following reasons:

- they are capable of treating up to 80% of the turbid water runoff from the disturbed areas providing far greater levels of protection for downstream waters;
- the design allows for retention of water for construction purposes reducing reliance and the cost associated with importing water;
- water treatment costs are less than conventional batch basins; and
- there is less risk to personnel that do not have to apply coagulants and/or flocculants during periods of rainfall or wet ground conditions.

TABLE OF CONTENTS

Annexures

Tables

Figures

Photographs

1 Introduction

1.1 Overview

AMPYR Australia Pty Ltd (AMPYR) and Shell Energy (Shell) propose to develop the Wellington Battery Energy Storage System (the project). The project involves the development of a large-scale battery energy storage system (BESS) with a discharge capacity of 500 megawatts (MW) and a storage capacity of 1,000 megawatt hours (MWh). The project also incorporates an on-site substation and connection infrastructure to facilitate transfer of energy to and from the electrical grid, and ancillary infrastructure.

The project will be developed within privately owned land (Lot 32 DP 622471) and will incorporate either an overhead or underground transmission line and upgrade works to the Wellington Substation in the adjoining TransGrid owned landholding (Lot 1 DP 1226751). Physical infrastructure associated with the BESS will occupy an area of up to 13 ha, however during construction, the project will require a disturbance area of up to 19 ha (the project site).

The site is located within the New South Wales (NSW) Government declared Central-West Orana Renewable Energy Zone and will complement nearby existing and proposed renewable energy generation assets in the region by smoothing out fluctuations in electricity supply from these new intermittent power sources, providing system security and other network services. In operation, the project will be one of the largest battery storage projects in NSW and will contribute to the overall storage capacity and reliability of the National Electricity Market.

1.2 Location and context

The site proposed to be developed is located within the Dubbo Regional Council local government area (LGA) at 6773 Goolma Road (battery energy storage system and transmission line) and 6909 Goolma Rd (transmission line and Wellington Substation upgrade) at Wuuluman. It will be located directly adjacent to the TransGrid owned Wellington Substation and is approximately 2.2 km north-east of the township of Wellington and 44 km south-east of the township of Dubbo.

The regional setting is presented in Figure 1.1 and the site and its surrounding local context is shown in Figure 1.2.

The locality surrounding the project contains a variety of landscapes within an agricultural setting. Most of the local and sub-regional setting has been cleared for grazing and/or cultivation. There are no major National Parks, nature reserves, conservation areas or State forests close to the project. key land uses surrounding the site include:

- cropping and grazing activities;
- correctional centres including the Macquarie Correctional Centre and Wellington Correctional Centre north of the site;
- renewable energy generating facilities including the Wellington Solar Farm immediately north of the site;
- electricity infrastructure including the TransGrid Wellington Substation and associated transmission lines; and
- residences along Goolma Road, Twelve Mile Road, Cadonia Drive, and Cadia Place.

Land surrounding the project is relatively flat, apart from a hill approximately 600 m east of the project, which rises about 100 m above the majority of the site. The project is directly south of the Wellington Solar Farm and adjacent and east of the TransGrid Wellington substation.

The site is within the Macquarie River catchment and Macquarie River is approximately 2 km south-east of the site.

1.3 Assessment framework

The project is State significant development (SSD) pursuant to Schedule 1 of the State Environmental Planning Policy (Planning Systems) 2021 (Planning Systems SEPP). Accordingly, approval for the project is required under Part 4 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act).

This land, soils and erosions assessment (LSEA) report supports the Environmental Impact Statement (EIS) for the project. It documents the assessment methodology, results and the mitigation and management measures proposed to minimise any unavoidable residual impacts to land and soils arising from the project.

The key objectives of this report are to:

- describe the applicable regulatory framework relevant the project;
- describe and characterise the existing land and soil resources relevant to the project;
- identify and assess potential land capability, soil erosion, sedimentation and rehabilitation impacts of the project construction and operation;
- satisfy the Secretary's Environmental Assessment Requirements (SEARs) for the project pertaining to land, soil, erosion and sediment control; and
- identify appropriate mitigation and management measures for the project.

This LSEA has been prepared in accordance with requirements of the NSW Department of Planning and Environment (DPE) which were set out in the SEARs for the project, issued on 1 October 2021. The SEARs identify matters which must be addressed in the EIS and essentially form its terms of reference. Table 1.1 lists individual requirements relevant to this LSEA and where they are addressed in this report.

Table 1.1 SEARs for the assessment of land and soils and erosion

Requirement	Section addressed
Land	
Detailed justification of the suitability of the site and that the site can accommodate the proposed development having regard to its potential environmental impacts, permissibility, strategic context and existing site constraints.	Section 8 provides details of site impacts and suitability
An assessment of the potential impacts of the development on existing and approved land uses on the site and adjacent land, including: • consideration of agricultural land, flood prone land, Crown lands, mining, quarries, mineral or petroleum rights; • a soil survey to determine the soil characteristics and consider the potential for erosion to occur; and • a cumulative impact assessment of nearby developments.	Section 3.5 provides details of the site specific soil survey and Section 4 addresses soil erosion hazard
An assessment of the compatibility of the development with existing land uses, during construction, operation and after decommissioning, including: • consideration of the zoning provisions applying to the land, including subdivision (if required); • completion of a Land Use Conflict Risk Assessment in accordance with the Department of Industry's Land Use Conflict Risk Assessment Guide; and • assessment of impact on agricultural resources and agricultural production on the site and region.	Section 3.7 considers land zoning provisions Section 5.1.4 provides an assessment of impact on agricultural resources and production A LUCRA has been completed in Appendix H of the EIS

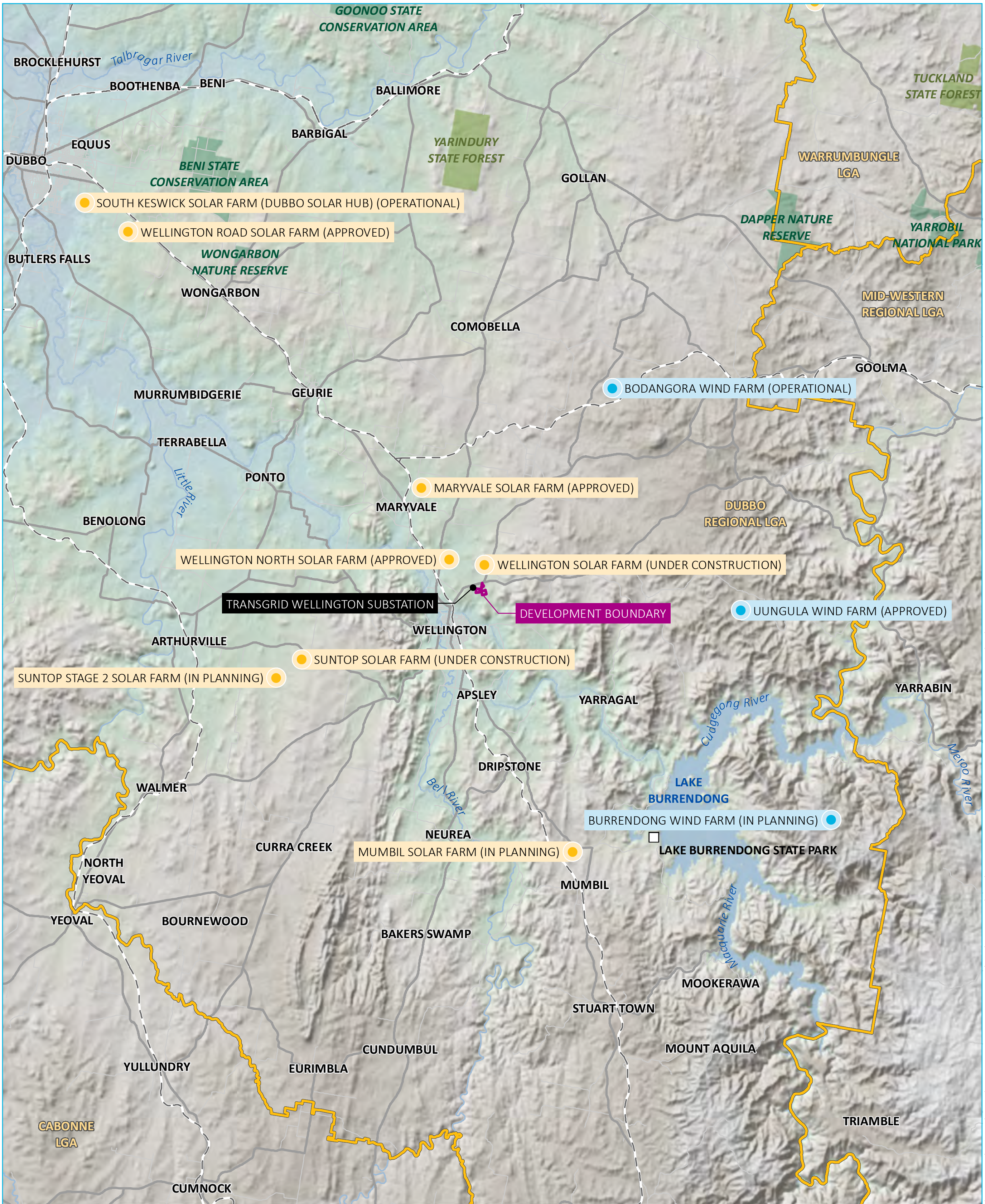
Table 1.1 SEARs for the assessment of land and soils and erosion

Requirement	Section addressed
Water	
A description of the erosion and sediment control measures that would be implemented to mitigate any impacts in accordance with *Managing Urban Stormwater: Soil & Construction* (Landcom 2004)	Section 6 describes the proposed approach to erosion and sediment control management and describes the proposed mitigation measures.

This report comprises of the following sections:

- a description of the project, local setting and surrounds;
- a description of relevant environmental constraints (eg rainfall, topography, land use and vegetation, waterways and floodplains and existing soil types);
- a summary of the assessment methodology;
- an overview of the site land capability, soil landscapes and soil types likely to be present on-site and commentary on their constraints relevant to erosion risk;
- an erosion hazard assessment including;
    - findings of the erosion site hazard inspection and soil analysis (laboratory characterisation);
    - an erosion risk assessment based on the Revised Universal Soil Loss Equation (RUSLE) methodology and applicable soil erodibility (K-Factor) and monthly rainfall erosivity (R-Factor);
    - description of best-practice procedures and strategies to mitigate erosion and sediment risk;
    - conceptual design standards for drainage, erosion and sediment controls consistent with IECA BPESC Guideline (IECA 2008); and
    - recommended control measures for specific site locations and likely forms of ground disturbance (eg trenching, cuts and fills, roads, hard-stands and office areas);
- assessment of likely construction and operation impacts to land and soils; and
- overview of mitigation measures and monitoring requirements for the project.

A number of technical terms have been utilised throughout this report for the discussion of land, soils and erosion. These are explained in the Abbreviations.



Source: EMM (2022); DPIE (2022); DFSI (2017); GA (2011); ASGC (2006)

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KEY

- Development boundary
- Lake Burrendong State Park
- Rail line
- Major road
- Minor road
- River
- Named waterbody
- Local government area
- NPWS reserve
- State forest

Renewable energy project

- Solar farm
- Wind farm

Regional setting

Wellington Battery Energy Storage System
Land, soils and erosion assessment
Figure 1.1

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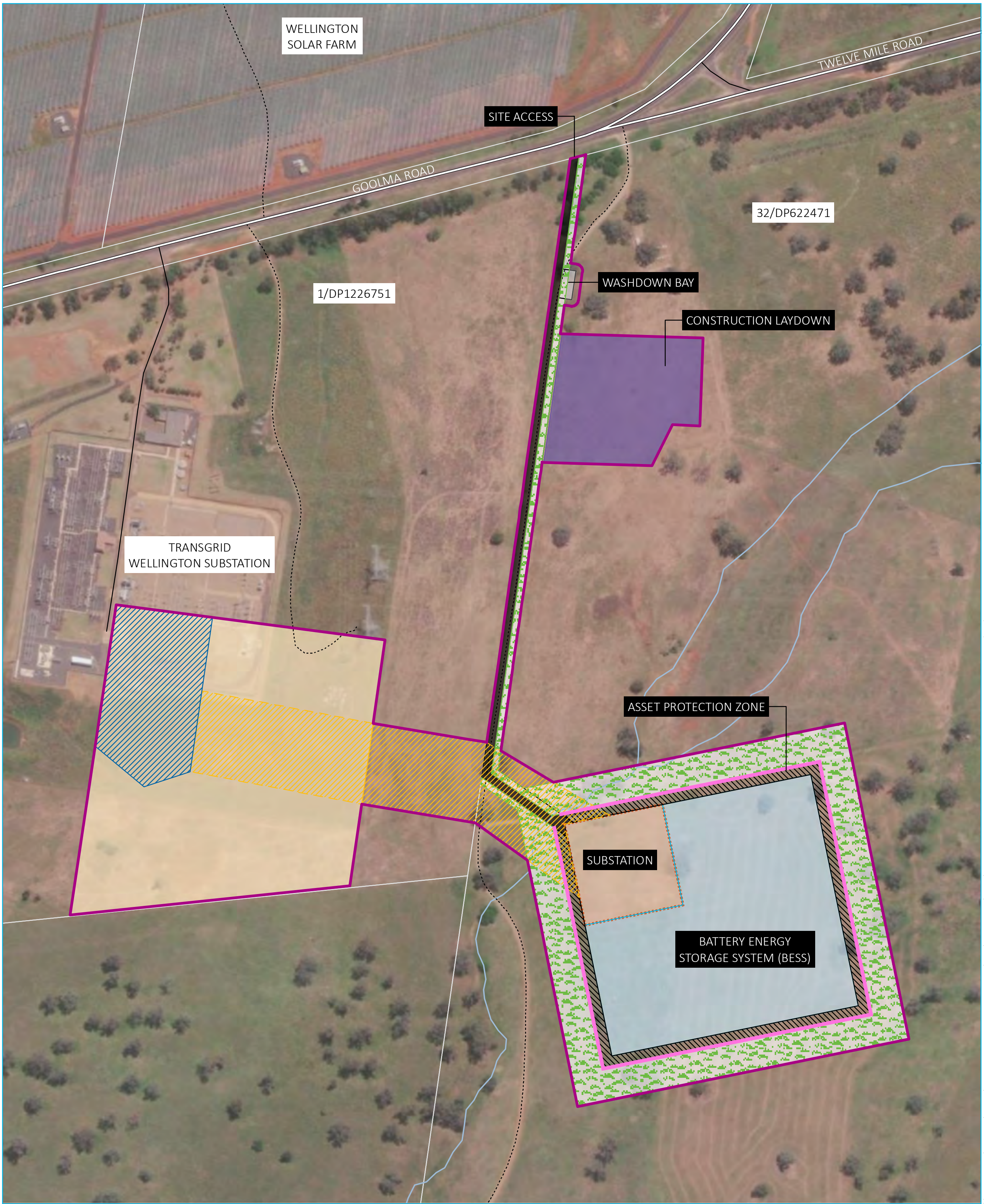

Source: EMM (2022); AMPYR (2022); ESRI (2022); DFSI (2017); ICSM (2014)

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KEY

Development boundary

Project components

- Indicative asset protection zone (10 m)
- Indicative transmission connection corridor
- Indicative TransGrid substation upgrade core infrastructure area
- Indicative TransGrid substation upgrade disturbance area
- Battery Energy Storage System (BESS) (battery rows offset at 6 m spacing and setback from substation)
- Substation
- Washdown bay
- Construction laydown
- Indicative landscaping (post construction)
- Access road
- Indicative location of noise bund

Existing environment

- Major road
- Minor road
- Vehicular track
- Watercourse/drainage line
- Cadastral boundary

Project area

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Land, soils and erosion assessment
Figure 1.2

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2 Project description

2.1 Project overview

The project consists of the construction and operation of a major grid-scale battery project immediately adjacent to the Wellington substation. The project will have a power output of 500 MW and an energy storage capacity of 1,000 MWh. The project will comprise:

- lithium-ion (Li-ion) batteries inside battery enclosures;
- power conversion systems (PCS) incorporating inverters and transformers;
- an aboveground or underground transmission line to the Wellington Substation and associated easement;
- an on-site substation comprising two 330 kilovolt (kV) transformer bays and ancillary infrastructure;
- cabling and collector units;
- upgrade of the TransGrid Wellington Substation, which may include an additional 330 kV switch bay with power transformers (which would be installed as an alternative to the transformer bays being located on the BESS site), switchyard bench extensions to the south of the existing bench and relocation of security fencing;
- ancillary infrastructure (eg control and office building, washdown bay, lighting and fencing); and
- an Asset Protection Zone (APZ).

A full description of the project is provided in Chapter 3 of the EIS.

Construction of the project is expected to commence in May 2023, subject to labour and equipment availability. Construction may be undertaken as a single stage, or over two stages. Construction of the project will be undertaken over a minimum of 8 months and up to a maximum of 12-18 months under normal circumstances. For the staged construction scenario, Stage 1 would likely include 300 MW installed discharge capacity, all civil and enabling works, installation of batteries, one transformer and switchgear and associated structural, mechanical and electrical works, and connection to the substation. Stage 2 would consist of 200 MW, including installation of a second transformer and associated switchgear and batteries. It is anticipated that construction of Stage 2 would commence approximately 6-12 months following completion of Stage 1 works.

TransGrid has advised that the Wellington Substation upgrade works may incorporate installation of one new 330 kV switch bay and multiple transformers (which would be installed as an alternative to the transformer bays being located on the BESS site), and may be installed in stages to coincide with the staged construction of the BESS should a staged approach be adopted.

Operation of the project is expected to commence from 2024 for a period of approximately 20 years, at which point the project will be decommissioned. Throughout its operational life, certain components and technologies may be replaced and/or upgraded, however such works are unlikely to be intensive. The BESS will operate 24 hours a day, 7 days a week and be operated remotely, with regular infrastructure maintenance undertaken onsite.

2.1.1 Concept design

The project is subject to detailed design. Aspects of the project (including the siting of project elements and construction methodology) are subject to change during detailed design process but will otherwise not lie beyond the development boundary identified on Figure 1.1. This EIS is based on consideration of reasonable worse case environmental impacts to allow flexibility in design and construction methodology.

2.2 Construction

2.2.1 Physical disturbance

Permanent project infrastructure will occupy an area of up to 13 ha. During construction, the project will require a disturbance area of up to 19 ha.

Vegetation clearing, cut and fill and bulk earthworks will be required to establish desired design levels to facilitate project infrastructure. Gravel cover will be established to allow for a managed surface that is partially permeable. Project infrastructure and equipment will either be established on concrete pads or mounted on skids affixed to the concrete pads. Depending on further detailed design, piled foundations may be required in certain areas to accommodate project infrastructure. A new access will be constructed suitable for anticipated construction and operational vehicle movements. The existing bench at the Wellington substation will be extended to the south to accommodate the proposed upgrades at that facility.

Limited ground disturbance may also be required to facilitate a temporary construction compound/laydown area and washdown area at the site entrance. The siting of this area will be clear of established trees and located mostly within previously disturbed areas.

Areas disturbed during construction and not required for the operation of the project will be rehabilitated following completion of construction. An asset protection zone will be established and maintained on an ongoing basis for bushfire protection purposes.

3 Existing environment

3.1 Climate

Climate and rainfall data have been obtained from the Bureau of Meteorology (BoM) Wellington D&J Rural Station (No. 065034), where monitoring commenced in 1881. The project site has a warm temperate climate and is characterised by warm summers and cool winters with generally consistent rainfall.

Long-term mean maximum and minimum annual temperature are 24.4°C and 9.4°C respectively, average annual rainfall is 616 millimetres per year (mm/year) and annual average pan evaporation rates between 1,600–1,800 mm/year. Average monthly 9 am windspeeds range between 3.9–8.0 kilometres per hour (km/hr), being highest in October and lowest in June (BoM 2021a; BoM 2021b).

Mean monthly maximum and minimum temperature and mean rainfall are presented in Figure 3.1 (BoM 2021a).

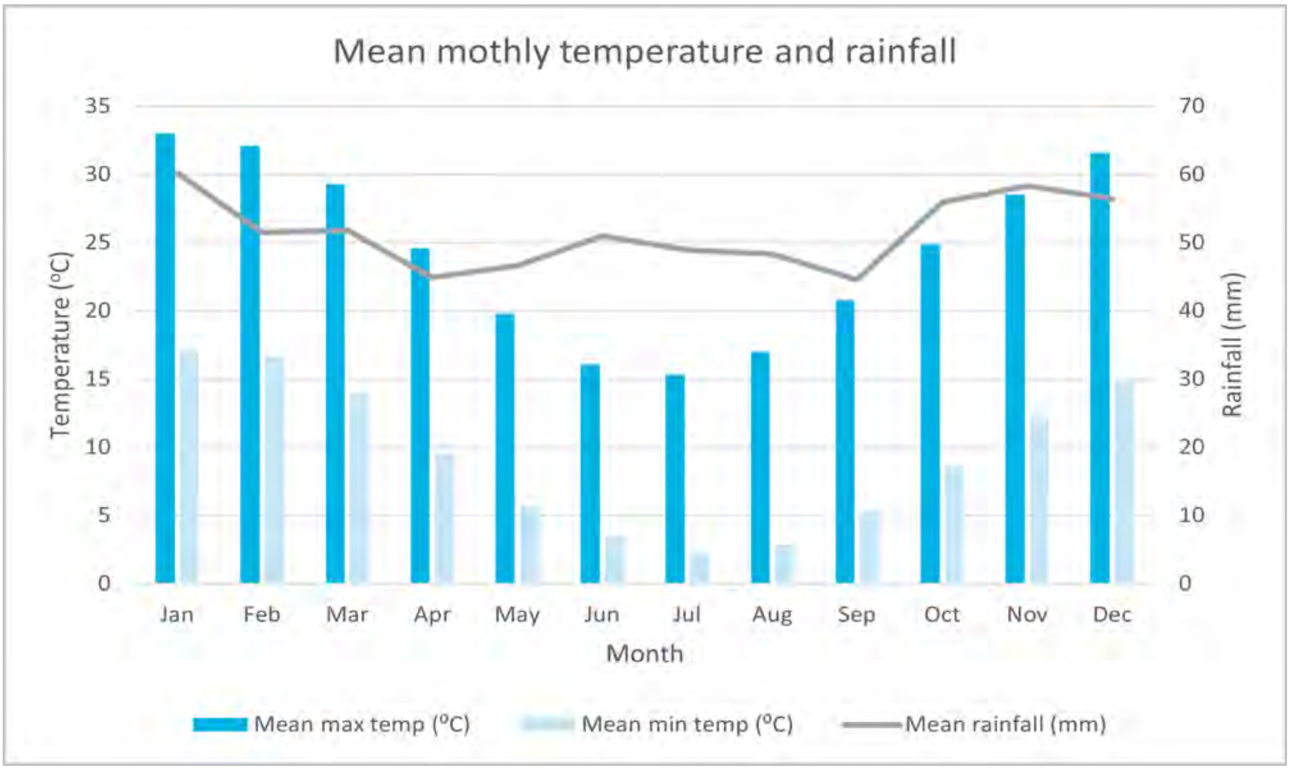


Figure 3.1 Mean monthly rainfall and mean wind speed (BoM 2021a)

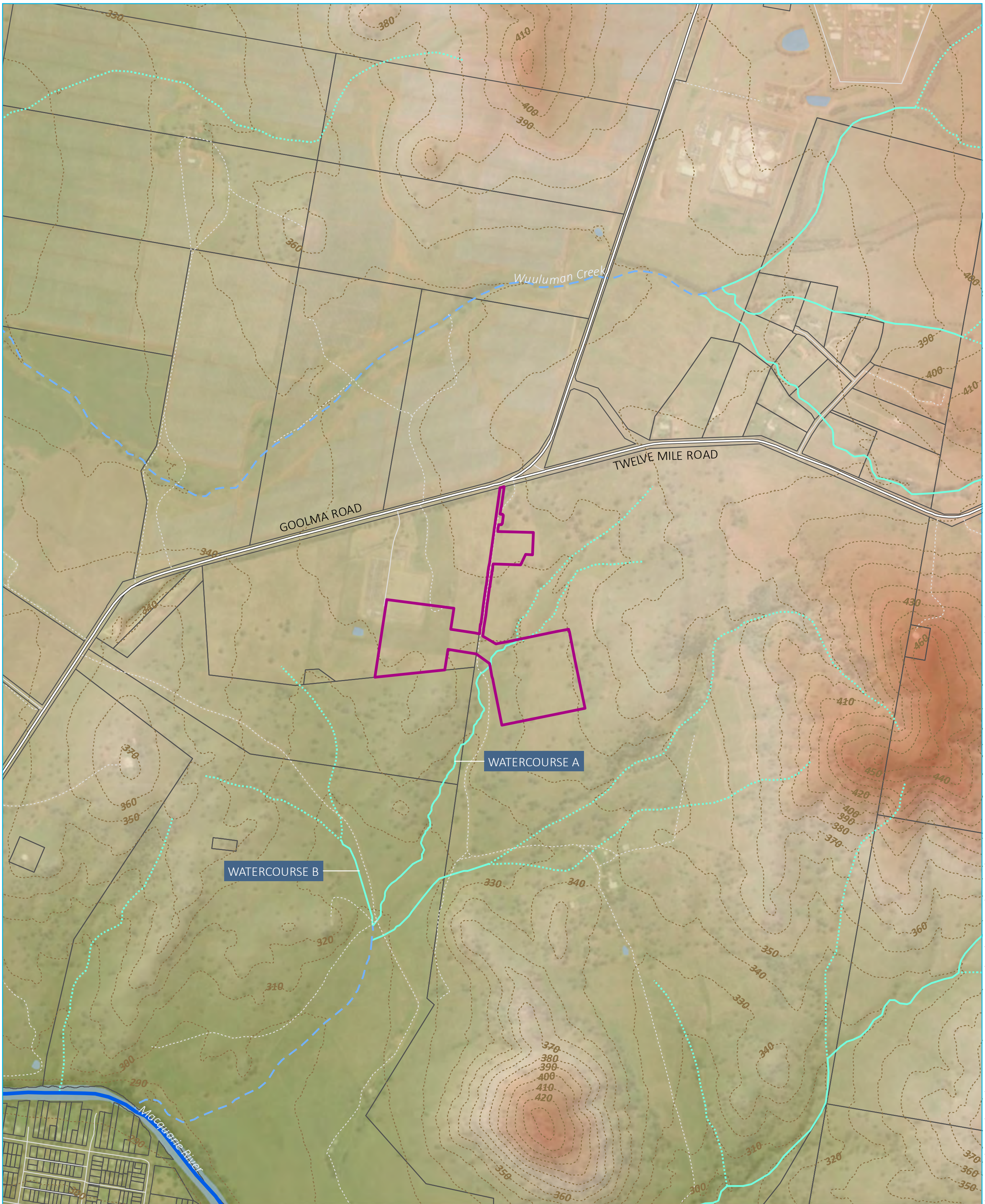
3.2 Topography

The project site has relatively consistent relief, sloping consistently at around 5% to the southwest from a high of 480 metres (m) relative to Australian Height Datum (AHD), with a minor rise of 340 mAHD located to the west of the project site (refer Figure 3.2). Approximately 2 kilometres (km) to the south of the project site is Mount Nanima, a peak of 436 mAHd (NSW SS 2017).

Spatial analysis of the project site slopes is shown in Table 3.1.

Table 3.1 Project site slope percentages

Project component	Area (ha)	Minimum	Maximum	Mean	Standard deviation
Development/disturbance boundary	19.3	0.09	15.37	4.27	2.47
Operational boundary	13.3	0.14	9.79	5.00	1.16
Substation	0.88	2.07	6.69	4.48	0.92
Battery Energy Storage System (BESS)	4.21	3.20	9.79	5.28	1.03
0.143.861.641.10Washdown bay	0.04	1.84	5.35	3.57	0.72
Construction laydown	1.50	0.77	16.24	5.79	1.64
Indicative landscaping	3.26	2.23	10.17	5.31	1.48
Indicative asset protection zone (10 m)	0.93	0.09	15.37	4.44	2.76
TransGrid substation upgrade works area	6.54	2.36	7.48	3.78	0.81



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Source: EMM (2022); AMPYR (2021); ESRI (2021); DFSI (2017); DPI (2015); ICSM (2014)

0 0.5 1 km

GDA 1994 MGA Zone 55

N

KEY

Development boundary	Waterbody	Elevation
Major road	Strahler stream order	468 mAHD
Minor road	1st order	
Vehicular track	2nd order	
Topographic contour (10 m)	3rd order	281 mAHD
Cadastral boundary	9th order	

Site drainage and topography

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Land, soils and erosion assessment
Figure 3.2

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3.3 Surface water

Surface water conditions relevant to the project have been described by EMM in a separate Water assessment report (EMM 2022). The project site lies predominantly within the catchment of an ephemeral second order watercourse, referred to as Watercourse A (refer Figure 3.2). Minor portions of the development lie on the catchment boundaries of a neighbouring, ephemeral second order watercourse to the west (Watercourse B) and Wuuluman Creek to the north. All watercourses are tributaries to the Macquarie River, immediately upstream of the township of Wellington. Upstream of the Macquarie River lies Burrendong Dam, a major online gated structure which provides irrigation and municipal water supply, hydroelectric power generation and flood mitigation, controlling downstream flood levels in the Macquarie River.

3.4 Soils

The assessment of soils, erosion and land comprised a desktop review and site inspection. Existing information on soils and soil environments for the development footprint was sourced from:

- NSW soil and land information system (SALIS) (DPIE 2021a), accessed through eSPADE (DPIE 2020a);
- Australian Soil Classification system soil type mapping of NSW (DPIE 2021b);
- Great Soil Group (GSG) Soil Type map of NSW (DPIE 2021c);
- Inherent soil fertility (DPIE 2020b);
- Land and Soil Capability Mapping for NSW (DPIE 2020c); and
- Soil Landscapes of Central and Eastern NSW (DPIE 2020d).

A site inspection was undertaken on 21 December 2021, including assessment of erosion hazard and opportunistic sampling of soils at five sites from across the project area site to determine soil characteristics and the potential for erosion to occur.

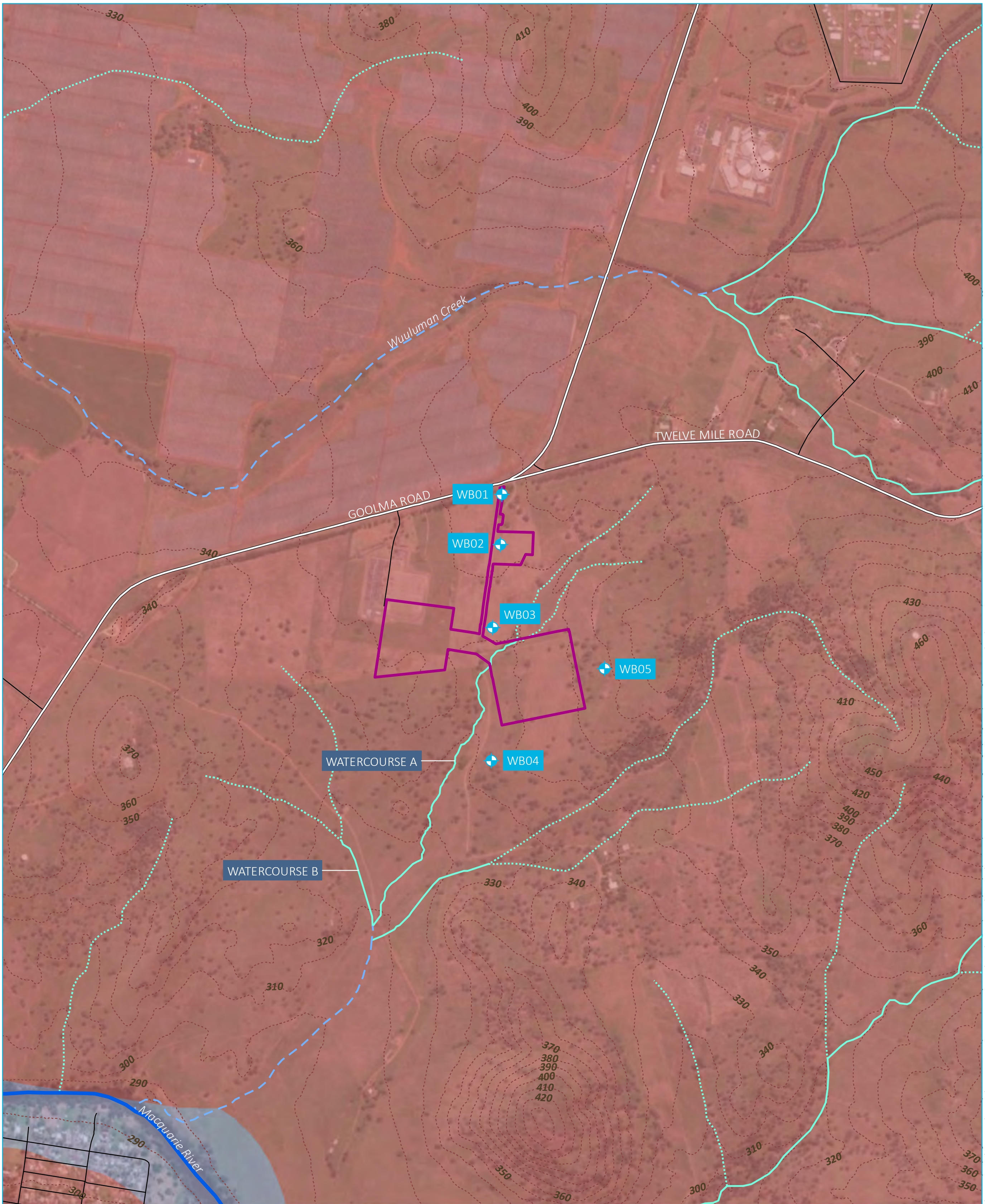
3.4.1 Australian Soil Classification

The Australian Soil Classification scheme (Isbell et al 2021) 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 (DPIE 2021b) identifies that the site encompasses one soil order, Ferrosols, described in Table 3.2 and illustrated in Figure 3.3.

Table 3.2 Summary of regional ASC soil mapping

Soil Type	ASC description [1]	Agricultural potential [2]
Ferrosols (FE)	• Soils with B2 horizons that are high in free iron oxide and lacking a strong texture contrast between the A and B horizons. • Soils other than Vertosols, Hydrosols and Calcarosols that: – have B2 horizons in which the major part has a free iron oxide content greater than 5% Fe in the fine earth fraction (<2 mm); and – do not have a clear or abrupt textural B horizon or a B2 horizon in which at least 0.3 m has vertic properties.	• Generally high agricultural potential. • Good structure and moderate to high chemical fertility and water holding capacity. • High rainfall equivalents may suffer from acidification and nutrient leaching. • May be subject to structural decline after repeated cultivation.

Notes: 1. per Isbell (2021).
2. per Gray and Murphy (2002).



Source: EMM (2022); AMPYR (2021); ESRI (2021); DFSI (2017); DPIE (2021); ICSM (2014)

0 0.5 1 km
GDA 1994 MGA Zone 55
N

KEY

- Development boundary
- Soil sampling location
- Major road
- Minor road
- Topographic contour (10 m)

Strahler stream order
- 1st order
- 2nd order
- 3rd order
- 9th order

Australian soil classification
- Dermosols
- Ferrosols

eSPADE modelled ASC mapping

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Land, soils and erosion assessment
Figure 3.3

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3.4.2 Great soil groups

Great soil groups (GSG) is a soil classification system developed by Stace et al. (1968) based on the description of soil properties such as colour, texture, structure, drainage, lime, iron, organic matter and salt accumulation, as well as on theories of soil formation. The GSG classification has since been superseded by the ASC and commonly GSG soils have been converted to their ASC equivalent in many mapping systems.

Historic soil mapping identified from NSW government mapping (DPIE 2021c) for the project site are displayed in Table 3.3 with their corresponding ASC equivalents and associated soil landscapes.

Table 3.3 Regional soil mapping – Great soil groups

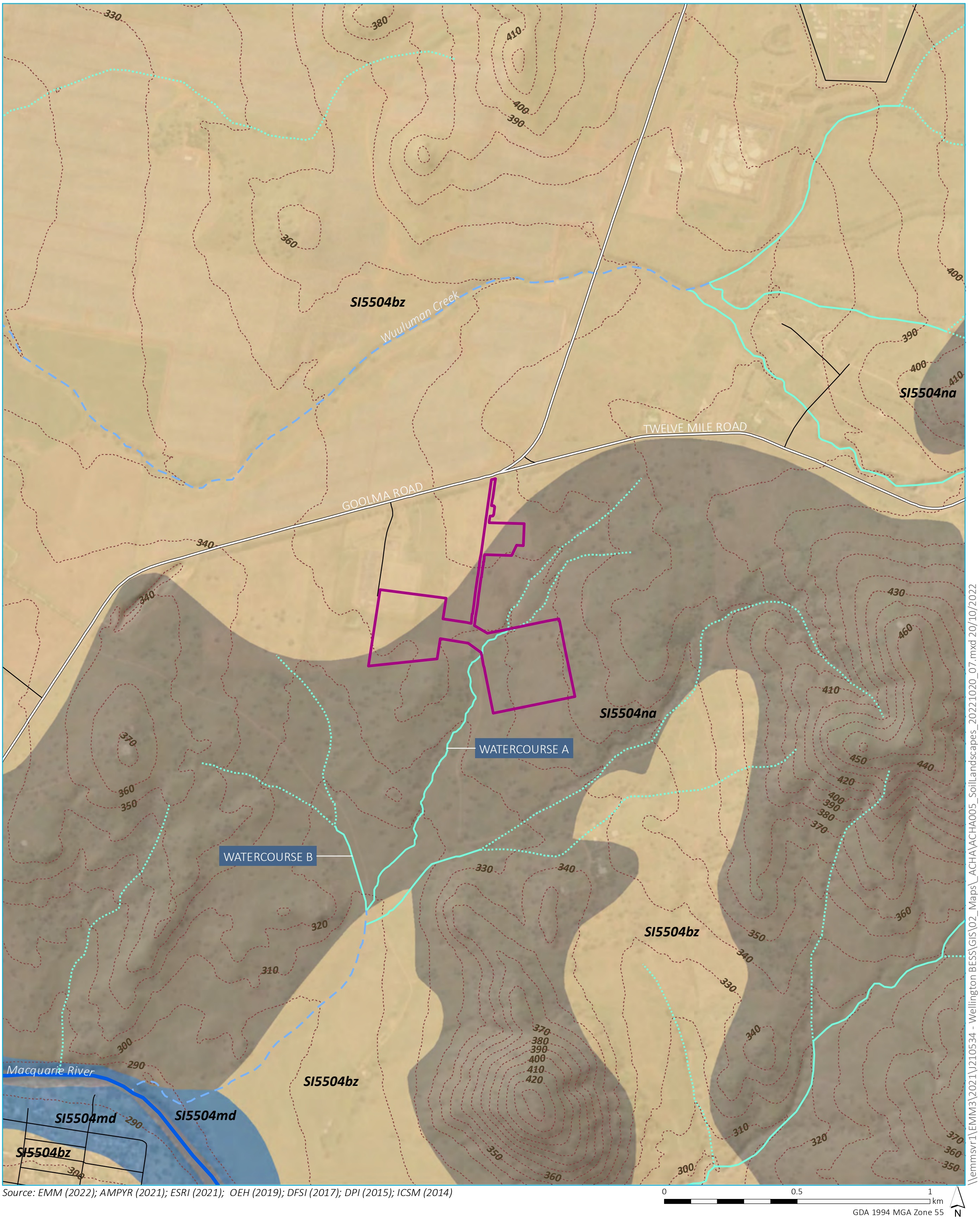
GSG	ASC equivalent	Soil landscape
Euchrozems (E)	Ferrosols	Bodangora (bz), Nanima (na)

3.4.3 Soil landscapes

Soil Landscapes of Central and Eastern NSW mapping (DPIE 2020d) is a compilation of 40 soil landscape maps based on 1:100,000 and 1:250,000 topographic sheets, providing an inventory of soil and landscape properties of the areas and identifying major soil and landscape qualities and constraints. Soil and topographic features are integrated into single units with relatively uniform land management requirements.

The project site is located on the Soil Landscapes of the Dubbo 1:250,000 Sheet (Murphy et al 2010).

The project site is predominantly located on the Nanima soil landscape (15.1 ha) with areas of the Bodangora soil landscape (4.2 ha) associated to the north and south of project site (refer Figure 3.4). Soil landscapes are described in Table 3.4 with their dominant soil materials described in Table 3.5.



Source: EMM (2022); AMPYR (2021); ESRI (2021); OEH (2019); DFSI (2017); DPI (2015); ICSM (2014)

KEY

Development boundary
Major road
Minor road
Topographic contour (10 m)

Strahler stream order
1st order
2nd order
3rd order
9th order

Soil landscape
SI5504bz | Bodangora
SI5504md | Macquarie-dubbo
SI5504na | Nanima

eSPADE soil landscapes

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Land, soils and erosion assessment
Figure 3.4

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Table 3.4 Site soil landscapes

Soil landscape	Landscape	Soils	Vegetation and land use	Limitations and degradation
Bodangora (bz)	391 km^2 undulating low hills. Andesite and associated shale, tuff and limestone. Relief 40–100 m, slopes 3–10%.	Euchrozems (Gn3.13) with Non-calcic Brown Soils (Dr2.12) and shallow soils (Um6.23) on some hillocks and steep slopes. Pockets of Terra Rossa Soils (Um6.13; Dr4.13) associated with limestone.	Open-woodland community dominated by a white box (*Eucalyptus albens*) – yellow box (*Eucalyptus melliodora*) – white cypress pine (*Callitris columellaris*) community. White box (*E. albens*) occupies the upper slopes, sometimes in association with grey box (*Eucalyptus microcarpa*), with white cypress pine (*C. columellaris*) on the crests and ridge lines. Yellow box (*E. melliodora*) occupies the mid and lower slopes and the drainage lines and valley basins, sometimes with fuzzy box (*Eucalyptus conica*) and grey box (*E. microcarpa*). There are also scattered kurrajongs (*Brachychiton populneus*). Land use is dryland cropping of wheat, canola, oats and legume crops. Grazing of improved pasture and lucerne. Urban development.	High erosion hazard under cultivation and low cover levels; moderate fertility; friable surface soils; moderate to high shrink-swell potential in subsoils; aggregated clays may leak in earthworks. Slight to moderate sheet erosion and areas of moderate gully erosion, although many of these are now stabilised. A few areas of previously severe gully erosion have been stabilised. The long history of cropping has led to erosion in the past.
Nanima (na)	270 km^2 rolling low hills. Andesite, hornfels, shale, tuff and limestone. Relief 80–150 m; slopes 5–20%.	Euchrozems (Gn3.13; Dr4.13; Gn3.12; Dr4.12) and Non-calcic Brown Soils (Dr2.23) with shallow loams (Um4.13) on crests. Small pockets of Terra Rossa Soils (Um6.13; Uf6.21) on limestone.	Open-woodland community dominated by white box (*E. albens*), yellow box (*E. melliodora*) and white cypress pine (*C. columellaris*). White box (*E. albens*) occupies the upper slopes with white cypress pine (*C. columellaris*) preferring the crests and ridge lines. Yellow box (*E. melliodora*) occupies the mid and lower slopes and drainage lines. Kurrajongs (*B. populneus*) are also common. Land use is dry land cropping; grazing on native and improved pastures.	Moderate fertility; friable surface soils; steep slopes often with rock outcrop; moderate to high available waterholding capacity; very high erosion hazard under cultivation; moderate to high shrink-swell potential; aggregated clays may leak in earthworks. Minor to moderate sheet erosion; minor gully erosion.

Table 3.5 Soil landscape – Soils

Soil	ASC description [1]	Limitations
Nanima (na)		
Euchrozems	**Topsoil:** A1 horizon. Friable, dark reddish-brown clay loam; strong polyhedral structure; pH 6.0; to 15 cm depth. **Subsoil:** B21 horizon. Dark reddish-brown light clay; strong structure; pH 6.0; to 50 cm depth. Grading to – B22 horizon. Dark reddish-brown to 80 cm, grading to heavy clay; strong structure; pH 7.0; dark reddish-brown heavy clay; strong structure; pH 7.0 to 120 cm depth; calcium carbonate, largely diffuse, is common at this depth. Weathered andesite may occur at 80–120 cm.	**Soil fertility:** Moderate soil fertility; N and P required with continued land use and S if canola is grown. Surface soils neutral to slightly acidic, generally not susceptible to acidification. Moderate to high soil physical fertility, surface soils are friable and relatively stable to soil structure decline, although they may still set hard if surface cover is low. Subsoils have no limitations for root growth. The soil profile is permeable and waterholding capacity is high to moderate. Rock outcrop is common. **Erosion hazard:** Soils are only slightly to moderately erodible, but slopes are 5 to 20% and 300 to 1,000 m long. There is a high erosion hazard under cropping, especially if soils are in a cultivated condition and surface cover is low. This is seen in the remnants of severe erosion that has occurred in the past. Soil conservation earthworks and/or conservation farming practices are necessary to control erosion. **Salinisation:** Soil salinity problems are absent and unlikely to occur in the future. **Foundation hazard:** Moderate to high shrink-swell activity of the subsoils of the Euchrozems are a significant limitation to foundations. **Landscape limitations:** The erosion hazard is the major landscape limitation, but rock outcrop may also affect land use. **Rural capability:** Most of the area is only suitable for grazing because of slopes and rock outcrop (Class IV, VI). Small areas of footslopes may be used for cropping (Class II, III).
Non-calcic Brown Soils	**Topsoil:** A1 horizon. Hardsetting dark reddish-brown loam or clay loam; stony; weak structure; pH 6.5; to 10 cm depth. A2 horizon. Light reddish-brown loam or clay loam; weak structure; pH 6.5; to 30 cm depth. **Subsoil:** B21 horizon. Reddish-brown medium clay; moderate structure; pH 7.0; to 80 cm depth. B22 horizon. Reddish-brown medium clay; moderate structure; pH 7.0; to 120 cm depth.	
Terra Rossa Soils	**Topsoil:** A horizon. Hardsetting, reddish-brown loam; weak structure; pH 8.5; to 10 cm depth. Gradual boundary to – **Subsoil:** B horizon. Reddish-brown light clay with moderate structure; pH 8.5; to 20 cm depth; limestone rock below soil.	
Bodangora (ba)		
Euchrozems	**Topsoil:** Dark reddish-brown clay loams to light clays, moderately well structured with sub-angular or angular blocky peds. Field pH increases from 5.5 to 7.0 in the A horizon; to 35 cm depth. Gradual boundary to – **Subsoil:** Moderate to strongly structured reddish-brown light to medium clays with smooth-faced, sub-angular or polyhedral peds. Gravel increases with depth and soft nodules of calcium carbonate begin to appear at about 90 cm depth. Field pH 8.0 to 8.5.	**Soil fertility:** Moderate soil fertility, N and P required with continued land use and S if canola is grown. Soils generally not susceptible to acidification. Moderate to high soil physical fertility, surface soils are friable and relatively stable to soil structure decline. Although they may still set hard if surface cover is low. Subsoils have no limitations for root growth. The soil profile is permeable and waterholding capacity is high to moderate.

Table 3.5 Soil landscape – Soils

<table>
<tr><th>Soil</th><th>ASC description [1]</th><th>Limitations</th></tr>
<tr><td>Non-calcic Brown Soils</td><td>Topsoil:
Hardsetting, gravelly (50–90%) dark reddish-brown fine sandy loams to sandy clay loams with weak crumb or sub-angular blocky peds; pH 6–7; to 30 cm depth. Clear boundary to –
Subsoil:
Gravelly, dark reddish-brown, light medium clays with moderately structured fine sub-angular blocky peds; pH 8.0; weathered rock is encountered at about 80 cm.</td><td rowspan="2">Erosion hazard:
Soils are only slightly to moderately erodible but slopes are 3 to 10% and relatively long (1,000 to 3,000 m), so there is a high erosion hazard under cropping, especially if soils are in a cultivated condition and surface cover is low. This is seen in the remnants of severe erosion that has occurred in the past. Soil conservation earthworks and or conservation farming practices are necessary to control erosion.
Salinisation:
Low levels of salinity are apparent and there are isolated occurrences across the landscape. Landform elements affected include drainage lines, depressions, footslopes.
Foundation hazard:
Moderate to high shrink-swell activity of the subsoils of the Euchrozems are a significant limitation to foundations.
Landscape limitations:
The erosion hazard is the major landscape limitation.
Rural capability:
This landscape has highly productive agricultural land with most of the area being Class II or Class III cropping land. Small areas of Class IV land are associated with upper slopes and ridges or crests.</td></tr>
<tr><td>Terra Rossa Soils</td><td>Topsoil:
Friable dark reddish-brown fine sandy clay loams to clay loams with moderately structured, fine angular blocky, smooth-faced peds. pH 5.5; to 12 cm depth. Clear boundary to –
Subsoil:
Dark reddish-brown, clay loams to medium clays; strongly structured, fine angular blocky peds with some limestone gravel at depth; pH 7.0–8.0, becoming 8.0 to 8.5 at depth.</td></tr>
</table>

3.4.4 Inherent soil fertility

Inherent soil fertility is used as a general indication of a soil's capacity to retain and release nutrients and soil water for use by vegetation and is a function of the interrelationship between physical, chemical and biological components in the soil. The inherent fertility is derived using a relative classification developed by Charman (1978) and based on the regionally mapped soil types.

Per the eSPADE database (DPIE 2020a, DPIE 2020b) the soils of the project site have variable inherent soil fertility of 'moderately high' (Table 3.6).

Table 3.6 Inherent soil fertility

Inherent soil fertility	ASC	Description[1]
Moderately high	Ferrosols	Soils with high fertility in their virgin state but this fertility is significantly reduced after only a few years of cultivation.

Note: Per Chapman (1978)

3.4.5 Land and soil capability

The *Land and Soil Capability Assessment Scheme* (OEH 2012) ('LSC Scheme') assesses the inherent physical capacity of the land to sustain a range of land uses (and management practices) in the long term without leading to degradation of soil, land, air and water resources. The LSC Scheme considers the inherent biophysical features of the land and soil, and their associated hazards and limitations, to these land uses. Each hazard is given a rating between 1 (best, highest capability land) and 8 (worst, lowest capability land). The overall LSC class of the land is based on the most limiting feature/hazard.

The LSC classes present at a site can be determined at various scales, ranging from state, regional to farm scale, varying in accuracy according to the information and resolution associated with them. With reference to the eSPADE database (DPIE 2020a) and DPIE (2020c) the state scale mapping completed for NSW shows the project site is Classes 3 and 6 (Figure 3.5), representing land with high capability to low capability (Table 3.7).

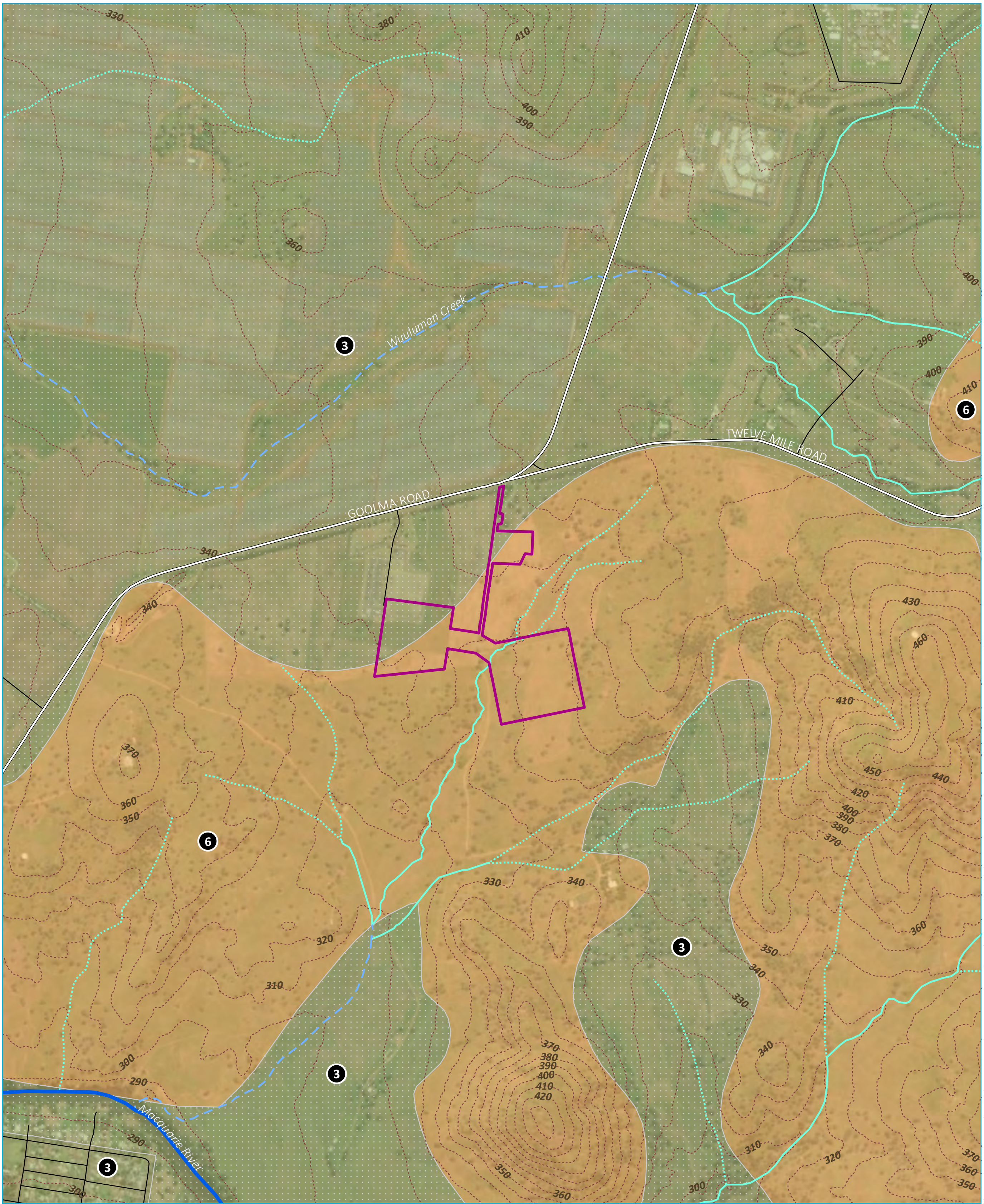
Table 3.7 Land and soil classifications mapped for the project site

LSC Class [1]	Description	ASC (Land system)
Class 3 – High capability land	• Land has moderate limitations. • Capable of sustaining high-impact land uses, such as cropping with cultivation, using more intensive, readily available and widely accepted management practices. • However, careful management of limitations is required for cropping and intensive grazing to avoid land and environmental degradation.	Ferrosol (Bodangora)
Class 6 – Low capability land	• Land has very high limitations for high-impact land uses. • Land use restricted to low-impact land uses such as grazing, forestry and nature conservation. • Careful management of limitations is required to prevent severe land and environmental degradation.	Ferrosol (Nanima)

Note: Per OEH 2012

3.4.6 Acid sulphate soils

Acid sulphate soils (ASS) probability mapping has been completed along the NSW coast over 128 map sheets at 1:25,00 scale (Naylor *et al* 1998). The desktop assessment identified that there are no ASS or potential ASS in the project site, in accordance with the Guidelines for the Use of Acid Sulfate Soil Risk Maps (Naylor *et al* 1998). The NSW OEH Acids Sulphate Risk Map (OEH 2018) indicates that the nearest site with a high probability of ASS is approximately 350 km southeast of the project site and as such there is at low risk from ASS. ASS are typically found in coastal areas which does not apply to the project site.



Source: EMM (2022); AMPYR (2021); ESRI (2021); DFSI (2017); OEH (2017); ICSM (2014)

0 0.5 1 km

GDA 1994 MGA Zone 55

KEY

- Development boundary
- Major road
- Minor road
- Topographic contour (10 m)

Strahler stream order

- 1st order
- 2nd order
- 3rd order
- 9th order

- Biophysical Strategic Agricultural Land

Land and soil capability

- 3 | Moderate limitations
- 6 | Very severe limitations

eSPADE modelled LSC mapping and BSAL

Wellington Battery Energy Storage System
Land, soils and erosion assessment
Figure 3.5

3.4.7 Site soil chemistry

During the site inspection (21 December 2021), opportunistic sampling of soils was undertaken at five sites from across the project site (excluding the TransGrid substation upgrade works area) to determine soil characteristics and the potential for erosion to occur. Sampling locations are shown alongside regional ASC mapping in Figure 3.3.

A National Association of Testing Authorities (NATA) and Australasian Soil and Plant Analysis Council (ASPAC) accredited laboratory, East West Enviro Ag Pty Ltd (NATA accreditation 12360 and 15708), was used to ensure that laboratory testing was undertaken using scientifically correct methods. The analyses undertaken on sampled soils is provided in Table 3.8.

Table 3.8 Soil chemical analysis

Horizons	Analysis performed
Topsoil	pH; EC; Cl- (1:5); exchangeable cations (Ca, Mg, Na, K, Al) and CEC (NH4Cl or Ammonium Acetate); OC and OM (Walkley and Black); PSA[1] (Gravel (>2 mm), Coarse sand (0.2–2 mm), Fine sand (0.02–0.2 mm), Silt (2–20 micrometres; µm), Clay (<2 µm); Colwell P; Sulfate Sulfur; Total P, Total N, nitrate N, Ammonium N, micro nutrients (Boron (B), Copper (Cu), Iron (Fe), Manganese (Mn), Zinc (Zn)); ESP: Emerson Aggregate Test (EAT).
Subsoil	pH, EC, Cl- (1:5); exchangeable cations (Ca, Mg, Na, K, Al) and CEC (NH4Cl or Ammonium Acetate); PSA[1] (Gravel (>2 mm), Coarse sand (0.2–2 mm), Fine sand (0.02–0.2 mm), Silt (2–20 µm), Clay (<2 µm)); ESP, Emerson Aggregate Test (EAT).

Detailed laboratory results are provided in Annexure A and laboratory reports are provided in Annexure B. Interpretation of the laboratory analysis results is based predominantly on guidelines provided in:

- *Soil Chemical Methods* (Rayment & Lyons 2011);
- *Analytical methods and interpretations used by the Agricultural Chemistry Branch for soil and land surveys* (Bruce & Rayment 1982);
- *Soil testing and some soil test interpretations used by the Queensland Department of Primary Industries* (Rayment & Bruce 1984); and
- *Interpreting soil test results – what do all the numbers mean?* (Hazelton & Murphy 2016).

References in the following sections to levels, such as low, moderate and high, are defined in the above guidelines and reflect a designated rating for the parameters discussed.

Due to a lack of soil characterisation or classification undertaken on site, it cannot be confirmed if the sites described consist of the same soil type. The sites have been described separately as two soils groups according to variances in chemical characteristics.

i WB01, WB04 and WB05

Sites 1, 4 and 5 have similar chemical characteristics. Topsoil pH is variable, ranging from strongly acid to neutral, becoming mildly to moderately alkaline in the subsoils. Topsoil fertility is moderate, with low to moderate nitrogen levels, moderate to very high potassium, high to very high phosphorous and low to moderate organic carbon levels. Salinity is very low to low throughout the profiles. The cation exchange capacity (CEC) is moderate (5–15 cmol(+)/kg) in the topsoils, becoming moderate to high (>15 cmol(+)/kg) in the subsoils. The cation balances (as per Agriculture Victoria (2020)) are acceptable, with sufficient levels of calcium, some elevated magnesium levels in sites 4 and 5, and generally sufficient levels of potassium. Sodium levels are slightly elevated (>1%) but are non-sodic (<5%). The Calcium:Magnesium (Ca:Mg) ratios are Ca low (1–4) to balanced (4–6).

ii WB02 and WB03

Sites 2 and 3 have similar soil pH to the previously described sites, being slightly acid to neutral becoming moderately to very strongly alkaline in the subsoils. The topsoils have low to moderate fertility, being low in phosphorous, moderate in nitrogen and organic carbon with high to very high potassium levels. The topsoils have very low salinity, whilst the subsoils are low in salinity in W03 and moderately saline in W02. The soil CEC is low (<5 cmol(+)/kg) in the topsoil of W02 and high (>15 cmol(+)/kg) in the W03 topsoil but are moderate to high throughout the subsoils. The soil cation balances are poor, with deficient calcium levels throughout except for the W03 topsoil, whilst magnesium levels are highly elevated, being 20% of CEC in the topsoils and 30–50% of CEC through the subsoils. Potassium is sufficient in the topsoils but deficient in the subsoils whilst W02 has highly sodic (25–35% exchangeable sodium percentage (ESP)) subsoil, though the W03 subsoils are consistently non-sodic. The Ca:Mg ratios reflect the poor cation balance, with Ca low (1–4) levels in the topsoils and upper subsoils becoming Ca deficient (<1), also known as magnesic, in the subsoils.

iii Summary

The soil chemistry across the site is generally consistent in soil pH and salinity, with minor salinity increase in the W02 subsoils. Topsoil fertilities are generally moderate but have varying deficiencies between the two soil groups described. The primary difference in the identified soil groups relates to the poor cation balance of W02 and W03 which indicate possible dispersion risk due to elevated magnesium levels as well as sodicity present in W02.

The soil chemistry results for the submitted samples indicates that some soils (represented by W02 and W03) present within the project site likely have dispersive characteristics that would present an erosion risk, as indicated by the ESP and low Ca:Mg ratio. The Ca:Mg ratio can be an indicator of possible erosion hazard, as in sufficient amounts magnesium can behave similarly to elevated sodium (sodicity) and cause dispersion and subsequent erosion. A Ca:Mg ratio of below one (1) are thought to indicate this potential risk, and soils with a Ca:Mg ratio of <0.1 are referred to as magnesic by Isbell et al. (2021).

Photograph 3.1 Landscape photo of site W02 (proposed Laydown area)

3.5 Biophysical Strategic Agricultural Land (BSAL)

Strategic agricultural land in NSW is safeguarded through two primary measures: classification as Biophysical Strategic Agricultural Land (BSAL) or the implementation of Critical Industry Clusters (CICs).

BSAL is defined in the Interim Protocol for Site Verification and Mapping of Biophysical Strategic Agricultural Land (‘BSAL’) (OEH 2013), the ‘Interim Protocol’, as land with a rare combination of natural resources highly suitable for agriculture. A total of 2.8 million hectares of BSAL has been identified and mapped at a regional scale across the State.

The NSW Government has mapped BSAL across the whole of NSW, based on a desktop study. The BSAL shown on the maps comprises land which meets criteria described in the interim Protocol. The criteria used to measure BSAL under the original Strategic Regional Land Use Plans (SRLUP) were based on three regional scale parameters:

1. Soil Fertility – based on the regional scale Draft Inherent General Fertility of NSW (Section 3.4.4, DPIE 2020b).
2. Land and Soil Capability – based on the regional scale Land and Soil Capability Mapping of NSW (Section 3.4.5, DPIE 2020c).
3. Access to reliable water supply, defined as:
    a) rainfall of 350 mm or more per annum (9 out of 10 years);
    b) a regulated river (maps show those within 150 m);
    c) a 5th order or higher unregulated river (maps show those within 150 m);
    d) an unregulated river which flows at least 95% of the time (maps show those within 150 m); or
    e) highly productive groundwater sources, as declared by the NSW Office of Water. These are characterised by bores having yield rates greater than 5 litres per second (L/s) and total dissolved solids (TDS) of less than 1,500 milligrams per litre (mg/L) and exclude miscellaneous alluvial aquifers, also known as small storage aquifers.

There is a minor area (~0.9 ha) of BSAL mapped within the disturbance area associated with the project (refer Figure 3.5). This area will comprise a section of the site access track that connects with Goolma Road, the washdown bay, and a portion of the temporary construction laydown area. It should be noted that a portion of BSAL to be impacted by the project is already impacted by the existing access track, therefore project activities are not expected to impact this area significantly. There is significant BSAL mapped north of the site (opposite Goolma Road and Twelve Mile Road) and there are also areas mapped as BSAL within the landholding to the east and south that will not be impacted by the project.

3.6 Land use

Land use within the project site was assessed utilising the NSW Landuse 2017 mapping (version 1.2 of the dataset, updated 2020, DPIE 2020e) accessed via the NSW Sharing and Enabling Environmental Data (SEED) mapping portal (DPIE 2020f). The 2017 mapping captures how the landscape in NSW is being used for food production, forestry, nature conservation, infrastructure and urban development.

The 2017 land use mapping utilises the standards of the Australian Collaborative Land Use Mapping Program (ACLUMP) and using the Australian Land Use and Management (ALUM) Classification Version 8. The Australian land use and management (ALUM) classification is a three-tiered hierarchical structure featuring primary, secondary and tertiary class which are broadly structured by the potential degree of modification and the impact to the 'natural state', essentially native land cover. In this system the primary and secondary classes relate to land use, the main use of the land defined by the management objectives of the land manager. The tertiary classes can include other information such as commodity groups, specific commodities, land management practices and vegetation information.

The ALUM classification features six primary classes, five primary classes of land use distinguished by increasing level of intervention or potential impact on the natural state, as well as water being included as the sixth primary class. These six primary classes are then subdivided. The six primary classes are detailed in Table 3.9.

Table 3.9 ALUM classification

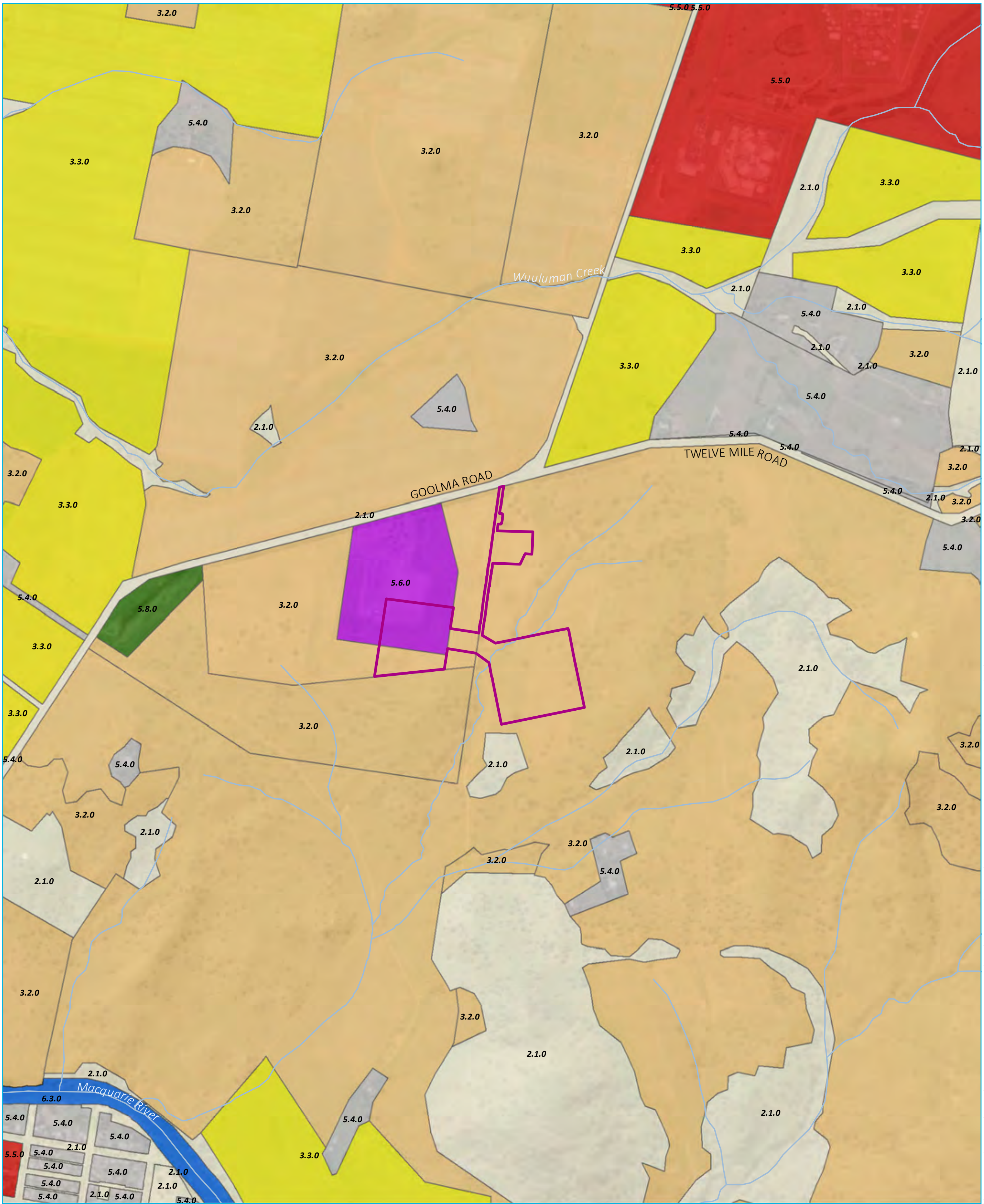
ALUM class	Overview	Description
1	Conservation and natural environments	Land used primarily for conservation purposes, based on maintaining the essentially natural ecosystems present.
2	Production from relatively natural environments	Land used mainly for primary production with limited change to the native vegetation.
3	Production from dryland agriculture and plantations	Land used mainly for primary production based on dryland farming systems.
4	Production from irrigated agriculture and plantations	Land used mostly for primary production based on irrigated farming.
5	Intensive uses	Land subject to extensive modification, generally in association with closer residential settlement, commercial or industrial uses.
6	Water	Water features (water is regarded as an essential aspect of the classification, but it is primarily a cover type).

Under the ALUM classification and mapping, the project site is predominantly mapped as ALUM 3.2.0, grazing modified pastures. There are minor areas of ALUM 2.1.0, grazing native vegetation, and ALUM 5.6.5, Electricity substations and transmission.

A detailed breakdown of the project site ALUM classification is contained in Table 3.10 and shown in Figure 3.6.

Table 3.10 Project site ALUM classification

ALUM primary class	ALUM secondary class	ALUM tertiary class	Project site (ha)
2	2.1.0 Grazing native vegetation	2.1.0 Grazing native vegetation	0.0002
3	3.2.0 Grazing modified pastures	3.2.0 Grazing modified pastures	14.99
5	5.6.0 Utilities	5.6.5 Electricity substations and transmission	4.36



Source: EMM (2022); AMPYR (2021); ESRI (2021); DFSI (2017); DPIE (2017); ICSM (2014)

0 0.5 1 km

GDA 1994 MGA Zone 55

N

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KEY

- Development boundary
- Watercourse/drainage line

Land use

- 2.1.0 Grazing native vegetation
- 3.2.0 Grazing modified pastures
- 3.3.0 Cropping
- 5.4.0 Residential and farm infrastructure
- 5.5.0 Services
- 5.6.0 Utilities
- 5.8.0 Mining
- 6.3.0 River

Agricultural land uses and resources (ALUM)

Wellington Battery Energy Storage System
Land, soils and erosion assessment
Figure 3.6

EMM creating opportunities

3.7 Land zoning

The Wellington Local Environmental Plan 2011 identifies land use zones and the type of land uses that are permitted (with or without consent) or prohibited in each zone on any given land identified within the Dubbo Regional Local Government Area (LGA). Land zoning within the project site was assessed utilising the LEP - Land Zoning mapping (DPIE 2022) accessed via the NSW SEED mapping portal (DPIE 2020e) is shown in Table 3.11.

Table 3.11 Project site land zoning

Land zoning code	Land zoning class	Area (ha)
RU1	Primary Production	12.0
SP2	Classified Road - Infrastructure	0.0002
SP2	Electricity Generating Works - Infrastructure	7.34

3.8 Agriculture

3.8.1 Agricultural land use

Data was collected in the 2015–16 agricultural census for two areas relevant to the project, the 302,536 ha of the Wellington region within the 753,454 ha of the entire Dubbo Regional LGA. The land use as per ALUM for both areas is shown in Table 3.12.

Table 3.12 Agricultural land use

Land use	Dubbo Regional LGA[1]	
	Area (ha)	Area of LGA (%)
Cropping – dryland	217,088	28.81
Cropping – irrigated	5,441	0.72
Horticulture – dryland	128	0.02
Horticulture – irrigated horticulture	165	0.02
Livestock – grazing modified pastures	162,445	21.56
Livestock – grazing native vegetation	232,741	30.89
Livestock – intensive animal production	238	0.03
Livestock – irrigated pastures	457	0.06
Livestock – land in transition	25	0.00
Agriculture – total	**618,728**	**82.11**

Note: ABARES 2021a, Catchment scale land use of Australia – update December 2020.

As per ABARES 2021a, 82.12% of the Dubbo Regional LGA land area is utilised for agriculture, with 52.55% being livestock production and 29.53% cropping, with nature conservation utilising 11.63%. The Dubbo Regional LGA lies within the Far West and Orana region of NSW, which has an agricultural sector dominated by grazing native vegetation, occupying 249,600 square kilometres (km^2) or 74% of the 57,300 km^2 of the region land (ABARES 2021b).

3.8.2 Agricultural production

In 2018–2019 the most important commodities in the Far West and Orana region (based on the gross value of agricultural production) were cattle and calves ($289 million) followed by and sheep and lambs ($248 million) and wool ($235 million). These commodities together contributed 74 per cent of the total value ($1 billion) of agricultural production in the region (ABARES 2021b).

Agricultural productivity for selected commodities for the Dubbo Regional LGA is presented in Table 3.13.

Table 3.13 Value of agricultural commodities – 2015–2016

Agricultural commodity	Dubbo Region
	Gross value ($m)[1]
Livestock products – wool	$10.61
Livestock products – milk	$7.47
Livestock products – eggs	$0.00
Livestock products – Total	**$18.09**
Livestock slaughtered and other disposals - Sheep and lambs	$7.92
Livestock slaughtered and other disposals - Cattle and calves	$19.88
Livestock slaughtered and other disposals - Goats	$0.07
Livestock slaughtered and other disposals - Pigs	$0.12
Livestock slaughtered and other disposals – Total	**$28.00**
Crops – broadacre – total	$14.67
Horticulture – Nurseries, cut flowers or cultivated turf	$0.61
Horticulture – fruits, nuts, excluding grapes (human consumption)	$0.24
Horticulture –grapes	$0.02
Horticulture –vegetables (human consumption)	$0.69
Hay – total	$4.38
Crops – Total[2]	**$20.62**
Total agriculture – all commodities	**$66.70**

Note: 1. ABS 2017, Value of Agricultural Commodities Produced, Australia, 2015-16.

2. All crops include broadacre, hay, silage and horticultural produce.

Consistent with the regional profile, the primary agricultural productivity of the Dubbo Regional LGA is livestock products and disposals (including domestic slaughtering and exports).

Indicative $/ha values for selected commodities are given in Table 3.14. These provide a broad indication of land productivity for agricultural land use categories and the relative impacts on agricultural productivity associated with the project. These figures are limited by the variation between recorded parameters for both agricultural productivity and land use for the Mudgee Region–West and Dubbo Regional LGA.

Table 3.14 Indicative annual commodity value per hectare

Area	Commodity sector	Production value ($m)	Land use (ha)[1]	Value ($/ha)
Dubbo Regional LGA	Livestock	$46.08	395,906	$116.39
	Cropping	$20.62	222,822	$92.54

Note: Per ABARES 2021a, Catchment scale land use of Australia – update December 2020 and ABS 2017, Value of Agricultural Commodities Produced, Australia, 2015-16 (Table 3.12).

4 Erosion hazard analysis

The process for the assessment of erosion hazard in NSW is detailed in Section 4.4.1 of Landcom (2004). It is a two-part process that firstly considers the overall project erosion hazard in considering slope and rainfall erosivity (R-Factor). This is followed by a more detailed assessment where land soil loss classes (SLC) are determined using annual soil loss, calculated using the revised universal soil loss equation (RUSLE) with site specific slopes and a nominal slope length of 80m. The SLC dictates specific erosion management and mitigation measures as detailed in Landcom (2004).

An assessment of the erodibility of the soil itself is important as the presence or absence of a highly erodible dispersive soil will significantly influence the project drainage, erosion and sediment control requirements.

When a sodic soil (exchangeable sodium percentage (ESP) >6%), or a magnesic soil (exchangeable magnesium percentage (EMP) >20%) comes into contact with non-saline water, water molecules are drawn in-between the clay platelets causing the clay to swell to such an extent that individual clay platelets are separated from the aggregate. This process is known as dispersion. Dispersive soils have an extreme rill, gully and tunnel erosion risk and can erode irrespective of surface treatments (eg rock lining) applied to the soil surface.

4.1 Soil erosion hazard analysis

The erosion potential of a soil is determined by its physical and chemical properties and is expressed as its K-Factor (t.ha.h)/(ha.MJ.mm). Table 4.1 provides a soil erodibility ranking for K-Factor from Rosewell (1993).

Table 4.1 Rosewell (1993) soil erosion ranking

K-Factor (t ha h $ha^{-1}MJ^{-1}mm^{-1}$)	Erosion potential
<0.02	Low
>0.02 to <0.04	Moderate
>0.04	High

The modelled K-Factors for the project site were determined from the eSpade 2.1 database (DPIE 2020a). The modelled K-Factors range from 0.03–0.05 t ha h $ha^{-1}MJ^{-1}mm^{-1}$, which indicate that the project topsoils have a moderate to high erosion potential.

Site specific soil testing show subsoils in the vicinity of the laydown area to be strongly sodic and the remainder of the subsoils to be magnesic and therefore have potential to disperse.

Landcom (2004) recommends increasing the K-Factor for dispersive soils by 10% but provides no scientific justification for this. Loch *et al.* 1998 measured and range of various sodic soils across NSW and QLD with K-Factors ranging from 0.056–0.106 t ha h $ha^{-1}MJ^{-1}mm^{-1}$. A K-Factor of 0.071 t ha h $ha^{-1}MJ^{-1}mm^{-1}$ has been adopted to determine the erosion hazard of project subsoils.

4.2 Slope and rainfall erosivity erosion hazard analysis

The overall project water erosion hazard is determined using the process described in section 4.4.1 of Landcom (2004); however, as it does not consider the K-Factor, the erosion hazard can be considerably underestimated. If a low erosion hazard is determined, no further delineation of erosion hazard is required. If a high erosion hazard is determined, then further assessment to determine the SLC is required.

SLCs are determined by calculating the annual average soil loss using the RUSLE with a nominal 80 m slope length and soil surface cover factor (C-Factor); RUSLE calculates the annual average erosion in tonnes per hectare per year (t/ha/yr) from rill and inter-rill (sheet) erosion. It does not consider gully or tunnel erosion and does not calculate peak erosion. Landcom (2004)[1] nominates additional requirements for land of SLC 4 and higher.

The first step in the hazard assessment uses a nomograph from Figure 4.6 of Landcom (2004) (reproduced as Figure 4.1) that considers slope of the land and the Rainfall Erosivity (R-Factor) to provide a low or high erosion hazard.

The rainfall erosivity (R-Factor) is calculated using the formula:

$$R= 164.74\ (1.1177)^{S}\ S^{0.6444}$$

where, S is the 0.5EY, 6-hour event in mm/h (Rosewell & Turner 1992). For the project S equals 7.20 mm/h (BoM 2020). The calculated R-Factor for the project is 1,310 $MJmmha^{-1}h^{-1}$.

The project has average slopes ranging from 3.5% to 5.8% (Figure 3.2).

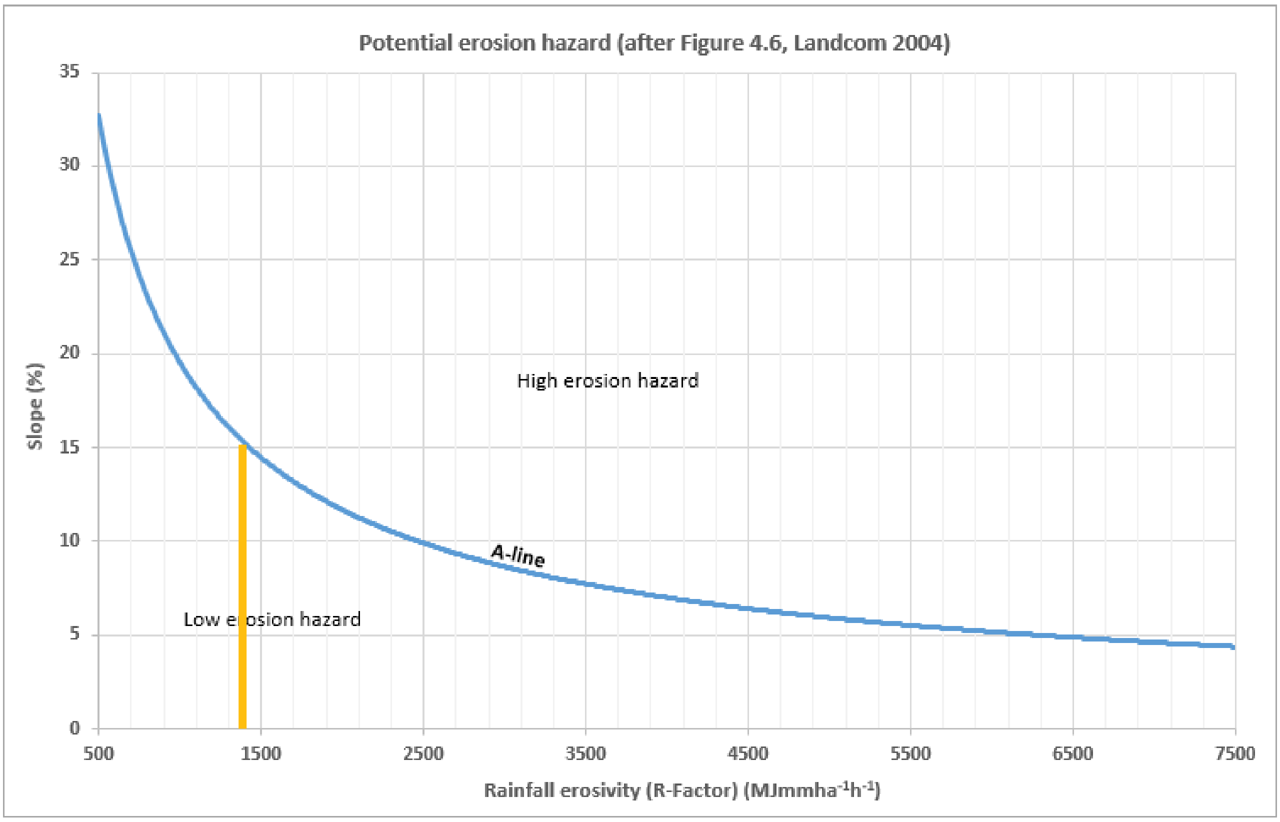

Figure 4.1 Assessment of potential erosion hazard (Landcom 2004)

Applying these parameters to the erosion hazard nomograph results in a low erosion hazard due to slope and rainfall erosivity, and determination of the SLC's is therefore not required. Any slopes greater than 15% will have a high erosion hazard. Both the indicative landscaping area and TransGrid substation upgrade works area have individual maximum slopes exceeding 15% (16.24% and 15.37% respectively), however the mean slope for these areas is well below 15%. Spatial analysis of the project site slopes is shown in Table 3.1.

Source: EMM (2022); AMPYR (2021); ESRI (2021); DFSI (2017); OEH (2017); ICSM (2014)

0 0.5 1 km

GDA 1994 MGA Zone 55

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KEY

Development boundary

Major road

Minor road

Topographic contour (10 m)

Strahler stream order

1st order

2nd order

3rd order

9th order

Soil erosion (bare)

<20 t/ha/yr

20 - <50 t/ha/yr

50 - <200 t/ha/yr

200 - <500 t/ha/yr

500 - 1,000 t/ha/yr

eSPADE modelled soil erosion

Wellington Battery Energy Storage System
Land, soils and erosion assessment
Figure 4.2

EMM creating opportunities

Annual average erosion due to sheet and rill erosion in t/ha/y modelling using the Revised Universal Soil Loss is calculated in Table 4.2.

Table 4.2 Modelled annual average soil erosion

Parameter	Substation/BESS	Laydown area	TransGrid substation upgrade works area
Rainfall Erosivity (R-Factor)	1,310 $MJmmha^{-1}h^{-1}$	1,310 $MJmmha^{-1}h^{-1}$	1,310 $MJmmha^{-1}h^{-1}$
Soil erodibility (K-Factor)	0.071 t ha h $ha^{-1}MJ^{-1}mm^{-1}$	0.071 t ha h $ha^{-1}MJ^{-1}mm^{-1}$	0.071 t ha h $ha^{-1}MJ^{-1}mm^{-1}$
Length/slope (LS-Factor) (Landcom 2004)	2.53	1.26	1.82
Area	9.27 ha[1]	1.50 ha	6.54 ha[2]
Conservation practice (P-Factor) Landcom 2004)	1.3	1.3	1.3
Cover (C-Factor) Landcom 2004)	1	1	1
Annual average soil loss (t/ha/y)	2835.8	228.5	1439.2
Annual average soil loss for area (t/y)	**305.9**	**152.4**	**220.1**

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2. Or simply delete these lines of text if not required.

The two key triggers for sediment basins in Landcom 2004 are a disturbed area greater than 2,500 m^2 and an annual average soil loss greater than 150 t/y off the disturbed area. These are triggered for the substation/BESS, TransGrid substation upgrade works area and laydown area. The laydown area only just achieves an average soil loss greater than 150 t/y which could be potentially reduced by using temporary stabilising measures such as trafficable soil stabilising polymers or the use of gravelled hardstand to reduce soil loss below the threshold of 150 t/y.

5 Impact assessment

5.1 Land and soil capability

5.1.1 Construction soil impacts

The soil disturbance during construction has the potential to result in the following impacts:

- reduction in soil stability and increased susceptibility to erosion due to vegetation removal or soil exposure, especially as the subsoil is sodic and dispersive in areas;
- erosion of soil due to exposing soils, disturbing dispersive subsoils and concentration of flow;
- loss of structure and water holding capacity due to mechanical compaction;
- loss or degradation of topsoil material viable for use in rehabilitation;
- introduction of salinity or sodicity into the topsoil material if soil is inadequately managed;
- risk of exposing buried contaminants (pesticides and hydrocarbons); and
- introduction of contaminants into soil material (eg hydrocarbons from plant).

i Soil mixing

Impacts on soils and LSC are typically a function of topsoil loss or degradation during construction and/or soil inversion due to poor soil management. Topsoil has the highest biological activity, organic matter, and plant nutrients which are all key components of a productive soil. The potential loss of this upper layer of soil impacts the ability of the soil to provide nutrients, regulate water flow, and resist pests and disease.

Inappropriate separation of topsoil and subsoils during stripping and stockpiling can result is less fertile topsoils due to introduced constraints or potentially constrained subsoils forming the upper of the soil profile. Mixing of the soil profile can also result in increased stoniness of surface soils impacting the ability to cultivate the soil. Given the anticipated nature of the subsoils encountered in the project site inappropriate soil handling practices represents a key risk for land and soil capability.

Loss of nutrients and nutrient holding capacity, results in a less fertile environment for crop and pasture production. The organic matter and finer soil particles, primarily clays, responsible for soil fertility can be readily eroded when exposed leaving larger, less reactive particles such as sand and gravel.

ii Compaction

Topsoil degradation can result in organic matter reduction which can lead to soil density increases and subsequent compaction. Compaction lowers the infiltration rate of water into the soil profile and reduces the plant available water holding capacity. Compaction also reduces gaseous exchange. Lower organic matter levels are also associated with weaker soil aggregates and therefore greater risk of further erosion and soil crusting, exacerbating the noted hard setting limitation described in Section 3.4.

Construction equipment, such as plant movement, can also compact the soil resulting in reduced water holding capacity, increased runoff and therefore erosion potential and reduced plant root and shoot penetration.

5.1.2 Operation soils impacts

Impacts to soils during operation are expected to be minimal however legacy issues from inappropriate design and construction could include:

- erosion of soil resources to excessive concentration of flow and inappropriate channel lining and flow energy dissipation;
- tunnel erosion in cable trenches due to inadequately compacted and ameliorated dispersive subsoils; and
- exposure of dispersive soils in cut and fill batters and excavations.

5.1.3 Changes to project land and soil capability

As described in Section 3.4.5, indicative site assessment of LSC and the eSPADE database (DPIE 2020a) and DPIE (2020c), LSC mapping has determined the project site is mapped at the state scale as LSC Classes 3 and 6 which represent land with high to low capability for productive use without resulting in land degradation, but is predominantly Class 6 with low capability for productive use.

Lands subject to permanent infrastructure will not be able to be used for cropping or cattle grazing once constructed. The lands are currently used for cattle grazing.

The land will not be available for agriculture during the life of the project. However, the LSC status of lands subject to infrastructure with a small footprint or temporary disturbances will be able to be maintained or reinstated following appropriate landform design and rehabilitation.

It is expected the LSC status of most of the project disturbances will be able to be re-established if the recommended management and mitigation measures are implemented.

Appropriate management and mitigation techniques are provided in sections 6 and 7.

5.1.4 Agricultural productivity impacts

Extrapolating from data contained in sections 3.6 and 3.8 the 19.3 ha of the project disturbance area, if fully developed, would encompass some 14.99 ha of land in the project site used for grazing as per Table 3.10. Were this 14.99 ha to be developed (change of use) it would be valued at approximately $1,894.59 in annual productivity based on estimated agricultural values for the Dubbo Regional LGA (Table 5.1). The project development boundary of 13.3 ha encompasses some 8.94 ha of grazing land and would have an estimated annual productivity value of approximately $1,040.53.

Table 5.1 Estimated Project land value

Area	Commodity sector	Estimated land value ($/ha)	Project site (ha)[1]	Project land value ($)
Dubbo Regional LGA	Livestock	$116.39	14.99	$1,894.59
	Cropping	$92.54	NA	NA
			TOTAL	**$1,894.59**

Given the small disturbance area this is not a significant loss of agricultural land value based on annual productivity. Once the project reaches the end of its investment and operational life, the project infrastructure will be decommissioned and the project site returned to its pre-existing land use, namely suitable for grazing of sheep and cattle, or another land use as agreed by the project owner and the landholder at that time.

Project impacts are anticipated to be limited primarily to the direct project site with minimal impact to adjacent lands.

5.2 Erosion and sediment control

5.2.1 Construction erosion and sediment control impacts

Potential construction erosion and sediment control impacts include:

- downstream or offsite discharge of sediment and turbid run-off from the erosion of exposed soils particularly dispersive subsoils:
  - degradation of stock drinking and irrigation water;
  - infilling of waterway pools; and
  - diversion of waterway flow due to sediment deposition and associated bed and bank erosion;
- erosion and subsequent sedimentation of creeks and waterways due inappropriately designed and constructed watercourse crossing;
- mud tracking from vehicles and machinery to public roads;
- increased potential for rill and gully erosion due to modification of flow conditions from sheet flow to concentrated flow from constructed land forms (roads, tracks, hardstands) and drains;
- incision and widening of downstream drainage lines due to modification of the run-off hydrograph due to an increase in impermeable surface such as roads, hardstands, roofs and other infrastructure;
- tunnel erosion under or beside foundations for towers, light poles etc and along cable trenches due to dispersive soils; and
- dust emissions from unsealed roads, hardstands and exposed soils.

5.2.2 Operational erosion and sediment control impacts

Potential operational erosion and sediment control impacts include:

- offsite discharge of sediment and turbid run-off from on-going erosion from drainage, landform and infrastructure design not cognisant of dispersive subsoils;
- increased maintenance costs for on-going stabilisation of landforms, roads, drains and cable trenches;
- operation and maintenance of sediment control structures due to on-going erosion;
- tunnel erosion under or beside foundations for towers, light poles etc and along cable trenches due to dispersive soils; and
- dust emissions from unsealed roads, hardstands and exposed soils.

Appropriate management and mitigation techniques are provided in sections 6 and 7.

6 Management of impacts

AMPYR will adopt the following soils, drainage, erosion and sediment control management strategies to address the identified LSC and erosion and sedimentation impacts.

6.1 Mitigation measures

6.1.1 Land and soil capability

As part of the Construction Environmental Management Plan (CEMP) for the project, soil management measures are recommended to ensure the preservation of soil resources, including:

- assessment of topsoil depths to be stripped prior to stripping to minimise the mixing of topsoil and subsoil;
- attempt to strip and manage different soils types separately;
- avoid mixing topsoil with subsoil during stripping operations;
- avoid stripping topsoil following heavy rain periods that leaves the soil structure saturated;
- avoid compaction of topsoil during stripping and stockpiling operations;
- amelioration of topsoil and, where necessary, subsoil during stripping operations in accordance with a soil scientists' recommendations. Ameliorants should be applied prior to stripping of their respective layers, to maximise mixing of the ameliorants during the stripping process;
- stockpile topsoil separately from subsoil (if it is necessary to strip subsoil);
- where practical and possible, the subsoils and topsoils should be located so that stockpiled material is placed on the same underlying soil unit;
- protection of stockpiles from erosion using soil stabilising polymers, cover crops or other forms of stabilisation;
- revegetation of long-term topsoil stockpiles with native plant community types to minimise stockpile water logging, the generation of anaerobic conditions, help maintain topsoil biological viability and to create a seed store; and
- test stockpiled subsoil and topsoil to determine amelioration requirements prior to reinstatement.

It is assumed that preserving and rehabilitating land and soil resources in a suitable condition, comparable to the established baseline conditions, will restore agriculture to pre-construction production capability.

6.1.2 Erosion and sediment control

AMPYR has generally planned the location of project infrastructure to utilise the existing topography where practicable, to avoid major land reshaping during the construction phase and rehabilitation phase as far as possible, and to minimise land disturbance and the alteration of drainage patterns. Some cut to fill will be required for the both the battery energy storage system, substation and laydown area.

As dispersive subsoils are present within the project site, the drainage and landform design will need to:

- avoid concentration of flow and maintain sheet flow conditions where practicable;
- avoid excavating drains in dispersive soils and locate roads, hardstands and pads to utilise the natural slope so that water drains away as required;
- maintain the velocity of flows below 0.3 m/s;
- avoid the use of structures that pond water and can cause tunnel erosion such as check dams and channel banks in concentrated flows and benches on cut and fill batters;
- use back-push diversion in lieu of channel banks if it is necessary to divert flow;
- ameliorate dispersive soils particularly in cable trenches and fill embankments where there is a high risk of tunnel erosion; and
- use high efficiency sediment basins (Type B) with flow activated dosing systems to treat turbid runoff to protect downstream receivers.

A site-specific soil sampling program is recommended to be undertaken to identify erosion and agronomic soil constraints as part of project planning/design.

i Minimising the extent and duration of land disturbance

As part of the CEMP, land disturbance processes will be developed to ensure unnecessary land disturbance does not occur, including provision for site inspection by the site Environmental Manager or delegate prior to disturbance to identify any necessary environmental, cultural, drainage and erosion and sediment controls are planned and implemented as required.

Initial earthworks and major land disturbing activities to avoid high rainfall erosivity period (summer storm season) November through to March where practical to minimise erosion. Where major land disturbing works need to occur in high rainfall erosivity periods then a commensurate level of erosion and sediment control needs to be adopted.

Sediment and turbid runoff are only generated when erosion occurs therefore progressive stabilisation and rehabilitation of disturbed areas is fundamental to successful erosion and sediment control. The timing of stabilisation and rehabilitation works needs to consider:

- proximity to sensitive receptors;
- soil erosivity;
- slope gradient and length;
- time of year (rainfall risk); and
- site access.

Table 6.1 provides guidance on the recommended timing and C-Factors of stabilisation and rehabilitation works with soil erosion risk as the main determining factor as required by Landcom (2004).

Table 6.1 Maximum C-Factors during construction and post-construction[1]

Feature/area	C-Factor	Requirement
During construction		
Waterways and land below the 2y ARI flood levels including stockpiles	0.10	When working in waterways and flood prone lands a C-Factor of ≤0.1 is to be achieved if the 3-day forecast indicates rain causing runoff is likely.
Land above 2yr ARI flood levels flood levels (including stockpiles).	0.15	A C-Factor of ≤0.15 is to be achieved within 20 working days of inactivity, even though works might continue later.
Post construction		
Waterways and other areas subjected to concentrated flows	0.05	Applies after 10 working days from completion of formation and before they are allowed to carry any concentrated flows.
Stockpiles	0.10	Applies after 10 working days from completion of formation. Maximum C-Factor of 0.10 equals 60 percent ground cover
All other land	0.15	In periods of expected 'low' rainfall erosivity during the rehabilitation period, achieve a C-Factor of less than 0.15. Maximum C-factor of 0.15 equals 50% ground cover
	0.10	In periods of 'moderate' to 'high' rainfall erosivity during the rehabilitation period, achieve a C-Factor of less than 0.1. Set in motion a program that should ensure it would reduce permanently to less than 0.05 within a further 60 days.

ii Controlling water movement through the site

The following water movement measures are recommended for the site:

- Clean upslope run-on should be diverted around areas of ground disturbance to minimise the erosion potential and volume of turbid runoff that needs to be treated. Linear topsoil stockpiles should be able to be used for this purpose upslope of the anticipate cut batters required for both the Substation/BESS and laydown area landforms.
- Access tracks should be designed and constructed to avoid the concentration of flow where possible. The roads should have a crowned profile in most instances with a minimum cross fall of 4% to minimise the formation of corrugations, with infall and outfall drainage only where necessary.
- Track drainage should be turned out using back push diversion banks or trapezoidal mitre drains where possible. Drains will need to be lined (generally rock) where flow velocities exceed the maximum permissible velocity of the soil.
- Track surfaces should be stabilised using a soil stabilising polymer emulsion design to minimise erosion, turbid runoff, dust emissions, watering and maintenance.
- The waterway crossings should be a low-level concrete causeway with low flow culverts and a stilling pond type energy dissipator to minimise erosion of the watercourse downstream of the crossing.
- Early installation of the causeway should be a priority during track construction to allow the safe passage of clean run-on water.

- Rainfall falling onto the roofs of offices and workshop facilities is clean water and should be captured using gutters and stored in tanks for re-use and overflows directed away from active construction areas.
- Turbid water runoff from the substation/BESS, laydown and where practicable, access tracks should be diverted to Type B sediment basins for treatment.
- Sediment Basins should be constructed as a priority before any other land disturbances to maximise the capture of sediment and turbid runoff.
- Fuel storages should be self-bunded and other hydrocarbon and chemical storages bunded in accordance with AS1940.

iii Minimise soil erosion

The most effective form of sediment control is erosion control. Sediment and turbid water are only generated when erosion occurs. Effective erosion control must be a fundamental component of AMPYR drainage, erosion and sediment control strategies.

The types of erosion that can potentially occur on the project are:

- raindrop splash erosion;
- sheet erosion;
- rill erosion;
- gully erosion;
- chemical erosion (dispersion); and
- creek bed and bank erosion.

Raindrop splash erosion is most effectively controlled by providing soil surface cover. This can be achieved within the project site by:

- minimising the extent and duration of soil disturbance;
- retaining vegetation and other soils surface cover (gravel, rock, timber debris);
- progressively stabilising and rehabilitating disturbed areas; and
- covering and binding exposed soils with soil stabilising polymers, vegetation and gravel.

Rill erosion is effectively controlled by minimising slope length and gradient. This can be achieved within the project site by:

- ensuring cut and fill batters are flatter than 1(v):3(h) so that they can be topsoiled and successfully rehabilitated;
- minimising disturbance to steeply grading areas where possible;
- maintaining sheet flow conditions where possible;
- reducing slope gradient and length;

- avoiding disturbance to dispersive soils;
- treating dispersive soils with gypsum; and
- progressively revegetating disturbed areas.

Gully erosion is effectively controlled by minimising the concentration of flow and slowing flow velocity. This can be achieved within the project site by:

- maintaining sheet flow where possible;
- using trapezoidal shaped, low gradient mitre drains on tracks to divert flow off the tracks to stable grassed areas at regular intervals;
- lining drains where flow velocities exceed the maximum permissible velocity of the soil (temporary and permanent);
- avoiding disturbance to dispersive soils;
- treating dispersive soils with gypsum if disturbed; and
- progressively stabilising and revegetating disturbed areas.

Chemical erosion is effectively controlled by minimising the disturbance of dispersive soils and maintaining sheet flow conditions. This can be achieved in the project sites by:

- avoiding the concentration of flow where dispersive soils are present;
- utilising the natural topography for water management where possible;
- avoiding the use of excavated drains and channels;
- avoiding ponding water on areas of dispersive soil (not using check dams, channel banks, benches etc);
- avoiding disturbance of dispersive soils;
- treating dispersive soils with gypsum if disturbed particularly in cable trenches and pipelines;
- running cable trenches along the contour instead of down gradient; and
- using trench breakers that extend into the insitu soils in cable trenches as per Figure 6.1.

Energy dissipaters will need to be used at the outlets of drains and spillways to reduce flow velocities to less than the maximum permissible velocity for the soil type. Stilling pond and roughness type dissipators are recommended.

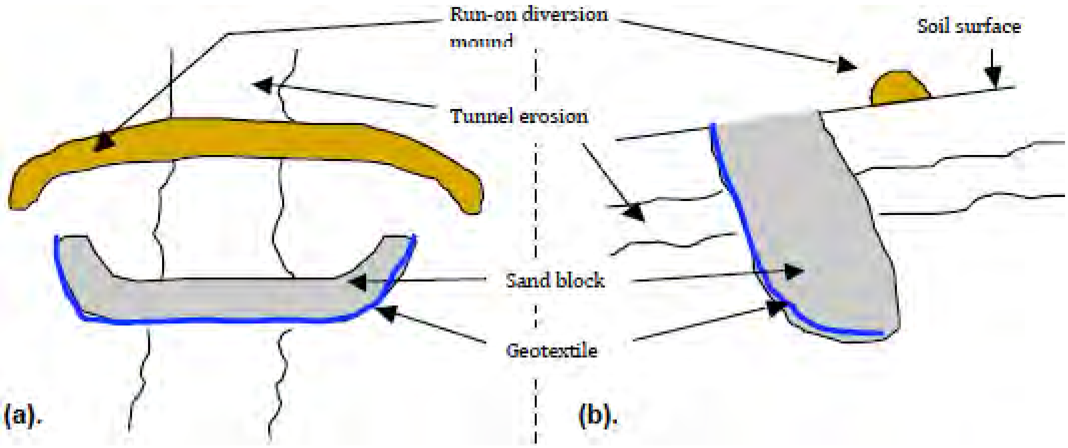

Figure 6.1 Cable trench breaker layout for dispersive soils (DPIW 2009)

iv Promptly stabilising disturbed areas

As recommended in Section 6.1.2, progressive stabilisation and rehabilitation of disturbed areas should be undertaken to minimise erosion and the generation of sediment and turbid runoff. Due to the gentle slope gradients on site and presence of suitable quality topsoil, bonded fibre matrix hydro-mulches (BFM) are considered appropriate for site rehabilitation purposes.

It is EMM's experience that the Australian made straw based BFM's are the most appropriate and cost effective for direct seeding of vegetation on slopes up to 1(v):2(h). Topsoil should not be applied to slopes steeper than 1:2 as there is a risk it will slump. For slopes steeper than 1:2 a hydraulically applied growth medium (HGM) is recommended. Recommended application rates for BFM and HGM are provided in Table 6.2.

Table 6.2 Recommended HGM application rates

Slope gradient	Organic matter	Binder
<1(v):3(h)	4,000 kg/ha	As per supplied in the bag
>1:3 but ≤1:2	6,000 kg/ha	Additional 400L/ha EnviroBinder™
>1:2	8,000 to 10,000kg/ha	Additional 600L/ha EnviroBinder™

AMPYR will ensure that non-water soluble, mineral based, biologically inoculated fertilisers are used in any revegetation works to not impact on background landowners participating in organic or carbon farming initiatives.

v Maximise sediment retention on site

As discussed in Section 6.1.2, the most effective form of sediment control is erosion control. Irrespective of how well designed and implemented erosion control is on site, sediment and turbid water will always be generated from exposed areas during rainfall events.

Type 2 and 3 sediment controls (silt fences, check dams) will be ineffective at protecting the site creek from turbid runoff from the clay and dispersive clay soils are present within the project. Type B high efficiency sediment basins with flow activated dosing systems are recommended where calculated soil loss exceeds 150 t/y from disturbed areas (applicable to the substation/BESS area, laydown area and TransGrid substation upgrade works area) or control of turbidity is required to protect creek systems. As discussed in Section 4.2, EMM considers that using enhanced erosion control measures, such as trafficable soil stabilising polymers or gravelled hardstand, in the construction laydown area could reduce soil loss below the threshold of 150 t/y and remove the requirement for a sediment basin.

In-stream sediment controls should be avoided where possible by scheduling works in creeks to avoid the summer storm season.

It is recommended that AMPYR implement a Water Movement Permit system on site to minimise the potential for accidental turbid water discharge during pumping and dewatering activities on site. Water Movement Permits are generally issued by the site Environmental Manager or delegate.

vi Maintain drainage, erosion and sediment control measures

Drainage, erosion and sediment control measures should be implemented at all times until their function is no longer required.

Inspections of control measures need to be undertaken following rainfall that causes run-off or monthly during dry conditions.

Inspections should be undertaken by the site Environmental Manager or delegate. That person shall have the following knowledge:

- an understanding of site environmental values that could be impacted by site construction and operation;
- an understanding of the requirements of the Ministers Conditions of Approval and Environmental Protection Licence that are relevant to drainage, erosion and sediment control;
- a good working knowledge of drainage, erosion and sediment control fundamentals and the project specific application thereof;
- ability to provide advice and guidance on appropriate measures and procedures to maintain the site at all times in a condition representative of regionally specific best practice, and that is reasonably likely to achieve the required standards; and
- a good working knowledge of the correct installation, operation and maintenance procedures for the full range of drainage, erosion and sediment control measures used on the project.

AMPYR will need to maintain control measures to maximum practicable extent so that control measures:

- will best achieve the sites required environmental protection including achieving the water quality criteria specified in the Environmental Protection Licence in the nominated design storm event;
- are in accordance with the specified operational standard for each drainage, erosion and sediment control measure; and
- prevents or minimises safety risks.

All water, debris and sediment removed from control measures shall be disposed of in a manner that will not create an erosion or pollution hazard.

vii Monitor and adjust drainage, erosion and sediment control practices to achieve the desired performance standard.

It is recommended that a hierarchical ESC planning system be adopted for construction and operation of the project consisting of an overarching project wide ESCP with Progressive ESCPs for all disturbance areas to ensure that the projects ESCPs are dynamic documents that can and will be modified as site conditions change, or if the adopted control measures fail to achieve the desired treatment standard.

The ESCPs are recommended to be prepared and certified by a suitably qualified and experienced Certified Professional in Erosion and Sediment Control (CPESC).

If a site inspection or environmental monitoring identifies a significant failure of the adopted drainage, erosion and sediment control measures, a critical evaluation of the failure should be undertaken to determine the cause and appropriate modifications made to the control measures on site and ESCPs amended.

viii Drainage, Erosion and Sediment Control Competence

All project personnel including contractors are recommended to have an appropriate level of drainage, erosion and sediment training. Three levels of competency training for personnel are recommended:

- Level 1 – basic awareness level training and provided during the site induction;
- Level 2 – half day training for foreman, engineers, project managers etc on the legal aspects of drainage, erosion and sediment control, fundaments and site-specific strategies, techniques and requirements; and
- Level 3 – detailed one day training course where drainage, erosion and sediment control is a regular component of their daily activities and competence is required.

7 Rehabilitation

At the end of the project design life, the site will be rehabilitated to a condition as near as practicable to the condition that existed prior to construction of the facility and in consultation with the landowner.

Initial rehabilitation will involve removal of the laydown area. Any road base or gravel will be stripped and removed; pre-existing landforms will be re-established by pushing any fill material back into the cuts (if required). Stripped topsoil will be re-spread over the entire area and then seeded with appropriate grass and legume species.

Rehabilitation of the substation/BESS will involve the removal of all infrastructure – cables within cable trenches, overhead powerlines, tracks, substations, battery storage and all other infrastructure associated with the project other than that requested by the background landowners to remain. Examples of infrastructure that may remain may include access roads, hard stand areas, sheds and tracks.

It is expected that any watercourse crossing causeways will remain for future use by landowner.

EMM recommends that a soil sampling program be undertaken as part of subsequent project planning/design so that the depth of topsoil and subsoil is understood. This can be used to guide minimum soil depths for rehabilitation works so that the pre-project LSC can be re-established, particularly in areas where hardstands, tracks and sediment basins are removed.

Stripping and preservation of topsoil resources is a key component of rehabilitation planning, and it is recommended that AMPYR develop suitable soil stripping management practices that guide the stripping and long-term management of topsoil resources.

Species for rehabilitation will be cover crops, legumes and pasture species as agreed with the landowner.

8 Conclusion

8.1 Suitability of the site

The site suitability with respect to land, soils and erosion is adequate, being located in proximity to already disturbed areas, such as the existing substation, and being located and land of comparably low land capability and productivity compared to surrounding areas. The surrounding areas of better land capability have already been disturbed and utilised for other projects, such as the Wellington Solar Farm, and the minor footprint of the project site further reduces likely impacts.

8.2 Evaluation of the project

This land and rehabilitation assessment has considered available mapping for the project to characterise the existing environment and identify land, soil and erosion constraints within, and impacts arising from, the Wellington BESS project. The assessment recommends mitigation measures to reduce the impacts from the project wherever possible.

8.2.1 Soil assessment

Most of the site footprint is located on Ferrosol soil types. Ferrosols generally have high agricultural potential due to good structure and moderate to high chemical fertility and water holding capacity. The soil landscapes present both have noted soil erosion risks, particularly where surface cover is low or under cultivation. Soil management practices will be key to maintain suitable soil cover and minimise exposure of erosion-prone subsoils.

With reference to the eSPADE database (DPIE 2020a) and DPIE (2020c), the project site is mapped at the state scale as LSC Classes 3 and 6, predominantly Class 6. These LSC classes represent land with high (Class 3) to low (Class 6) capability for productive use without resulting in land degradation. The site suitability with respect to agriculture considers the inherent LSC class in addition to the extensive amount of land utilised for agriculture within the LGA, of which the project is a very minor area.

Whilst the land and soil capability of agricultural lands in the project site are unlikely to change from their current capability, provided appropriate management and mitigation measures are implemented, the lands will be effectively unavailable for agricultural use during the life of the project.

Impacts to adjacent land relevant to agriculture are expected to be minimal, with the primary potential impact being associated with sediment deposition or erosion from the project site, which can be suitably managed and mitigated.

8.2.2 Erosion and sediment control

Site subsoils have a high erosion potential due to their sodic and/or magnesic properties. The project civil design needs to include the recommended management and mitigation measures for dispersive soils detailed in chapter 6 otherwise erosion and associated sedimentation in the construction and operational phases can be anticipated. If the recommended measures are implemented, then the erosion and subsequent sedimentation risk will be low with minimal residual impacts.

Both the substation/BESS and TransGrid substation upgrade works area will require the construction of sediment basins during the construction phase, whilst the construction laydown area could require a sediment basin as discussed in Sections 4.2 and 6.1.2v. Type B sediment basins with flow activated dosing systems are recommended for the following reasons:

- they are capable of treating up to 80% of the turbid water runoff from the disturbed areas providing far greater levels of protection for downstream waters;
- the design allows for retention of water for construction purposes reducing reliance and the cost associated with importing water;
- water treatment costs are less than conventional batch basins; and
- there is less risk to personnel that do not have to apply coagulants and/or flocculants during periods of rainfall or wet ground conditions.

Abbreviations

Item	Definition
ABS	Australian Bureau of Statistics
AC	Alternating current
ACHA	Aboriginal cultural heritage assessment
AHIMS	Aboriginal Heritage Information Management System
AMPYR	AMPYR Australia Pty Ltd
BESS	Battery energy storage system
BSAL	Biophysical strategic agricultural land
CEEC	Critically endangered ecological community
CWO	Central-West Orana
DC	Direct current
Disturbance footprint	Land that would be disturbed for the construction and operation of the project, including access routes and transmission connections.
DPI	Department of Primary Industries
DPE	Department of Planning and Environment
EEC	Endangered ecological community
EIS	Environmental Impact Statement
EMM	EMM Consulting Pty Limited
EPA	NSW Environment Protection Authority (EPA)
EP&A Act	NSW *Environmental Planning and Assessment Act 1979*
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
ESC	Erosion and sediment control
ESP	Exchangeable sodium percentage
ha	hectares
km	kilometres
kV	Kilovolt
LEP	Local Environmental Plan
LGA	Local government area
LSC	Land and soil capability
MW	Megawatts
Non-associated residences	Residences near the project site that are not the subject of an access licence and option agreement (landholder agreement).
NSW	New South Wales
PV	Photovoltaic

Item	Definition
REZ	Renewable Energy Zone
SEARs	Secretary's Environmental Assessment Requirements
SIA	Social impact assessment
SSD	State significant development

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Annexure A

Soil chemistry data

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A.1 WB01

Table A.1 Site WB01 – nutrient chemistry data

Depth (m)	pH (H_2O)	Nitrate nitrogen (mg/kg)	Soil Fertility[1]								Organic matter (%)	Boron (mg/kg)	Sulfate sulfur (mg/kg)	Trace Elements (Extractable)			
			Total nitrogen		Bicarbonate extr. P (Colwell)		Total organic carbon		Exch. potassium cations					Copper (mg/kg)	Zinc (mg/kg)	Manganese (mg/kg)	Iron (mg/kg)
			(%)	Rating	(mg/kg)	Rating	(%)	Rating	(meq/100 g)	Rating							
0–0.1	7.06	14.6	0.22	M	40.2	H	1.92	M	1.24	VH	3.36	1.25	15.6	25	46	572	31300

Table A.2 Site WB01 – soil profile chemistry data

Depth (m)	Particle size (%)[2]					pH (H_2O)	EC (dS/m)	EC rating[3]	Cl^- (mg/kg)	Exchangeable cations (meq/100 g)						ESP (%)	Sodicity (NS, S, SS)	Emerson Class	Ca:Mg ratio
	Clay	Silt	Fine Sand	Coarse Sand	Gravel					Al^{+3}	Ca^{+2}	Mg^{+2}	K^+	Na^+	CEC				
0–0.1	21.5	9.6	24.4	38.7	5.8	7.1	0.08	VL	9.1	0.00	7.78	1.05	1.24	0.04	10.10	0.4	NS	3b	7.4
0.2–0.3	31.0	5.1	20.2	21.9	21.8	7.3	0.05	VL	4.71	0.00	9.32	1.83	1.27	0.07	12.50	0.5	NS	3b	5.1
0.4–0.5	42.6	5.8	19.6	18.1	13.9	8.3	0.15	L	4.81	0.00	9.58	2.08	0.92	0.04	12.60	0.3	NS	4	4.6

Notes: 1. Bruce & Rayment (1982) ratings – very low (VL), low (L), moderate (M), high (H), very high (VH).

2. Gravel (>2 mm), Coarse sand (0.2–2 mm), Fine sand (0.02–0.2 mm), Silt (2-20 µm), Clay (<2 µm).

3. Rayment & Lyons (2011) – very low salinity (VL), low salinity (L), moderately saline (M), highly saline (H), extremely saline (E).

A.2 WB02

Table A.3 Site WB02 – nutrient chemistry data

Depth (m)	pH (H_2O)	Soil Fertility[1]										Organic matter (%)	Boron (mg/kg)	Sulfate sulfur (mg/kg)	Trace Elements (Extractable)			
		Nitrate nitrogen (mg/kg)	Total nitrogen		Bicarbonate extr. P (Colwell)		Total organic carbon		Exch. potassium cations						Copper (mg/kg)	Zinc (mg/kg)	Manganese (mg/kg)	Iron (mg/kg)
			(%)	Rating	(mg/kg)	Rating	(%)	Rating	(meq/ 100 g)	Rating								
0–0.1	6.10	8.8	0.19	M	19.3	L	1.80	M	0.56	H		1.99	0.51	14.1	20	24	272	28,300

Table A.4 Site WB02 – soil profile chemistry data

Depth (m)	Particle size (%)[2]					pH (H_2O)	EC (dS/m)	EC rating[3]	Cl^- (mg/kg)	Exchangeable cations (meq/100 g)						ESP (%)	Sodicity (NS, S, SS)	Emerson Class	Ca:Mg ratio
	Clay	Silt	Fine Sand	Coarse Sand	Gravel					Al^{+3}	Ca^{+2}	Mg^{+2}	K^+	Na^+	CEC				
0–0.1	14.1	6.9	33.3	30.4	15.3	6.1	0.06	VL	9.32	0.00	2.81	1.06	0.56	0.22	4.64	4.8	NS	3a	2.7
0.2–0.3	42.6	4.0	18.4	30.4	4.6	8.4	0.16	L	126	0.00	4.33	3.86	0.33	3.02	11.50	26.2	SS	1	1.1
0.35–0.45	42.7	3.7	20.0	20.8	12.8	9.5	0.51	M	441	0.00	3.81	4.32	0.32	4.55	13.00	35.0	SS	3b	0.9

Notes: 1. Bruce & Rayment (1982) ratings – very low (VL), low (L), moderate (M), high (H), very high (VH).

2. Gravel (>2 mm), Coarse sand (0.2–2 mm), Fine sand (0.02–0.2 mm), Silt (2-20 µm), Clay (<2 µm).

3. Rayment & Lyons (2011) – very low salinity (VL), low salinity (L), moderately saline (M), highly saline (H), extremely saline (E).

A.3 WB03

Table A.5 Site WB03 – nutrient chemistry data

Depth (m)	pH (H_2O)	Nitrate nitrogen (mg/kg)	Soil Fertility[1] Total nitrogen (%)	Total nitrogen Rating	Bicarbonate extr. P (Colwell) (mg/kg)	Bicarbonate extr. P (Colwell) Rating	Total organic carbon (%)	Total organic carbon Rating	Exch. potassium cations (meq/ 100 g)	Exch. potassium cations Rating	Organic matter (%)	Boron (mg/kg)	Sulfate sulfur (mg/kg)	Trace Elements (Extractable) Copper (mg/kg)	Zinc (mg/kg)	Manganese (mg/kg)	Iron (mg/kg)
0–0.1	6.71	13.9	0.14	M	19.1	L	1.58	M	1.39	VH	1.79	0.66	14.6	39	42	378	26,500

Table A.6 Site WB03 – soil profile chemistry data

Depth (m)	Particle size (%)[2] Clay	Silt	Fine Sand	Coarse Sand	Gravel	pH (H_2O)	EC (dS/m)	EC rating[3]	Cl^- (mg/kg)	Exchangeable cations (meq/100 g) Al^{+3}	Ca^{+2}	Mg^{+2}	K^+	Na^+	CEC	ESP (%)	Sodicity (NS, S, SS)	Emerson Class	Ca:Mg ratio
0–0.1	27.2	8.2	29.5	29.5	5.6	6.7	0.07	VL	4.72	0.01	18.05	4.66	1.39	0.17	24.28	0.7	NS	3b	3.9
0.2–0.3	33.9	2.1	23.2	36.4	4.4	7.2	0.03	VL	2.17	0.00	15.40	6.98	0.77	0.27	23.40	1.2	NS	3b	2.2
0.8–0.9	38.6	9.6	24.0	20.8	7.0	8.5	0.18	L	3.7	0.00	8.24	9.57	0.68	0.36	18.80	1.9	NS	4	0.9
1.1–1.2	27.9	7.9	28.8	27.4	8.0	8.7	0.16	L	<2.0	0.00	7.75	12.40	0.78	0.85	21.80	3.9	NS	4	0.6

Notes: 1. Bruce & Rayment (1982) ratings – very low (VL), low (L), moderate (M), high (H), very high (VH).

2. Gravel (>2 mm), Coarse sand (0.2–2 mm), Fine sand (0.02–0.2 mm), Silt (2-20 µm), Clay (<2 µm).

3. Rayment & Lyons (2011) – very low salinity (VL), low salinity (L), moderately saline (M), highly saline (H), extremely saline (E).

A.4 WB04

Table A.7 Site WB04 – nutrient chemistry data

Depth (m)	pH (H_2O)	Nitrate nitrogen (mg/kg)	Soil Fertility[1]								Organic matter (%)	Boron (mg/kg)	Sulfate sulfur (mg/kg)	Trace Elements (Extractable)			
			Total nitrogen		Bicarbonate extr. P (Colwell)		Total organic carbon		Exch. potassium cations					Copper (mg/kg)	Zinc (mg/kg)	Manganese (mg/kg)	Iron (mg/kg)
			(%)	Rating	(mg/kg)	Rating	(%)	Rating	(meq/ 100 g)	Rating							
0–0.1	5.91	7.9	0.09	L	44.3	H	1.17	L	0.45	M	1.37	0.35	12.8	56	43	820	35,700

Table A.8 Site WB04 – soil profile chemistry data

Depth (m)	Particle size (%)[2]					pH (H_2O)	EC (dS/m)	EC rating[3]	Cl^- (mg/kg)	Exchangeable cations (meq/100 g)						ESP (%)	Sodicity (NS, S, SS)	Emerson Class	Ca:Mg ratio
	Clay	Silt	Fine Sand	Coarse Sand	Gravel					Al^{+3}	Ca^{+2}	Mg^{+2}	K^+	Na^+	CEC				
0–0.1	7.9	6.0	30.4	32.8	22.9	5.9	0.06	VL	5.99	0.01	11.85	3.23	0.45	0.17	15.69	1.1	NS	7	3.7
0.1–0.2	20.0	8.9	26.3	29.1	15.7	6.9	0.05	VL	4.06	0.01	20.62	7.53	0.23	0.30	28.68	1.1	NS	5	2.7

Notes: 1. Bruce & Rayment (1982) ratings – very low (VL), low (L), moderate (M), high (H), very high (VH).

2. Gravel (>2 mm), Coarse sand (0.2–2 mm), Fine sand (0.02–0.2 mm), Silt (2-20 µm), Clay (<2 µm).

3. Rayment & Lyons (2011) – very low salinity (VL), low salinity (L), moderately saline (M), highly saline (H), extremely saline (E).

A.5 WB05

Table A.9 Site WB05 – nutrient chemistry data

Depth (m)	pH (H_2O)	Nitrate nitrogen (mg/kg)	Soil Fertility[1]								Organic matter (%)	Boron (mg/kg)	Sulfate sulfur (mg/kg)	Trace Elements (Extractable)			
			Total nitrogen		Bicarbonate extr. P (Colwell)		Total organic carbon		Exch. potassium cations					Copper (mg/kg)	Zinc (mg/kg)	Manganese (mg/kg)	Iron (mg/kg)
			(%)	Rating	(mg/kg)	Rating	(%)	Rating	(meq/ 100 g)	Rating							
0–0.1	6.43	8.3	0.10	M	118.0	VH	1.49	L	1.47	VH	1.78	0.99	15.2	25	32	425	41,300

Table A.10 Site WB05 – soil profile chemistry data

Depth (m)	Particle size (%)[2]					pH (H_2O)	EC (dS/m)	EC rating[3]	Cl^- (mg/kg)	Exchangeable cations (meq/100 g)						ESP (%)	Sodicity (NS, S, SS)	Emerson Class	Ca:Mg ratio
	Clay	Silt	Fine Sand	Coarse Sand	Gravel					Al^{+3}	Ca^{+2}	Mg^{+2}	K^+	Na^+	CEC				
0–0.1	27.1	14.3	30.7	13.2	14.7	6.4	0.06	VL	3.96	0.00	9.47	2.85	1.47	0.14	13.90	1.0	NS	3b	3.3

Notes: 1. Bruce & Rayment (1982) ratings – very low (VL), low (L), moderate (M), high (H), very high (VH).

2. Gravel (>2 mm), Coarse sand (0.2–2 mm), Fine sand (0.02–0.2 mm), Silt (2-20 µm), Clay (<2 µm).

3. Rayment & Lyons (2011) – very low salinity (VL), low salinity (L), moderately saline (M), highly saline (H), extremely saline (E).

Annexure B

Soil laboratory reports

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ANALYSIS REPORT SOIL

PROJECT NO:	**EW220481**	**Date of Issue:**	**21/02/2022**
Customer:	EMM Consulting	Report No:	1
Address:	Suite 01 20 Chandos Street ST LEONARDS NSW 2065	Date Received:	8/02/2022
		Matrix:	Soil
Attention:	Harry Savage	Location:	J210534
Phone:	0416 295 292	Sampler ID:	Client
Fax:		Date of Sampling:	19/01/2022
Email:	hsavage@emmconsulting.com.au	Sample Condition:	Acceptable

Comments:
3b = moderate to slight dispersion of the remould. 3a = severe dispersion of the remould.

Results apply to the samples as submitted. All pages of this report have been checked and approved for release.

Signed: Stephanie Cameron
Laboratory Operations Manager

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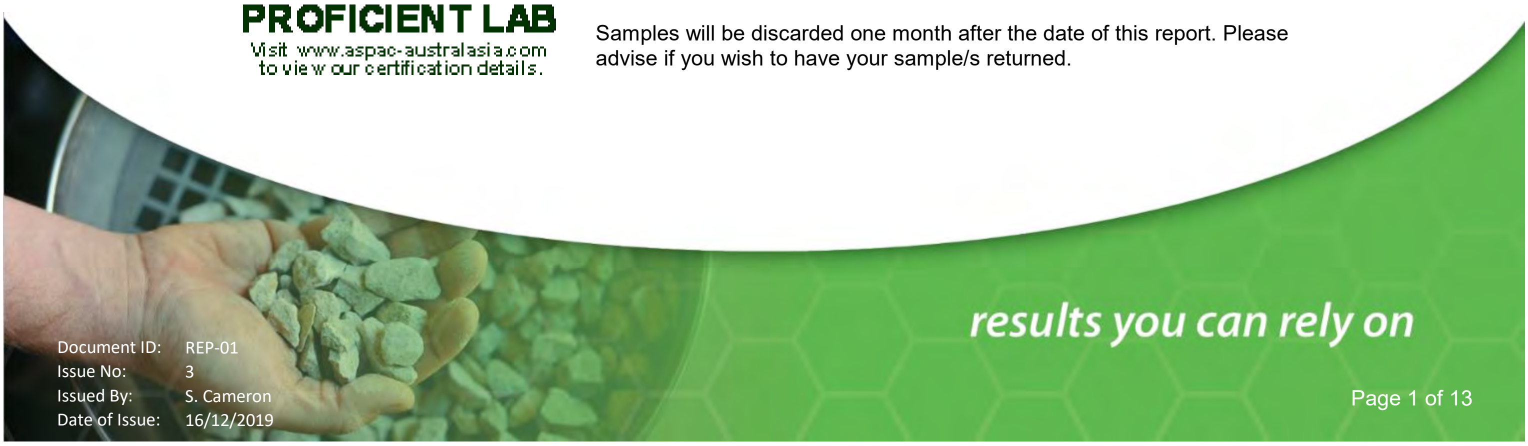
East West is certified by the Australian-Asian Soil & Plant Analysis Council to perform various soil and plant tissue analysis. The tests reported herein have been performed in accordance with our terms of accreditation.

This report must not be reproduced except in full and EWEA takes no responsibility of the end use of the results within this report.

This analysis relates to the sample submitted and it is the client's responsibility to make certain the sample is representative of the matrix to be tested.

Samples will be discarded one month after the date of this report. Please advise if you wish to have your sample/s returned.



ANALYSIS REPORT

PROJECT NO: EW220481 **Location: J210534**

				CLIENT SAMPLE ID	W01	W01	W01	W02
				DEPTH	0-10	20-30	40-50	0-10
Test Parameter	**Method Description**	**Method Reference**	**Units**	**LOR**	**220481-1**	**220481-2**	**220481-3**	**220481-4**
pH (1:5 in H20)	Electrode	R&L 4A2	pH units	na	7.06	7.34	8.26	6.10
pH (1:5 in CaCl2)	Electrode	R&L4B2	pH units	na	6.36	6.65	7.70	5.32
Chloride Soluble	DA	DAP-06	mg/kg	2	9.1	4.71	4.81	9.32
Electrical Conductivity	Electrode	R&L 3A1	dS/m	0.01	0.08	0.05	0.15	0.06
Total N (LECO)	LECO	R&L 7A5	mg/kg	50	2171	NA	NA	1922
Extractable Nitrate-N	DA	DAP-03	mg/kg	0.5	14.6	3.2	2.0	8.8
Ammonium - N (Ex)	ExKCl/UV-Vis	PMS-22	mg/kg	2	3.8	3.6	3.3	4.0
Phosphorus (Total)	HNO3/HCLO4 ICP	ICP-03	mg/kg	40	414	NA	NA	433
Organic Carbon (LECO)	LECO	R&L 6B3	%	0.05	1.92	NA	NA	1.80
Phosphorus (Colwell)	Bicarb/UV-Vis	R&L 9B1	mg/kg	1	40.2	NA	NA	19.3
Sulfate - S (KCl40)	KCl40/ICP	R&L 10D1	mg/kg	3	15.6	NA	NA	14.1
Extractable Copper	DTPA/ICP	R&L 12A1	mg/kg	0.2	1.73	NA	NA	1.72
Extractable Zinc	DTPA/ICP	R&L 12A1	mg/kg	0.2	1.54	NA	NA	0.91
Extractable Manganese	DTPA/ICP	R&L 12A1	mg/kg	0.5	20.1	NA	NA	25.8
Extractable Iron	DTPA/ICP	R&L 12A1	mg/kg	0.5	14.2	NA	NA	175
Extractable Boron	Hot CaCl2/ICP	R&L 12C2	mg/kg	0.2	1.25	NA	NA	0.51
Exchangeable Aluminium	KCl/ICP	R&L 15G1	mg/kg	1	NA	NA	NA	NA
Exchangeable Aluminium	Calculation	R&L 15J1	cmol/kg	na	NA	NA	NA	NA
Exchangeable Potassium	ICP-OES	R&L 15C1	mg/kg	10	484	497	357	218
Exchangeable Calcium	ICP-OES	R&L 15C1	mg/kg	20	1555	1864	1916	561
Exchangeable Magnesium	ICP-OES	R&L 15C1	mg/kg	10	126	219	249	127
Exchangeable Sodium	ICP-OES	R&L 15C1	mg/kg	10	<10.0	15.0	<10.0	50.7
Exchangeable Potassium	R&L 15C1	R&L 15C1	cmol/kg	na	1.24	1.27	0.92	0.56
Exchangeable Calcium	R&L 15C1	R&L 15C1	cmol/kg	na	7.78	9.32	9.58	2.81
Exchangeable Magnesium	PMS-15C1	PMS-15C1	cmol/kg	na	1.05	1.83	2.08	1.06
Exchangeable Sodium	R&L 15C1	R&L 15C1	cmol/kg	na	0.04	0.07	0.04	0.22

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ANALYSIS REPORT

PROJECT NO: EW220481 **Location: J210534**

				CLIENT SAMPLE ID	W01	W01	W01	W02
				DEPTH	0-10	20-30	40-50	0-10
Test Parameter	**Method Description**	**Method Reference**	**Units**	**LOR**	**220481-1**	**220481-2**	**220481-3**	**220481-4**
ECEC	Calculation	PMS-15C1	cmol/kg	na	10.1	12.5	12.6	4.64
Ca/Mg Ratio	Calculation	PMS-15C1	cmol/kg	na	7.40	5.11	4.62	2.65
K/Mg Ratio	Calculation	PMS-15C1	cmol/kg	na	1.18	0.70	0.44	0.53
Exchangeable Potassium %	Calculation	PMS-15C1	%	na	12.3	10.2	7.26	12.0
Exchangeable Calcium %	Calculation	PMS-15C1	%	na	76.9	74.7	75.9	60.4
Exchangeable Magnesium %	Calculation	PMS-15C1	%	na	10.4	14.6	16.5	22.8
Exchangeable Sodium %	Calculation	PMS-15C1	%	na	0.43	0.52	0.34	4.75
Exchangeable Aluminium %	Calculation	PMS-15C1	%	na	NA	NA	NA	NA
Total Cadmium	ICP-OES	AS4479.2	mg/kg	0.5	2.9	NA	NA	2.6
Total Chromium	ICP-OES	AS4479.2	mg/kg	0.5	38	NA	NA	34
Total Copper	ICP-OES	PMS-09	mg/kg	na	25	NA	NA	20
Total Iron	HNO3/HCLO4 ICP	PMS-09	mg/kg	0.5	31300	NA	NA	28300
Total Lead	ICP-OES	AS4479.2	mg/kg	0.5	13	NA	NA	7.1
Total Manganese	HNO3/HCLO4 ICP	PMS-09	mg/kg	0.5	572	NA	NA	272
Total Nickel	ICP-OES	AS4479.2	mg/kg	0.5	21	NA	NA	13
Total Zinc	ICP-OES	PMS-09	mg/kg	na	46	NA	NA	24
Total Potassium	ICP-OES	PMS-09	mg/kg	20	2570	NA	NA	1830
Total Calcium	ICP-OES	PMS-09	mg/kg	105	3320	NA	NA	2070
Total Magnesium	ICP-OES	PMS-09	mg/kg	50	1240	NA	NA	1070
Total Sodium	ICP-OES	PMS-09	mg/kg	10	159	NA	NA	226
Total Sulphur	ICP-OES	PMS-09	mg/kg	3	213	NA	NA	176
Total Aluminium	ICP-OES	PMS-09	mg/kg	1	16600	NA	NA	12600
Emerson Aggregate Test	Class	PMS-21	Number	na	3b	3b	4	3a
Exchangeable Potassium	ICP-OES	R&L 15D1	mg/kg	10	NA	NA	NA	NA
Exchangeable Calcium	ICP-OES	R&L 15D1	mg/kg	20	NA	NA	NA	NA
Exchanheable Magnesium	ICP-OES	R&L 15D1	mg/kg	10	NA	NA	NA	NA

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ANALYSIS REPORT

PROJECT NO: EW220481 **Location: J210534**

				CLIENT SAMPLE ID	W01	W01	W01	W02
				DEPTH	0-10	20-30	40-50	0-10
Test Parameter	**Method Description**	**Method Reference**	**Units**	**LOR**	**220481-1**	**220481-2**	**220481-3**	**220481-4**
Exchangeable Sodium	ICP-OES	R&L 15D1	mg/kg	10	NA	NA	NA	NA
Gravel >2.0mm	Sieve	ASTMD422-63	%	na	5.8	21.8	13.9	15.3
Coarse Sand 0.2-2.0mm	Sieve	ASTMD422-63	%	na	38.7	21.9	18.1	30.4
Fine Sand 0.02-0.2mm	Sieve	ASTMD422-63	%	na	24.4	20.2	19.6	33.3
Silt 0.002-0.02mm	Hydrometer	ASTMD422-63	%	na	9.6	5.1	5.8	6.9
Clay <0.002mm	Hydrometer	ASTMD422-63	%	na	21.5	31.0	42.6	14.1

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ANALYSIS REPORT

PROJECT NO: EW220481 **Location: J210534**

					W02	W02	W03	W03
				CLIENT SAMPLE ID				
				DEPTH	20-30	35-45	0-10	20-30
Test Parameter	**Method Description**	**Method Reference**	**Units**	**LOR**	**220481-5**	**220481-6**	**220481-7**	**220481-8**
pH (1:5 in H20)	Electrode	R&L 4A2	pH units	na	8.38	9.48	6.71	7.22
pH (1:5 in CaCl2)	Electrode	R&L4B2	pH units	na	7.10	8.53	6.17	6.54
Chloride Soluble	DA	DAP-06	mg/kg	2	126	441	4.72	2.17
Electrical Conductivity	Electrode	R&L 3A1	dS/m	0.01	0.16	0.51	0.07	0.03
Total N (LECO)	LECO	R&L 7A5	mg/kg	50	NA	NA	1852	NA
Extractable Nitrate-N	DA	DAP-03	mg/kg	0.5	1.7	0.70	13.9	2.5
Ammonium - N (Ex)	ExKCl/UV-Vis	PMS-22	mg/kg	2	3.4	3.0	3.9	5.8
Phosphorus (Total)	HNO3/HCLO4 ICP	ICP-03	mg/kg	40	NA	NA	292	NA
Organic Carbon (LECO)	LECO	R&L 6B3	%	0.05	NA	NA	1.58	NA
Phosphorus (Colwell)	Bicarb/UV-Vis	R&L 9B1	mg/kg	1	NA	NA	19.1	NA
Sulfate - S (KCl40)	KCl40/ICP	R&L 10D1	mg/kg	3	NA	NA	14.6	NA
Extractable Copper	DTPA/ICP	R&L 12A1	mg/kg	0.2	NA	NA	3.05	NA
Extractable Zinc	DTPA/ICP	R&L 12A1	mg/kg	0.2	NA	NA	0.54	NA
Extractable Manganese	DTPA/ICP	R&L 12A1	mg/kg	0.5	NA	NA	22.4	NA
Extractable Iron	DTPA/ICP	R&L 12A1	mg/kg	0.5	NA	NA	38.0	NA
Extractable Boron	Hot CaCl2/ICP	R&L 12C2	mg/kg	0.2	NA	NA	0.66	NA
Exchangeable Aluminium	KCl/ICP	R&L 15G1	mg/kg	1	NA	NA	<1.00	NA
Exchangeable Aluminium	Calculation	R&L 15J1	cmol/kg	na	NA	NA	0.01	NA
Exchangeable Potassium	ICP-OES	R&L 15C1	mg/kg	10	128	125	NA	300
Exchangeable Calcium	ICP-OES	R&L 15C1	mg/kg	20	865	762	NA	3071
Exchangeable Magnesium	ICP-OES	R&L 15C1	mg/kg	10	463	518	NA	837
Exchangeable Sodium	ICP-OES	R&L 15C1	mg/kg	10	694	1046	NA	63.1
Exchangeable Potassium	R&L 15C1	R&L 15C1	cmol/kg	na	0.33	0.32	NA	0.77
Exchangeable Calcium	R&L 15C1	R&L 15C1	cmol/kg	na	4.33	3.81	NA	15.4
Exchangeable Magnesium	PMS-15C1	PMS-15C1	cmol/kg	na	3.86	4.32	NA	6.98
Exchangeable Sodium	R&L 15C1	R&L 15C1	cmol/kg	na	3.02	4.55	NA	0.27

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ANALYSIS REPORT

PROJECT NO: EW220481 **Location: J210534**

				CLIENT SAMPLE ID	W02	W02	W03	W03
				DEPTH	20-30	35-45	0-10	20-30
Test Parameter	**Method Description**	**Method Reference**	**Units**	**LOR**	**220481-5**	**220481-6**	**220481-7**	**220481-8**
ECEC	Calculation	PMS-15C1	cmol/kg	na	11.5	13.0	NA	23.4
Ca/Mg Ratio	Calculation	PMS-15C1	cmol/kg	na	1.12	0.88	NA	2.20
K/Mg Ratio	Calculation	PMS-15C1	cmol/kg	na	0.09	0.07	NA	0.11
Exchangeable Potassium %	Calculation	PMS-15C1	%	na	2.85	2.47	NA	3.29
Exchangeable Calcium %	Calculation	PMS-15C1	%	na	37.5	29.3	NA	65.7
Exchangeable Magnesium %	Calculation	PMS-15C1	%	na	33.5	33.2	NA	29.8
Exchangeable Sodium %	Calculation	PMS-15C1	%	na	26.2	35.0	NA	1.17
Exchangeable Aluminium %	Calculation	PMS-15C1	%	na	NA	NA	0.09	NA
Total Cadmium	ICP-OES	AS4479.2	mg/kg	0.5	NA	NA	2.4	NA
Total Chromium	ICP-OES	AS4479.2	mg/kg	0.5	NA	NA	50	NA
Total Copper	ICP-OES	PMS-09	mg/kg	na	NA	NA	39	NA
Total Iron	HNO3/HCLO4 ICP	PMS-09	mg/kg	0.5	NA	NA	26500	NA
Total Lead	ICP-OES	AS4479.2	mg/kg	0.5	NA	NA	6.8	NA
Total Manganese	HNO3/HCLO4 ICP	PMS-09	mg/kg	0.5	NA	NA	378	NA
Total Nickel	ICP-OES	AS4479.2	mg/kg	0.5	NA	NA	27	NA
Total Zinc	ICP-OES	PMS-09	mg/kg	na	NA	NA	42	NA
Total Potassium	ICP-OES	PMS-09	mg/kg	20	NA	NA	3760	NA
Total Calcium	ICP-OES	PMS-09	mg/kg	105	NA	NA	3620	NA
Total Magnesium	ICP-OES	PMS-09	mg/kg	50	NA	NA	2890	NA
Total Sodium	ICP-OES	PMS-09	mg/kg	10	NA	NA	169	NA
Total Sulphur	ICP-OES	PMS-09	mg/kg	3	NA	NA	171	NA
Total Aluminium	ICP-OES	PMS-09	mg/kg	1	NA	NA	20400	NA
Emerson Aggregate Test	Class	PMS-21	Number	na	1	3b	3b	3b
Exchangeable Potassium	ICP-OES	R&L 15D1	mg/kg	10	NA	NA	544	NA
Exchangeable Calcium	ICP-OES	R&L 15D1	mg/kg	20	NA	NA	3610	NA
Exchanheable Magnesium	ICP-OES	R&L 15D1	mg/kg	10	NA	NA	559	NA

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ANALYSIS REPORT

PROJECT NO: EW220481 **Location: J210534**

				CLIENT SAMPLE ID	W02	W02	W03	W03
				DEPTH	20-30	35-45	0-10	20-30
Test Parameter	**Method Description**	**Method Reference**	**Units**	**LOR**	**220481-5**	**220481-6**	**220481-7**	**220481-8**
Exchangeable Sodium	ICP-OES	R&L 15D1	mg/kg	10	NA	NA	39.6	NA
Gravel >2.0mm	Sieve	ASTMD422-63	%	na	4.6	12.8	5.6	4.4
Coarse Sand 0.2-2.0mm	Sieve	ASTMD422-63	%	na	30.4	20.8	29.5	36.4
Fine Sand 0.02-0.2mm	Sieve	ASTMD422-63	%	na	18.4	20.0	29.5	23.2
Silt 0.002-0.02mm	Hydrometer	ASTMD422-63	%	na	4.0	3.7	8.2	2.1
Clay <0.002mm	Hydrometer	ASTMD422-63	%	na	42.6	42.7	27.2	33.9

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ANALYSIS REPORT

PROJECT NO: EW220481 **Location: J210534**

					W03	W03	W04	W04
				CLIENT SAMPLE ID				
				DEPTH	80-90	110-120	0-10	10-20
Test Parameter	**Method Description**	**Method Reference**	**Units**	**LOR**	**220481-9**	**220481-10**	**220481-11**	**220481-12**
pH (1:5 in H20)	Electrode	R&L 4A2	pH units	na	8.53	8.68	5.91	6.91
pH (1:5 in CaCl2)	Electrode	R&L4B2	pH units	na	7.99	8.12	5.44	6.57
Chloride Soluble	DA	DAP-06	mg/kg	2	3.70	<2.0	5.99	4.06
Electrical Conductivity	Electrode	R&L 3A1	dS/m	0.01	0.18	0.16	0.06	0.05
Total N (LECO)	LECO	R&L 7A5	mg/kg	50	NA	NA	1464	NA
Extractable Nitrate-N	DA	DAP-03	mg/kg	0.5	<0.5	1.4	7.9	2.4
Ammonium - N (Ex)	ExKCl/UV-Vis	PMS-22	mg/kg	2	3.7	4.9	4.0	3.4
Phosphorus (Total)	HNO3/HCLO4 ICP	ICP-03	mg/kg	40	NA	NA	796	NA
Organic Carbon (LECO)	LECO	R&L 6B3	%	0.05	NA	NA	1.17	NA
Phosphorus (Colwell)	Bicarb/UV-Vis	R&L 9B1	mg/kg	1	NA	NA	44.3	NA
Sulfate - S (KCl40)	KCl40/ICP	R&L 10D1	mg/kg	3	NA	NA	12.8	NA
Extractable Copper	DTPA/ICP	R&L 12A1	mg/kg	0.2	NA	NA	2.81	NA
Extractable Zinc	DTPA/ICP	R&L 12A1	mg/kg	0.2	NA	NA	0.84	NA
Extractable Manganese	DTPA/ICP	R&L 12A1	mg/kg	0.5	NA	NA	49.5	NA
Extractable Iron	DTPA/ICP	R&L 12A1	mg/kg	0.5	NA	NA	135	NA
Extractable Boron	Hot CaCl2/ICP	R&L 12C2	mg/kg	0.2	NA	NA	0.35	NA
Exchangeable Aluminium	KCl/ICP	R&L 15G1	mg/kg	1	NA	NA	<1.00	<1.00
Exchangeable Aluminium	Calculation	R&L 15J1	cmol/kg	na	NA	NA	0.01	0.01
Exchangeable Potassium	ICP-OES	R&L 15C1	mg/kg	10	267	304	NA	NA
Exchangeable Calcium	ICP-OES	R&L 15C1	mg/kg	20	1647	1549	NA	NA
Exchangeable Magnesium	ICP-OES	R&L 15C1	mg/kg	10	1148	1490	NA	NA
Exchangeable Sodium	ICP-OES	R&L 15C1	mg/kg	10	82.2	196	NA	NA
Exchangeable Potassium	R&L 15C1	R&L 15C1	cmol/kg	na	0.68	0.78	NA	NA
Exchangeable Calcium	R&L 15C1	R&L 15C1	cmol/kg	na	8.24	7.75	NA	NA
Exchangeable Magnesium	PMS-15C1	PMS-15C1	cmol/kg	na	9.57	12.4	NA	NA
Exchangeable Sodium	R&L 15C1	R&L 15C1	cmol/kg	na	0.36	0.85	NA	NA

ANALYSIS REPORT

PROJECT NO: EW220481 **Location: J210534**

				CLIENT SAMPLE ID	W03	W03	W04	W04
				DEPTH	80-90	110-120	0-10	10-20
Test Parameter	**Method Description**	**Method Reference**	**Units**	**LOR**	**220481-9**	**220481-10**	**220481-11**	**220481-12**
ECEC	Calculation	PMS-15C1	cmol/kg	na	18.8	21.8	NA	NA
Ca/Mg Ratio	Calculation	PMS-15C1	cmol/kg	na	0.86	0.62	NA	NA
K/Mg Ratio	Calculation	PMS-15C1	cmol/kg	na	0.07	0.06	NA	NA
Exchangeable Potassium %	Calculation	PMS-15C1	%	na	3.63	3.58	NA	NA
Exchangeable Calcium %	Calculation	PMS-15C1	%	na	43.7	35.5	NA	NA
Exchangeable Magnesium %	Calculation	PMS-15C1	%	na	50.8	57.0	NA	NA
Exchangeable Sodium %	Calculation	PMS-15C1	%	na	1.90	3.91	NA	NA
Exchangeable Aluminium %	Calculation	PMS-15C1	%	na	NA	NA	0.05	0.05
Total Cadmium	ICP-OES	AS4479.2	mg/kg	0.5	NA	NA	3.4	NA
Total Chromium	ICP-OES	AS4479.2	mg/kg	0.5	NA	NA	96	NA
Total Copper	ICP-OES	PMS-09	mg/kg	na	NA	NA	56	NA
Total Iron	HNO3/HCLO4 ICP	PMS-09	mg/kg	0.5	NA	NA	35700	NA
Total Lead	ICP-OES	AS4479.2	mg/kg	0.5	NA	NA	5.3	NA
Total Manganese	HNO3/HCLO4 ICP	PMS-09	mg/kg	0.5	NA	NA	820	NA
Total Nickel	ICP-OES	AS4479.2	mg/kg	0.5	NA	NA	51	NA
Total Zinc	ICP-OES	PMS-09	mg/kg	na	NA	NA	43	NA
Total Potassium	ICP-OES	PMS-09	mg/kg	20	NA	NA	1420	NA
Total Calcium	ICP-OES	PMS-09	mg/kg	105	NA	NA	21800	NA
Total Magnesium	ICP-OES	PMS-09	mg/kg	50	NA	NA	4450	NA
Total Sodium	ICP-OES	PMS-09	mg/kg	10	NA	NA	188	NA
Total Sulphur	ICP-OES	PMS-09	mg/kg	3	NA	NA	182	NA
Total Aluminium	ICP-OES	PMS-09	mg/kg	1	NA	NA	18800	NA
Emerson Aggregate Test	Class	PMS-21	Number	na	4	4	7	5
Exchangeable Potassium	ICP-OES	R&L 15D1	mg/kg	10	NA	NA	174	88.1
Exchangeable Calcium	ICP-OES	R&L 15D1	mg/kg	20	NA	NA	2369	4124
Exchanheable Magnesium	ICP-OES	R&L 15D1	mg/kg	10	NA	NA	388	904

ANALYSIS REPORT

PROJECT NO: EW220481 **Location: J210534**

Test Parameter	Method Description	Method Reference	Units	LOR	220481-9	220481-10	220481-11	220481-12
				CLIENT SAMPLE ID	W03	W03	W04	W04
				DEPTH	80-90	110-120	0-10	10-20
Exchangeable Sodium	ICP-OES	R&L 15D1	mg/kg	10	NA	NA	38.3	69.6
Gravel >2.0mm	Sieve	ASTMD422-63	%	na	7.0	8.0	22.9	15.7
Coarse Sand 0.2-2.0mm	Sieve	ASTMD422-63	%	na	20.8	27.4	32.8	29.1
Fine Sand 0.02-0.2mm	Sieve	ASTMD422-63	%	na	24.0	28.8	30.4	26.3
Silt 0.002-0.02mm	Hydrometer	ASTMD422-63	%	na	9.6	7.9	6.0	8.9
Clay <0.002mm	Hydrometer	ASTMD422-63	%	na	38.6	27.9	7.9	20.0

ANALYSIS REPORT

PROJECT NO: EW220481 **Location: J210534**

				CLIENT SAMPLE ID	**W05**			
				DEPTH	**0-15**			
Test Parameter	**Method Description**	**Method Reference**	**Units**	**LOR**	**220481-13**			
pH (1:5 in H20)	Electrode	R&L 4A2	pH units	na	6.43			
pH (1:5 in CaCl2)	Electrode	R&L4B2	pH units	na	5.83			
Chloride Soluble	DA	DAP-06	mg/kg	2	3.96			
Electrical Conductivity	Electrode	R&L 3A1	dS/m	0.01	0.06			
Total N (LECO)	LECO	R&L 7A5	mg/kg	50	1853			
Extractable Nitrate-N	DA	DAP-03	mg/kg	0.5	8.3			
Ammonium - N (Ex)	ExKCl/UV-Vis	PMS-22	mg/kg	2	3.6			
Phosphorus (Total)	HNO3/HCLO4 ICP	ICP-03	mg/kg	40	605			
Organic Carbon (LECO)	LECO	R&L 6B3	%	0.05	1.49			
Phosphorus (Colwell)	Bicarb/UV-Vis	R&L 9B1	mg/kg	1	118			
Sulfate - S (KCl40)	KCl40/ICP	R&L 10D1	mg/kg	3	15.2			
Extractable Copper	DTPA/ICP	R&L 12A1	mg/kg	0.2	2.87			
Extractable Zinc	DTPA/ICP	R&L 12A1	mg/kg	0.2	0.86			
Extractable Manganese	DTPA/ICP	R&L 12A1	mg/kg	0.5	24.5			
Extractable Iron	DTPA/ICP	R&L 12A1	mg/kg	0.5	52.7			
Extractable Boron	Hot CaCl2/ICP	R&L 12C2	mg/kg	0.2	0.99			
Exchangeable Aluminium	KCl/ICP	R&L 15G1	mg/kg	1	NA			
Exchangeable Aluminium	Calculation	R&L 15J1	cmol/kg	na	NA			
Exchangeable Potassium	ICP-OES	R&L 15C1	mg/kg	10	573			
Exchangeable Calcium	ICP-OES	R&L 15C1	mg/kg	20	1894			
Exchangeable Magnesium	ICP-OES	R&L 15C1	mg/kg	10	342			
Exchangeable Sodium	ICP-OES	R&L 15C1	mg/kg	10	31.9			
Exchangeable Potassium	R&L 15C1	R&L 15C1	cmol/kg	na	1.47			
Exchangeable Calcium	R&L 15C1	R&L 15C1	cmol/kg	na	9.47			
Exchangeable Magnesium	PMS-15C1	PMS-15C1	cmol/kg	na	2.85			
Exchangeable Sodium	R&L 15C1	R&L 15C1	cmol/kg	na	0.14			

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PROJECT NO: EW220481 **Location: J210534**

				CLIENT SAMPLE ID	W05			
				DEPTH	0-15			
Test Parameter	**Method Description**	**Method Reference**	**Units**	**LOR**	**220481-13**			
ECEC	Calculation	PMS-15C1	cmol/kg	na	13.9			
Ca/Mg Ratio	Calculation	PMS-15C1	cmol/kg	na	3.32			
K/Mg Ratio	Calculation	PMS-15C1	cmol/kg	na	0.52			
Exchangeable Potassium %	Calculation	PMS-15C1	%	na	10.5			
Exchangeable Calcium %	Calculation	PMS-15C1	%	na	68.0			
Exchangeable Magnesium %	Calculation	PMS-15C1	%	na	20.5			
Exchangeable Sodium %	Calculation	PMS-15C1	%	na	1.00			
Exchangeable Aluminium %	Calculation	PMS-15C1	%	na	NA			
Total Cadmium	ICP-OES	AS4479.2	mg/kg	0.5	3.9			
Total Chromium	ICP-OES	AS4479.2	mg/kg	0.5	108			
Total Copper	ICP-OES	PMS-09	mg/kg	na	25			
Total Iron	HNO3/HCLO4 ICP	PMS-09	mg/kg	0.5	41300			
Total Lead	ICP-OES	AS4479.2	mg/kg	0.5	2.4			
Total Manganese	HNO3/HCLO4 ICP	PMS-09	mg/kg	0.5	425			
Total Nickel	ICP-OES	AS4479.2	mg/kg	0.5	82			
Total Zinc	ICP-OES	PMS-09	mg/kg	na	32			
Total Potassium	ICP-OES	PMS-09	mg/kg	20	1860			
Total Calcium	ICP-OES	PMS-09	mg/kg	105	6700			
Total Magnesium	ICP-OES	PMS-09	mg/kg	50	3960			
Total Sodium	ICP-OES	PMS-09	mg/kg	10	141			
Total Sulphur	ICP-OES	PMS-09	mg/kg	3	128			
Total Aluminium	ICP-OES	PMS-09	mg/kg	1	20900			
Emerson Aggregate Test	Class	PMS-21	Number	na	3b			
Exchangeable Potassium	ICP-OES	R&L 15D1	mg/kg	10	NA			
Exchangeable Calcium	ICP-OES	R&L 15D1	mg/kg	20	NA			
Exchanheable Magnesium	ICP-OES	R&L 15D1	mg/kg	10	NA			

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ANALYSIS REPORT

PROJECT NO: EW220481 **Location: J210534**

				CLIENT SAMPLE ID	**W05**			
				DEPTH	**0-15**			
Test Parameter	**Method Description**	**Method Reference**	**Units**	**LOR**	**220481-13**			
Exchangeable Sodium	ICP-OES	R&L 15D1	mg/kg	10	NA			
Gravel >2.0mm	Sieve	ASTMD422-63	%	na	14.7			
Coarse Sand 0.2-2.0mm	Sieve	ASTMD422-63	%	na	13.2			
Fine Sand 0.02-0.2mm	Sieve	ASTMD422-63	%	na	30.7			
Silt 0.002-0.02mm	Hydrometer	ASTMD422-63	%	na	14.3			
Clay <0.002mm	Hydrometer	ASTMD422-63	%	na	27.1			

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Soils are air dried at 40^{o}C and ground <2mm.

NB: LOR is the Lowest Obtainable Reading.

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