

Appendix

E

E.8 | Land and Rehabilitation Assessment

Dinawan Wind Farm

Land and Rehabilitation Assessment

Prepared for Spark Renewables Pty Ltd

May 2024

Dinawan Wind Farm

Land and Rehabilitation Assessment

Spark Renewables Pty Limited

E220305 RP7

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Version	Date	Prepared by	Reviewed by	Comments
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Executive summary

ES1 Introduction

Spark Renewables Pty Limited (Spark Renewables) proposes to develop the Dinawan Wind Farm (the project). The project includes the installation, operation, maintenance and decommissioning of up to approximately 200 wind turbine generators (WTGs) and associated infrastructure. The project will have a generation capacity of up to approximately 1,200 megawatts (MW) alternating current (AC), equivalent to the needs of 700,000 households per year. The project will assist in meeting NSW and Australian Government emissions reduction targets and will abate approximately 3.2 million tonnes of greenhouse gases annually. The project is State significant development (SSD) pursuant to schedule 1 of State Environmental Planning Policy (Planning Systems) 2021 (Planning Systems SEPP).

The project is on the traditional lands of the Wiradjuri people and several smaller nations of the Murrumbidgee plains, about halfway between the towns of Coleambally and Jerilderie. The project lies within the Murrumbidgee and Edward River local government areas (LGAs) in New South Wales (NSW).

This land and rehabilitation assessment (LRA) forms part of the environmental impact statement (EIS) for the project. The LRA considers the project both in terms of development corridor and development footprint to provide flexibility in final infrastructure layout.

ES2 Existing environment

ES2.1 Soils and land capability

Assessment of the project area's existing conditions consisted of a review of available regional data and mapping for factors such as climate, geology, and soils. A soil survey was conducted across the project area and included:

- classification of soil orders as per the *Australian Soil Classification* (ASC) (Isbell & NCST 2021)
- description of soil characteristics
- assessment in line with NSW *Land and soil capability assessment scheme* (NSW LSC Scheme) (OEH 2012).

The Jerilderie (jex) soil landscape is the likely dominant landscape in the project area based on modelling of the Australian Soil Classification (host to Vertosols) and great soil groups. The hazards discussed for the soil landscape highlight erosion hazard, wind erosion leading to scalding when underlain by sodic soils, the high clay soil's poor trafficability when wet, and their hard-setting nature.

A soil survey consisting of a total of 15 soil investigation sites was conducted within the project area, with profiles of similar morphological properties grouped into three soil profile classes (SPCs) with one phase. These SPCs consisted primarily of Vertosols with minor Dermosols, Sodosols and Arenosol soil orders. The soils encountered were generally consistent with the regional soil landscapes, with similar hazards observed on-site, including erosion hazard, poor drainage and subsoil constraints of salinity, sodicity and likely dispersion.

Indicative assessment of state scale land and soil capability (LSC) mapping, utilising the eSPADE database (DPIE 2020a) and *Land and Soil Capability Mapping for NSW* (DPIE 2020c), has determined the project area is mapped predominantly as Classes 4 and 6, representing land with moderate to low capability for productive use without resulting in land degradation. Verification of site-specific LSC revealed consistent LSC class compared to regional mapping, identifying predominantly LSC Class 4, 5 and 6 present, based on the 15 sample locations.

ES2.2 Agriculture

Of the project area (39,061 ha), approximately 717.2 ha is unavailable for agriculture (due to land uses such as water, conservation areas, roads, and other permanent infrastructure). Of the remaining land, approximately 35,718 ha is utilised for grazing livestock and 2,541 ha is used for cropping.

Considering the development footprint of the project (1,339 ha), the typical gross annual productivity for livestock grazing was estimated. The estimate was based on the calculated agricultural values for the Murrumbidgee LGA and Edward River LGA for an equivalent sized area. Considering the entire development footprint, agricultural land value was estimated at approximately \$368,483 with an upper range estimate of \$574,784 (based on the gross productivity estimates from the NSW Murray Region).

ES2.3 Erosion

Erosion hazard was assessed as per Section 4.4.1 of Landcom (2004). The erosion potential of soils of the project area, expressed as K-factor, is moderate to high due to the presence of sodic, dispersive soils. Assessment of rainfall erosivity indicates erosion hazard will be high for areas where slopes exceed 21% (limited to less than 0.05% of the total project area due to the region's flat topography).

The development corridor has a low erosion hazard based on mean slope. Localised areas of steep slopes present a high erosion hazard, primarily associated with the constructed irrigation channels present on-site.

Soil loss classes (SLCs) were calculated to map erosion risk for project specific slopes and soil characteristics.

ES3 Assessment of impacts

ES3.1 Soils and land and soil capability

Soil disturbance has the potential to result in the following impacts:

- reduction in soil stability and increased susceptibility to erosion due to vegetation removal, soil exposure or inversion, especially as the subsoil is sodic and dispersive
- erosion of soil due to exposing soils, disturbing dispersive subsoils and concentration of flow
- reduction of soil quality, quantity and associated LSC and agricultural productivity
- loss or degradation of topsoil material viable for use in rehabilitation
- introduction of salinity, sodicity or other constraints into the topsoil material if soil is inadequately managed.

With no planned disturbance to areas outside of the nominated development corridor, impacts to soil quality or LSC of adjacent lands are not anticipated. The development footprint impacts a very small amount of land within the South West Renewable Energy Zone (REZ), predominantly in LSC Class 4 (0.12%).

ES3.2 Agriculture

The land within the development footprint will be temporarily unavailable for the current land use (i.e. predominantly sheep and cattle grazing with some cropping) during construction, removing some \$368,483 in annual agricultural productivity based on estimates on livestock and cropping land use and LGA productivity information. Impacts to agricultural productivity during operations will be mitigated by the proposed continued use of the land for sheep and cattle enterprises.

The development corridor and development footprint are proposed across two large landholdings. These landholdings have existing agricultural enterprises within them but due to the selective placement of the WTGs and other project infrastructure, it is unlikely that the project will result in any segmentation of the existing land uses. The existing agricultural land use will continue on land adjacent to the development footprint during construction and operations.

The construction and operation of the project have the potential to increase biosecurity risks through increased weeds and pests.

ES3.3 Erosion and sedimentation

Potential erosion and sediment control impacts include:

- off-site discharge of sediment and turbid runoff from the erosion of exposed soils, particularly dispersive subsoils:
 - degradation of stock drinking and environmental waters
 - infilling of waterway pools
 - diversion of waterway flow due to sediment deposition and associated bed and bank erosion
- 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 landforms (roads, tracks, hardstands) and drains
- increased erosion and subsequent sedimentation due to pavement rutting and pavement degradation from increased light and heavy vehicles traffic on unsealed access roads
- tunnel erosion under or beside foundations for built infrastructure and along pipe and cable trenches due to dispersive soils
- dust emissions from unsealed roads, hardstands and exposed soils
- off-site discharge of sediment and turbid runoff from ongoing erosion from drainage, landform and infrastructure design not cognisant of dispersive subsoils
- increased maintenance costs for ongoing stabilisation of landforms, roads, drains and cable trenches
- operation and maintenance of sediment control structures due to ongoing erosion.

ES4 Management and mitigation

ES4.1 Soils and land and soil capability

As part of the Construction Environmental Management Plan (CEMP) or similar for the project, it is proposed to implement soil management measures to ensure the preservation of soil resources, including:

- topsoil and subsoil segregation and prevention of mixing
- attempt to strip and manage different soils orders or mapping units separately
- soil handling practices
- soil amelioration

- soil stockpiling practices including segregation and surface cover
- erosion prevention to preserve soil quantity.

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

ES4.2 Agriculture

During operations, the land within the development footprint is expected to continue to be used for cattle and sheep enterprises. Controls to manage impacts associated with weeds, pathogens and pest species will be implemented as part of the CEMP or similar.

ES4.3 Erosion and sedimentation

Suitable erosion and sediment control measures and principles should be employed to minimise any erosion and manage any sediment that is generated. Measures and principles should include:

- minimising the extent and duration of land disturbance
- controlling water movement through the development corridor
- minimising soil erosion
- promptly stabilising disturbed areas
- maximising sediment retention on-site
- maintaining drainage, erosion and sediment control measures
- monitoring and adjusting drainage, erosion and sediment control practices to achieve the desired performance standard.

ES5 Conclusion

The project has the potential to impact on soil quality and quantity, resulting in increased erosion and the reduction of agricultural productivity.

The development footprint will not be able to be used for livestock grazing during construction. However, following construction, part of the development footprint will continue to be used for livestock grazing. Impacts to agricultural productivity are therefore considered minor.

The soil quality and LSC status of the land within the development footprint will also be rehabilitated at the end of operations, following appropriate landform design, soil stripping and management and rehabilitation, as recommended in the management and mitigation measures. Infrastructure with a small footprint or temporary disturbance will be able to be reinstated sooner.

The significance of the removal of LSC Class 3, 4, 5 and 6 land is minor due to its limited change in utilisation (grazing) from its theoretical capability of grazing (LSC 4–6). The removal of LSC Class 4 land is minor with the project, during construction, removing approximately 0.12% of LSC Class 4 land mapped within the South West REZ. Following construction this area will be rehabilitated where possible effectively reducing the percentage of land changed from its existing agricultural land use.

Overall, potential land and soil impacts during construction and operation are considered minor and can be adequately managed through the implementation of the recommended mitigation measures.

Abbreviations

Item	Definition
ABS	Australian Bureau of Statistics
AC	alternating current
AHD	Australia Height Datum
ACLUMP	Australian Collaborative Land Use and Management Program
ALUM	Australian Land Use and Management
ASC	Australian Soil Classification
ASS	acid sulfate soils
BESS	battery energy storage system
BGL	below ground level
BoM	Bureau of Meteorology
CEMP	Construction Environmental Management Plan
cm	centimetre
CWO	Central-West Orana
DC	direct current
DP	deposited plan
DPHI	NSW Department of Planning, Housing and Infrastructure
DPI	NSW Department of Primary Industries
EAT	Emerson Aggregate Test
EC	electrical conductivity
ECEC	effective cation exchange capacity
EIS	Environmental Impact Statement
EMgP	exchangeable magnesium percentage
EMM	EMM Consulting Pty Limited
EnergyCo	Energy Corporation of NSW
EPA	NSW Environment Protection Authority
EP&A Act	NSW <i>Environmental Planning and Assessment Act 1979</i>
EPP	exchangeable potassium percentage
ESCP	Erosion and Sediment Control Plan
ESP	exchangeable sodium percentage
g	gram
GSG	Great Soil Group
GW	gigawatt

Item	Definition
ha	hectare
HGL	hydrogeological landscape
km	kilometre
kV	kilovolt
LEP	Local Environmental Plan
LGA	local government area
LRA	Land and Rehabilitation Assessment
LSC	land and soil capability
LUCRA	Land Use Conflict Risk Assessment
m	metres
mm	millimetres
MW	megawatts
NATA	National Association of Testing Authorities
NSW	New South Wales
Planning Systems SEPP	State Environmental Planning Policy (Planning Systems) 2021
PV	photovoltaic
REZ	Renewable Energy Zone
RUSLE	Revised Universal Soil Loss Equation
SEARs	Secretary's Environmental Assessment Requirements
SLC	soil loss class
SLR	Soil and Land Resources
SMU	soil mapping unit
SPC	soil profile class
SSD	State significant development
SSI	State significant infrastructure
WTG	wind turbine generator

Glossary

- **Project area:** The land required for the project. The project area contains the entirety of all landholdings that overlap with the development corridor and is approximately 39,061 ha. The project area is the maximum area considered for the project based on the extent of land where Spark Renewables holds landholder agreements. The project area includes parts of Goolgumbla Road, Wilson Road, Fernbank Road, McLennons Bore Road and Kidman Way (including the road easement) and Coleambally Outfall Drain, where site access and/or electrical cabling may be required.
- **Development corridor:** The development corridor is the land within the project area where project components may be placed, providing the necessary flexibility for component placement during detailed design (i.e. micro-siting). The development corridor is wholly within the project area.
- **Development footprint:** The indicative extent of the project's ground disturbance area, including earthworks, associated with permanent infrastructure and temporary construction facilities. The development footprint will be within the development corridor; however, its exact location will be confirmed following detailed design.
- **Site access point:** The proposed locations where all construction and operation traffic will access the development footprint. Access across the development footprint will be possible via internal tracks.
- **Associated residence:** A dwelling whose owners have parts of their property included in a land agreement with Spark Renewables for the project (i.e. host landholder dwellings).
- **Non-associated residence:** A dwelling whose owners do not have parts of their property included in a land agreement with Spark Renewables for the project.

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1 Introduction

1.1 Overview

Spark Renewables Pty Limited (Spark Renewables) proposes to develop the Dinawan Wind Farm (the project). The project includes the installation, operation, maintenance and decommissioning of up to approximately 200 wind turbine generators (WTGs) and associated infrastructure. The project is on the traditional lands of the Wiradjuri people and several smaller nations of the Murrumbidgee plains, about halfway between the towns of Coleambally and Jerilderie and lies within the Murrumbidgee and Edward River local government areas (LGAs) in New South Wales (NSW). The regional and local context of the project is shown in Figure 1.1 and Figure 1.2, respectively.

The project is within the South West Renewable Energy Zone (REZ), a region selected by the NSW Government for its significant potential for renewable energy generation and regional development.

The project will connect to the Dinawan Substation, currently under construction as part of the Project EnergyConnect interconnector that will run between Robertstown in South Australia and Wagga Wagga in NSW. The substation and interconnector are a separate approved project that is being built by Transgrid.

The main objective of the project is to generate renewable energy, consistent with NSW Government policy for development of infrastructure for renewable energy generation, and will significantly contribute to the target of 3.98 gigawatts (GW) of generation planned in the South West REZ. The project will have a generation capacity of up to approximately 1,200 megawatts (MW) alternating current (AC), equivalent to the needs of 700,000 NSW households per year. It will assist in meeting NSW and Australian Government emissions reduction targets and will abate approximately 3.2 million tonnes of greenhouse gases annually.

The project is State significant development (SSD) pursuant to schedule 1 of State Environmental Planning Policy (Planning Systems) 2021 (Planning Systems SEPP). Accordingly, approval for the project is required under Part 4, Division 4.7 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act).

This land and rehabilitation assessment (LRA) forms part of the environmental impact statement (EIS) for the project.

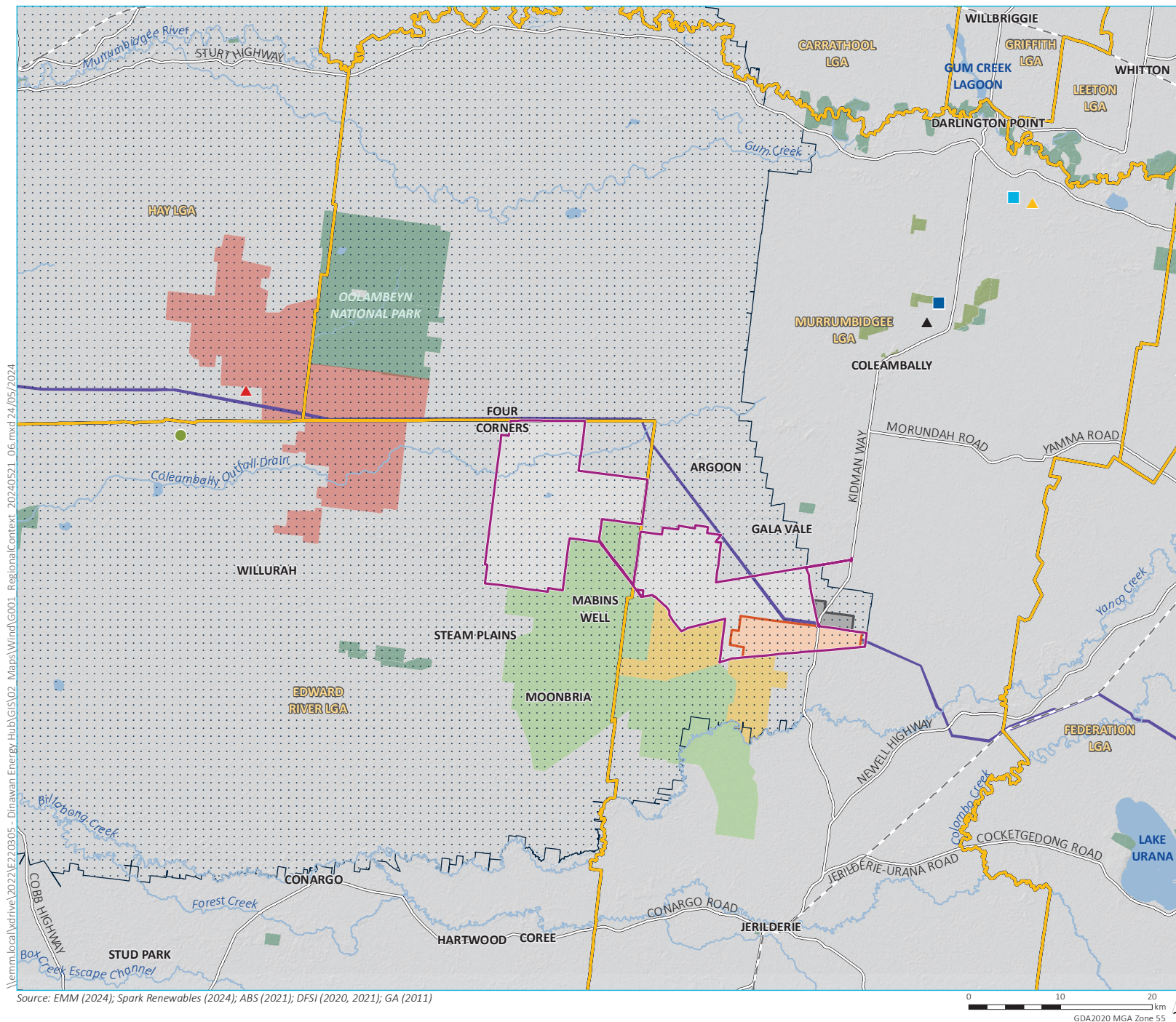
1.2 Assessment approach and requirements

1.2.1 Objectives

This LRA documents the assessment methodology, results and the mitigation and management measures proposed to address any unavoidable residual impacts to land and soils arising from the project.

The key objectives of this report are to:

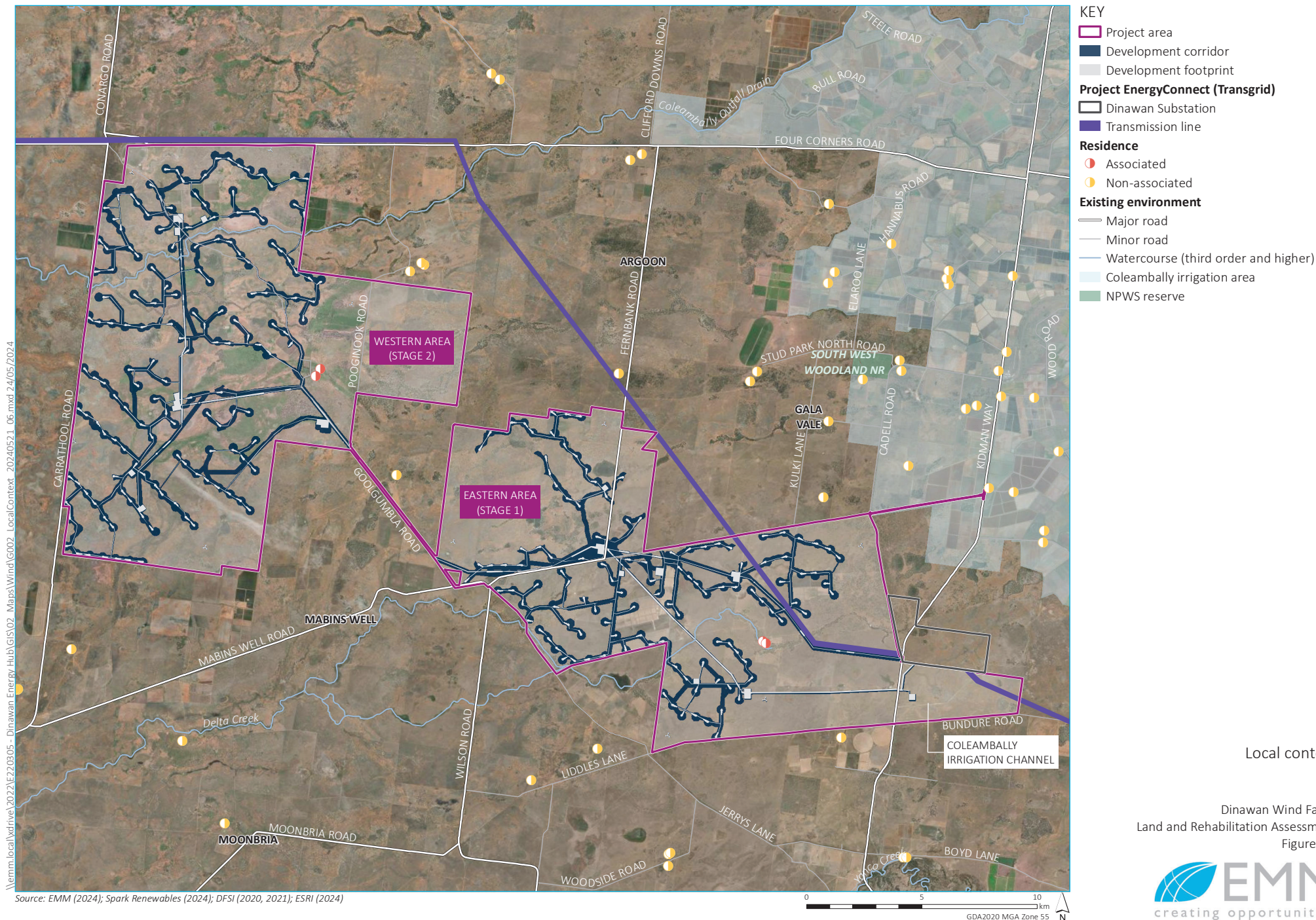
- describe the applicable regulatory framework relevant to the project
- describe and characterise the existing land and soil resources relevant to the project
- identify and assess potential land capability, soil erosion, sedimentation, agricultural and rehabilitation impacts of the project construction and operation
- satisfy the Secretary's Environmental Assessment Requirements (SEARs) for the project pertaining to land (Table 1.1)
- identify appropriate mitigation and management measures for the project.



- KEY**
- Project area
 - Dinawan Solar Farm project area
 - Renewable Energy Zone
- Project EnergyConnect (Transgrid)**
- Dinawan Substation
 - Transmission line
- Neighbouring renewable energy developments**
- ▲ Coleambally Solar Farm (operating)
 - ▲ Darlington Point Solar Farm (operating)
 - Coleambally BESS (approved)
 - ▲ Yarrabee Solar Farm (approved)
 - ▲ Pottinger Solar Farm (proposed)
 - Pottinger Wind Farm (proposed)
 - Woodland BESS (proposed)
 - Yanco Delta Wind Farm (approved)
 - Argoon Wind Farm (proposed)
 - Bullawah Wind Farm (proposed)
- Existing environment**
- Rail line
 - Major road
 - Named watercourse
 - Named waterbody
 - NPWS reserve
 - State forest
 - Local government area

Regional context

Dinawan Wind Farm
Land and Rehabilitation Assessment
Figure 1.1



1.2.2 Secretary's Environmental Assessment Requirements

This LRA has been prepared in accordance with requirements of the NSW Department of Planning, Housing and Infrastructure (DPHI) which were set out in the SEARs for the project, originally issued on 14 December 2022. 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 LRA and where they are addressed in this report.

Table 1.1 LRA assessment related SEARs

Requirement	Section addressed
A 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 10 and Chapter 2 of EIS
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.	Agricultural land considered in Sections 3.5.6 and 3.8 Soil characteristics described in Section 4.2 Cumulative impact assessment detailed in Section 7.4 and Chapter 6 of EIS.
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 (LUCRA) in accordance with the Department of Industry's <i>Land Use Conflict Risk Assessment Guide</i>; and • assessment of impact on agricultural resources and agricultural production on the site and region.	Land zoning considered in Section 3.7 LUCRA completed in Section 7.5 and Attachment A Agricultural impact assessment in Section 7.2

1.3 Structure of the report

The LRA comprises the following sections:

- Chapter 2 includes a description of the project, local setting and surrounds.
- Chapter 3 characterises the existing environment, including relevant environmental constraints (rainfall, topography, land use and vegetation, waterways and floodplains and existing soil information).
- Chapter 4 includes the outcomes of the soil survey that was used to determine the soil orders present in the project area and their classification under the Australian Soil Classification (ASC).
- Chapter 5 presents an assessment of land and soil capability (LSC) as per the NSW *Land and Soil Capability Assessment Scheme* (OEH 2012) (LSC Scheme).
- Chapter 6 provides an erosion hazard assessment as per *Managing urban stormwater: soils and construction* (Landcom 2004), 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 Landcom (2004) and International Erosion Control Association (IECA) *Best Practice Erosion and Sediment Control Guideline* (BPESC) (IECA 2008)
 - recommended control measures for specific site locations and likely forms of ground disturbance (e.g. trenching, cuts and fills, roads, hard-stands and office areas).
- Chapter 7 presents an assessment of likely construction and operation impacts to land, soils, and agriculture.
 - Chapter 8 provides an overview of mitigation measures and monitoring requirements for the project.
 - Chapter 9 presents a rehabilitation strategy from the perspective of both completion of construction and the completion of the operational phase of the project overall.

1.4 Terminology

Several technical terms have been utilised throughout this report for the discussion of land use, soils and erosion. These are explained in the Glossary.

2 Project description and setting

2.1 Project overview

A full project description is provided in Chapter 3 of the EIS and an overview of the project layout is shown in Figure 2.1 and Figure 2.2. The project will comprise the following key components:

- a network of approximately 200 (3 blade) WTGs across two areas
- electrical collection system, substations and control rooms
- electricity transmission line infrastructure connecting the project substations to the Dinawan Substation
- operations and maintenance infrastructure, including site offices and amenities, buildings, equipment and maintenance sheds and laydown, storage and parking areas
- temporary construction facilities, including worker accommodation facility, construction compounds, site offices and amenities, concrete batching plants, construction materials storage (including stockpiles), laydown areas, temporary meteorological masts, borrow pits, water tanks and storage and parking areas
- other permanent infrastructure, including hardstands, water tanks, permanent meteorological masts, new access tracks and upgrades to existing access tracks
- access points from the public road network and public road upgrades to facilitate the delivery of WTG components.

2.2 Project areas

The project area is approximately 39,061 ha and encompasses 349 land parcels (Figure 1.2). The majority of land within the project area is privately owned, and can be considered as two distinct areas, the eastern wind area and the western wind area. The land within the project area is predominantly used for sheep and cattle grazing, plus some irrigated cropping.

Within the project area, the development corridor is approximately 7,256 ha (Figure 1.2). The development corridor is the land within the project area where project components may be placed, providing the necessary flexibility for component placement during detailed design (i.e. micro-siting). The development corridor has been refined based on the results of environmental surveys, including biodiversity, Aboriginal cultural and historical heritage surveys, and with consideration of community and regulatory stakeholder feedback.

A development footprint has also been provided and is approximately 1,339 ha within the development corridor. This assessment assumes that the development footprint will be disturbed. As part of detailed design, the development footprint may move within the development corridor; however, total direct surface disturbance is not anticipated to increase.

Direct impacts for public road upgrade works are required on Kidman Way, McLennons Bore Road, Wilson Road, Fernbank Road and Goolgumbra Road (Figure 1.2) and will facilitate access to the development corridor. From the site access points, private internal roads will be used to traverse the development corridor.

The preferred point of connection to Transgrid's network is via the Dinawan Substation, which forms part of Project EnergyConnect and will be constructed on land adjacent to the project area. An overhead transmission line will connect the project's collector substations to the Dinawan Substation.

2.3 Project staging

It is anticipated that the project will be constructed in two stages:

- Stage 1 will be construction of the eastern wind area, including associated public road upgrades, grid connection infrastructure and workforce accommodation facility. Stage 1 is within the Murrumbidgee LGA.
- Stage 2 will be construction of the western wind area, including associated public road upgrades, grid connection infrastructure and workforce accommodation facility. Stage 2 is predominantly within the Edward River LGA, with the exception of additional public road upgrades and grid connection infrastructure within Murrumbidgee LGA.

The project's generation capacity and connection to the electricity grid is dependent on the outcomes of the South West REZ Access Scheme and the construction of electricity grid infrastructure (including Dinawan Substation). For the purposes of this assessment, it has been assumed that the project will connect to Dinawan Substation and project infrastructure will be housed within the full extent of the development footprint (i.e. this assessment has assessed impacts associated with the construction and operation of both stages 1 and 2).

2.4 Related development

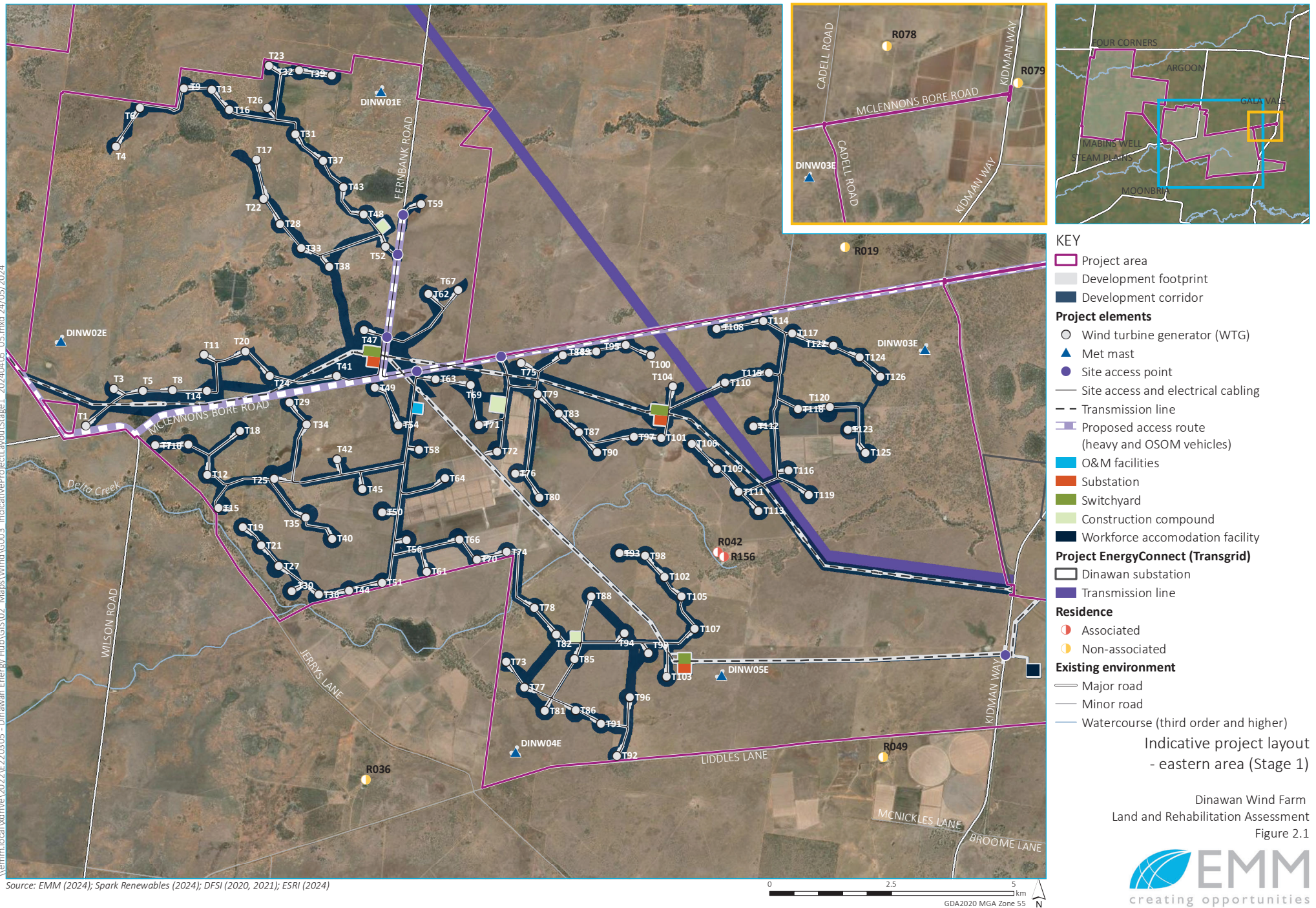
The project is part of the Dinawan Energy Hub, a hybrid wind, solar farm, and battery energy storage system (BESS) within the Murrumbidgee and Edwards River LGAs of NSW. Dinawan Energy Hub has a potential capacity of up to 2.3 gigawatts (GW) based on the land available and capacity of the Dinawan Substation. Preliminary resource monitoring indicates that a mix of approximately 70% wind and 30% solar results in a relatively flat, diurnal generation profile. That is, the strong solar resource during the daytime complements the high level of wind resource that peaks overnight, balancing generation over a 24-hour period.

Dinawan Energy Hub will be delivered through two separate, but related, SSD applications to DPHI:

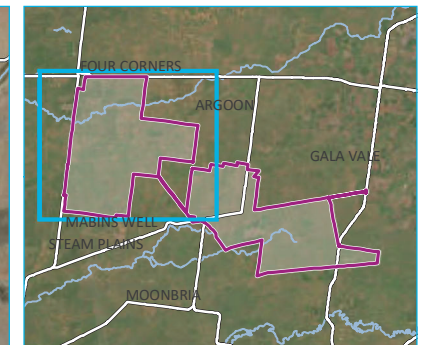
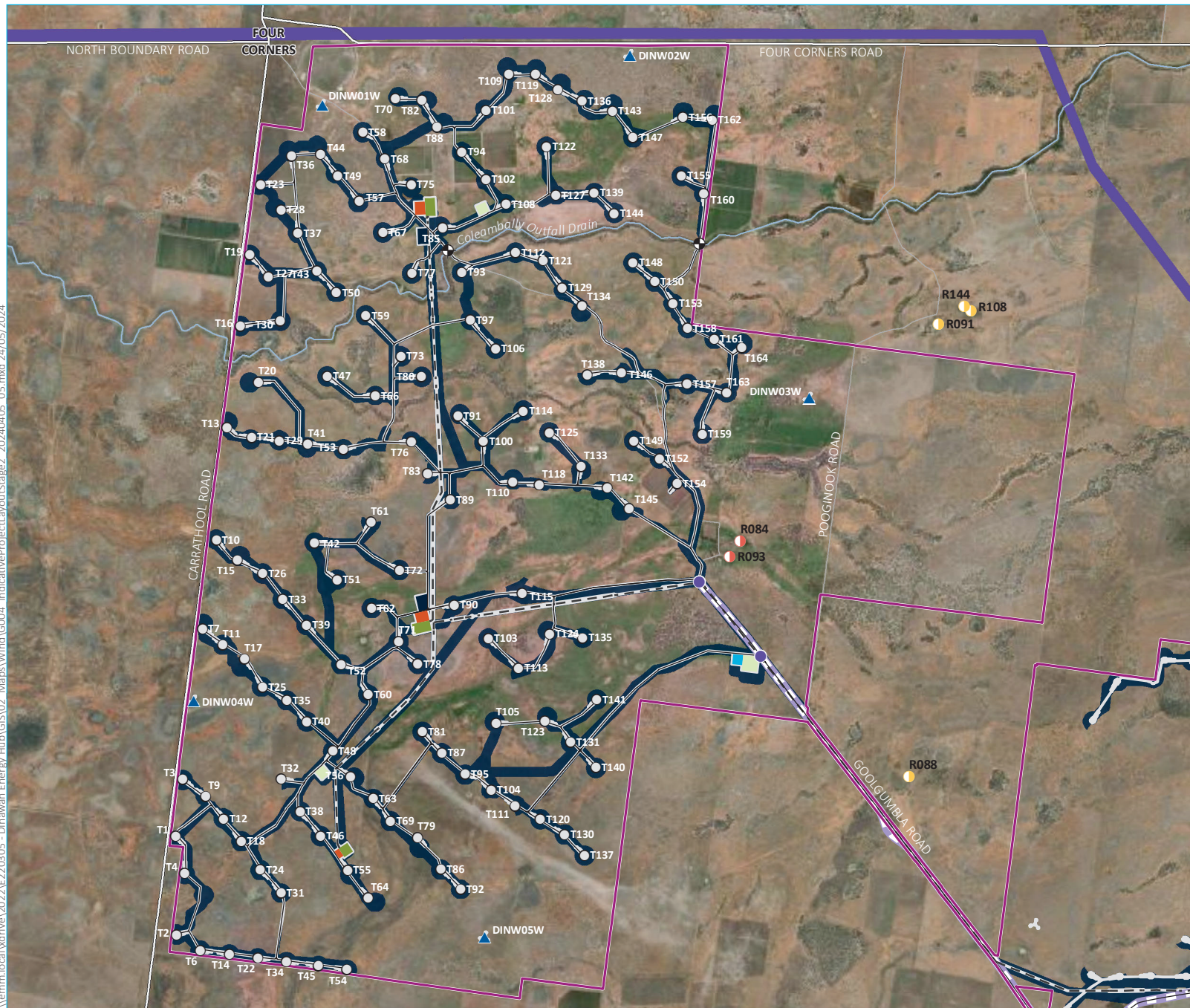
- Dinawan Wind Farm (SSD-50725708) – comprising a large-scale wind development up to 1,500 MW
- Dinawan Solar Farm (SSD-50725959) – comprising a large-scale solar development up to 800 MW, including a BESS.

This LRA addresses the Dinawan Wind Farm. A separate LRA addresses the Dinawan Solar Farm.

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- KEY**
- Project area
 - Development footprint
 - Development corridor
- Project elements**
- Wind turbine generator (WTG)
 - Met mast
 - Site access point
 - Site access and electrical cabling
 - Transmission line
 - Proposed access route (heavy and OSOM vehicles)
 - O&M facilities
 - Substation
 - Switchyard
 - Construction compound
 - Workforce accommodation facility
- Project EnergyConnect (Transgrid)**
- Transmission line
- Residence**
- Associated
 - Non-associated
- Existing environment**
- Bridge
 - Major road
 - Minor road
 - Watercourse (third order and higher)

Indicative project layout
- western area (Stage 2)

Dinawan Wind Farm
Land and Rehabilitation Assessment
Figure 2.2

3 Existing environment

3.1 Climate

Climate and rainfall data have been obtained from the Bureau of Meteorology (BoM) Tocumwal Airport site (Station number 074106) where monitoring commenced in 1897. The project area is characterised by hot, dry summers and is classified as grassland and warm (persistently dry), under the modified Koppen classification based on 30-year climatology between 1961 to 1990.

Long-term mean maximum and mean minimum annual temperatures are 32 °C and 13.9 °C, respectively, over 51 years. Average annual rainfall is 447 millimetres per year (mm/year) since 1897, with highest rainfall typically occurring in the winter months. Average annual average pan evaporation rates are between 1,600 and 1,800 mm/year based on at least 10 years climatology between 1975 to 2005. Average monthly 9:00 am windspeeds range between 11.1 and 6.2 kilometres per hour (km/h), and 3:00 pm wind speeds between 12.5 and 8.5 km/h. Peak wind gusts are most likely to occur in the summer months (BoM 2021a; BoM 2021b).

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

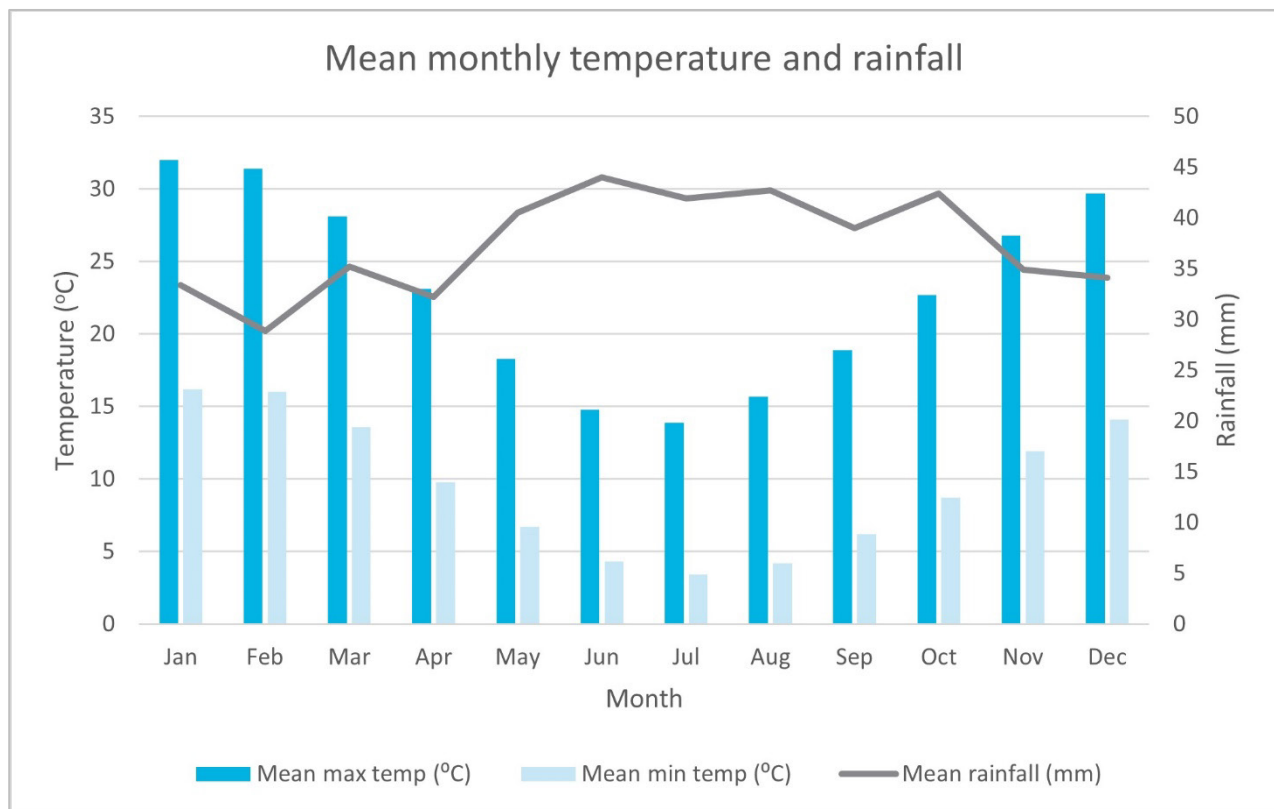


Figure 3.1 Mean monthly rainfall and mean wind speed (BoM 2021a)

The BoM wind roses for Tocumwal Airport show the prevailing wind conditions are south-westerly to north-easterly, with higher wind speeds occurring in the afternoons. The topography reveals very limited local relief, resulting in limited sheltered areas.

Wind roses summarise the occurrence of winds at a location, showing their strength, direction, and frequency. The percentage of calm conditions is represented by the size of the centre circle, the bigger the circle, the higher is the frequency of calm conditions. Each branch of the rose represents wind coming from that direction, with north to the top of the diagram. Eight directions are used. The branches are divided into segments of different thickness and colour, which represent wind speed ranges from that direction. Speed ranges of 10 km/h are used in these wind roses. The length of each segment within a branch is proportional to the frequency of winds blowing within the corresponding range of speeds from that direction (BoM 2021a).

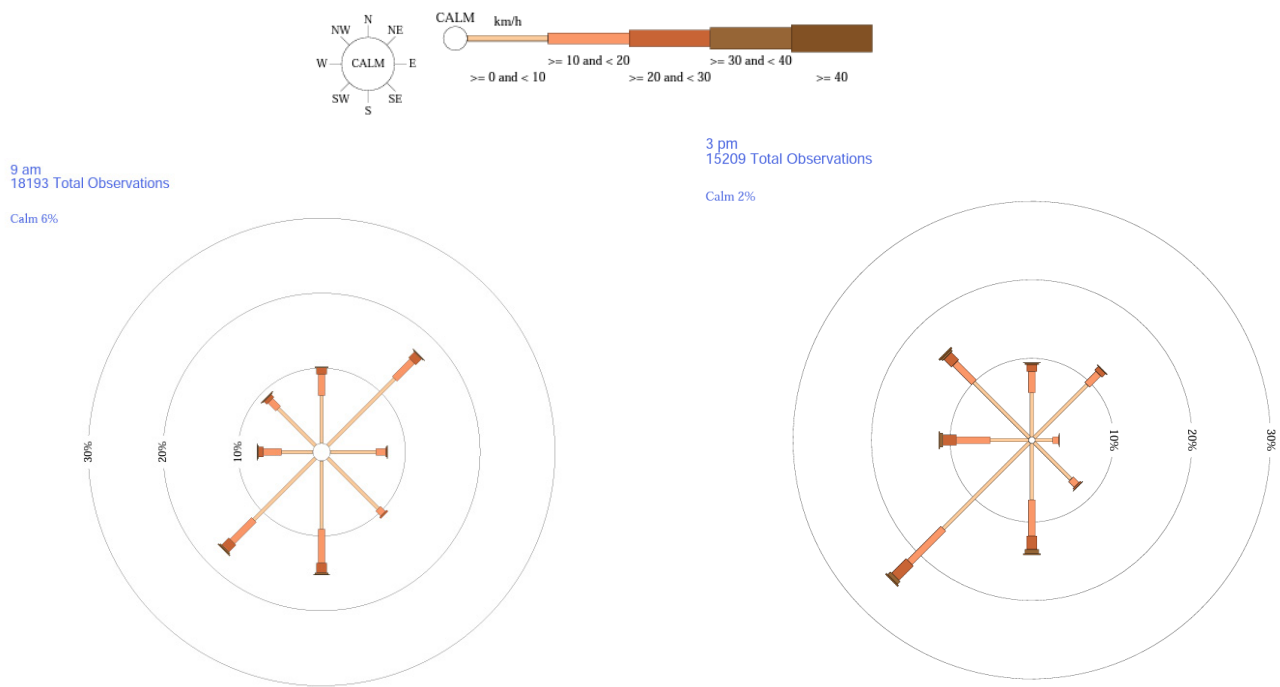


Figure 3.2 Mean 9am and 3pm wind speed and direction plot (BoM 2021a)

3.2 Topography

Assessment of topography within the project area was based on the Digital Elevation Model, sourced from LIDAR captured for the project. All slope values described below are approximations based on this data and relative distances between selected key features.

The Australian Riverine Plain is the country's largest drainage basin and encompasses many rivers with their origins in the eastern highlands which is an uplifted zone flanking the south-east of the continent. A riverine plain composed of coalescing alluvial fans and floodplain assemblages are generated from relict and active alluvial, aeolian and lacustrine processes formed from surficial clayey sediments.

Conditions during the Holocene since the Last Glacial Maximum are known to be highly arid where aeolian process are dominant as indicated by the surficial sediments that are composed from parna, which is a silty, carbonate rich clay derived from dry lake beds and alluvial deposits that are distributed evenly over much of the south-east of the continent. Contemporary landscapes in the riverine plains are characterised by highly sinuous, laterally unconfined, suspended load streams. The Murrumbidgee River, a major channel approximately 42 km south of the project area, has been found to have four major periods of adjustment since the Last Glacial Maximum (Fried 1993). Source-bordering dunes are common under these conditions such that measured water content of sand dunes in the Riverine Plains show very low field moisture content.

The project area is between Jerilderie and Coleambally, crossing Kidman Way north of Yanco Creek. The topographical features of the project area are limited, with drainage paths the only major features. The project area can be described as a plain with general slope of <1%. Minor depressions exist as ephemeral drainage line segments and ponds/swamps which are possibly remnants of a paleochannel meander. Local gilgai has also been reported to be associated with the project area.

The mean elevation of the project area is 105.7 m Australian Height Datum (mAHD) and maximum elevation is 108.7 mAHD. There is a westerly dip across the width of the project area (east to west) with a mean slope of 0.3%.

The greatest areas of slope within the project area are typically associated with the banks of dams, drainage lines and irrigation channels.

3.3 Surface water

The project is within the lower Murrumbidgee River catchment in southern NSW which drains a total area of around 84,000 km². The Murrumbidgee River flows in a south-westerly direction from its headwaters in Kosciuszko National Park to the floodplains at the western end of the catchment where the project is situated.

The project is situated to the north of Yanco Creek, which has a regulated offtake from the Murrumbidgee River and flows generally south-west and ultimately to the Murray River via Billabong Creek, Edward River and Wakool River.

The project area includes catchments draining to Delta Creek and the Coleambally Outfall Drain. The Coleambally Outfall Drain is a major outlet drainage channel, part of the Coleambally Irrigation Co-Operative (CICL), and includes contribution from Bublebundie and Blind Creek. Delta Creek is a minor, ephemeral waterway which also drains in a south-westerly direction during significant rainfall, although does not connect to any downstream major channel unless the area is flooded.

The project area is largely flat with some minor drainage depressions that temporarily hold water during and following rainfall before eventually flowing in a south-westerly direction. Several minor topographic depressions on the floodplain hold water for longer, creating scattered swamp environments within the project area.

North-east of the project area is the Coleambally Irrigation Area which is run by CICL and supplies irrigation and drainage services to nearly 500 farms. CICL's area of operations spans over 400,000 ha including over 300,000 ha which is serviced by the Coleambally Outfall Drain. The water supply is from the regulated Murrumbidgee River and access to water is based on the Murrumbidgee Regulated River Water Sharing Plan 2016 (CICL 2021).

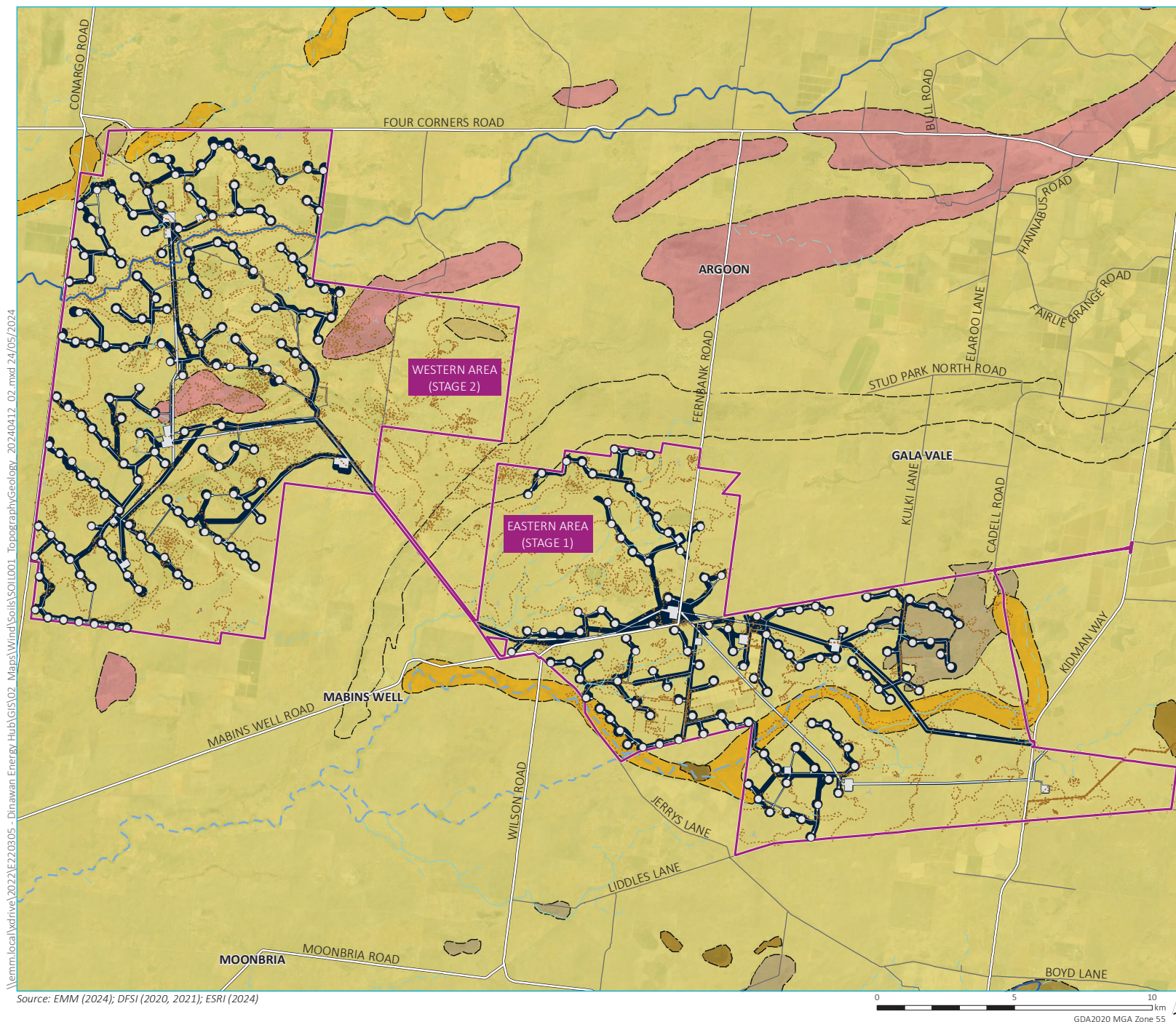
There are several first and second order watercourses, two third order watercourses and the Coleambally Outfall Drain which is mapped as greater than a fourth order watercourse, mapped within the project area. All watercourses within the project area are ephemeral. The Coleambally Irrigation Channel runs through the project area east of Kidman Way and the Coleambally Outfall Drain runs through the western part of the project area.

3.4 Geology

The geology of the project area is described in the NSW Seamless Geology database, version 2.1 (May 2021). Alluvial floodplain deposits (CZaf) are the main unit with aeolian sand plains (Qds) protruding into the north-east corner. There is an alluvial strip (Qa) that underlies the drainage paths into Delta Creek.

Table 3.1 **Geology**

Geology	Map unit	Age	Dominant lithology	Description
Alluvial deposits	CZaf	Cenozoic (0-66 Ma)	Silt, very fine- to medium-grained lithic to quartz-rich sand, clay.	Unconsolidated alluvial clay, silt, sand, and gravel deposits, usually in raised areas away from active alluvial systems
Alluvial deposits	Qa	Quaternary (0-2.58 Ma)	Unconsolidated grey to brown to beige humic (±)micaceous silty clay, quartz-(±)lithic silt, fine- to medium-grained quartz-rich to quartz-lithic sand, polymictic pebble to cobble gravel (as sporadic lenses); sporadic palaeosol horizons.	Current and recent mud, silt, sand and gravel deposited by river (alluvial) systems.
Aeolian deposits – flat plains to sand dunes.	Qds	Quaternary (0-2.58 Ma)	Clayey, silty to fine-grained sand, silty clay at depth; abundant regolith & pedogenic carbonate, extensively modified by pedogenesis.	Sand dune systems deposited by wind (aeolian). Older (Pleistocene) dunes are vegetated and stable. Younger (Holocene) dunes are not vegetated and may be highly mobile depending on wind and wave action.
Aeolian deposits – flat plains to sand dunes.	Qdds	Quaternary (0-2.58 Ma)	Poorly sorted to bi-modal, very fine- to medium-grained feldspathic quartz sand.	Source-bordering dunes deposited by wind (aeolian).
Lacustrine deposits	Ql	Quaternary (0-2.58 Ma)	Friable to plastic, finely laminated grey clay, silty clay, humic clay, grey paleosols; locally includes medium- to fine-grained sand.	Lacustrine deposits form when lakes are filled with sediment during wet periods. After the water evaporates, mud, silt and sand are left in the now dry lakebed. Some large, man-made lakes are also included in this category.



- KEY**
- Project area
 - Development corridor
 - Development footprint
 - Wind turbine generator (WTG)
- Geological boundaries & faults**
- Geological boundary, inferred
 - Geological boundary, position approximate
- Surface geology (250k)**
- Aeolian sand plain
 - Alluvial channel deposits - meander-plain facies
 - Alluvial floodplain deposits
 - Alluvium
 - Claypan and lacustrine deposits
 - Playa lake deposits
 - Source-bordering dunes
- Strahler stream order**
- 1st order
 - 2nd order
 - 3rd order
 - 9th order
- Existing environment**
- Major road
 - Minor road
 - Topographic contour (1 m interval)

Topography and geology

Dinawan Wind Farm
Land and Rehabilitation Assessment
Figure 3.3



3.5 Soils

The assessment of soils, erosion and land comprised a desktop review of existing information on soils and soil environments for the project area sourced from:

- NSW Soil and Land Information System (SALIS) (DPIE 2021b), accessed through eSPADE (DPIE 2020a)
- *Soil and Land Resources of Central and Eastern NSW Mapping* (OEH 2018)
- *Hydrogeological Landscapes of New South Wales and the Australian Capital Territory* (DPE 2022)
- *Australian Soil Classification system soil type mapping of NSW* (DPIE 2021c)
- *Great Soil Group Soil Type map of NSW* (DPIE 2021d)
- *Inherent soil fertility* (DPIE 2020b)
- *Land and Soil Capability Mapping for NSW* (DPIE 2020c).

Due to the broad-scale nature of much of the available regional mapping for soils and soil environments, the present mapping proximal to the project area, as well as present in the project area, is described to suitably characterise the potential environment.

3.5.1 Soil and Land Resources of Central and Eastern NSW

Soil and Land Resources of Central and Eastern NSW Mapping (OEH 2018) is a compilation of seven soil and land resource products of baseline natural resource maps for seven areas, including:

- Hawkesbury-Nepean catchment
- Liverpool Plains catchment
- Merriwa Plateau
- Moree Plains
- Murray catchment
- Australian Capital Territory
- Hunter region.

These maps comprise 1,117 soil landscape map units inventorying soil and landscape information with relatively uniform land management requirements, allowing major soil and landscape qualities and constraints to be identified.

A small part of the project area is within the *Reconnaissance Soil and Land Resources of the Murray Catchment* (OEH 2010) dataset providing standardised and seamless land and soil information across the region at 1:250,000 scale. The remaining project area currently has no soil landscape mapping and instead relies on mapping of ASC and Great Soil Group (GSG), discussed further in Sections 3.5.3 and 3.5.4.

The relevant soil and land resource (SLR) map units are described in Table 3.2 with their noted landscape limitations summarised in Table 3.3.

Table 3.2 **Soil and land resource landscapes**

Soil landscape	Landscape	Soils (GSG)	Geology	Existing land degradation
Jerilderie (jex)	Broad level plains on alluvium of the Riverine Plains. Slopes <1%, local relief <5 m, elevation 80–120 m. This soil landscape covers the intermediate rainfall zone of the plains characterised by open boree woodlands and open grasslands before grading into the westerly Chenopod shrublands of the Hay (hyx) soil landscape; to the south-east, as rainfall rises, this soil landscape grades into the Wait-A-While (wal) landscape. Gilgais occur locally.	Red and Brown Sub-plastic Chromosols and Sodosols (Red-brown Earths/transitional Red-brown Earths), with Reddish Brown Chromosol/Vertosols (transitional Red-brown Earths/Brown Podzolic Soils) and Grey and Brown Self-mulching and Epipedal Vertosols (Cracking Grey and Brown Clays). These soils are closely related to the prior stream network, palaeochannels and drainage. However, the lower rainfall, relative to the Wait-a-While (wal) soil landscape, means that woodland and forest have given way to grasslands and open plains. Consequently, topsoils have less organic matter and depth. Wind erosion potentially increases, and cracking clay soils increase in percentage. Less leaching of the soil profile occurs, and lime is more common and occurs shallower in the subsoil; often locally associated with gypsum. Self-mulching and non-self-mulching clays occur in association with gilgai.	Cainozoic/Quaternary alluvium of the Shepparton Formation (Czsws) on the Riverine Plains. Parent materials include clays, silts and sands from various past flow regimes of the Murray and Murrumbidgee Rivers and their associated palaeochannels.	Topsoils are often fragile and held together by surface crusts of lichens/moss (cryptogams). Topsoil destruction followed by wind erosion leads to localised severe scalding (particularly when underlain by sodic subsoils). Heavier cracking soils are less prone to wind erosion; however, these soils have very poor trafficability when wet, deform easily and are hard setting when dry (apart from pockets of self-mulching soils). Subsoils contain variable amounts of salt content. This is not a problem if water tables remain low. However, if water tables rise, the salt becomes mobile and leads to salinisation.
Coleambally (clo)	Undulating sandplain derived from re-worked alluvium. Sand ridges and swales. Prior stream aeolian infills. Slopes 1–5%, local relief <5 m, elevation 70–140 m. Extensively cleared box – cypress grassy woodland.	Arenic Rudosols (Siliceous Sands) dominate this unit, occasionally grading to Red Kandosols (Red Earths). Adjacent levees/lower slopes commonly support scalded Red and Brown Sodosols (Solodic Soils/Red Brown Earths). Occasionally confined within the unit are low lying channels containing Grey and Brown Vertosols (Cracking Clays).	Re-worked materials from unnamed Cainozoic alluvium (Cza). Thermoluminescence dating (Page et al. 1996) has estimated the ages of the prior streams and these ridges – the streams were active during periods 30–100 thousand years ago, the ridges were therefore formed later.	Wind and sheet erosion is common especially on crests and upper slopes. Wind erosion may cause selective loss of clay particles, greatly reducing the already low water-holding capacity and fertility of the topsoil. Rabbits commonly occur throughout the landscape and cause widespread disturbance and loss of ground cover leading to erosion. In cleared and cultivated areas, topsoils are considerably thinner with less organic carbon than in uncleared areas. High recharge hazard. Localised salinity hazard and high water tables at boundary with alluvial plain.

Table 3.2 **Soil and land resource landscapes**

Soil landscape	Landscape	Soils (GSG)	Geology	Existing land degradation
Coleambally var. a (cloa)	Level sandplains: prior stream aeolian infills. Slopes <5%, local relief <3 m, elevation 60–140 m. Extensively to completely cleared box - cypress woodland.	Arenic Rudosols (Siliceous Sands) on higher sandy ridges, Red and Brown Kandosols (Red Earths) on some less distinct rises, Red Sodosols (Red-brown Earths) with sandy topsoils on levees. Minor Brown Vertosols (Cracking Clays) on some included lower depressions where the clay plain reveals itself through the shallow sandy aeolian sheet.	Relict east-west distributary network of prior stream ridges of the Murrumbidgee and Murray River systems, part of the Shepparton Formation (Czsws). They originate from past climates where sandy bedload dominated streams were flowing across the plain.	Wind and sheet erosion is common especially on crests and upper slopes. Wind erosion may cause selective loss of clay particles, greatly reducing the already low water-holding capacity and fertility of the topsoil. Rabbits commonly occur throughout the landscape and cause widespread disturbance and loss of vegetative cover leading to erosion. In cleared areas, topsoils are considerably thinner with lower carbon content than in uncleared and uncultivated areas. High recharge hazard. Localised salinity hazard at boundary with plain.
Coleambally var. b (clob)	Prior stream sand ridges which exhibit fairly narrow and sinuous characteristics, and are usually quite clearly defined and raised above the surrounding plain. Slopes <5%, local relief <3 m, elevation 80–130 m. Mixed bluebush, old-man saltbush and pine dominate.	Arenic Rudosols (Siliceous Sands) on higher sandy ridges, Red and Brown Kandosols (Red Earths) on some less distinct rises, Red Sodosols (Red-brown Earths) with sandy topsoils on levees.	Relict east-west distributary network of prior stream ridges of the former Murray and Murrumbidgee River systems, part of the Shepparton Formation (Czsws). These originate from past climates where sandy bedload dominated streams were flowing across the plain.	Soils are dominated by non-cohesive sands, so wind and sheet erosion are potential problems especially on crests and upper slopes. Wind erosion may cause selective loss of clay particles, greatly reducing the already low water-holding capacity and fertility of the topsoil. High recharge hazard. Localised salinity hazard at boundary with plain. On levees, wind erosion has removed some sandy topsoil resulting in scalding particularly where surfaces have been disturbed.
Niemur River (nmu)	Active inset floodplains and meander plains of the Niemur, Edward and Wakool Rivers and their tributaries and distributaries, extending from Lockhart in the east into the far west of the catchment. Includes incised stream channels with steep banks, flood runners, oxbows, levees and floodplains 300–1,500 m wide. Slopes 0-3%, up to 50% on banks; local relief 0–9 m, elevation 60–180 m. Partly cleared river red gum grassy woodlands.	Grey or other dark-coloured Vertosols dominate (Grey Cracking Clays), often with a slightly sandy B3 horizon. These occasionally grade to Grey or Brown Chromosols (Brown Clays/Brown Podzolic Soils). Occasional Redoxic Hydrosols (no suitable group) occur in frequently waterlogged areas.	Quaternary Alluvium (Qa), comprising clay, silt and sand in decreasing order.	Localised topsoil structure decline and damage occurs after grazing in wet conditions.

Table 3.2 **Soil and land resource landscapes**

Soil landscape	Landscape	Soils (GSG)	Geology	Existing land degradation
Yanga lunettes (ylw)	Crescent-shaped dune rises formed on the eastern margins of lakebeds and relict water bodies. Slopes <20%, local relief <30 m, elevation 80-120 m. Partially cleared box - cypress woodlands.	Arenic Rudosols (Siliceous Sands) to Calcic Calcarosols (Calcareous Soils) dominate this landscape, along with Red and Brown Kandosols (Red and Brown Earths) to Subplastic Chromosols (Duplex soils) and occasional Brown Sodosols (Solodic Soils) on lower slopes.	Quaternary aeolian sediments (Qdl). Beach sands from lake foreshores are often buried or partly buried by aeolian clay pellets, which have originated from deflation of saline lakebed sediments. Both sand and clay pellet materials may be identified in a lunette catena. Aeolian bedding planes within the lunette are common.	Wind erosion is common, especially where topsoils and surface cover have been disturbed (over-grazing, rabbits, or intense cultivation). Sheet erosion may also occur on some side slopes. Lower slope scalding and topsoil loss occur on those lunettes with sodic soils.

Table 3.3 Soil and land resource limitations

Limitation	Hazard	Soil and land resource areas					
		Jerilderie (jex)	Coleambally (clo)	Coleambally var a. (cloa)	Coleambally var b. (clob)	Niemer River (nmu)	Yanga lunettes (ylw)
Landscape	Steep slopes	Not observed	Not observed	Not observed	Not observed	Localised	Localised
	Mass movement	Not observed	Not observed	Not observed	Not observed	Not observed	Not observed
Soils	Shallow Soils	Not observed	Not observed	Not observed	Not observed	Not observed	Not observed
	Non-cohesive Soils	Localised	Widespread	Widespread	Widespread	Not observed	Widespread
Erosion	Sheet erosion	Not observed	Localised	Widespread	Widespread	Not observed	Widespread
	Gully erosion	Not observed	Not observed	Not observed	Not observed	Localised	Localised
	Wind erosion	Localised	Widespread	Widespread	Widespread	Not observed	Widespread
Hydrology	Seasonal waterlogging	Localised	Not observed	Not observed	Not observed	Widespread	Not observed
	Flood hazard	Localised	Not observed	Not observed	Not observed	Widespread	Not observed
Salinity	Recharge zone	Localised	Widespread	Widespread	Widespread	Localised	Widespread
	Discharge Zone	Localised	Localised	Localised	Localised	Widespread	Localised
	Salinity Hazard	Localised	Localised	Localised	Not observed	Localised	Localised

3.5.2 Hydrogeological landscapes

Hydrogeological landscape (HGL) boundaries and descriptions have been derived for several areas across NSW based on how salinity manifests itself in the landscape and how differences in salinity are expressed across the landscape. A HGL spatially defines areas of similar salt stores and pathways for salt mobilisation and relies on the integration of a number of factors: geology, soils, slope, regolith depth, and climate; an understanding of the differences in salinity development; and the impacts (land salinity/salt load/water electrical conductivity) in landscapes. Derivative maps showing overall salinity hazard and individual hazard due to salinity expressed as land salinity, salt export (load) and stream EC are available. Overall salinity hazard uses a five-class system (very low, low, moderate, high, very high) whilst hazard due to land salinity, salt export and stream EC uses a three-class system (low, moderate, high) (DPE 2022).

The project area is outside of the project level HGL mapping areas and is limited to state-wide mapping shown in Table 3.4.

Table 3.4 **Hydrogeological landscapes for the Project area**

HGL	Description	Salt export	Land salinity hazard	Overall salinity hazard
State-wide	No report available	Low	High	Moderate

3.5.3 Australian Soil Classification

The ASC scheme (Isbell & NCST 2021) is a multi-category scheme with soil orders defined based on diagnostic horizons or materials and their arrangement in vertical sequence as seen in an exposed profile. State-wide mapping (DPIE 2021c) identifies that the project area encompasses three soil orders, primarily Vertosols with small, isolated inclusions of Rudosols and Chromosols (Figure 3.4), described in Table 3.5.

The landscape of the Riverine Plains is composed from coalescing alluvial features and floodplain assemblages of fine-grained sands and upward fining clays.

Chromosols are texture contrast soils with a sandy to loamy topsoil overlaying a clay B horizon. They generally have good properties but can be hardsetting with prolonged cropping and are among the most widespread agricultural soils in Australia. They have moderate water-holding capacity and can be prone to soil acidification and structure decline.

Rudosols have little, if any, pedologic organisation. Rudosols are generally young soils which have had little time to pedologically modify parent sediments or rocks. They can vary widely in terms of depth and texture. Many Rudosols are stratified and some are highly saline. Topsoils of Rudosols are commonly some minor organic accumulation on the surface with weathered parent material.

Vertosols have either clayey field texture (light – heavy clay) or >35% clay, that exhibit vertic properties. The potential for aeolian soil erosion is moderate to high when the soil is dry due to the fine particle size of clays. This effect is enhanced by cultivation and the removal of groundcover vegetation. The major limitations of these groups can include poor/reduced permeability, poor root penetration and flooding.

Table 3.5 **Summary of regional ASC soil mapping**

Soil Type	ASC description ¹	Agricultural potential ²
Chromosol (CH)	• Soils with strong texture contrast between A and B horizons which are <i>not strongly acid</i> and are <i>not sodic</i>. • Soils other than Hydrosols with: – with a <i>clear or abrupt textural B horizon</i> – in which the major part of the upper 0.2 m of the B2t horizon (or the major part of the entire B2t horizon if it is less than 0.2 m thick) is <i>not sodic</i> and <i>not strongly acid</i>. • Soils with strongly sub plastic upper B2t horizons are also included even if they are sodic.	• Generally moderate agricultural potential. • Moderate chemical fertility and water-holding capacity. • Can be susceptible to soil acidification and soil structural decline.
Rudosol (RU)	• Soils with generally little, if any, pedologic organisation apart from; – minimal development of an A horizon; or – presence of less than 10% of a B horizon in fissures of the parent material or sapriolite. • The soils are apedal or only weakly structured in the A1 horizon and show no pedological colour changes apart from the darkening of an A1 horizon. • Typically young soils in the sense that soil forming factors have had little time to pedologically modify parent rocks or sediments. • Component soils can vary widely in terms of texture and depth; many are stratified and some are highly saline.	• Most have low or very low agricultural potential. • Typically thin, rocky and/or sandy with low chemical fertility. • Alluvial soils are often deep, fertile and have high agricultural potential.
Vertosol (VE)	• Clay soils with shrink-swell properties that exhibit strong cracking when dry and at depth have slickensides and/or lenticular structural aggregates. • Soils which have all the following: – a clay field texture of 35% or more clay throughout the solum except for thin, surface crusty horizons 0.03 m or less thick – when dry, open cracks occur at some time in most years³. These are at least 5 mm wide and extend upward to the surface or to the base of any plough layer, peaty horizon self-mulching horizon, or thin, surface crusty horizon. • Slickensides and/or lenticular peds occur at some depth in the solum.	• Generally high agricultural potential. • High chemical fertility and water holding capacity but require significant amounts of rain before water is available to plants. • Gypsum and/or lime may be required to improve the structure. • Heavy plastic clays can be difficult to respread and cultivate, especially when wet. • Shrink-swell phenomena creates foundation problems for buildings and infrastructure.

Notes: 1. per Isbell & NCST (2021)
2. per Gray and Murphy (1999)
3. note that there is no crack frequency criterion as in the Factual Key (Isbell & NCST 2021)

3.5.4 Great soil groups

Great soil groups 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 great soil groups classification has since been superseded by the ASC and commonly great soil groups soils have been converted to their ASC equivalent in many mapping systems.

Historic soil mapping identified from NSW government mapping (DPIE 2021d) for the project area are displayed in Table 3.6 with their corresponding ASC equivalents and associated soil landscapes and land resource areas.

Table 3.6 **Regional soil mapping – great soil groups**

Great soil groups	ASC equivalent	Typical soil landscape
Red-brown earths (RBE)	Chromosols	Coleambally var. a
Siliceous sands (SS)	Rudosols	Coleambally and var. b
Grey, brown and red clays (GC, BC & RC)	Vertosols	Jerilderie, Niemur River

3.5.5 Inherent soil fertility

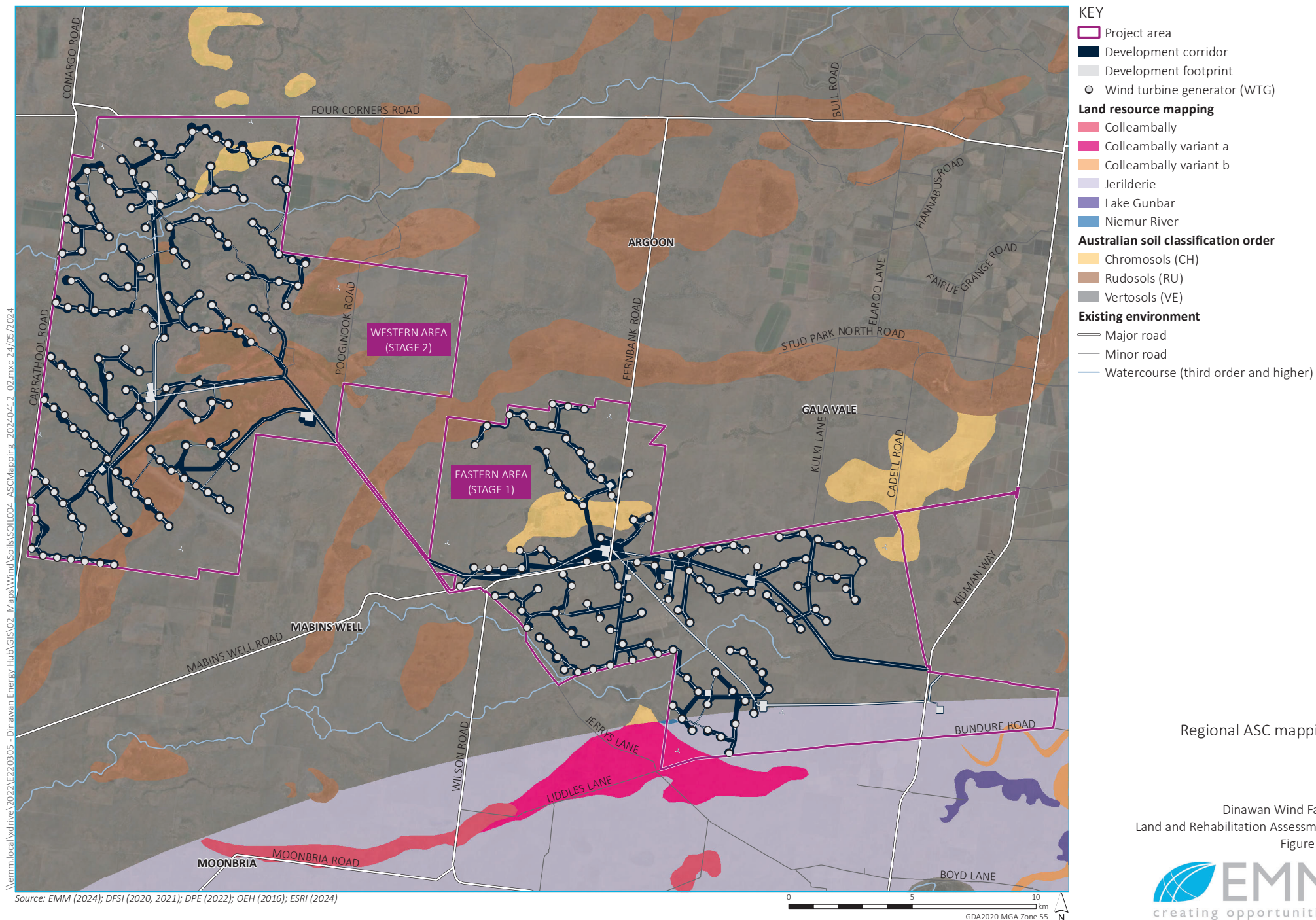
Inherent soil fertility is used as a general indication of a soil's capacity to retain and release nutrients and soil water for use by vegetation and is a function of the interrelationship between physical, chemical and biological components in the soil. The inherent fertility is derived using a relative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

Per the eSPADE database (DPIE 2020a) the state scale mapping completed for NSW shows that the soils of the project area have variable inherent soil fertility ranging from 'moderate' to 'low' (Table 3.7).

Table 3.7 **Inherent soil fertility**

Inherent soil fertility	ASC	Description ¹
Moderate	Chromosols, Vertosols	Soils with low to moderate fertilities that usually require fertiliser and/or have some physical restrictions for arable use.
Low	Rudosols	Soils which, due to their poor physical and/or chemical status, only support limited plant growth. The maximum agricultural use of these soils is sparse grazing. This group includes shallow and sandy or stony soils which by virtue of their poor water retention characteristics can support only limited plant growth.

1. Per Chapman (1978)



3.5.6 Land and soil capability

The NSW *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.

i Project area

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 area is identified as Classes 3, 4 and 6 representing land ranging from high to low capability (Figure 3.5, Figure 3.6 and Table 3.8) with individual LSC hazards from eSPADE shown in Table 3.9. It is noted only a very small proportion of the project area is mapped as Class 3 (associated with areas of proposed access roads along McLennons Bore Road), with the majority mapped as Class 4 and the balance mapped as Class 6 (Table 3.11).

Table 3.8 Land and soil capability classifications mapped for the project area

LSC Class ¹	Description	ASC (typical soil landscape)
Class 3 – High capability land	- Land has moderate limitations and is capable of sustaining high-impact land uses - 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	Vertosols (Jerilderie and Wait-A-While)
Class 4 – Moderate capability land	- Land has moderate to high limitations for high-impact land uses - Will largely restrict land use to grazing, some horticulture (orchards), forestry and nature conservation - The limitations need to be carefully managed to prevent long-term degradation.	Vertosols (Jerilderie)
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	Chromosols (Coleambally var. a) Rudosols (Coleambally and var. b, Yanga lunettes) Vertosols (Niemur River)

Notes 1. Per OEH 2012

Table 3.9 LSC classes mapped for the project area

ASC (typical soil landscape)	LSC hazard								Final LSC
	Water	Wind	Structure	Acidification	Salinity	Waterlogging	Shallow soils	Mass movement	
Vertosols (Jerilderie and Wait-A-While)	1	2	3	1	3	3	1	1	3
Vertosol (Jerilderie)	1	4	4	1	NR	3	1	1	4
Chromosol (Coleambally var. a)	3	6	1	2	NR	1	1	1	6
Rudosol (Coleambally)	2	6	1	4	NR	1	1	1	6
Rudosol (Coleambally var. b)	2	6	1	3	NR	1	1	1	6
Vertosol (Niemur River)	4	2	3	1	NR	6	1	1	6
Rudosol (Yanga lunettes)	3	6	1	4	NR	1	1	1	6

NR. not recorded in dataset.

ii South West REZ

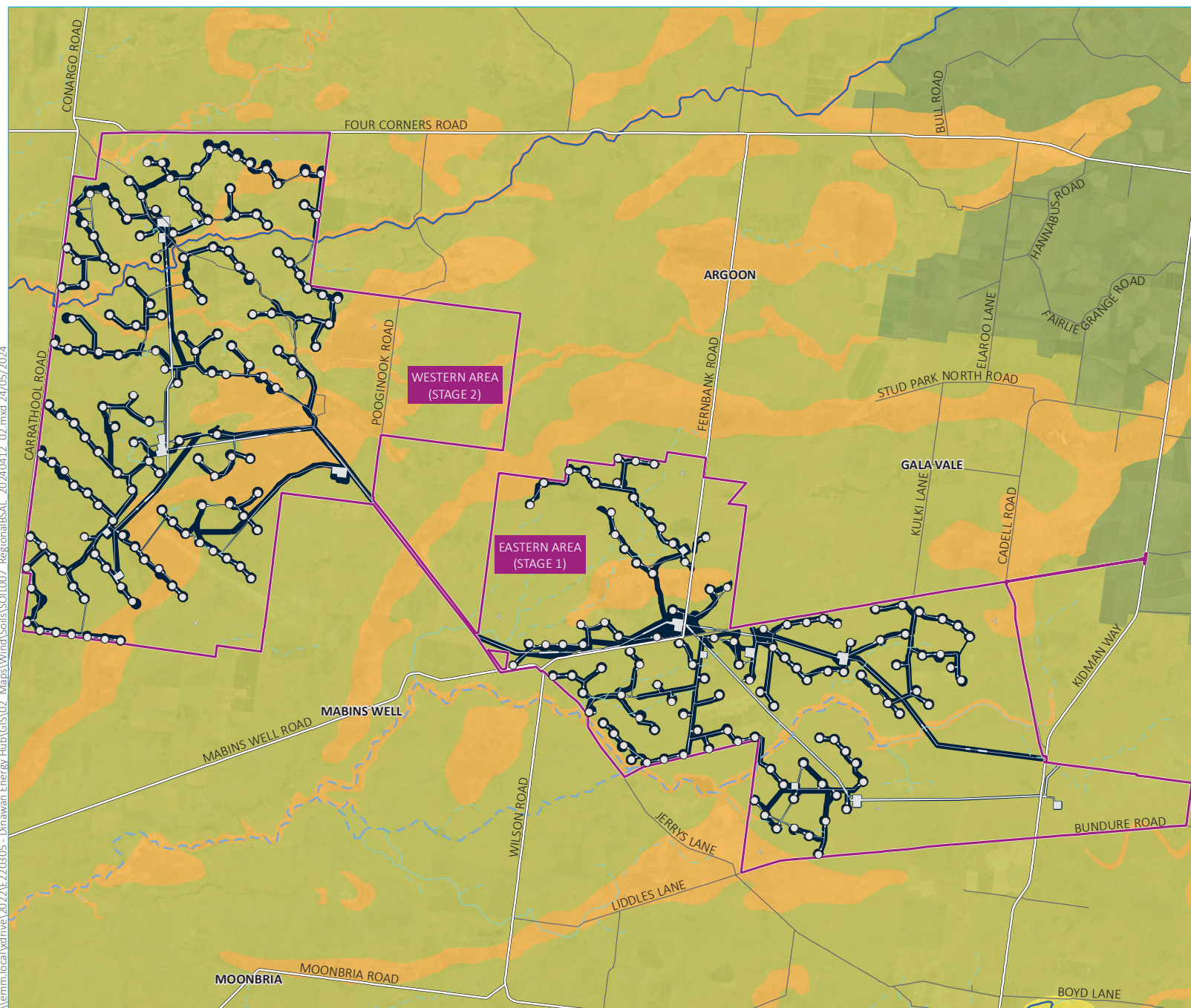
Assessment of LSC mapping across the South West REZ, totalling an area of 2,782,832 ha (excluding water), is shown in Table 3.10 and provides context to support consideration of potential impacts on highly productive land as a result of the construction of renewable energy developments within this region.

LSC mapping across the South West REZ shows predominantly moderate (Class 4) (36%) to moderate-low capability (Class 5) (41%) land across the South West REZ. This will likely limit land use to grazing, forestry and nature conservation with occasional cropping with restricted cultivation.

Table 3.10 LSC classes mapped for the South West REZ

Area	LSC Class								Excluded
	1	2	3	4	5	6	7	8	Water
Hectares	0	0	1,739	988,411	1,129,856	341,583	249,807	71,436	406
Percentage of total (%)	0	0	<1	36	41	12	9	3	NA

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- KEY**
- Project area
 - Development corridor
 - Development footprint
 - Wind turbine generator (WTG)
- Land and soil capability**
- 3 - Moderate limitations
 - 4 - Moderate to severe limitations
 - 5 - Severe limitations
 - 6 - Very severe limitations
- Strahler stream order**
- 1st order
 - 2nd order
 - 3rd order
 - 9th order
- Existing environment**
- Major road
 - Minor road

Regional LSC mapping

Dinawan Wind Farm
Land and Rehabilitation Assessment
Figure 3.5



Source: EMM (2024); DFSI (2020, 2021); DPE (2022); ESRI (2024)



3.5.7 Acid sulfate soils

Acid sulfate soils (ASS) probability mapping has been completed along the NSW coast over 128 map sheets at 1:25,000 scale (Naylor *et al* 1998). The desktop assessment identified that there are no ASS or potential ASS in the project area, in accordance with the *Guidelines for the Use of Acid Sulfate Soil Risk Maps* (Naylor *et al* 1998). The NSW Acids Sulfate Risk Map (OEH 2018) indicates that the nearest site with a high probability of ASS is approximately 200 km south-east of the project area and as such the project area is at little risk from ASS.

The Australian Soil Resource Information System (ASRIS) Atlas of Australian ASS mapping (Fitzpatrick *et al.* 2011) has mapped the project area as Cn(p4), Extremely Low Probability of Occurrence, the lowest probability allocation.

ASS are typically found in coastal areas which does not apply to the project area. Inland ASS theoretically has the potential to occur within the project area in association with any waterway where suitable conditions prevail (such as sulfate salinised areas in inland regions with anoxic conditions and abundant organic matter). Such conditions are generally rare and associated predominantly with sustained anoxic aquatic environments, like inland lakes, not minor ephemeral waterways which characterise the project area. However, a study of ASS risk in the lower Murray-Darling Basin, commissioned by the NSW Office of Environment and Heritage (OEH), suggests inland sulfidic soils are correlated with incised channels through alluvial floodplains with halite salinity and gypsum soils of the Shepparton Formation. The lateral migration of groundwater from drainage channels through variegated clays and silts with polymictic lenses that are characteristic of the Shepparton Formation soils is thought to generate ASS and is commonly associated with sodic soils. Where channels were formed in the Connambidgal Formation, which are characterised by channel sands and clay playetts, these areas did not correlate with the presence of sulfidic soils (Tulau and Morand 2013).

3.5.8 Desktop review summary

A summary of the land and soil mapping available from eSPADE (DPIE 2020a) is presented in Table 3.11.

Table 3.11 Regional soil mapping summary

Great soil groups	ASC	Typical soil landscape	Inherent soil fertility	LSC class	Project area (ha)	Development corridor (ha)
Grey, brown and red clays	Vertosols	Jerilderie (jex) Wait-A-While (wal)	Moderate	3	5.36	5.36
Grey, brown and red clays and siliceous sands	Vertosols	Jerilderie (jex)	Moderate	4	32,861.31	6,511.49
Grey, brown and red clays and red-brown earths	Chromosols	Coleambally var. a (cloa)	Moderate	6	1,248.02	163.56
Grey, brown and red clays	Rudosols	Coleambally var. b (clob)	Low	6	<0.01	-
Grey, brown and red clays	Vertosols	Niemur River (nmu)	Moderate	6	1,362.84	52.26
Siliceous sands	Rudosols	Coleambally (clo) Yanga lunettes (ylw)	Low	6	3,583.51	523.10
				<i>Total</i>	39,061	7,256

Limited soil landscape data is available for the project area; hence, an assumed soil landscape has been provided in Table 3.11 based on ASC and great soil group mapping. The Jerilderie (jex) soil landscape is likely to be the dominant landscape in the project area based on modelled presence of Vertosols within the project area.

The available desktop information for the project area indicates it is predominantly on land mapped as LSC Classes 4 and 6, representing land ranging from moderate to low capability, with very small areas mapped as LSC Class 3 of high capability.

Generally, the project area consists of texture-contrast topsoils, which when dried can make them vulnerable to wind erosion leading to scalding, especially on crests and upper slopes. Wind erosion can preferentially erode clay particles, leading to a gradual reduction in water-holding capacity. Heavier, cracking soils are less prone to wind erosion, but they have poor trafficability when wet and are hard setting. The loss of groundcover within the project area has potentially led to thinning of topsoils and has enhanced the erosion hazard where gully erosion is present. Salinity levels within the project area are relatively fixed, but rising water tables do present a risk of mobilising stored salts and therefore can increase salinity hazard.

Project specific soil chemistry data indicating the hazards posed by the soils present are contained in Section 4.2.

3.6 Land use

Land use within the project area was assessed utilising *Catchment Scale Land Use of Australia* (ABARES 2021), a national compilation of catchment scale land use data for Australia (CLUM) compiled at a resolution of 50 m by 50 m. Catchment scale land use data was produced by combining land tenure and other types of land use information, fine-scale satellite data and information collected in the field by the Australian Collaborative Land Use and Management Program (ACLUMP).

The CLUM mapping (ABARES 2021) utilises the standards of the ACLUMP and the Australian Land Use and Management (ALUM) Classification Version 8. The ALUM classification is a three-tiered hierarchical structure featuring primary, secondary and tertiary classes 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, including 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 3.12.

Table 3.12 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.

Table 3.12 **ALUM classification**

ALUM class	Overview	Description
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 area is predominantly mapped as ALUM 3.2.0, grazing modified pastures and ALUM 3.3.0, cropping. There are areas of ALUM 2.1.0, grazing native vegetation, and small areas of ALUM 5.4.0, residential and farm infrastructure and ALUM 1.3.0, other minimal use, with a tertiary class of 1.3.3, residual native cover.

This is mostly consistent with the current and historical land uses observed on-site, which include primarily livestock grazing on modified pasture and native vegetation, with cropping activity occurring to a lesser extent.

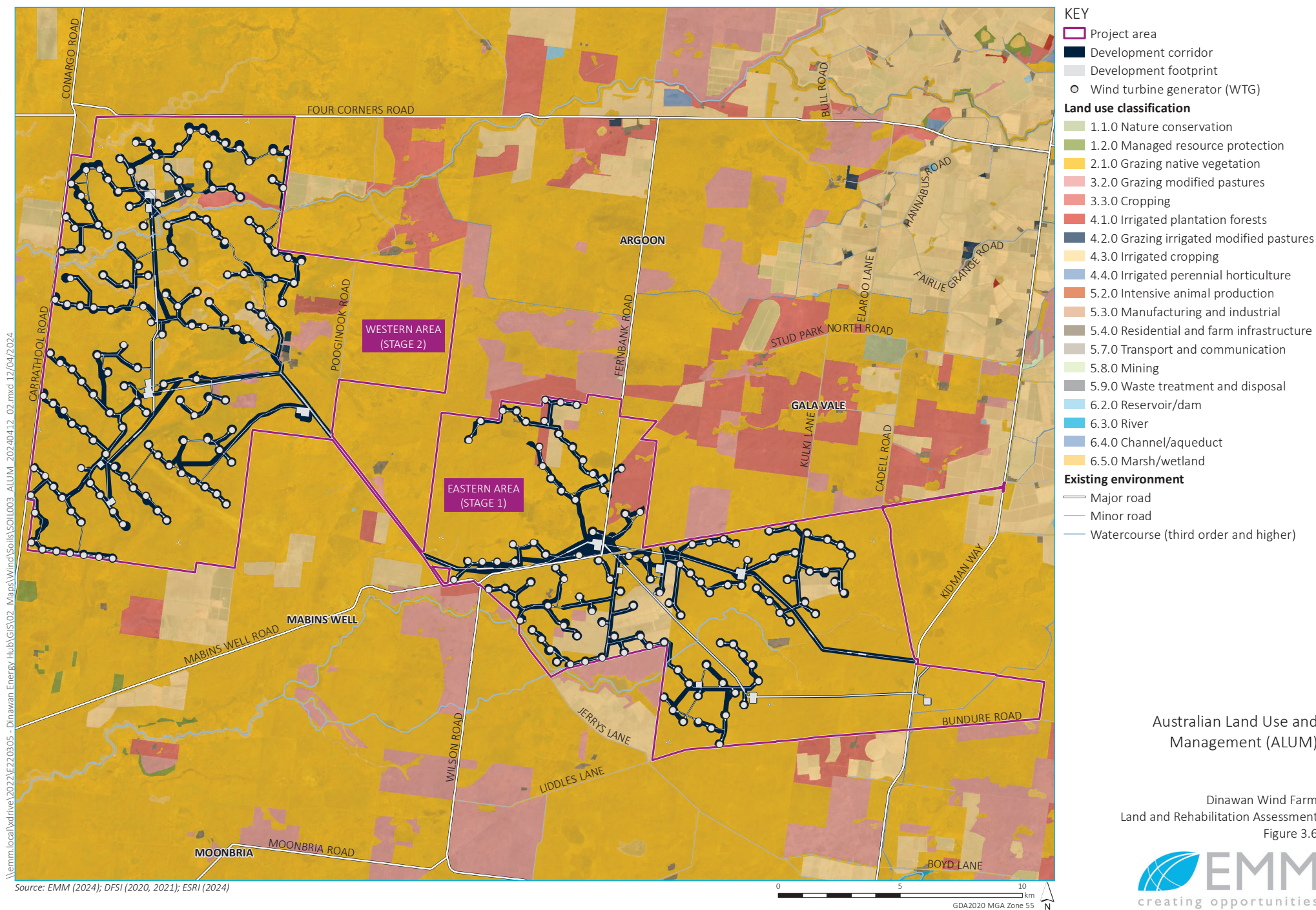
The development corridor is predominantly mapped as ALUM 2.1.0, grazing native vegetation. Smaller areas include 4.3.0, irrigated cropping; 3.3.0, cropping, and 3.2.0, grazing modified pastures.

A detailed breakdown of the ALUM classification of the project area, development corridor and development footprint is contained in Table 3.13 and shown in Figure 3.6.

Table 3.13 **Project area ALUM classification**

ALUM primary class	ALUM secondary class	ALUM tertiary class	Project area (ha)	Development corridor (ha)	Development footprint (ha)
1	1.2.0 Managed resource protection	1.2.0 Managed resource protection	3.9	3.2	0.1
2	2.1.0 Grazing native vegetation	2.1.0 Grazing native vegetation	35,280.6	6,531.3	1,223.1
3	3.2.0 Grazing modified pastures	3.2.0 Grazing modified pastures	384.1	88.4	16.2
3	3.3.0 Cropping	3.3.0 Cropping	783.1	94.0	15.0
4	4.2.0 Grazing irrigated modified pastures	4.2.0 Grazing irrigated modified pastures	53.0	11.1	2.9
4	4.3.0 Irrigated cropping	4.3.0 Irrigated cropping	1,758.0	479.5	75.7
5	5.2.0 Intensive animal production	5.2.0 Intensive animal production	0.3	<0.1	<0.1
5	5.4.0 Residential and farm infrastructure	5.4.0 Residential and farm infrastructure	71.8	5.5	0.5
5	5.4.0 Transport and communication	5.7.1 Airports/aerodromes	4.9	0.3	0.0
5	5.8.0 Mining	5.8.0 Mining	3.1	0.0	0.0
5	5.8.0 Mining	5.8.2 Quarries	1.1	0.1	0.0
6	6.2.0 Reservoir/dam	6.2.0 Reservoir/dam	2.6	2.5	0.1
6	6.4.0 Channel/aqueduct	6.4.0 Channel/aqueduct	21.6	0.2	0.1
6	6.5.0 Marsh/wetland	6.5.0 Marsh/wetland	693.1	39.6	4.9

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



Source: EMM (2024); DFSI (2020, 2021); ESRI (2024)

3.7 Land zoning

The western wind area is subject to the Conargo Local Environmental Plan 2013 (Conargo LEP), which 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 LGA. The western wind area is zoned RU1 Primary Production (Figure 3.7).

The eastern wind area is subject to the Jerilderie Local Environmental Plan 2012 (Jerilderie LEP). Land within the eastern wind area is primarily zoned RU1 Primary Production with the exception of land within the Kidman Way road reserve, which is zoned SP2 Classified Road (Figure 3.7).

3.8 Agriculture

The project is within Murrumbidgee LGA, Edward River LGA and the Murray Natural Resource Management (NRM) Region of NSW. The assessment of project impacts to agricultural land has been limited to assessment based on available regional agricultural and land use data.

3.8.1 Strategic agricultural land

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). The Stage Significant Agricultural Land (SSAL) map is currently in draft format on public exhibition for comment and feedback and is not yet approved or implemented for any purpose but has been considered in addition to BSAL and CICs.

The presence of BSAL, SSAL and CICs within the project area is described below.

3.8.2 Biophysical Strategic Agricultural Land (BSAL)

BSAL is defined in the *Interim Protocol for Site Verification and Mapping of Biophysical Strategic Agricultural Land* (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 criteria used to measure BSAL were based on three regional scale parameters: soil fertility, LSC and access to reliable water supply.

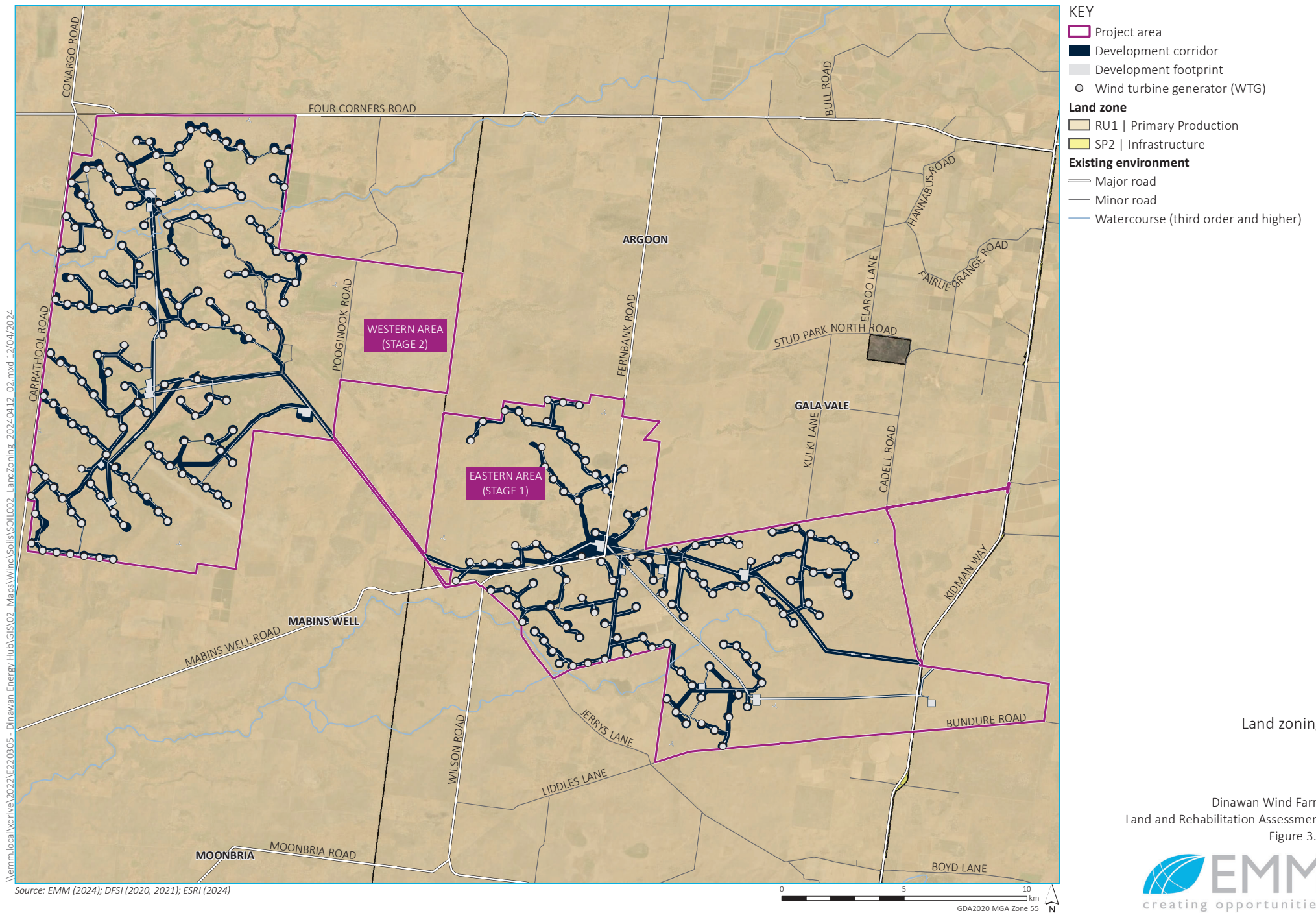
There is no mapped BSAL in the project area with the nearest approximately 105 km to the east associated with alluvial land around the Murrumbidgee River to the west of Wagga Wagga.

3.8.3 State Significant Agricultural Land (SSAL)

NSW Department of Primary Industries (DPI) is undertaking a mapping program across NSW to assist state and local government, along with other organisations and industries to recognise and value SSAL. Loss of access to agricultural resources and increased incidents of agricultural land use conflict in the rural landscape have the potential to create inefficient land use shifts. This can result in a net loss of value to the State through:

- direct and indirect economic loss of produce and markets
- loss of primary industries, associated businesses and services and related employment
- social decline and loss of community connectivity.

Knowing where SSAL is situated and understanding its location, value and contribution will assist in making decisions about current and future allocation of land.



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Source: EMM (2024); DFSI (2020, 2021); ESRI (2024)

Land zoning

Dinawan Wind Farm
Land and Rehabilitation Assessment
Figure 3.7

The draft SSAL mapping prepared by DPI was on public exhibition for comment and feedback until 31 January 2022. The biophysical criteria used to map SSAL include: LSC, inherent soil fertility, pH and water availability. The data utilised for the development of the SSAL mapping is predominantly regional-scale mapping or modelling and subject to associated data limitations for application at a property scale.

There are small areas of mapped SSAL within the project area associated with apparent cultivation.

3.8.4 Critical Industry Clusters (CICs)

CICs are concentrations of highly productive industries within a region that are related to each other, contribute to the identity of that region and provide significant employment opportunities. The creation of these industry clusters aims to protect this high-quality agricultural land from the impacts of Coal Seam Gas (CSG) and mining activities.

No CICs are present within the project area.

3.8.5 Agricultural water resources

Impacts on water resources, including those used for agricultural purposes, are considered in the Water Resources Assessment (EMM 2024) and summarised below.

i Drainage and surface water

Due to the ephemeral nature and, therefore, limited supply of surface water in the area, this source is unreliable for agricultural purposes and its use is thus limited. Irrigation infrastructure within the project area typically comprises constructed open channels to convey water on the surface; however, this is regulated via pumping, flow gates and dams in a network arrangement.

ii Groundwater

Groundwater uses in the area are split between stock and domestic and irrigation. Significant water licence holdings are owned by property owners within and surrounding the project area. Productive groundwater resources are at significant depths below ground and utilise a regional scale aquifer.

3.8.6 Agricultural land uses

i Regional

The Murray NRM has agricultural land use dominated by livestock grazing (41.98% of NRM land use), predominantly of native vegetation (31.75%), and cropping (38.65%), predominantly dryland cropping (23.23%) (ABARES 2021b).

The Murrumbidgee LGA has a similar distribution of livestock grazing (50.46% of LGA land use) and cropping (41.21%), similarly dominated by grazing of native vegetation (44.12%) but with a greatly increased presence of irrigated cropping (31.18%) compared to dryland cropping of the LGA (ABARES 2021a). Edward River LGA has a much higher rate of livestock grazing (70.39% of LGA land use), dominated by native vegetation grazing (67.51% of LGA land use) with a high portion of irrigated cropping (21.89% of LGA land use) compared to dryland cropping (2.04% of LGA land use) (ABARES 2021c).

The agricultural land uses of the LGAs and NRM region are shown in Table 3.14.

Table 3.14 **Agricultural land use**

Land use	Murrumbidgee LGA ¹		Edward River LGA ²		Murray Region ²	
	Area (ha)	Area of LGA (%)	Area (ha)	Area of LGA (%)	Area (ha)	Area of NRM (%)
Cropping – dryland	68,991	10.03	18,122	2.04	973,206	23.23
Cropping – irrigated	214,516	31.18	194,456	21.89	645,895	15.42
Horticulture – dryland	21	<0.1	4	<0.1	463	<0.1
Horticulture – intensive plant production	NR	NR	NR	NR	5,432	0.13
Horticulture – irrigated horticulture	1,660	0.24	45	0.01	64	0
Livestock – grazing modified pastures	43,639	6.34	25,601	2.88	428,521	10.23
Livestock – grazing native vegetation	303,603	44.12	599,758	67.51	1,330,108	31.75
Livestock – intensive animal production	440	0.06	484	0.05	2,703	0.06
Livestock – irrigated pastures	1,159	0.17	1,844	0.21	38,764	0.93
Livestock – land in transition	22	0.00	NR	NR	508	0.01
Agriculture – total	634,051	92.14	840,314	94.59	3,425,664	81.77
Land area - total	688,087	-	888,344	-	4,189,702	-

Notes:

1. ABARES 2021a, Catchment scale land use profile dashboard – Local government areas.
 2. ABARES 2021b, Catchment scale land use profile dashboard – Natural Resource Management regions.
- NR. no statistic recorded in dataset.

ii Local

Land use at the project area level was developed using ALUM land use and knowledge of the agricultural activities occurring on the different landholdings. Of the total development corridor, 51.2 ha is unavailable for agriculture due to the presence of marsh and wetlands, irrigation channels, dams, residential and farm infrastructure, managed resource protection areas, and small areas used for quarrying and airport/aerodrome. Within the remaining area, approximately 6,631 ha is utilised for grazing livestock and 574 ha is used for cropping.

3.8.7 Agricultural production

Agricultural productivity for selected commodities for the Murray NRM, Murrumbidgee LGA and Edward River LGA is presented in Table 3.15 from the Australian Bureau of Statistics (ABS) *2020-21 Value of Agricultural Commodities Produced (VACP)* collection which measures agriculture's contribution to the Australian economy (ABS 2022).

The primary agricultural productivity of Murrumbidgee LGA is cropping (78.3% of gross agricultural productivity), predominantly broadacre cropping and fruit and nuts (excluding grapes) which comprise 63.1% and 17.8% of cropping productivity, respectively. Agricultural productivity relating to livestock is primarily associated with slaughter and disposals, particularly of poultry (45.75% of disposals productivity), with livestock products dominated by milk (68.3%) and wool (31.63%).

The primary agricultural productivity of Edward River LGA is cropping (64.01% of gross agricultural productivity), predominantly broadacre cropping, which comprises 63.56% of total cropping within the LGA, followed by vegetables which comprise 17.22%. Livestock related agricultural productivity is primarily associated with slaughter and disposals (22.53% of gross agricultural productivity), especially poultry (47.19% of disposals productivity). Livestock products account for 13.46% of gross agricultural productivity within the LGA, comprising mostly milk (55.75% of livestock products) and wool (44% of livestock products).

The Murray NRM region shows a slightly reduced balance of cropping productivity, with cropping comprising 62.23% of gross agricultural productivity, predominantly broadacre cropping which comprises 76.3% of cropping productivity. Agricultural productivity relating to livestock is consistent with the Murrumbidgee LGA, primarily associated with slaughter and disposals, but with variation in greatly reduced poultry and increased cattle production (42.7% of disposals productivity), with livestock products balanced between milk (50.8%) and wool (46.20%).

Variation of cropping productivity, particularly increased fruit and nut productivity, between Edward River LGA and Murrumbidgee LGA and Murray NRM region is consistent with the increased presence of irrigated horticultural practices observed in the land use.

Table 3.15 Value of agricultural commodities – 2020-2021

Agricultural commodity	Murrumbidgee LGA ¹		Edward River LGA ¹		Murray NRM Region ²	
	Gross value (\$m) ³	Local value (\$m) ⁴	Gross value (\$m) ³	Local value (\$m) ⁴	Gross value (\$m) ³	Local value (\$m) ⁴
Crops – broadacre – total	232.01	212.93	132.76	119.92	941.58	860.79
Hay – total	9.17	9.17	17.90	17.90	90.67	90.67
Nurseries, cut flowers or cultivated turf - total	7.82	7.05	13.98	12.59	36.36	32.74
Fruit and nuts (excluding grapes) - total	65.50	57.99	7.88	6.79	54.46	47.94
Fruit and nuts - Grapes - total	24.73	24.73	0.37	0.35	8.91	8.72
Vegetables - total	28.21	24.60	35.97	28.43	102.33	83.85
Crops – total⁵	367.44	336.47	208.86	185.99	1,234.32	1,124.71
Livestock products – wool	9.98	9.42	19.33	18.26	94.07	88.84
Livestock products – milk	21.55	21.55	24.49	24.49	103.39	103.39
Livestock products – eggs	0.02	0.02	0.11	0.09	6.17	5.51
Livestock products – total	31.55	30.99	43.93	42.85	203.63	197.74

Table 3.15 Value of agricultural commodities – 2020-2021

Agricultural commodity	Murrumbidgee LGA ¹		Edward River LGA ¹		Murray NRM Region ²	
	Gross value (\$m) ³	Local value (\$m) ⁴	Gross value (\$m) ³	Local value (\$m) ⁴	Gross value (\$m) ³	Local value (\$m) ⁴
Livestock slaughtered and other disposals - Sheep and lambs	14.61	13.44	29.33	26.97	138.25	127.12
Livestock slaughtered and other disposals - Cattle and calves	18.30	16.91	27.15	25.09	232.86	215.20
Livestock slaughtered and other disposals - Pigs	5.12	4.68	16.96	15.50	141.54	129.36
Livestock slaughtered and other disposals - Poultry	32.09	31.50	34.69	34.07	32.87	32.27
Livestock slaughtered and other disposals - Other n.e.c.	0.03	0.03	24.35	23.52	0.13	0.13
Livestock slaughtered and other disposals – total	70.16	66.57	73.50	67.62	545.65	504.07
Total agriculture – all commodities	469.14	434.03	326.30	296.50	1,983.60	1,826.52

Notes:

1. ABS 2022, Value of Agricultural Commodities Produced by Local Government Area - 2020-21
2. ABS 2022a, Value of Agricultural Commodities Produced by Natural Resource Management regions - 2020-21
3. Gross values are those realised at the point(s) of valuation where ownership of the commodity is relinquished by the agricultural industry.
4. Local values are derived using survey and administrative sources to remove marketing and transport costs. They are the value placed on recorded production at the place of production, including indirect taxes.
5. All crops includes broadacre, hay, silage and horticultural (fruit and nuts, grapes, vegetables and nurseries, cut flowers or cultivated turf) produce.
6. *NR*. no statistic recorded in census dataset.

3.8.8 Productivity values

i Regional

Indicative dollar per hectare (\$/ha) values for selected commodities are given in Table 3.16 based on the available land use and productivity data described in Table 3.14 and Table 3.15. 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 inability to derive the specific land uses to suitable levels to associate to specific commodity production. This limiting factor results in a grouping of land use and commodity into general livestock, cropping and horticultural categories. Given the land use within the project area (i.e. sheep and cattle grazing), calculations have only been completed for livestock based on:

- productivity values (Table 3.15) including:
 - livestock including slaughtered, disposals and products
 - cropping including broadacre and hay only due to the site-specific land use not including any horticulture or vegetable production

- land use (Table 3.14) including:
 - all livestock land use of grazing modified pastures and native vegetation
 - dryland and irrigated cropping land use.

Table 3.16 **Indicative annual commodity values per hectare**

Area	Commodity sector	Land use (ha)	Production value (\$m) ²		Value (\$/ha)	
			Gross	Local	Gross	Local
Murrumbidgee LGA	Livestock	348,863	101.71	97.56	291.54	279.66
	Cropping	283,507	241.18	222.10	850.70	783.39
Edward River LGA	Livestock	625,359	117.43	110.47	187.79	176.65
	Cropping	212,578	150.66	137.82	708.73	648.33
Murray NRM Region	Livestock	1,800,604	749.28	701.81	416.13	389.77
	Cropping	1,619,101	1,032.25	951.47	637.55	587.65

Notes:

1. ABARES 2021a, Catchment scale land use profile dashboard – Local government areas
2. ABS 2022, Value of Agricultural Commodities Produced by Local Government Area - 2020-21.

Extrapolating from the indicative annual commodity values for the Murrumbidgee LGA, Edward River LGA, and Murray NRM region, an area equivalent to the development footprint (totalling 1,339 ha):

- grazing land is valued between \$124,035 and \$169,618 in gross annual productivity
- cropping land is valued between \$11,623 and \$63,207 in gross annual productivity
- total land value (grazing and cropping) is estimated at \$368,483 with an upper estimate of \$574,784 based on the Murray NRM Region, in gross productivity.

It is expected that the estimated land values determined for the development footprint are an upper estimate. The LGA-wide productivity values (Table 3.16) include known highly productive land, which inflate the average productivity value per hectare compared to the project's development footprint. This is further confirmed by the discrepancy between LGA and Murray Region land value estimates.

A breakdown of the estimated land value of the development footprint is provided in Table 3.17.

Table 3.17 **Estimated development footprint land value**

Area	Commodity sector	Estimated land value (\$/ha)		Development footprint (ha) ¹	Project land value (\$)	
		Gross	Local		Gross	Local
Murrumbidgee LGA	Livestock	291.54	279.66	581.8	\$169,618	\$162,706
	Cropping	850.70	783.39	74.3	\$63,207	\$58,206
			<i>Sub total</i>	<i>656.1</i>	<i>\$232,825</i>	<i>\$220,912</i>
Edward River LGA	Livestock	187.79	176.65	660.5	\$124,035	\$116,677
	Cropping	708.73	648.33	16.4	\$11,623	\$10,633
			<i>Sub total</i>	<i>676.9</i>	<i>\$135,658</i>	<i>\$127,310</i>
NSW Murray Region	Livestock	416.13	389.77	1,242.3	\$516,958	\$484,211
	Cropping	637.55	587.65	90.7	\$57,826	\$53,300
			<i>Sub total</i>	<i>1,333</i>	<i>\$574,784</i>	<i>\$537,511</i>

Notes:

1. The development footprint includes approximately 6 ha of non-productive land use mapping which includes areas of dams, channels, wetlands, buildings and areas for managed resource protection

4 Soil field investigation

The soil assessment comprised the following:

- a desktop review of existing information and the current state of the environment within the project area (Section 3)
- a field soil survey to validate and inform the soil orders present within the project area (Section 4.1)
- determination of the soil profile classes (SPCs) present in the project area and their key physical and chemical characteristics (Section 4.2).

The soil assessment provides key information used in the LSC assessment (Section 5) and erosion hazard assessment (Section 6).

4.1 Soil survey methodology

A field soil survey was completed across the project area from 20–21 February 2023 to examine the soil and landform properties of the project area, with samples obtained for laboratory analysis.

The soil survey was completed with due regard for relevant soil resources, shown in Table 4.1.

Table 4.1 Soil survey resources

Activity	Guideline
Soil sampling and survey	<i>Australian Soil and Land Survey: Guidelines for surveying soil and land resource— second edition</i> (McKenzie et al. 2008)
Classification of soil types	<i>The Australian Soil Classification – third edition</i> (Isbell & NCST 2021)
Soil physical measurements and interpretation	<i>Soil physical measurement and interpretation for land evaluation</i> (McKenzie et al. 2002)
Soil chemical measurements and interpretation	<i>Soil Chemical Methods – Australasia</i> (Rayment & Lyons 2011)

In addition to the four resources shown in Table 4.1, the *Australian Soil and Land Survey Field Handbook* (NCST 2009) completes the *CSIRO Australian Soil and Land Survey Handbook Series*, a national standard for terminology and methodologies used in land resource assessment and associated activities. The soil survey described in this section has been conducted with due regard and reference to these standards.

The sampling program (site selection and intensity) and field and laboratory analyses undertaken are described in Section 4.1.1.

4.1.1 Sample site selection and density

Due to the extensive nature of the project area, a detailed soil survey and mapping exercise was not completed. Site investigations focused on surveying the project area as an integrated free survey, designed on the premise that many land characteristics are interdependent and tend to occur in correlated sets (NSCT 2009). Investigation sites are irregularly located according to the survey teams' judgement to enable the delineation of soil boundaries. Soil boundaries can be abrupt or gradual, and catena and topo-sequences are used to aid the description of gradual variation.

The investigation sites were distributed according to variations in the available land characteristics, including desktop soil mapping, elevation, landform, and geology (Section 3). The aim was to provide at least one detailed site description for each combination of these factors to assess their influence on soil distribution across the site area. A total of 15 soil sites were investigated within the project area.

i Soil investigation site locations and observation classes

The soil investigation site locations are detailed in Table 4.2 and shown in Figure 4.1.

Soil observation classes are described in Table 4.3 as defined by Schoknecht *et al.* (2008). It should be noted that nearly all soil profile morphology and site description information (where possible) was collected at all investigation sites, and variation between Class I and Class IV in this survey has been primarily split based on depth of soil excavation between Class I (typically 1.2 m) and Class IV (0.3–0.6 m).

Table 4.2 Soil investigation sites

Site	Coordinates		Soil observation class ¹	Site	Coordinates		Soil observation class ¹
	Latitude	Longitude			Latitude	Longitude	
DWF01	-34.9132696	145.4916625	Class III (a)	DWF09	-35.0229394	145.612955	Class III (a)
DWF02	-34.8882259	145.4409216	Class IV (a)	DWF10	-34.9679049	145.588258	Class III (a)
DWF03	-34.8713193	145.4940721	Class I	DWF11	-35.0029824	145.640933	Class III (a)
DWF04	-34.939098	145.4361749	Class IV (a)	DWF12	-34.9790860	145.6380239	Class IV (a)
DWF05	-34.9953511	145.4079542	Class III (a)	DWF13	-35.0547601	145.6250442	Class IV (a)
DWF06	-34.9918373	145.4400232	Class III (a)	DWF14	-35.0339362	145.6747111	Class III (a)
DWF07	-35.0068500	145.4665971	Class III (a)	DWF15	-35.0209729	145.7619038	Class III (a)
DWF08	-34.9703893	145.4840235	Class IV (a)				

Notes 1. Per Schoknecht et al. 2008

Table 4.3 **Soil profile observation classes**

Observation class		Brief description	% of observations ¹		Notes
			Target	Achieved	
Class I	Detailed profile description with no laboratory analysis	Detailed soil profile morphology and site description used to characterise the main soils and landscapes (including geology, substrate and vegetation) in a survey area.	20–30	7%	One (7%) site achieved Class I based on full assessment to a depth of 1.2 m below ground level (BGL), but nine were also submitted for laboratory analysis.
Class II Deep (>2 m) boring	Class II (a) Deep (>2 m) core (preferred) or auger boring with no laboratory analysis	Deep borings examine the substrate and regolith below the normal depth of soil description. They are important where subsolum and substrate properties influence land use. They are essential if irrigated land uses are proposed. Deep boring allows consideration of factors such as impermeable or permeable layers, salt accumulations, groundwater depth and salinity.	<5	-	-
	Class II (b) Deep (>2 m) core (preferred) or auger boring with limited or nonstandard ² laboratory analysis				-
Class III Profile sampled for laboratory analysis	Class III (a) Profile with limited or non-standard ² laboratory analysis	Representative profiles where samples are taken for laboratory analyses (either limited, non-standard or standard ² laboratory analysis).	5–10	-	-
	Class III (b) Profile with standard ² laboratory analysis	Sampling is usually conducted to characterise typical or reference soils in a survey.		60%	Nine (60%) profiles had samples submitted for laboratory analysis, though two of these profiles had only two samples submitted.
Class IV Brief mapping observation	Class IV (a) Brief mapping observation with some soil morphological data recorded	Less detailed soil profile inspection of sufficient depth to identify the SPC and correlate to soils already described in the area. Some morphological data is recorded (e.g. surface soil colour or texture, depth of A horizon etc.). Salient soil features for soil classification, suitability assessment etc are recorded.	30–60	33%	Five (33%) sites achieved Class IV(a).

Table 4.3 **Soil profile observation classes**

Observation class	Brief description	% of observations ¹		Notes
		Target	Achieved	
Class IV (b) Brief mapping observation with no soil morphological data recorded	Sites where no morphological data is recorded. Quick observation (e.g. vegetation or lithology type, erosion, degree of rockiness) at a point to confirm mapping boundaries, SPC or other site characteristics that may assist in mapping or specific data requirements. Includes 'rapid landscape assessment' where visual observations are made (often recorded from a vehicle) to complement other more detailed observations.	<20	-	-

Notes: 1. For medium intensity surveys (1:25,000–1:100,000)
 2. Standard laboratory analysis = pH, EC (electrical conductivity), Cl (chloride), cations, PSA (particle size analysis), 15 bar, ADMC (air dry moisture content) per sample

4.1.2 Field methodology

i Profile description

Soil site descriptions were undertaken in accordance with NCST (2009) and classified using the ASC (Isbell & NCST 2021). Soil site descriptions include a soil profile description, site observations and photographs taken of the soil profile and landscape at each location. These profile descriptions are included in Attachment A.

Site observations include descriptions of:

- location (GPS)
- landform (including slope and morphology)
- geology
- surface characteristics (e.g. gilgai and rockiness)
- vegetation.

Soil profile descriptions include (where applicable) details of:

- horizon depths and designation
- soil surface condition (crusting, cracking, self-mulching)
- boundary distinctness
- field texture (ribboning technique as per NCST (2009))
- colour (hue and chroma using the Munsell colour chart)
- mottles
- coarse fragments (visual assessment of shape, size and distribution)
- structure and pedality
- segregations
- hydrology (profile drainage and permeability)
- field tests (e.g. pH).

ii Photographs

Photographs of the excavated soil profiles were taken, along with photos of the surrounding landscape. Select photographs of representative SPC and landscapes are shown in Section 4.2 and profiles submitted for laboratory analysis are shown in Attachment B.

4.1.3 Soil samples

Table 4.4 summarised the soil sampling activities undertaken.

Table 4.4 **Soil sampling activities**

Activity	Description
Soil core locations (sites)	Sampling locations were recorded with Field Maps GPS location software used on a mobile phone. Where the above was not possible the estimated position coordinates are retrieved from online mapping georeferencing.
Soil coring	Where pre-excavated pits or exposures were not available, hand auguring was undertaken with the use of a 75–100 mm Jarret auger or a shovel and crowbar where required. Soil cores were extended to a maximum of 1.2 m BGL or refusal.
Abandonment	Where hand augured, soil cores were backfilled to the existing natural ground level using soil retrieved during soil coring.
Decontamination	Prior to commencing each soil core, bulk soil material was removed from the auger head.
Soil logging	Soil characteristics were described and profiles classified in accordance with the <i>Australian Soil and Land Survey Field Handbook</i> (NCST 2009) and the <i>Australian Soil Classification</i> (Isbell & NCST 2021) respectively. In addition to soil descriptions, the associated landscape features, including terrain, land use, areas of degradation, slopes and vegetation were recorded and photographed.
Soil sampling	Soil samples, approximately 500 g in mass, were obtained directly from the auger at nominal depths of 0–0.1 m, 0.2–0.3 m, 0.5–0.6 m, 0.8–0.9 m and 1.1–1.2 m, depending on sample site depth. These depths sometimes varied to accommodate horizon boundaries. Discrete soil samples were collected and placed into resealable plastic bags for dispatch to the laboratory.
Labelling	Sample bags were labelled with the survey identification, 'DWF', sample site number and depth. For instance, a sample collected at site DWF 01 at a depth of 0–10 cm BGL was labelled as follows: DWF 01, 0–10 cm.
Dispatch	Samples were stored out of direct sunlight and transported by road for analysis at East West EnviroAg Pty Ltd (Tamworth, NSW).

4.1.4 Laboratory analysis

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 given in Table 4.5.

Table 4.5 **Soil chemical analysis**

Horizons	Indicative sampled depths ¹	Analysis performed
Topsoil	0.0–0.1 m	pH; EC; Cl ⁻ (1:5); exchangeable cations (Ca, Mg, Na, K, Al) and ECEC (NH ₄ Cl or Ammonium Acetate); OC and OM (Walkley and Black); 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); PSA (Gravel (>2 mm), Coarse sand (0.2–2 mm), Fine sand (0.02–0.2 mm), Silt (2–20 micrometres; µm), Clay (<2 µm)).
Subsoil	0.2–0.3 m 0.5–0.6 m 0.8–0.9 m 1.1–1.2 m	pH, EC, Cl ⁻ (1:5); exchangeable cations (Ca, Mg, Na, K, Al) and ECEC (NH ₄ Cl or Ammonium Acetate); ESP, Emerson Aggregate Test (EAT), PSA (Gravel (>2 mm), Coarse sand (0.2–2 mm), Fine sand (0.02–0.2 mm), Silt (2–20 micrometres; µm), Clay (<2 µm)).

Notes:

1. These depths will vary to accommodate horizon boundaries.

Detailed laboratory results are provided in Attachment B. Soil ‘fertility’ is utilised to describe the assessment of topsoil Nitrogen (total), Potassium (exchangeable), Phosphorous (Colwell) and Organic Carbon. Interpretation of the laboratory analysis results is based predominantly on guidelines provided in:

- *Soil Chemical Methods – Australasia* (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)
- *Interpreting soil test results – what do all the numbers mean?* (Hazelton & Murphy 2016).

4.2 Soil profile classes

Soil profiles were described at 15 locations. The soil at each detailed site was classified using the ASC system (Isbell & NCST 2021). Soils with comparable profiles determined by similar morphological properties, physico-chemical properties, parent material, representative landforms and geomorphological position in the landscape were grouped into soil profile classes (‘SPCs’, McKenzie *et al.* 2008).

Soils across the project area were grouped into three SPCs, with one soil phase subdivision, based primarily on classification under the ASC, with the project area consisting predominantly of cracking clay Vertosols and smaller areas of deep, sandy Arenosols, and texture contrast Sodosols, generally consistent with regional soil mapping described in Section 3.

Table 4.6 Soil profile classes

SPC	Concept	Typical ASC	Landform and vegetation	Associations	Sites
1	Deep, cracking, reddish brown clays with sodic, moderate structure, medium clay subsoils	Vertosols [VE]	Level plains and infilled streams with predominantly flat (0–1%) slopes and complete land clearing for pasture, associated with desert woodlands and floodplain transition forests.	• SLR: Jerilderie • ASC: Vertosols • GSG: Grey, Brown and Red Clays	1, 2, 4, 5, 7, 9, 12, 13, 14
1a	Deep, hard setting, reddish brown clays with surfaces of clay loams grading to sodic, medium clay subsoils	Dermosols [DE]	Level plains with predominantly flat (0–1%) slopes and extensive to complete land clearing for pasture, associated with inland floodplain woodlands.	• SLR: Jerilderie • ASC: Dermosols	15
2	Deep sandy soils with minimal structural development and reddish brown, loamy coarse sands over yellowish red sandy loams	Arenosols [RE]	Level plains with predominantly flat (0–1%) slopes and minor saddle features. Extensive to complete land clearing for pasture, associated with Riverine sandhill woodlands	• ASC: Arenosols • GSG: Siliceous Sands	3, 10

Table 4.6 **Soil profile classes**

SPC	Concept	Typical ASC	Landform and vegetation	Associations	Sites
3	Deep, texture contrast soils with surfaces of brown to red, sandy loams to sandy clay loams including bleached A2 horizon over subsoils of red, mottled light to light-medium sodic clays	Sodosols [SO]	Level plains with predominantly flat (0–1%) slopes and lower slopes adjacent to minor elevations. Extensive to complete land clearing for pasture, associated with inland riverine woodlands and desert woodlands	• ASC: Sodosols • GSG: Red Brown Earths	6, 8, 11

4.2.1 SPC01

SPC01 topsoils are characterised by cracking behaviour when dry and may occasionally host surface crusts. Topsoils are brown to dark brown and are predominantly light to light medium clays with moderate to strong subangular blocky structure. Structure may occasionally vary too weak to massive. Mottles are not observed through the major part of the topsoil. Topsoil pH is slightly acid becoming moderately alkaline in the subsoils.

Subsoils are brown to reddish brown through the major part of the profile and are moderate to strong subangular blocky to lenticular in structure with light to medium clay textures. Mottles are common through the major part of the profile in low to moderate abundance with no coarse fragments observed throughout the depth of the profile. Very few to few, soft, calcareous, fine segregations are common in the subsoils.

SPC01 soils are typically classified under the ASC as *Brown Vertosols [VEAB]* with site DWF09 being a representative example of an *Episodic-Endocalcareous, Epipedal, Brown Vertosol* as detailed in Table 4.7.

Table 4.7 **SPC01 typical landform and representative profile description**

Landform			
Slope:	0–1%	Runoff:	Very slow
Morphological type:	Flat	Permeability:	Slowly permeable
Landform element:	Plains and prior streams	Drainage:	Imperfectly drained
Landform pattern:	Plain	Surface condition:	Firm, cracking (up to 4 mm), occasional surface crust
Relief modal class:	Level plain	Disturbance:	Complete clearing; pasture
Surface coarse fragments:	Not observed.	Rock outcrop:	Not observed

Table 4.7 SPC01 typical landform and representative profile description

Vegetation: Desert woodlands and floodplain transition forests. Groundcover 50–80%



DWF09 – Soil profile (surface top left, 0.3 m increments)

DWF09 - landscape

Profile description			
Easting:	-35.0229394	Northing:	145.612955
ASC Soil Order:	Episodic-Endocalcareous, Epipedal, Brown Vertisol	ASC Family Criteria:	EQRW
Horizon	Depths (m)	Description	
A1 – topsoil	0.00–0.20	Dark greyish brown (10YR 4/2); light medium clay; strong subangular blocky structure of 5–10 mm; pH 7.0; gradual boundary to -	
B21 – subsoil	0.20–0.50	Brown (10YR 4/3); medium clay; strong subangular blocky/lenticular structure of 5–10 mm; pH 8.5; diffuse boundary to -	
B22 – subsoil	0.50–0.80	Brown (7.5YR 4/4); light medium clay; moderate subangular blocky structure of 5–10 mm; 2–10% faint orange mottles of <2 mm; <2% soft calcareous segregations of 2–6 mm; pH 9.0; diffuse boundary to -	
B3 – transition subsoil	0.80–1.20	Light reddish brown (2.5YR 6/3); clay loam; weak structure of 2–5 mm, <2% faint orange mottles of 5–15 mm; 2–10% soft calcareous segregations of 2–6 mm; pH 9.0; layer continues.	

i SPC01: Soil chemistry

Soils of SPC01 are typically poorly fertile with low nitrogen and organic carbon, moderate (occasionally very low) phosphorous but very high exchangeable potassium. Soil pH ranges from slightly acid topsoils to moderately (occasionally strongly) alkaline subsoils.

Topsoils are slightly sodic (exchangeable sodium percentage (ESP) >3–6%) to sodic (ESP >6–15%) with subsoils consistently sodic in the upper subsoils (0.2–0.3 mBGL) to strongly sodic with depth (21–31% ESP). Topsoil salinity is commonly very low, increasing with depth through the profile with lower subsoils (0.5–1.0 mBGL) being typically very highly to extremely saline.

Effective cation exchange capacity (ECEC) is typically high (> 15 cmol(+)kg⁻¹) through the profile. ECEC balance is generally poor with consistently low or deficient (<65%) exchangeable calcium percentage (ECaP) of 30–50% and elevated (>20%) exchangeable magnesium percentage (EMgP) of 30–50% throughout the depth of the profile. The calcium to magnesium ratio (Ca:Mg) is typically calcium low (1–4) and deficient (<1) throughout the depth of the profile.

The Emerson aggregate test (EAT) results return topsoils of class 3a (severe dispersion of remoulded soil) and 3b (slight to moderate dispersion of remoulded soil) and subsoils of 6 (no dispersion of remoulded soil, no carbonate or gypsum, complete flocculation after further suspension and agitation), 2 (slaking with some dispersion) and occasionally 1 (slaking and complete dispersion of air-dry aggregates in water. Despite the high sodicity and poor cation balance, the subsoils, particularly at depth, are not consistently dispersive. This is potentially due to the extremely high salinity of the soils, which increases the critical ESP level required for soil dispersion.

Table 4.8 SPC01 soil chemistry summary

Depths (m)	pH	Texture	Cation balance and Ca:Mg	Salinity	Sodicity
0.00–0.15	Slightly acid	Light medium clay	Poor and Ca low	Very low	Slightly sodic, moderate dispersion risk
0.15–0.50	Moderately alkaline	Light medium clay	Poor and Ca low to deficient	Low to moderate	Sodic, high dispersion risk
0.50–1.20	Moderately alkaline	Medium clay	Poor and Ca low to deficient	Very high	Strongly sodic, moderate dispersion risk

ii SPC01: key features

The key features of SPC01 include:

- cracking or self-mulching topsoils
- moderate to strong subangular blocky structure through the majority of the subsoil
- sodic and saline subsoils.

4.2.2 SPC01a

SPC01a soils are a variant of SPC01 soils, such that they share many characteristics but are separated by the absence of cracking topsoils, being hardsetting when dry. SPC01a topsoils are massive, dark brown, moderately thick, clay loam fine sandy textures.

Subsoils transition to reddish brown with depth and are characterised by light-medium clay texture and strong subangular blocky structure. No mottles are observed through the depth of the profile, but few, nodular, calcareous, fine segregations may be observed in the lower horizons (below 0.5 m) of the subsoil.

DWF15, classified under the ASC as a *Sodic, Hypocalcic, Red Dermosol [DEAA]*, is representative of SPC01a soils and is detailed in Table 4.9.

Table 4.9 SPC01a typical landform and representative profile description

Landform			
Slope:	0–1%	Runoff:	Very slow
Morphological type:	Flat	Permeability:	Slowly permeable
Landform element:	Plain	Drainage:	Imperfectly drained
Landform pattern:	Plain	Surface condition:	Hardsetting
Relief modal class:	Level plain	Disturbance:	Extensive to complete clearing; pasture

Table 4.9 SPC01a typical landform and representative profile description

Surface coarse fragments:	Not observed	Rock outcrop:	Not observed
Vegetation:	Inland floodplain woodlands. Groundcover 50–80%		



DWF15 – Soil profile (surface top left, 0.3 m increments) **DWF15 - landscape**

Profile description			
Easting:	-35.0209729	Northing:	145.7619038
ASC Soil Order:	Sodic, Hypocalcic, Red Dermosol	ASC Family Criteria:	BEMOV
Horizon	Depths (m)	Description	
A1 – topsoil	0.00–0.20	Dark brown (7.5YR 3/3); clay loam, fine sandy; massive; pH 6.5; abrupt boundary to -	
B21 – subsoil	0.20–0.50	Dusky red (2.5YR 3/2); light medium clay; strong subangular blocky of 5–10 mm; pH 7.0; clear boundary to -	
B22 – subsoil	0.50–0.60	Reddish brown (5YR 4/3); light medium clay; moderate to strong subangular blocky structure of 5–10 mm; 2–10% calcareous nodular segregations; pH 8.0; layer continues.	

i SPC01a: Soil chemistry

Topsoils of SPC01a are typically moderately acid, with high exchangeable potassium and very low salinity. Topsoils are slightly sodic. Sodicity and salinity increases with depth, with subsoils ranging between sodic to strongly sodic and very low to moderate salinity.

ECEC of topsoils is typically moderate (5–15 cmol(+)kg⁻¹) and high though the subsoil. ECEC balance is generally poor with consistently low ECaP (40–50%) and elevated EMgP (30–40%) throughout the depth of the profile. Exchangeable aluminium percentages (EAIP) are slightly raised in topsoils (1.9%). Ca:Mg is typically calcium low.

EAT results are not available for this SPC. Dispersion risk is closely associated with soil sodicity and the interaction with soil salinity. Phase diagrams derived by Rengasamy et al. (1984) can be used to predict dispersion risk based on exchangeable sodium percentage and the electrical conductivity of the soil. Results suggest the possibility of highly dispersive soil horizon in the upper 0.5 m of the solum, with soils that may disperse spontaneously in water. Dispersion risk appears to decrease to moderate with depth, likely due to increased salinity, such that soils that may disperse by mechanical work (i.e. rainfall, irrigation of tillage).

Table 4.10 SPC01a soil chemistry summary

Depths (m)	pH	Texture	Cation balance and Ca:Mg	Salinity	Sodicity
0.00-0.20	Moderately acid	Clay loam	Poor and Ca low	Very low	Slightly sodic, moderate dispersion risk
0.20-0.50	Slightly alkaline	Light medium clay	Poor and Ca low	Very low	Sodic, high dispersion risk
0.50-0.60	Moderately alkaline	Light medium clay	Poor and Ca low	Moderate	Strongly sodic, moderate dispersion risk

ii SPC01a: Key features

The key features of SPC01a include:

- hardsetting clay loam topsoils
- moderate to subangular blocky structure through the majority of the subsoil
- sodic subsoils.

4.2.3 SPC02

Soils of SPC02 typically present with dark brown or reddish brown, loamy coarse sand A11 topsoils with single-grained structure and soft, loose surface conditions, grading to an A12 or B horizons of single grained, reddish brown to yellowish red sand, commonly coarse, to depths of >1.0 m. Lower horizons may occasionally grade to a single grained to weakly structured, sandy clay loam texture in the subsoils. No segregations or coarse fragments are observed throughout the depth of the profile.

SPC02 soils are represented by DWF10, a *Basic, Palic, Red Arenosols [RE]* under the ASC, as detailed in Table 4.11.

Table 4.11 SPC02 typical landform and representative profile description

Landform			
Slope:	0–1%	Runoff:	None
Morphological type:	Flat	Permeability:	High
Landform element:	Plain	Drainage:	Rapidly drained
Landform pattern:	Plain	Surface condition:	Soft, loose
Relief modal class:	Level plain	Disturbance:	Extensive to complete clearing; pasture
Surface coarse fragments:	Not observed	Rock outcrop:	Not observed
Vegetation:	Riverine sandhill woodlands. Groundcover 25–50%		

Table 4.11 SPC02 typical landform and representative profile description



DWF10 – Soil profile (surface top left, 0.3 m increments)			DWF10 - landscape		
Profile description					
Easting:		-34.9679049		Northing:	145.588258
ASC Soil Order:		Basic Palic Red Arenosols		ASC Family Criteria:	EKKW[WR]
Horizon	Depths (m)	Description			
A1 – topsoil	0.00–0.15	Dark brown (7.5YR 3/3); loamy coarse sand; single-grained; hydrophobic; pH 6.0; diffuse boundary to -			
A12 – topsoil	0.15–0.65	Reddish brown (5YR 4/4); coarse sand; single-grained; pH 6.0; diffuse boundary to -			
B1 – subsoil	0.65–1.05	Yellowish red (5YR 4/6); sand; single-grained; pH 6.5; gradual boundary to -			
B2 - subsoil	1.05–1.20	Reddish brown (5YR 4/4); sandy clay loam; single-grained; pH 7.5; layer continues.			

i SPC02: Soil chemistry

Topsoils of SPC02 soils are low in fertility with low exchangeable nitrogen, phosphorus and organic carbon with high potassium. Soils are not typically sodic (ESP <6%) and low in salinity (occasionally slightly sodic and very low salinity in upper subsoils). Topsoil pH is medium acid grading to slightly alkaline.

ECEC balance is good with ideal EC_{ap} and EM_{gP} values through the depth of the profile. Exchangeable potassium percentage (EPP) is consistently elevated (> 8%) and Ca:Mg is typically balanced (4–6). Lower subsoils may exhibit elevated EM_{gP}, lowered EPP and low calcium Ca:Mg.

Soil EAT class values are typically 5 (no dispersion of remoulded soil, no carbonate or gypsum, dispersion after further suspension and agitation) with lower subsoils of class 2 (slaking and some dispersion of air-dry aggregates in water) suggesting some dispersion hazard exists in the lower subsoils >1.0 m BGL if exposed.

Table 4.12 SPC02 soil chemistry summary

Depths (m)	pH	Texture	Cation balance and Ca:Mg	Salinity	Sodicity
0.00–0.15	Moderately acid	Sand	Good and Mg low	Low	Non-sodic, low dispersion risk
0.15–1.05	Slightly acid	Sand	Good and balanced to Mg low	Low to very low	Non to slightly sodic, low dispersion risk
1.05–1.20	Slightly alkaline	Sandy clay loam	Fair and Ca low	Low	Non-sodic, high dispersion risk

ii SPC02: Key features

The key features of SPC02 include:

- sandy textures containing no more than 15% clay content to >1.0 m depth
- no observable peds with minimal structural development through the topsoil
- no observable hard layers (cemented pans or saprolite)
- absence of any soil chemistry constraints.

4.2.4 SPC03

Soils grouped in SPC03 are characterised by moderately thick to thick, massive topsoils of dark brown to dark reddish brown, sandy loam, A1 over brown (moist) to light brown (dry), clayey sand to sandy loam A2 horizons.

Upper subsoils (0.20–0.75 m) are typically dark reddish brown to brown, moderate to strong subangular blocky structured light medium clays, with some weakly structured sandy clay loams. Lower subsoils (0.75–1.20 m) typically grade to weakly structured, yellowish brown, light clays or clay loam, sandy.

Few to common, soft, calcareous, fine to medium segregations are commonly observed through the major part of the subsoils. Mottles are common throughout the subsoils as very few to few, faint and distinct, fine to medium, orange to occasionally red mottles.

SPC03 soils are typically classified as *Red Sodosols [SOAA]* under the ASC and are represented by DWF06, a *Calcic, Subnatric, Red Sodosol*, as detailed in Table 4.13.

Table 4.13 SPC03 typical landform and representative profile description

Landform			
Slope:	0–1%	Runoff:	Slow
Morphological type:	Flat	Permeability:	Very slowly
Landform element:	Plain	Drainage:	Poorly drained
Landform pattern:	Plain	Surface condition:	Hardsetting, occasionally soft
Relief modal class:	Level plain	Disturbance:	Extensive to complete clearing; pasture
Surface coarse fragments:	Not observed	Rock outcrop:	Not observed
Vegetation:	Inland riverine woodlands and desert woodlands. Groundcover 30 - 60%		

Table 4.13 SPC03 typical landform and representative profile description



DWF06– Soil profile (surface top left, 0.3 m increments)

DWF06 - landscape

Profile description			
Easting:	-34.9918373	Northing:	145.4400232
ASC Soil Order:	Calcic, Subnatric, Red Sodosol,	ASC Family Criteria:	BELOW
Horizon	Depths (m)	Description	
A1 – topsoil	0.00–0.15	Dark brown (7.5YR 3/3); sandy loam; massive; pH 7.0; gradual boundary to -	
A2 – topsoil	0.15–0.25	Brown (7.5YR 4/3 [M]) to light brown (7.5YR 6/4 [D]); sandy loam; massive; pH 7.5; abrupt boundary to -	
B21 – subsoil	0.25–0.50	Dark reddish brown (5YR 3/3); light-medium clay; strong subangular blocky structure of 10–20 mm; pH 8.5; gradual boundary to -	
B22 - subsoil	0.50–0.80	Brown (7.5YR 4/4); light medium clay; moderate subangular blocky structure of 10–20 mm; 2–10% faint orange mottles of <5 mm; 2–10% soft calcareous segregations of 2–6 mm; pH 8.5; gradual change to -	
B23 - subsoil	0.80–1.05	Yellowish brown (10YR 5/4); light clay; weakly to moderate subangular blocky structure of 5–10 mm; <2% distinct orange mottles of <5 mm; 10–20% soft calcareous segregations of 2–6 mm; pH 8.5; diffuse boundary to -	
B3 – transitional subsoil	1.05–1.20	Light olive brown (2.5Y 5/3); light clay; weakly structured to apedal; <2% faint orange mottles of <5 mm; pH 8.5.	

i SPC03: Soil chemistry

Chemically, the topsoils of SPC03 are low to moderately fertile with low total nitrogen and organic carbon, moderate phosphorus and very high exchangeable potassium. Topsoils are moderately acid and slightly sodic, grading to moderately alkaline and strongly sodic with depth. Salinity levels are very low at the surface and also grade to very high in the lower subsoils.

Topsoil ECEC balance is typically moderate and fairly balanced and grades to high and poorly balanced with overall elevated EMgP and reduced ECaP. Localised elevation of exchangeable potassium percentage (EKP) may be present through topsoils. Ca:Mg ratio is commonly balanced at topsoil depth but is commonly calcium low to deficient through the major part of the subsoils.

Topsoils return a class 5 ranking from EAT and class 4 (no dispersion of remoulded soil, carbonate or gypsum present) through the major part of the subsoils; occasionally class 2 in upper subsoils. Overall dispersion hazard is present where topsoils are strongly sodic with very low salinity.

Table 4.14 **SPC01 soil chemistry summary**

Depths (m)	pH	Texture	Cation balance and Ca:Mg	Salinity	Sodicity
0.00–0.20	Moderately acid	Sandy loam	Fair and balanced	Very low	Slightly sodic, low dispersion risk
0.25–0.75	Moderately alkaline	Light medium clay	Poor and Ca low	Very low to high	Sodic to strongly sodic, high dispersion risk
0.75–1.00	Moderately alkaline	Light clay	Poor and Ca low	Very high	Strongly sodic, moderate dispersion risk

ii SPC03: Key features

The key features of SPC03 include:

- clear or abrupt texture contrast between sandy loam topsoils and light medium clay subsoils
- presence of A2 horizon
- sodic subsoils.

4.3 Summary

Soils across the project area, grouped into SPCs, are largely consistent with existing regional mapping of the ASC classes and soil and land resource information. The predominant soil order in the project area is Riverine Vertosols- deep, cracking, sodic clays of alluvial origin. Variations include Arenosols, which are extensively common for arid inland regions in and adjacent to existing or infilled waterways. Sodosols are also observed within the project area and are consistent with characteristic soil orders of the Riverine Plains.

It is important to note that boundaries between soil units can be abrupt (within 10 m), diffuse (>50 m) or somewhere in between. Owing to the natural variability between soil types, boundaries and landforms, the confidence levels of the SPC characteristics and distribution decrease with distance from the originally proposed and surveyed sites. Any conclusions or interpretations of the data collected from this survey and presented in this report can only serve as an indication of the type and distribution of soils potentially present and should not be relied upon as a comprehensive (exhaustive) assessment across the project area.

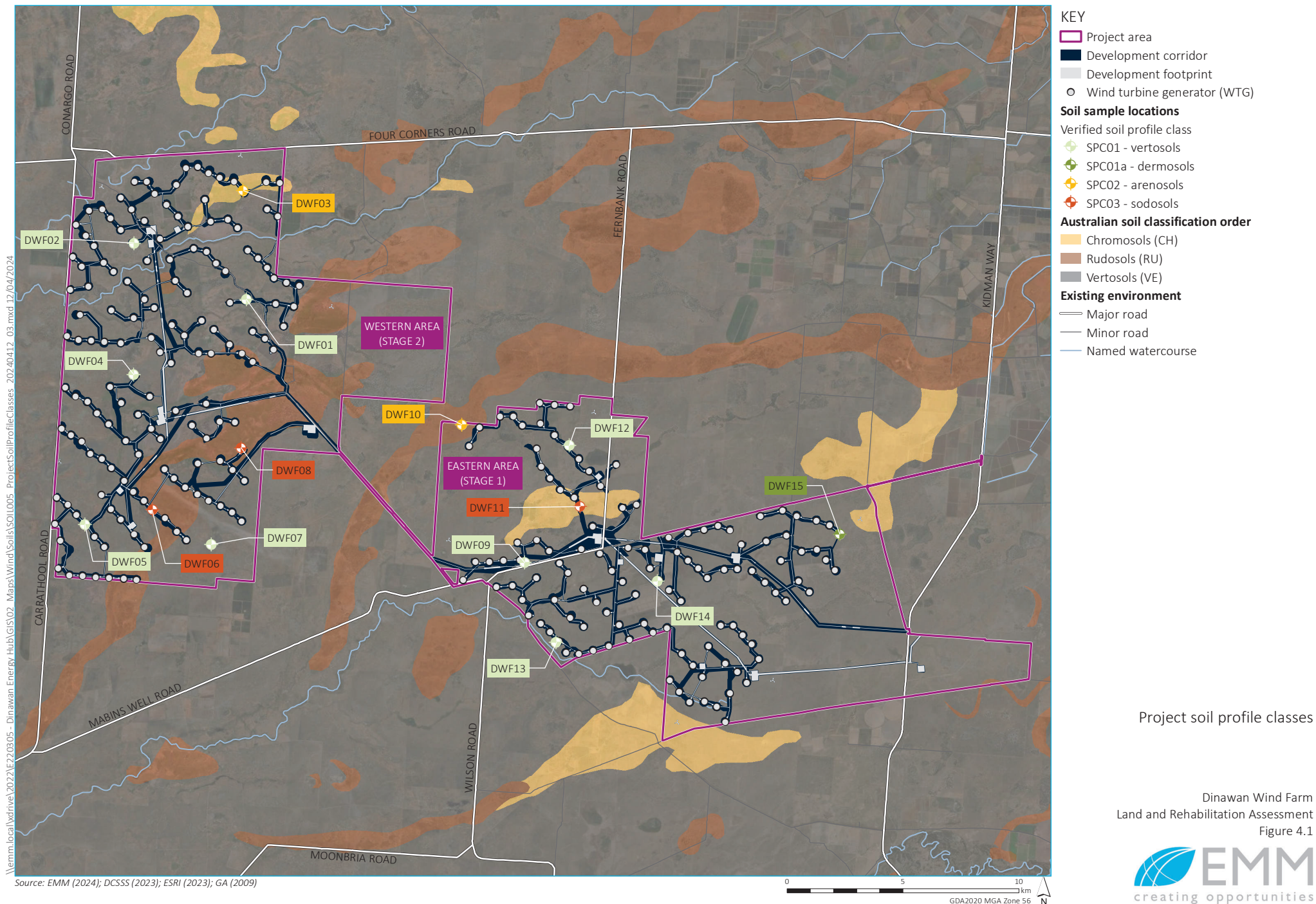
SPCs and the corresponding ASCs (after Isbell & NCST 2021) are shown in Figure 4.1.

4.4 Project soil hazards

The soils present on-site present a range of potential hazards, primarily due to subsoil constraints of salinity and sodicity. These constraints mean soil management, particularly around stripping, handling and backfill of subsoils, will need to be carefully considered and undertaken to prevent any soil mixing or erosion.

SPC01 and SPC01a soils are both strongly sodic and saline with poor cation balance, which results in the potential to disperse. This effect will be temporarily limited by the high salinity, but consistent exposure to non-saline water will result in soil dispersion and subsequent erosion. The heavy clay textures and presence of gilgai depressions will also result in limitations from poor soil drainage and waterlogging. The SPC03 soils are similarly constrained by salinity, sodicity and poor cation balance.

The SPC02 soils have no constraints relating to salinity or sodicity and pose much lower erosion risk from chemical instability, however their sandy, non-cohesive nature results in some erosion risk that still requires management to limit soil loss and downstream mobilisation of sediment.



5 Land and soil capability assessment

LSC assessments evaluate the capability of land to sustain a given land use, under specific land management practices, without resulting in soil and land degradation and adverse impacts on receiving environments. LSC assessments commonly use LSC classes to categorise land capability, based on the inherent biophysical features of the land and soil, and their associated hazards and limitations with the LSC class based on the most limiting biophysical feature or hazard. In a soil conservation context these LSC classes consider the most intensive, sustainable use possible for a given soil that will not result in degradation.

The LSC assessment for the project involved consideration of:

- land characteristics (e.g. topography and slope, soil properties, erodibility, dispersion potential, rockiness, drainage, infiltration, and climate)
- the proposed land use
- the activities or inputs required to achieve the desired land use
- the risks of damage to the land and soil, and off-site receptors, resulting from those activities
- the inter-relationship between the above.

The following sections describe the methodology and outcomes of the assessment.

5.1 Methodology

The LSC assessment has been undertaken using the NSW LSC Scheme (OEH 2012). The LSC Scheme assesses the capacity of subject land to support a range of land uses. The LSC Scheme considers the inherent biophysical features of the land and soil, and their associated hazards and limitations, to these land uses (Table 5.1). Each hazard is given a rating between 1 (best, highest capability land) and 8 (worst, lowest capability land).

Table 5.1 LSC assessment considerations

Biophysical features	Assessed hazards and limitations
Soil type	Soil structure decline
Slope	Water erosion; including sheet, rill and gully erosion
Landform position	Wind erosion
Soil acidity	Soil acidification
Soil salinity	Soil and landscape salinity and drainage
Drainage	Waterlogging
Rockiness	Shallow soils and rockiness
Climate	Mass movement

The overall LSC class of the land (Table 5.2) is based on the most limiting feature/hazard. The LSC classes present at a site can be determined at various scales, ranging from state or regional to farm scale, varying in accuracy according to the information and resolution associated with them. State scale mapping has been completed for NSW and for this site as detailed in Section 3.5.6.

Table 5.2 **LSC classes**

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

The LSC assessment completed involved the individual assessment of each soil investigation site to determine its LSC, as well as a collective assessment of the prevailing LSC of the SPCs determined to be present in the project area during the soil survey (Section 4).

5.2 Summary

The LSC framework and assessment is presented in Attachment D with detailed evaluation tables provided for each LSC hazard, with a summary provided below.

The LSC classes for the SPCs of the project area are shown in Table 5.3.

The predominant LSC class over the project area is Class 4 (moderate capability) and ranges from LSC Class 3 (high capability) to LSC Class 6 (low capability). Land suitable for cropping is typically identified as LSC Class 1 to 3, and the identified LSC and limitations indicates land primarily suited for pasture and grazing.

The primary limitations identified over the project area are typically due to wind (SPC02 - Arenosols), structural decline and salinity (SPC01 - Vertosols) and wind erosion, acidification, and waterlogging (PSC03 - Sodosols).

5.2.1 SPC01

SPC01 is predominantly LSC Class 4, primarily constrained by soil structural decline and secondarily by salinity.

Soil structural decline hazard is primarily influenced by the characteristics of the soil surface, assessed utilising surface soil texture and structure, degree of sodicity, cation balance (Ca:Mg ratio) and degree of self-mulching. Due to the clay textures, low Ca:Mg ratio and the common presence of sodicity in the SPC01 topsoils they are commonly classified as *mildly sodic/coarsely structured clay surface soil* with an LSC Class of 4.

Salinity hazard of the SPC01 soils is due to the low recharge potential and moderate salt store, with variation where discharge potential varies between low to moderate (refer to Section D.5). Discharge potential varies across this SPC based on landform position and presence of previous backswamps and playas which are prone to gilgai formation and form natural depressions.

i SPC01a

SPC01a is LSC Class 3 with no primary limiting factor.

5.2.2 SPC02

SPC02 is LSC Class 5, primarily constrained by wind erosion and secondarily by acidification, both due to the sandy, apedal topsoils.

Wind erosion hazard is a limitation due to the loamy coarse sand topsoil textures with high wind erodibility class and the high exposure of the plains. Site DWF10 has slightly reduced exposure due to its location in the lee of a small sequence of apparent dunes.

Soil acidification is the result of the very low buffering capacity of the loamy coarse sandy topsoils in conjunction with the medium acidity of the topsoils.

5.2.3 SPC03

SPC03 is LSC Class 5, primarily constrained by wind erosion and secondarily by acidification and waterlogging. Wind erosion and acidification are due to the sandy, apedal topsoils.

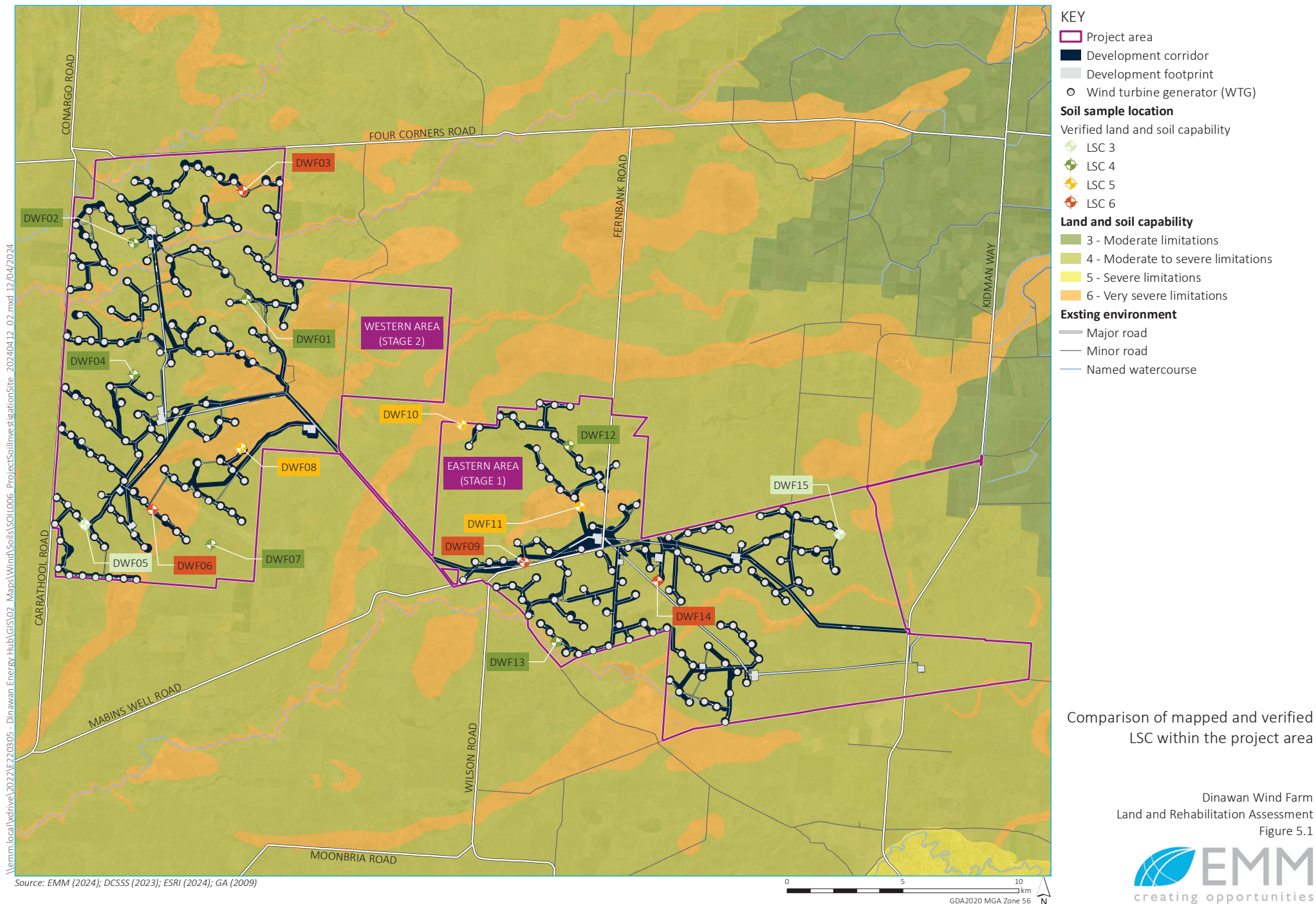
Wind erosion hazard is a limitation due to the sandy loam topsoil textures with moderate wind erodibility class and the high exposure of the plains.

Soil acidification is the result of the very low buffering capacity of the sandy loam topsoils in conjunction with the medium acidity of the topsoils.

Waterlogging hazard for SPC03 is due to observed soil permeability and drainage limitations, being generally slowly permeable and poorly drained with few mottles present.

Table 5.3 **Verified LSC classes within the project area**

Site ID	LSC hazard								Final LSC class
	Water	Wind	Structure	Acidification	Salinity	Waterlogging	Shallow soils	Mass movement	
SPC01 - Vertosols and Dermosols									
DWF01	1	3	4	3	4	3	1	1	4
DWF02	1	3	4	1	3	2	1	1	4
DWF04	3	3	4	1	4	2	1	1	4
DWF05	1	3	3	1	3	3	1	1	3
DWF07	1	3	4	1	4	4	1	1	4
DWF09	1	3	6	1	4	3	1	1	6
DWF12	1	3	4	1	3	3	1	1	4
DWF13	1	3	4	1	4	3	1	1	4
DWF14	1	3	6	1	4	4	1	1	6
DWF15	1	3	3	3	3	3	1	1	3
SPC02 - Arenosols									
DWF03	1	6	1	4	3	1	1	1	6
DWF10	1	5	1	4	3	1	1	1	5
SPC03 - Sodosols									
DWF06	1	5	3	4	4	4	1	1	5
DWF08	1	5	3	4	3	4	1	1	5
DWF11	1	5	3	4	3	4	1	1	5



6 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 if a high initial erosion hazard is triggered, calculated using the Revised Universal Soil Loss Equation (RUSLE) with site specific slopes and a nominal slope length of 80 m. The SLC dictates specific erosion management and mitigation measures as detailed in Landcom (2004).

6.1 Revised Universal Soil Loss Equation

The RUSLE is designed to predict the long term, average, annual soil loss (in tonnes per hectare per year (t/ha/yr)) from sheet and rill flow at nominated sites under specified management conditions. The equation is represented by:

$$A = R K L S P C$$

Where:

A = computed soil loss (tonnes per hectare per year (t/ha/yr))

R = rainfall erosivity factor ('R-factor')

K = soil erodibility factor ('K-factor')

LS = slope length/gradient factor ('LS-factor')

P = erosion control practice factor ('P-factor')

C = ground cover and management factor ('C-factor').

The main limitations of the RUSLE are that:

- it only predicts sediment entrained in the erosion process and does not predict sediment yields into particular sediment basins
- it predicts average annual soil loss and not that for a particular storm event
- it is effective for erosion through sheet and rill flow only on short slopes (<300 m) and not for concentrated flow or long slopes
- it does not adequately consider soil dispersibility in assessment of the K-factor.

6.1.1 Rainfall erosivity (R-factor)

Rainfall erosivity is the kinetic energy of raindrop impact and the rate of associated runoff, a measure of the ability of rainfall to cause erosion. The R-factor is a multi-annual average index that measures rainfall kinetic energy and intensity to describe the effect of rainfall on sheet and rill erosion and is used in the RUSLE to predict annual average rill and inter-rill (sheet erosion). Among the factors used within RUSLE, rainfall erosivity is of high importance as precipitation is the driving force of erosion and has a direct impact on the detachment of soil particles, the breakdown of aggregates and the transport of eroded particles via runoff. A precise assessment of rainfall erosivity requires recordings of precipitation at short time intervals (1–60 minutes) for a period of at least several years. The rainfall erosivity is calculated by multiplying the kinetic energy by the maximum rainfall intensity during a period of 30-minutes for each rainstorm. The R-factor accumulates the rainfall erosivity of individual rainstorm events and averages this value over multiple years.

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 5.48 mm/h (BoM 2020). The calculated R-Factor for the project is 907 MJmmha⁻¹h⁻¹.

Rainfall erosion hazard for the project area ranges from very low to low and is typically low through the year with the exception of February, where rainfall is only 1–2 mm below low. Table 6.1 provides an indication of the erosion hazard associated with monthly annual rainfall averages based on Tables 4.4.1 and 4.4.2 of IECA (2008).

Table 6.1 Monthly rainfall erosion hazard

Rainfall (monthly mm)	Erosion potential	Relevant months ¹
0–30	Very low	February
31–45	Low	January, March, April, May, June, July, August, September, October, November, December
46–100	Moderate	NA
101–225	High	NA
>225	Extreme	NA

Notes:

1. As per BoM 2021a mean monthly rainfall.

6.1.2 Soil erodibility (K-factor)

The erosion potential of a soil is determined by its physical and chemical properties and is expressed as its K-factor (t.ha.hr)/(ha.MJ.mm). K-factor is a quantitative description of the inherent erodibility of a particular soil; it is a measure of the susceptibility of soil particles to detachment and transport by rainfall and runoff. For a particular soil, the soil erodibility factor is the rate of erosion per unit erosion index from a standard plot. The K-factor reflects the fact that different soils erode at different rates when the other factors that affect erosion (e.g. infiltration rate, permeability, total water capacity, dispersion, rain splash, and abrasion) are the same. Texture is the principal factor affecting the K-factor, but electrochemical stability, structure, organic matter, and permeability also contribute.

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 (ESP >6%), or a magnesian soil (calcium:magnesium ratio <0.1) is exposed to 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 (e.g. rock lining) applied to the soil surface.

Table 6.2 provides a soil erodibility ranking for K-factor from IECA (2008).

Table 6.2 Soil erosion K-Factor erosion ranking

K-factor (t.ha.h / ha ⁻¹ .MJ ⁻¹ .mm ⁻¹)	Erosion potential
<0.02	Low
>0.02 but ≤0.04	Moderate

Table 6.2 Soil erosion K-Factor erosion ranking

K-factor (t.ha.h / ha ⁻¹ .MJ ⁻¹ .mm ⁻¹)	Erosion potential
>0.04 but ≤0.06	High
>0.06	Extreme

Adopted from Table F5 from IECA (2008)

The modelled K-Factors for the project area, determined from the eSPADE database (DPIE 2020a), range from 0.01–0.07 t ha h ha⁻¹MJ⁻¹mm⁻¹, predominantly 0.01–0.04 for the Vertosols and 0.05–0.07 for Rudosols and Chromosols, which indicate that the project soils have a variable erosion potential. The modelled K-Factors apply to a maximum depth of 100 mm (Yang et al. 2017). Yang et al (2017) used digital soil maps (DSMs) and NSW Soil and Land Information System to map and validate soil erodibility for soil depths up to 100 cm. They assessed eight empirical methods or existing maps on erodibility estimation and produced a harmonised high-resolution soil erodibility map for the entire state of NSW with improvements based on studies in NSW. The modelled erodibility values were compared with those from field measurements at soil plots for NSW soils and revealed good agreement.

The impact of dispersion is generally underestimated in the determination of K-Factor. Landcom (2004) and IECA (2008) recommend increasing the K-Factor for dispersive soils by 20% 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⁻¹MJ⁻¹mm⁻¹.

As described in Section 4.2, much of the project soils are likely to have dispersive subsoils and site soil sampling identified the presence of strongly sodic subsoils. K-Factors have been adopted based on calculations as per Landcom (2004) and McKenzie, Coughlan and Cresswell (2002) to determine the erosion hazard of project soils (Table 6.3).

Table 6.3 Soil K-Factor

SPC	ASC	Horizon	Sodicity	Salinity	Soil texture	K-factor (t.ha.h / ha ⁻¹ .MJ ⁻¹ .mm ⁻¹)	K-factor erosion potential
1	Vertosols	Topsoil	Slightly to sodic	Very low	Light to light medium clay	0.024	Moderate
		Subsoil	Strongly sodic	Very high to extreme	Light medium to medium clay	0.031	Moderate
1a	Dermosols	Topsoil	Slightly sodic	Low	Clay loam fine sandy	0.043	High
		Subsoil	Strongly sodic	Moderate	Light medium clay	0.034	Moderate
2	Arenosols	Topsoil	Non-sodic	Low	Loamy coarse sand	0.009	Low
		Subsoil	Non-sodic	Low	Sand to sandy clay loam	0.012	Low
3	Sodosols	Topsoil	Slightly sodic	Very low	Sandy loam	0.032	Moderate
		Subsoil	Strongly sodic	Moderate to very high	Light to light medium clay	0.035	Moderate

The installation of driven piles, excavation of cable and pipe trenches, construction of roads, tracks and ancillary facilities will expose subsoils and therefore, consideration of the erosion hazard posed by the dispersive subsoils is required.

EMM notes that soil materials sourced from off-site will potentially be imported to provide material for construction. These materials may have chemical and physical properties that render it more erodible than existing soils within the project area, particularly if the material is sodic or dispersive. Testing or characterisation of imported material should be undertaken so that its erosion potential can be determined.

6.1.3 Slope and gradient (LS-factor)

The LS-factor describes the combined effect of slope length and slope gradient on soil loss. It is the ratio of soil loss per unit area at any particular site to the corresponding loss from a specific experimental plot of known length and gradient and are derived from Table E3 of IECA (2008) or Table A1 of Landcom (2004).

6.1.4 Erosion control factor (P-factor)

The erosion control practice factor, P, is the ratio of soil loss with a nominated surface condition ploughed up and down the slope. It is reduced by practices that reduce both the velocity of runoff and the tendency of runoff to flow directly downhill. At construction sites, it reflects the roughening or smoothing of the soil surface by machinery, with a compacted and smooth surface condition being assigned a P-factor of 1.3 (IECA 2008).

6.1.5 Ground cover (C-factor)

The C-factor is the ratio of soil loss from land under specified crop or mulch conditions to the corresponding loss from continuously tilled, bare soil. In construction conditions, where surfaces are stripped of all soil cover and are effectively bare, C-factors are 1.

6.2 Project erosion hazard analysis

The first step in the hazard assessment uses a nomograph from Figure 4.6 of Landcom (2004) (Figure 6.1) that considers slope of the land and rainfall erosivity (R-Factor) to provide an indication of low or high erosion hazard.

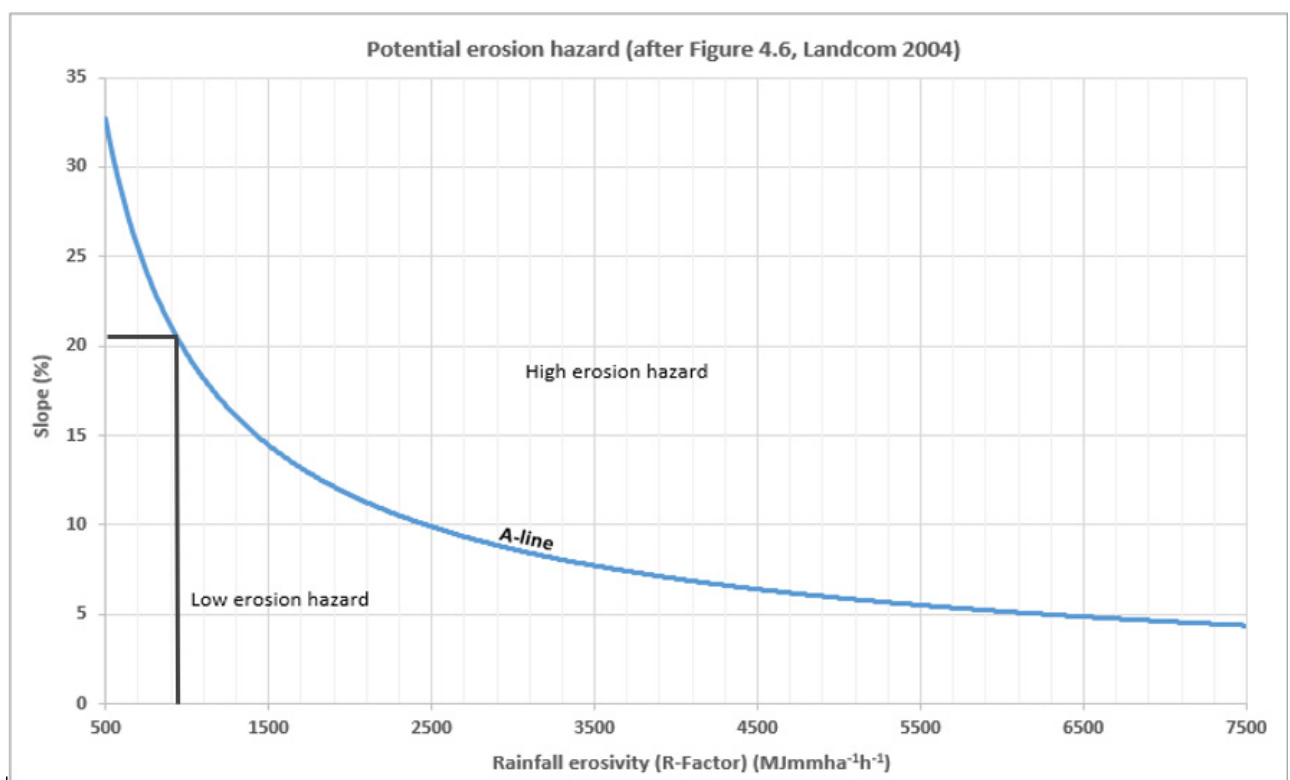


Figure 6.1 Assessment of potential erosion hazard (Landcom 2004)

Based on the application of the project R-Factor, potential erosion hazard will be high for areas where slopes exceed 21%. Project slopes are considered further below.

6.2.1 Project slopes

Slope ranges and associated erosion hazard for the key project elements are provided in Table 6.4.

Table 6.4 Slope ranges and erosion hazard for key project elements

Project element	Slope (min %)		Slope (max %)		Slope (mean %)		Erosion hazard	
	East wind area	West wind area	East wind area	West wind area	East wind area	West wind area	East wind area	West wind area
Project area	<0.1	<0.1	111.2	174.6	1.8	1.8	Low to high	Low to high
Development corridor and footprint	<0.1	<0.1	87.8	117.3	1.9	1.7	Low to high	Low to high

The majority of the development corridor has a low erosion hazard based on mean slope, though there are limited areas (less than 0.05% of the project area) of steep slopes (associated with constructed embankments, existing irrigation channels and material borrow pits all of which have very short flow lengths of less than 10 m) exceeding 21% slope that present a high erosion hazard as per Figure 6.1 and Table 6.4. As such, further assessment of erosion hazard is necessary in accordance with Section 4.4.2 of Landcom (2004) to determine SLCs (Table 6.5). Additionally, construction activities, such as cut and fill (should they be required), will result in small areas of steep slopes that will present a high erosion hazard per Landcom (2004).

It has been EMM's experience with other similar projects that cut and fill slopes associated with construction are likely to range from 1(v):4(h) (25%) to 1(v):2(h) (50%). Such slopes being greater than 21% trigger a high erosion hazard. As such, further assessment of erosion hazard is necessary in accordance with Section 4.4.2 of Landcom (2004) to determine SLCs (Table 6.5). Additionally, as per Landcom (2004) Section 4.4.2, areas of high erosion hazard require management consideration for constructed slopes as per Section 6.2.2ii.

6.2.2 Soil loss classes

SLCs (Table 6.5) are determined calculating the annual average soil loss using the RUSLE with a nominal 80 m slope length, soil surface cover factor (C-Factor) of 1 (100% bare soil) and a soil conservation factor (P-Factor) of 1.3 (compacted and smooth soil).

Table 6.5 Soil loss classes

Soil loss class (SLC)	Calculated soil loss (t/ha/yr)	Erosion hazard
1	0–150	Very low
2	151–225	Low
3	226–350	Low-moderate
4	351–500	Moderate
5	501–750	High
6	751–1,500	Very high
7	>1,500	Extremely high

Source: Adapted from Table 4.2 of Landcom (2004).

Calculated indicative soil loss in t/ha/yr for slopes ranging from 1–40% are provided in Table 6.6.

Table 6.6 Annual average soil loss t/ha/yr

Slope (%)	1	10	12	14	16	18	20	25	30	40
R-Factor (calculated)	907	907	907	907	907	907	907	907	907	907
LS (Table A1 Landcom 2004 and USDA 1997)	0.19	2.81	3.7	4.61	5.52	6.42	7.32	9.51	11.6	15.67
P (Table A2 Landcom 2004)	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
C (Figure A5 Landcom 2004)	1	1	1	1	1	1	1	1	1	1
SPC01										
K-Factor (Landcom 2004)	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031
Soil loss t/ha/y	6.9	102.7	135.3	168.5	201.8	234.7	267.6	347.7	424.1	572.9
SLC	1	1	1	2	2	3	3	3	4	5
SPC01a										
K-Factor (Landcom 2004)	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043
Soil loss t/ha/y	9.6	142.5	187.6	233.8	279.9	325.6	371.2	482.3	588.2	794.6
SLC	1	1	2	3	3	3	4	4	5	6
SPC02										
K-Factor (Landcom 2004)	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012
Soil loss t/ha/y	2.7	39.8	52.4	65.2	78.1	90.9	103.6	134.6	164.2	221.8
SLC	1	1	1	1	1	1	1	1	2	2
SPC03										
K-Factor (Landcom 2004)	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035
Soil loss t/ha/y	7.8	116.0	152.7	190.3	227.8	265.0	302.1	392.5	478.8	646.8
SLC	1	1	2	2	3	3	3	4	4	5

Applying the calculated annual average soil loss to Table 6.5 results in a SLC ranging from 1 (very low) to 7 (extremely high). There appears to be a change to moderate erosion risk (SLC 4) for SPC01, 01a and 3 at slopes exceeding 19–25% and to high erosion risk (SLC 5) at slopes between 26–35%. SPC02 does not exceed low erosion hazard until beyond slopes of 40% (Table 6.7).

It should be noted that the area in excess of 21% grade currently is less than 0.05% of the total project area.

Table 6.7 Project SLC estimated slope and area

SPC	SLC	Erosion hazard	Estimated slope range ¹
1	1–3	Very low to low-moderate	0–25%
	4	Moderate	>25–35%
	5	High	>35%

Table 6.7 Project SLC estimated slope and area

SPC	SLC	Erosion hazard	Estimated slope range ¹
1a	1–3	Very low to low-moderate	0–19%
	4	Moderate	>19–26%
	5	High	>26–36%
	6	Very high	>36%
2	1	Very low	0–27%
	2	Low	>27–40%
3	1–3	Very low to low-moderate	0–22%
	4	Moderate	>22–31%
	5	High	>31–40%

Notes: 1. To maximum slopes of 40% due to this being the maximum slope informed by Landcom (2004) RUSLE inputs.

i Erosion and sediment control construction timing

Lands with SLCs ≥ 4 trigger increased erosion and sediment control management requirements as stipulated in Section 4.4.2 of Landcom (2004). Additionally, land disturbing works in highly sensitive lands should be scheduled for periods when rainfall erosivity is low. Landcom (2004) defines highly sensitive lands as:

- always on SLC 7 lands
- at certain times of the year:
 - on SLC 5 or 6 lands in all rainfall zones
 - on SLC 4 lands in rainfall zones 5 and 11.

The project area is considered to be in rainfall Zone 10 though it is acknowledged that it is close to the boundary with Zone 12 (Figure 6.2). Low and high rainfall erosivity periods for Zone 10 are provided in Table 6.8 below and indicate times of year where land disturbance activities should be undertaken only with the application of special measures ('H') and where special measures are not required ('L').

Table 6.8 Zone 10 high and low rainfall erosivity periods

SLC	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1-4	L	L	L	L	L	L	L	L	L	L	L	L
5	H	H	H	H	L	L	L	L	L	L	L	L
6	H	H	H	H	H	L	L	L	L	L	H	H
7	H	H	H	H	H	H	H	H	H	H	H	H

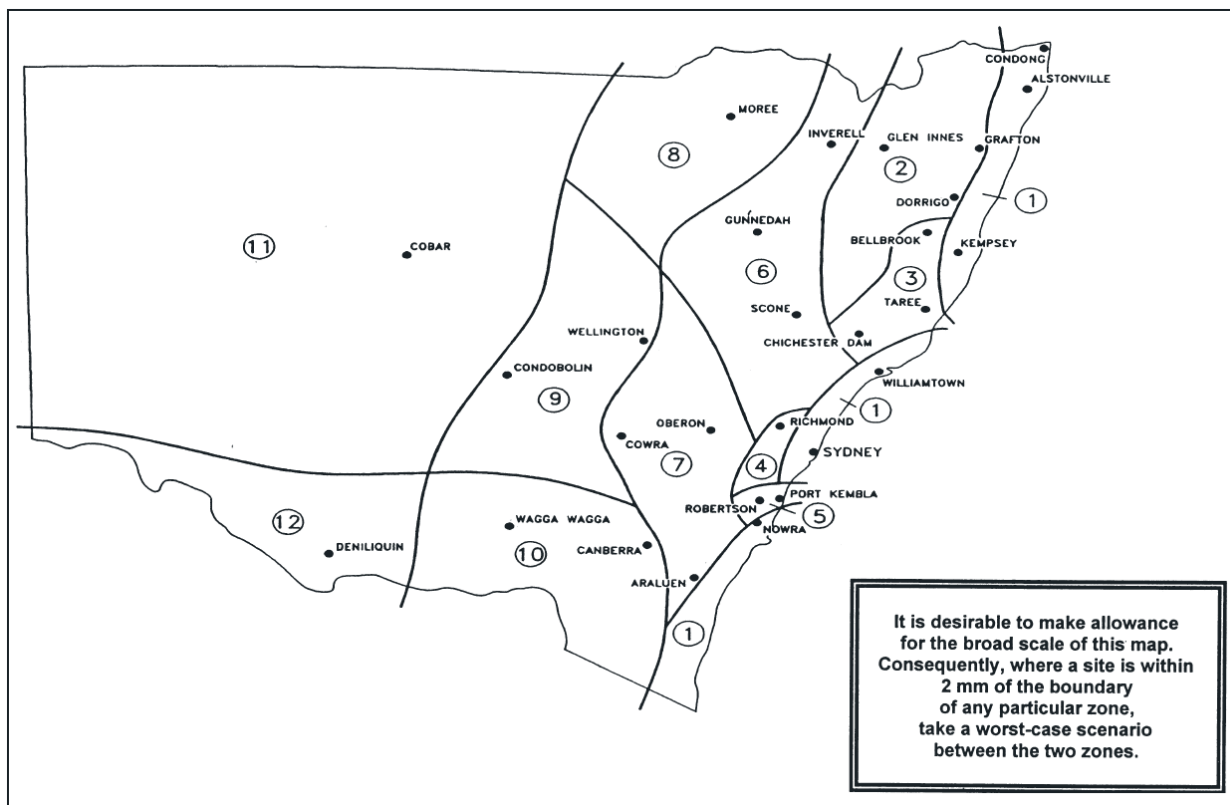


Figure 6.2 Rainfall zones

Source: Landcom (2004)

If it is not possible or is impractical to schedule activities to occur during periods when rainfall erosivity is low (Table 6.1), ideally ensure that any disturbed lands have C-Factors lower than 0.1 when the 3 day rainfall forecast predicts that rain is likely.

ii Design slope lengths

Figure 4.7 in Landcom (2004) (reproduced as Figure 6.3) nominates maximum slope design lengths based on gradient, K-Factor and R-Factor. Table 6.9 details application of Figure 6.3 to site constraints.

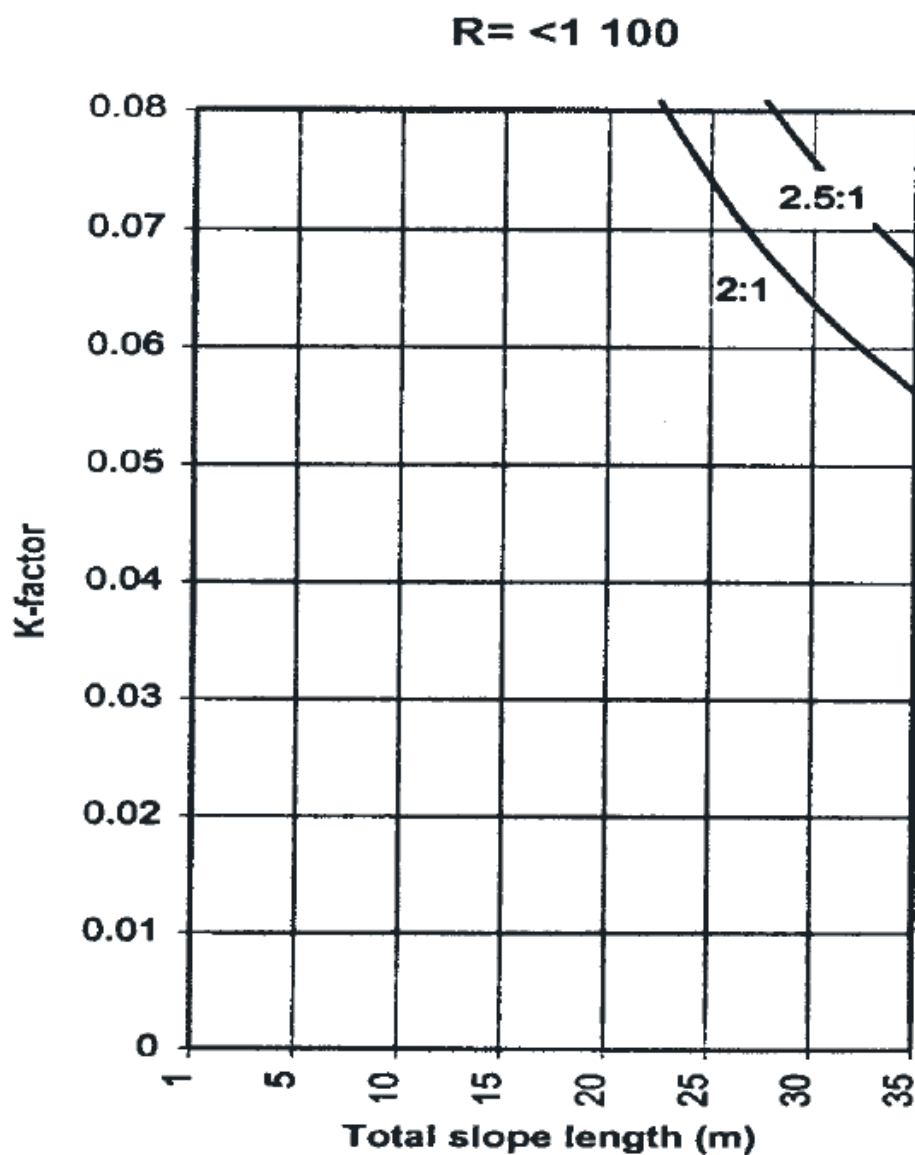


Figure 6.3 Maximum batter gradients for R-Factors <1100

Source: Figure 4.7 of Landcom (2004)

Table 6.9 Maximum recommended slope lengths

Slope gradient (H:V)	SPC01	SPC01a	SPC02	SPC03
2.5:1	No limit	No limit	No limit	No limit
2:1	No limit	No limit	No limit	No limit

6.3 Summary

An assessment of erosion hazard has been completed as per Landcom (2004) which considers the overall project erosion hazard based on slope and rainfall erosivity and subsequent determination of SLC.

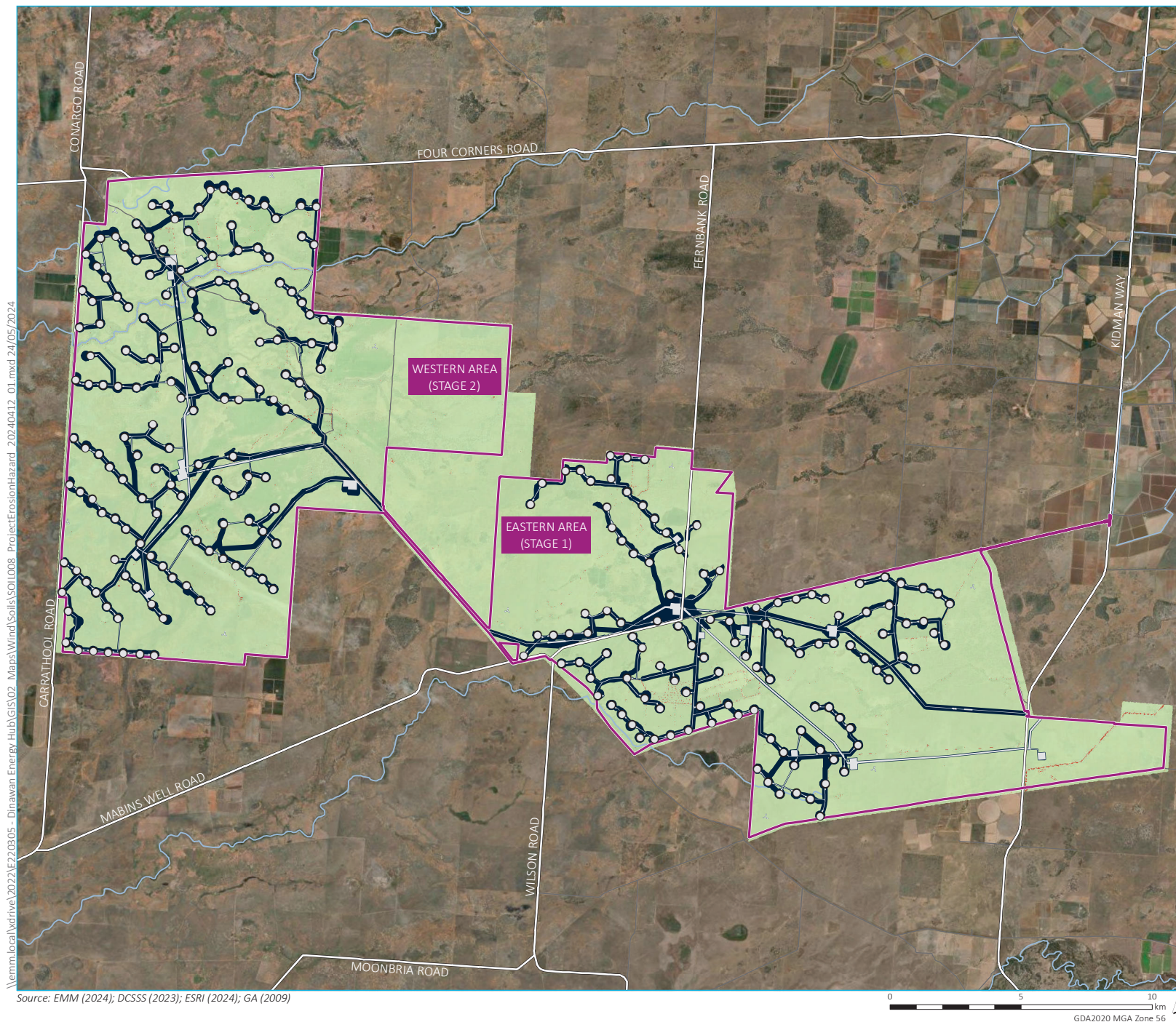
The erosion potential of soils of the development corridor and footprint, expressed as a K-factor, is typically low to moderate, due to sandy soils but can be high in areas of dispersive soils.

Assessment of rainfall erosivity indicates erosion hazard will be high for those areas where slopes exceed 21% (Figure 6.4), which aligns with the assessment of SLCs.

It was determined that there was a change to moderate (SLC 4) erosion risk for SPC01, 01a and 3 at slopes exceeding 19–25% and to high erosion (SLC 5) risk at slopes between 26–35%. SPC02 does not exceed low erosion hazard unless slope exceeds 40%.

The development corridor and development footprint have a low erosion hazard based on their flat topography and subsequent mean slope. Localised areas of steep slopes (approximately less than 0.05% of the project area) present a higher erosion hazard; however, these are primarily associated with the existing embankments of irrigation channels, as seen in Figure 6.4. Special measures will be implemented for these areas, where disturbance activities are necessary, for certain times of the year, which is January to March (based on Table 6.8).

Project-specific management and mitigation measures for erosion are provided in Section 8.3.



- KEY**
- Project area
 - Development corridor
 - Development footprint
 - Wind turbine generator (WTG)
- Erosion hazard**
- Low (<21%)
 - High (>21%)
- Exsting environment**
- Major road
 - Minor road
 - Named watercourse

Project erosion hazard

Dinawan Wind Farm
Land and Rehabilitation Assessment
Figure 6.4



\\emm.local\ydrive\2022\LE220305 - Dinawan Energy Hub\GIS\02 Maps\Wind\Soils\SOIL008 ProjectErosionHazard_20240412_01.mxd 24/05/2024

Source: EMM (2024); DCSSS (2023); ESRI (2024); GA (2009)

0 5 10
km
GDA2020 MGA Zone 56

7 Impact assessment

7.1 Land and soil capability

7.1.1 Construction soil impacts

Soil disturbance during construction has the potential to result in:

- reduction in soil stability and increased susceptibility to erosion due to vegetation removal or soil exposure, especially as the subsoils are commonly sodic and dispersive
- erosion of soil due to exposing soils, disturbing dispersive subsoils and concentration of flow
- reduction of soil quality, quantity and associated productivity
- 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, sodicity or other constraints into the topsoil material if soil is inadequately managed or from imported material.

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 in less fertile topsoils due to introduced constraints (such as sodicity or salinity) or potentially constrained subsoils forming the upper part 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 highly saline and strongly sodic nature of many of the subsoils encountered in the project area, and noted limitations of topsoil chemistry, inappropriate soil handling practices represents a key risk for land and soil capability.

Soil materials may be imported during construction. The soil material can potentially have less desirable physical and chemical properties than the in-situ soils and will need to be characterised and appropriately handled during works to ensure that it is suitably ameliorated (if required) and placed in a suitable portion of the recreated soil profile.

Loss of nutrients and nutrient holding capacity results in a less fertile environment. 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 that can lead to soil density increases and subsequent compaction. Construction equipment, such as plant movement, can also compact the soil resulting in reduced water holding capacity, increased runoff resulting in increased erosion potential and reduced plant root and shoot penetration.

Compaction lowers the infiltration rate of water into the soil profile and reduces the 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 topsoil fragility, crusting and hard setting limitation described in Section 4.2.

7.1.2 Operation impacts

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

- erosion of soil resources due to excessive concentration of flow and inappropriate channel lining and flow energy dissipation
- reduced topsoil nutrient and biological activity due to stockpiling
- tunnel erosion in cable trenches due to inadequately compacted and ameliorated dispersive subsoils
- exposure of dispersive soils in cut and fill batters and excavations (should they be required)
- splash erosion of footings due to inadequate soil surface cover.

7.1.3 Changes to land and soil capability within the development footprint

As described in Section 5, assessment of LSC has verified the development footprint contains the potential for LSC Classes 3 to 6 based on collected soil samples, with results indicating predominantly Class 4, representing a range of capability from high to low capability for productive use without resulting in land degradation. The land is currently used for sheep and cattle grazing, with minor areas of cropping.

The land within the development footprint will not be available for grazing or cropping during construction. During operation the impacted area will be decreased, with only tracks and WTG pads being permanently removed from agriculture for the life of the project.

The LSC status of land subject to new infrastructure (assuming a small footprint or temporary disturbance) will be able to be maintained or reinstated post-construction following appropriate soil management, landform design and appropriate rehabilitation. It is expected the LSC status of other areas within the development footprint will be able to be re-established at the completion of operations if the recommended management and mitigation measures are implemented.

Based on available mapping, the development footprint has the potential to impact a very small amount of LSC Class 3, 4 and 6 land within the South West REZ, predominantly in LSC Class 4 (0.12% of Class 4 land within the South West REZ), as shown in Table 7.1.

Table 7.1 Comparison of the project's LSC impacts in the context of the South West REZ

Area (ha)	LSC class							
	1	2	3	4	5	6	7	8
South West REZ	0	0	1,739	988,411	1,129,856	341,583	249,807	71,436
Development footprint	0	0	5	1,209	0	124	0	0
Reduction (%)	0	0	0.31%	0.12%	0	0.04%	0	0

Appropriate management and mitigation techniques are provided in Section 8.

7.2 Agricultural impacts

7.2.1 Agricultural productivity impacts

Extrapolating from data contained in Section 3.8.8, an area equivalent to the development footprint (1,339 ha) of typical grazing land, if fully developed, would be valued at \$368,483 in gross annual productivity based on calculated agricultural values for grazing and cropping within the Murrumbidgee LGA and Edward River LGA (Section 3.8.8i). This value could increase to as high as \$574,784 based on gross productivity estimates from the Murray NRM Region.

Whilst this is a loss of agricultural land value based on annual productivity and an assumption of the entire development footprint being developed and unavailable for intensive agriculture (such as cropping or cattle grazing), the disruption to productivity will be primarily due to lack of access to the land, as opposed to a reduction of the land capability. Additionally, the impact will be focused on the construction phase due to the increased disturbance area. During operations, available land that could still be utilised for some agricultural practice will increase (in comparison to the construction phase).

Once the project reaches the end of its investment and operational life, project infrastructure will be decommissioned and the land returned to its pre-existing land use, where practicable, namely suitable for grazing of sheep and cattle with limited cropping, or another land use as agreed by the project owner and the landholder at that time.

7.2.2 Fragmentation and displacement

The development footprint is broad and distributed across two large landholdings. However, project infrastructure will be primarily limited to access roads and isolated WTGs; therefore, the project has considered mitigating potential fragmentation of any existing agricultural landholdings or enterprises. The existing agricultural land use will continue on land adjacent to the development footprint during construction and operations.

If fully removed from agricultural land use, the development footprint would account for 0.10%, 0.08% and 0.04% of the agricultural land utilised in the Murrumbidgee LGA, Edward River LGA and Murray NRM Region, respectively.

7.2.3 Biosecurity

The construction and operation of the project has the potential to increase biosecurity risks through increased weeds and pests. Weeds and pathogens may be introduced through contaminated vehicles, plant and equipment, wind, and the import of contaminated soil, gravels, and other substrates as part of construction and operation. The introduction of weeds and pathogens may impact agricultural production within the project area and on adjoining land in several ways, such as:

- competition with crops on neighbouring land, resulting in increased farm-level weed management costs and/or reduced crop quality, value and profit margins
- competition with more desirable pasture/forage species, resulting in reduced livestock (sheep) productivity and profit margins
- creating undesirable harbour for pest animal species (e.g. rabbits), resulting in increased farm-level pest management costs and/or reduced yields due to pest animal grazing pressure on crops
- introduction of crop or livestock diseases, reducing market opportunities, productivity, and profit margins.

The introduction of new weeds and pathogens could compound management effort and costs on any existing weed species in the project area. Pest animals in the region include rabbits, foxes, and feral cats. Rabbit and fox numbers may increase because of activity generated by the project which could have potential flow on impacts to crops (grazing pressure) and livestock (predation) within and surrounding the project area.

7.2.4 Impacts to adjacent lands

Potential impacts to adjacent lands could include increased presence of biosecurity issues such as weeds and pests, as well as off-site impacts from erosion and sedimentation. Project impacts are anticipated to be limited primarily to the development footprint with minimal impact to adjacent lands.

The project will be compatible with adjacent land uses based on zoning as primary production (e.g. agriculture, renewable energy farms) during operation and after decommissioning with the implementation of recommended mitigation measures in Section 8.

Outcomes of consultation with neighbouring landholders and where their concerns have been addressed is provided in Chapter 5 of the EIS.

Cumulative impacts of the project and neighbouring developments on soils and LSC is discussed in Section 7.4.

7.3 Erosion and sediment control

7.3.1 Construction impacts

Potential erosion and sediment control impacts during construction include:

- off-site discharge of sediment and turbid runoff from the erosion of exposed soils particularly dispersive subsoils:
 - degradation of stock drinking water
 - infilling of waterway pools
 - diversion of waterway flow due to sediment deposition and associated bed and bank erosion
- erosion and subsequent sedimentation of creeks and waterways due to inappropriately designed and constructed creek and 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 landforms (roads, tracks, hardstands) and drains
- increased erosion and subsequent sedimentation due to pavement rutting and pavement degradation from increased light and heavy vehicles traffic on unsealed access roads
- incision and widening of downstream drainage lines due to modification of the local catchment runoff response as a result of an increase in impermeable surface such as roads, hardstands and roofs
- tunnel erosion under or beside foundations for WTGs, infrastructure and along cable trenches due to dispersive soils
- dust emissions from unsealed roads, hardstands, and exposed soils.

7.3.2 Operation impacts

Potential erosion and sediment control impacts during operations include:

- offsite discharge of sediment and turbid runoff from ongoing erosion from drainage, landform, and infrastructure design not cognisant of dispersive subsoils
- increased maintenance costs for ongoing stabilisation of landforms, roads, drains, and cable trenches
- operation and maintenance of sediment control structures due to ongoing erosion
- tunnel erosion under or beside foundations of WTGs, infrastructure, and along cable trenches due to dispersive soils
- dust emissions from unsealed roads, hardstands, and exposed soils, though reduced due to lower vehicle movements during operations.

Appropriate management and mitigation techniques are provided in Chapter 8.

7.4 Cumulative impacts

Proposed, approved, under construction and operational renewable energy developments (known at the time of EIS preparation) within and in the vicinity of the South West REZ have the potential to create a cumulative impact on soil and agricultural resources and are summarised in Table 7.2.

Table 7.2 Known projects with potential for cumulative impacts

Project	Reference	Type	LGA	Description	Status
Project EnergyConnect	SSI-9172452	Electricity transmission	Murrumbidgee, Edward River, Hay, Federation	New overhead transmission line, substations and accommodation facilities.	Approved – under construction
Dinawan Solar Farm	SSD-50725959	Solar farm and BESS	Murrumbidgee, Edward River	Construction and operation of 800 MW solar farm and 300 MW BESS.	Proposed – responding to submissions
Argoon Wind Farm	SSD-64935522	Wind farm and BESS	Murrumbidgee	Construction and operation of 480 MW wind farm - up to 106 WTGs and 477 MW BESS.	Proposed – EIS in preparation
Victoria to NSW Interconnect (VNI) West	Not yet on planning portal	Electricity transmission	Murrumbidgee, Edward River, Murray	New overhead transmission line connecting the high voltage electricity grids in NSW and Victoria.	Proposed – pre-scoping phase
Yanco Delta Wind Farm	SSD-41743746	Wind farm and BESS	Murrumbidgee, Edward River	Construction and operation of 1.5 GW wind farm - up to 208 WTGs.	Approved

Table 7.2 Known projects with potential for cumulative impacts

Project	Reference	Type	LGA	Description	Status
Pottinger Wind Farm	SSD-59235464	Wind farm and BESS	Edward River, Hay	Construction and operation of a wind farm with up to 108 WTGs, battery storage and associated infrastructure.	Proposed – EIS in preparation.
Pottinger Solar Farm	SSD-59254709	Solar farm and BESS	Hay Shire	Development of a 300 MW solar farm and associated infrastructure, including battery storage facility.	Proposed – EIS in preparation.
Coleambally Solar Farm	SSD-8208	Solar farm	Murrumbidgee	150 MW solar farm.	Operating
Coleambally BESS	SSD-23368211	BESS	Murrumbidgee, Edward River, Hay	Construction and operation of 100 MW BESS.	Approved – not constructed
Bullawah Wind Farm	SSD-50505215	Wind farm and BESS	Murrumbidgee	Construction and operation of 1 GW wind farm - up to 170 WTGs.	Proposed – EIS in preparation.
Darlington Point Solar Farm	SSD-8392	Solar farm and BESS	Murrumbidgee	275 MW solar farm (constructed). 200 MW BESS (under construction)."	Operating; however, BESS under construction.
Woodland Battery Energy Storage System	SSD-30526266	BESS	Murrumbidgee	Construction and operation of 200 MW/800 MWh BESS.	Proposed – under assessment
Yarrabee Solar Farm	SSD-9237	Solar farm and BESS	Narrandera	Construction and operation of 900 MW solar farm and BESS.	Approved – not constructed.
Currawarra Solar Farm	SSD-8437	Solar farm and BESS	Edward River	Construction and operation of 195 MW solar farm and BESS.	Approved – not constructed.
Tarleigh Park Solar Farm	SSD-8436	Solar farm and BESS	Edward River	Construction and operation of 90 MW solar farm and BESS.	Approved – not constructed.
The Plains Solar Farm	SSD-51219280	Solar farm and BESS	Hay	Construction and operation of 500 MW solar farm and 400 MW/1.6 GWh BESS.	Proposed – EIS in preparation.

Table 7.2 Known projects with potential for cumulative impacts

Project	Reference	Type	LGA	Description	Status
The Plains Wind Farm	SSD-50629707	Wind farm	Edward River	Construction and operation of 1.8 GW wind farm - up to 226 WTGs.	Proposed – EIS in preparation.
Tchelery Wind Farm	SSD-59701722	Wind farm	Edward River	Construction and operation of a wind farm with up to 120 WTGs and associated infrastructure.	Proposed – EIS in preparation.
Baldon Wind Farm	SSD-40138508	Wind farm	Edward River, Hay, Murray River	Construction and operation of 1 GW wind farm - up to 162 WTGs.	Proposed – EIS in preparation.

Cumulative impacts to soil, land and agriculture primarily relate to potentially reduced regional LSC and associated impacts to agricultural land productivity and availability within the South West REZ and relevant LGAs throughout construction and operation, as well as construction impacts on erosion and sediment control.

Impacts from projects may include site erosion and/or sediment resulting in reduced soil availability and sediment migration to watercourses that pass through or occur downstream of a construction site. All construction activities are required to operate under environmental management plans that will mitigate such impacts, as will be the case with the project. The project proposes to implement soil management measures and maintain existing pasture and cropping (where relevant) adjacent to WTGs and supporting infrastructure and therefore, during operation, an ongoing source of sediment to the receiving environment is considered unlikely.

Due to the identification of centralised REZs, cumulative impacts on availability of agricultural land within these areas is unavoidable; however, consistent with DPIE's (2022) *Large-Scale Solar Energy Guideline*, cumulative risk to agricultural land and productivity are considered very low based on the extent of land within these areas that will remain available for agricultural production during both construction and operations.

It is noted that the South West REZ has avoided land mapped as LSC Class 1 and 2 in its entirety and contains only 1,739 ha (<1%) of land mapped as LSC Class 3. The project will have a temporary impact on land that has predominantly been verified as LSC Class 4 and 6. Therefore, cumulative impacts on what is considered to be higher productivity agricultural land (under the LSC) within the South West REZ is considered to be negligible.

7.5 Land use conflict risk assessment

A LUCRA has been developed for the project using DPI's *Land Use Conflict Risk Assessment Guideline* (2011) (LUCRA Guideline). DPI defines the LUCRA as a system to identify and assess the potential for land use conflict to occur between neighbouring land uses (DPI 2011). The LUCRA assists with the assessment of the possibility for and potential level of future land use conflict between different parties.

DPI has identified that land use conflicts occur when one land user is perceived to infringe upon the rights, values or amenity of another (DPI 2011). In rural settings, this often occurs between different agricultural enterprises and other primary industries (DPI 2011).

Using the risk ranking matrix provided by DPI as a guide, a LUCRA was developed for the project and is provided in Attachment E. Potential land use conflicts identified as part of this process have been informed by engagement with residences near the project, surrounding agricultural operations, project landholders, relevant councils, and the local community.

The risk ranking matrix provided within the LUCRA Guideline defines a risk ranking from 1–25 with a score of 1 representative of the lowest risk and a score of 25 representative of the highest risk. Risk rankings are calculated by determining the probability of the potential conflict (as defined in Table 7.3) and identifying the consequences of the potential conflict, which include:

- Level 1: Severe
- Level 2: Major
- Level 3: Moderate
- Level 4: Minor
- Level 5: Negligible.

Table 7.3 **LUCRA probability table**

Level	Descriptor	Description
A	Almost certain	Common or repeating occurrence
B	Likely	Known to occur, or 'it has happened'
C	Possible	Could occur, or 'I've heard of it happening'
D	Unlikely	Could occur in some circumstances, but not likely to occur
E	Rare	Practically impossible

Source: DPI (2011).

As part of the preparation of the LUCRA (Attachment E), 30 potential conflicts have been considered, including potential for conflict as a result of:

- changes to the spread and distribution of weeds and increased presence of pest animals
- removal of agricultural land and subsequent reduction in productivity
- impacts to neighbouring agricultural operations, property values, council rates and local infrastructure and services
- amenity impacts during construction and operation (e.g. noise, dust, visual and traffic)
- increased soil erosion and impacts to surface water resources
- risks associated with the project (e.g. security, safety, health and fire).

Under the unmitigated scenario (i.e. without the implementation of the proposed management strategies), the risk ranking matrix identified potential for 14 high-risk conflicts (i.e. those with a risk ranking score of greater than 10). Through the implementation of the proposed management strategies described in Attachment E, the number of high-risk conflicts reduced to five, which reflects a reduction of approximately 36%.

Potential conflicts with a revised risk ranking of greater than 10 were limited to removal of agricultural land and subsequent reduction in productivity, visibility of project infrastructure during operation and risks associated with the project (namely in relation to safety and fire). It should be noted that although the probability of potential conflicts in relation to safety and fire are considered unlikely, the major consequence that correlated with the associated events maintained the revised risk ranking score at 14.

Performance targets have been proposed to ensure that the proposed methods of control identified within the LUCRA continue to be effective at addressing the identified potential conflicts. This includes:

- to reduce potential impacts on the future agricultural productivity of the land within the development footprint, rehabilitation objectives and strategies (including performance measures) will be established
- the Bushfire Management Plan will be reviewed after incidents of bushfire or other fire as well as annually at the end of each bushfire season and will be amended after the review process, if required, to increase its effectiveness.

8 Mitigation measures

8.1 Land and soil capability

The primary objective of the soil management approach is to reinstate disturbed areas to as near as practical to pre-existing environmental conditions by:

- avoiding, minimising or mitigating impacts to soils
- maintaining soil, particularly topsoil, quantity and quality
- restoring land to its potential productive capacity as soon as possible following completion of the activity
- returning the land to a stable landform.

As part of the Construction Environmental Management Plan (CEMP), soil management measures are recommended to ensure the preservation of soil resources. It is assumed that preserving and rehabilitating land and soil resources in a suitable condition, comparable to the established baseline conditions, will restore land and soil capability and agriculture to pre-construction production capability. These measures are detailed in Table 8.3.

8.2 Agriculture

8.2.1 Agricultural productivity

In addition to the maintenance and rehabilitation of pre-project soil and land capability, impacts to agriculture have been considered in the selection of the development footprint and development corridor. Where feasible, existing access tracks will be used to minimise disturbance requirements and use of otherwise productive land.

Once the project reaches the end of its operational life, a decision will be made to either decommission or re-power the facility, subject to approval requirements. If the project is decommissioned, all aboveground structures will be removed (unless otherwise agreed with landowners and regulators) and the site rehabilitated generally to its pre-existing land use, as far as practicable.

8.2.2 Biosecurity

It is recommended that the following controls to manage impacts associated with weeds, pathogens and pest species be implemented as part of the CEMP or similar:

- suitable hygiene and washdown protocols, including washdown and inspection of vehicles, plant and machinery when moving from areas with known populations of weed and pest species
- removal of identified weeds through methods such as herbicide spraying, scalping and hand-pulling
- where gravel, crushed rock or soil is required to be imported to site, care will be taken to ensure that the material is free from noxious weed and seed
- 1080 poison baiting programs and ripping of rabbit warrens and fox dens within the development footprint.

8.3 Erosion and sediment control

It is recommended to implement erosion and sediment control measures and site rehabilitation and revegetation in accordance with industry standard practice comprising Landcom (2004), *Managing Urban Stormwater: Soils and Construction - Volume 2A* and *Volume 2C* (DECC 2008a, 2008b) and IECA (2008). Proposed measures are outlined below and will be considered further and formalised as part of detailed design and will form part of the relevant management plan within the overall CEMP.

8.3.1 Drainage and landform design

It is recommended that project infrastructure be located within the development footprint 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.

Minor earthworks may be required for the preparation of the development footprint, including site levelling, access track formation and drainage works. Due to the flat landscape within the development footprint, site levelling is unlikely to be required over the majority of the development footprint. More extensive earthmoving may be required for cut/fill where a level pad is required for project components (e.g. on-site substations).

As dispersive subsoils are present within the development footprint, 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 to suitable rates to prevent erosion
- 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 (should they be required)
- use back-push diversion banks 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
- use sediment basins (Type D) where necessary to treat turbid runoff to protect downstream receivers.

8.3.2 Minimising the extent and duration of land disturbance

As part of the CEMP or similar, 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.

Earthworks and major land disturbing activities within high erosion risk areas (high erosion (SLC 5) slopes between 24–39% for various SPCs) will avoid the high rainfall erosivity period (summer storm season) of October through to April, particularly January to March (Table 6.8), 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 (such as waterbodies)
- soil erosivity
- slope gradient and length
- time of year (rainfall risk)
- site access.

Table 8.1 provides guidance on the recommended timing and C-Factors of stabilisation and rehabilitation works as required by Landcom (2004).

Table 8.1 Maximum C-Factors during construction and post-construction

Feature/area	C-Factor	Requirement
During construction		
Waterways and land below the 2-year average recurrence interval (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 the 2-year 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% 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.

Indicative C-Factors for some common stabilisation products that can be used to achieve target C-Factors are provided in Table 8.2 (the lower the C-Factor the better the erosion protection).

Table 8.2 **Indicative C-Factors for common soil stabilising products/techniques**

Product	C-Factor range	Rate/cover	Duration	Source
Grass cover	0.05	70%	Permanent	Landcom (2004)
Turf (Kikuyu)	<0.01	100%	Permanent	Landcom (2004)
Soil stabilising polymer	0.004–0.66	10–25% solution 0.1–1 mL/m ²	Not tested	Landloch (2015) Landloch and SEEC (2013) Landloch (2018)
Hydro-mulch	0.00–0.10	1,500 kg/ha 300-L binder/ha	3 months	Landcom (2004)
Bonded Fibre Matrix hydro-mulch (wood fibre)	0.00–0.10	5,000 kg/ha	6 months	Landcom (2004)
Hydraulically applied growth medium	0.006–0.008	4,500 kg/ha	Not tested	Landloch (2015)
Jute mesh	0.10–0.60	Not provided but expected to be 350 g/m ²	6–12 months	Landcom (2004)

8.3.3 Controlling water movement through the development footprint

The following water movement measures are recommended:

- 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 any cut batters that may be required for infrastructure 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.
- Access track drainage should be turned out using back-push diversion banks or trapezoidal mitre drains where possible. Drains will need to be suitably lined (generally rock) where flow velocities exceed the maximum permissible velocity of the soil (0.2 to 0.7 m/s).
- Access track surfaces should be stabilised to minimise erosion, turbid runoff, dust emissions, watering and maintenance.
- Rainfall falling onto the roofs of buildings 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 disturbed areas and, where practicable, access tracks should be diverted to Type D sediment basins for treatment.
- Sediment basins should be constructed as a priority before 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 Australian Standard 1940 *The storage and handling of flammable and combustible liquids*.

8.3.4 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 drainage, erosion, and sediment control strategies. The types of erosion that can potentially are:

- raindrop splash erosion
- sheet erosion
- rill erosion
- gully erosion
- chemical erosion (dispersion).

Raindrop splash erosion is most effectively controlled by providing soil surface cover. This can be achieved 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 area
- 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 by:

- if cut and fill batters are required, ensuring these 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
- progressively revegetating disturbed areas.

Gully erosion is effectively controlled by minimising the concentration of flow and slowing flow velocity. This can be achieved 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
- 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 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
- using trench breakers that extend into the in-situ soils in cable trenches as per Figure 8.1.

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.

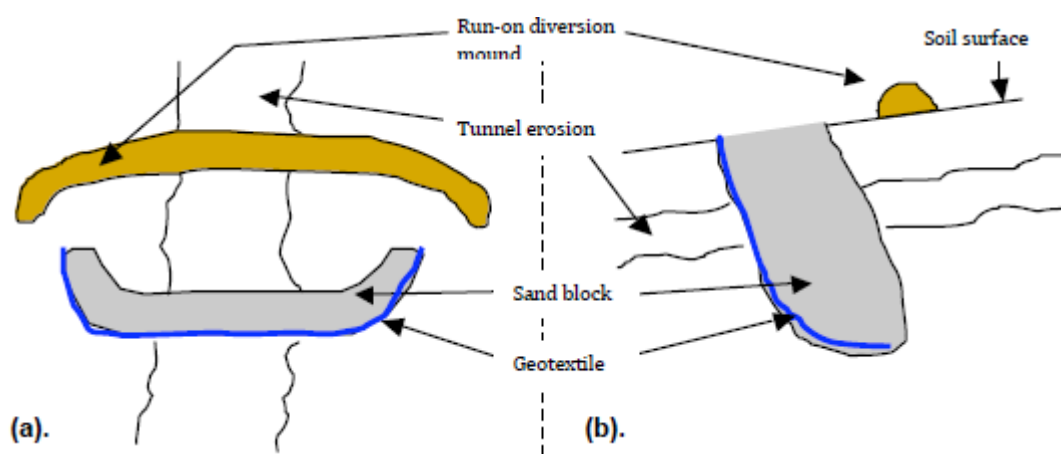


Figure 8.1 Cable trench breaker layout for dispersive soils (DPIW 2009)

8.3.5 Promptly stabilising disturbed areas

As recommended in Section 8.3.2, 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 and presence of suitable quality topsoil, bonded fibre matrix hydro-mulches are considered appropriate for project rehabilitation purposes.

Topsoil should not be applied to slopes steeper than 1(v):2(h) as there is a risk it will slump. For slopes steeper than 1(v):2(h), a hydraulically applied growth medium is recommended.

Ensure that non-water soluble, mineral based, biologically inoculated fertilisers are used in any revegetation works, if required, to not impact on proximal landowners participating in organic or carbon farming initiatives.

8.3.6 Maximise sediment retention on-site

As discussed in Section 8.3.4, the most effective form of sediment control is erosion prevention. 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 receiving environment, such as the drainage lines, from turbid runoff from the clay and dispersive clay soils present within the project area. Type D sediment basins are recommended where calculated soil loss exceeds 150 m³/y from disturbed areas or control of turbidity is required to protect watercourses. Using enhanced erosion control measures, such as trafficable soil stabilising polymers or gravelled hardstand, could reduce soil loss below the threshold of 150 m³/y and remove the requirement for a sediment basin.

The use of groundwater from existing bores within the development footprint and surrounds is proposed as the primary source of non-potable water for the project's construction and operation (refer to Water Resources Assessment, EMM 2024). The quality of the water is expected to be different to that of the existing surface water environment. The use of groundwater as the primary source of water will be subject to the requirements and controls outlined within the environmental management plans developed following the project's approval, covering both the construction and operational phases. Based on the proposed use of the water, it is likely that water will either infiltrate, evaporate, or be significantly dispersed, when used.

8.3.7 Maintenance

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 runoff or monthly during dry conditions. Inspections should be undertaken by the Environmental Manager or delegate. That person shall have the following knowledge:

- an understanding of project environmental values that could be impacted by site construction and operation
- an understanding of the requirements of the development consent conditions 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
- 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.

Maintain control measures to the maximum practicable extent so that control measures:

- are in accordance with the specified operational standard for each drainage, erosion and sediment control measure
- 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.

8.3.8 Monitoring

It is recommended that a hierarchical ESC planning system be adopted for construction and operation of the project consisting of an overarching project wide Erosion and Sediment Control Plan (ESCP) with progressive ESCPs for all disturbance areas to ensure that the project's ESCPs are dynamic documents that can and will be modified as 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 professional, such as a 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.

8.3.9 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 – training for foreman, engineers, project managers etc on the legal aspects of drainage, erosion and sediment control, fundamentals and site-specific strategies, techniques, and requirements
- Level 3 – detailed training course where drainage, erosion and sediment control is a regular component of their daily activities and competence is required.

8.4 Summary

A summary of the proposed mitigation measures is provided in Table 8.3.

Table 8.3 Summary of mitigation measures

ID	Mitigation measure	Timing
L1	As part of the CEMP or similar for the project, soil management measures are recommended to ensure the preservation of soil resources, including: • avoidance and minimisation of soil disturbance to the extent practical • assessment of topsoil depths to be stripped prior to stripping to minimise the mixing of topsoil and subsoil • preserving as much of the topsoil as possible • attempt to strip and manage different soils orders or mapping units separately • avoid mixing topsoil with subsoil during soil handling operations • where subsoils exhibit variance of constraints with depth consider managing subsoils in separate layers to minimise introduction of constraints higher into the soil profile • avoid stripping, handling or compacting soil following heavy rain periods that leaves the soil structure saturated • avoid compaction of soil 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) • ensuring reinstatement of soil horizons in the correct order and depths, where possible • 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 • stabilising long-term topsoil stockpiles to minimise stockpile waterlogging, the generation of anaerobic conditions, help maintain topsoil biological viability and nutrient cycling and to create a seed store • test stockpiled subsoil and topsoil to determine amelioration requirements prior to reinstatement • test any imported soil materials to characterise and determine suitable usage and amelioration requirements prior to reinstatement.	Pre-construction Construction Operation Closure and rehabilitation
L2	Undertake agricultural mitigation activities during the life of the project, including: • maintaining existing internal livestock fencing and other required infrastructure within the development footprint • avoiding interference with the operation of irrigation channels.	Operation

Table 8.3 **Summary of mitigation measures**

ID	Mitigation measure	Timing
L3	The following will be implemented to manage impacts associated with weeds, pathogens and pest species: • implementing hygiene and washdown protocols, including washdown and inspection of vehicles, plant and machinery when moving from areas with known populations of weed and pest species • removing identified weeds through methods such as herbicide spraying, scalping and hand-pulling • managing importation of gravel, crushed rock or soil to ensure that the material is free from noxious weed seed • implementing measures to manage pest fauna species within the development footprint.	Construction Operation Closure and rehabilitation
L4	Implement erosion and sediment control measures and site rehabilitation and revegetation in accordance with industry standard practice and formalise as part of detailed design and the CEMP or similar. Measures and principles should include: • minimising the extent and duration of land disturbance • controlling water movement through the development footprint • minimising soil erosion • promptly stabilising disturbed areas • maximising sediment retention on-site • maintain drainage, erosion and sediment control measures • monitor and adjust drainage, erosion and sediment control practices to achieve the desired performance standard • construction of suitable watercourse crossings • the installation of driven piles, excavation of cable and pipe trenches, construction of roads, tracks and ancillary facilities will expose subsoils and therefore, consideration of the erosion hazard specifically posed by the dispersive subsoils is required.	Pre-construction Construction Operation Closure and rehabilitation

9 Rehabilitation strategy

At the end of the project life, all aboveground structures will be removed (unless otherwise agreed with landowners and regulators) and the site rehabilitated generally to its pre-existing land use, as far as practicable.

Stripping and preservation of topsoil resources is a key component of rehabilitation planning, and it is recommended that suitable soil stripping management practices that guide the stripping and management of soil resources are developed and implemented. Any imported soil materials should be characterised and suitably ameliorated prior to reinstatement to ensure material is appropriately utilised.

Initial rehabilitation will involve removal of any temporary infrastructure, such as construction phase laydown areas that are no longer required for operations. Rehabilitation of the development footprint would occur following the cessation of operations. Rehabilitation would involve removal of the wind farm and any ancillary infrastructure. It is possible that some infrastructure may be retained where it is agreed with the landowners to do so (subject to appropriate development consent). For example, some infrastructure may have alternative uses that support future grazing activities such as access roads, hard stand areas, sheds and tracks.

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) with suitable management of topsoils and subsoils. Stripped topsoil will be re-spread over the entire area and then seeded with appropriate grass and legume species.

Subsoil and topsoil stripped and stockpiled during the construction phase will be replaced in reference order to when it was stripped and at similar profile depths such that the pre-project LSC can be re-established, particularly in areas where hardstands, tracks, and sediment basins (if required) are removed.

During rehabilitation, recommended construction management measures for soil handling and erosion prevention, as in Section 8, should be implemented to ensure soil and erosion is suitably managed during this stage.

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

10 Conclusion

This LRA report supports the EIS for the project and satisfies the relevant SEARs. It documents the assessment methodology, results and the mitigation and management measures proposed to address any unavoidable residual impacts to land, soils and agriculture arising from the project.

Potential land, soils and agriculture related impacts associated with the project were assessed, including impacts to:

- soil quality and quantity
- land and soil capability
- agricultural productivity
- erosion potential.

Overall, potential project-related and cumulative impacts during construction and operation are considered minor and can be adequately managed through the implementation of the recommended mitigation measures.

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Attachment A

Soil data sheets

SITE DESCRIPTION SHEET

MAP REFERENCE																MAP SHEETS										AIR PHOTO REFERENCE																ANNUAL RAINFALL				SOIL OR LAND CLASS				GREAT SOIL GROUP				PRINCIPAL PROFILE FORM				SURVEY				SITE				CARD																															
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NOTES AND DIAGRAMS

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SITE DESCRIPTION SHEET

MAP REFERENCE															AIR PHOTO REFERENCE															ANNUAL RAINFALL															SOIL OR LAND CLASS															GREAT SOIL GROUP															PRINCIPAL PROFILE FORM															SURVEY															SITE															CARD																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
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SITE DESCRIPTION SHEET

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SITE DESCRIPTION SHEET

MAP REFERENCE

MAP SHEETS

AIR PHOTO REFERENCE

DESCRIBED BY

DATE

LANDFORM ELEMENT

STREAM CHANNELS

LANDFORM PATTERN

STANDING WATER

ASPECT

SURVEY

SITE

CARD

EMERGENT

TALLEST STRATUM

MID STRATUM OR RAINFOREST SCLEROPHYLLS

LOWEST STRATUM

RAINFOREST ATTRIBUTES

SURVEY

SITE

CARD

SLOPE

ELEVATION

BIOLOGICAL

MICRORELIEF

EROSION

INUNDATION

SURFACE COARSE FRAGMENTS

ROCK OUTCROPS

COND. SURF. SOIL

DEPTH REGOLITH

SUBSTRATE MATERIAL

SURVEY

SITE

CARD

NOTES AND DIAGRAMS

SPARE ITEMS

HORIZON

DEPTH

COLOUR

MOIST.

MOYTTLES

FIELD TEXTURE

COARSE FRAGMENTS

STRUCTURE

CUTANS

VOIDS

PANS

SEGREGATIONS

FIELD pH

ROOTS

BOUND.

SURVEY

SITE

CARD

SITE DESCRIPTION SHEET

MAP REFERENCE																	MAP SHEETS										AIR PHOTO REFERENCE										ANNUAL RAINFALL					SOIL OR LAND CLASS					GREAT SOIL GROUP					PRINCIPAL PROFILE FORM					SURVEY					SITE					CARD				
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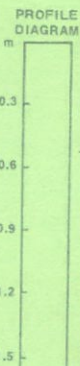
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NOTES AND DIAGRAMS

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SITE DESCRIPTION SHEET

MAP REFERENCE

Easting or Latitude 102

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SITE DESCRIPTION SHEET

MAP REFERENCE																MAP SHEETS										AIR PHOTO REFERENCE																				ANNUAL RAINFALL				SOIL OR LAND CLASS				GREAT SOIL GROUP				PRINCIPAL PROFILE FORM				SURVEY				SITE				CARD			
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Attachment B

Soil chemistry data

B.1 Soil chemistry data – SPC01

B.1.1 Site DWF01

Table B.1 Site DWF01 – nutrient chemistry data

Depth (cm)	pH (H ₂ O)	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	(cmol+)/kg	Rating							
0–10	6.27	–	–	–	–	–	–	–	–	0.74	H	–	–	–	–	–	–

Notes: 1. Ratings as described in Section 4.1.4.

Table B.2 Site DWF01 – soil profile chemistry data

Depth (cm)	Particle size (%) ¹					pH (H ₂ O)	EC (dS/m)	EC rating ²	Cl ⁻ (mg/kg)	Exchangeable cations (cmol+)/kg						ESP (%)	Sodicity (NS, S, SS)	EAT Class	Ca:Mg ratio	Critical Aluminium levels ³
	Clay	Silt	Fine Sand	Coarse Sand	Gravel					Al ⁺³	Ca ⁺²	Mg ⁺²	K ⁺	Na ⁺	CEC					
0–10	–	–	–	–	–	6.27	0.08	VL	32.7	0.02	3.56	3.42	0.74	0.49	8.22	5.98	LS	–	1.04	–
20–30	–	–	–	–	–	8.13	0.10	VL	24.7	0.02	10.8	13.5	1.06	3.81	29.2	13.0	S	–	0.80	–
80–90	–	–	–	–	–	8.29	1.82	VH	2515	0.02	10.3	16.2	0.76	9.44	36.7	25.7	SS	–	0.63	–

Notes: 1. Gravel (>2 mm), Coarse sand (0.2–2 mm), Fine sand (0.02–0.2 mm), Silt (2–20 µm), Clay (<2 µm)
2. Rayment & Lyons (2011) – very low salinity (VL), low salinity (L), moderately saline (M), highly saline (H), extremely saline (E)
3. Hazelton & Murphy (2016) – affects very sensitive plants (M), sensitive plants (H), tolerant plants (VH) and very tolerant plants (E).

Table B.3 **Site DWF01 – images**

Soil profile ¹	Landscape
	
Photograph B.1 DWF01 soil profile¹	Photograph B.2 DWF01 landscape

Notes: 1. Surface top left, 0.3 m increments.

B.1.2 Site DWF05

Table B.4 Site DWF05 – nutrient chemistry data

Depth (cm)	pH (H ₂ O)	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	(cmol+)/kg	Rating							
0–10	7.37	15.9	0.14	L	8.28	VL	1.72	M	0.00	VH	2.96	1.25	22.80	1.42	0.46	17.10	9.48

Notes: 1. Ratings as described in Section 4.1.4.

Table B.5 Site DWF05 – soil profile chemistry data

Depth (cm)	Particle size (%) ¹					pH (H ₂ O)	EC (dS/m)	EC rating ²	Cl ⁻ (mg/kg)	Exchangeable cations (cmol(+)/kg)						ESP (%)	Sodicity (NS, S, SS)	EAT Class	Ca:Mg ratio	Critical Aluminium levels ³
	Clay	Silt	Fine Sand	Coarse Sand	Gravel					Al ⁺³	Ca ⁺²	Mg ⁺²	K ⁺	Na ⁺	CEC					
0–10	53.5	13.0	21.2	11.4	0.9	7.37	0.11	VL	55.5	0.02	12.0	7.33	1.17	0.79	21.3	3.71	LS	3b	1.64	–
20–30	60.6	11.7	17.6	9.6	0.5	9.01	0.16	L	14.6	0.02	15.9	8.99	0.46	2.20	27.6	8.00	S	4	1.77	–
80–90	68.6	8.1	17.0	6.2	0.1	8.95	1.22	VH	1217	0.02	6.86	5.98	0.34	6.02	19.20	31.3	SS	6	1.15	–

Notes: 1. Gravel (>2 mm), Coarse sand (0.2–2 mm), Fine sand (0.02–0.2 mm), Silt (2–20 µm), Clay (<2 µm)
2. Rayment & Lyons (2011) – very low salinity (VL), low salinity (L), moderately saline (M), highly saline (H), extremely saline (E)
3. Hazelton & Murphy (2016) – affects very sensitive plants (M), sensitive plants (H), tolerant plants (VH) and very tolerant plants (E).

Table B.6 Site DWF05 – images

Soil profile ¹	Landscape
	

Photograph B.3 DWF05 soil profile¹

Photograph B.4 DWF05 landscape

Notes: 1. Surface top left, 0.3 m increments.

B.1.3 Site DWF09

Table B.7 Site DWF09 – nutrient chemistry data

Depth (cm)	pH (H ₂ O)	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	(cmol+)/kg	Rating							
0–10	6.73	6.1	0.12	L	29.2	M	1.04	L	–	VH	1.79	0.94	12.3	1.86	0.58	43.5	63.1

Notes: 1. Ratings as described in Section 4.1.4.

Table B.8 Site DWF09 – soil profile chemistry data

Depth (cm)	Particle size (%) ¹					pH (H ₂ O)	EC (dS/m)	EC rating ²	Cl ⁻ (mg/kg)	Exchangeable cations (cmol+)/kg						ESP (%)	Sodicity (NS, S, SS)	EAT Class	Ca:Mg ratio	Critical Aluminium levels ³
	Clay	Silt	Fine Sand	Coarse Sand	Gravel					Al ⁺³	Ca ⁺²	Mg ⁺²	K ⁺	Na ⁺	CEC					
0–10	47.0	10.9	21.2	20.0	0.8	6.73	0.09	VL	52.6	0.02	9.2	10.90	1.37	2.60	24.1	10.79	S	3a	0.85	–
20–30	61.8	7.8	17.2	12.7	0.5	8.30	0.49	M	515.0	0.02	6.8	9.66	0.39	4.45	21.3	20.80	SS	2	0.71	–
50–60	65.2	10.1	12.5	11.8	0.4	8.45	1.54	VH	2074.0	0.02	6.6	10.80	0.49	5.64	23.6	23.90	SS	6	0.61	–
80–90	47.5	16.1	18.0	17.5	0.9	8.01	2.00	E	1975.0	0.02	6.7	10.10	0.46	4.60	21.9	21.00	SS	6	0.67	–

Notes: 1. Gravel (>2 mm), Coarse sand (0.2–2 mm), Fine sand (0.02–0.2 mm), Silt (2–20 µm), Clay (<2 µm)
2. Rayment & Lyons (2011) – very low salinity (VL), low salinity (L), moderately saline (M), highly saline (H), extremely saline (E)
3. Hazelton & Murphy (2016) – affects very sensitive plants (M), sensitive plants (H), tolerant plants (VH) and very tolerant plants (E).

Table B.9 **Site DWF09 – images**

Soil profile ¹	Landscape
	
Photograph B.5 DWF09 soil profile¹	Photograph B.6 DWF09 landscape

Notes: 1. Surface top left, 0.3 m increments.

B.1.4 Site DWF07

Table B.10 Site DWF07 – nutrient chemistry data

Depth (cm)	pH (H ₂ O)	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	(cmol+)/kg	Rating							
0–10	6.82	8.4	0.08	L	21.3	M	0.88	L	0.00	VH	1.51	1.16	18.2	2.90	2.82	25.4	61.7

Notes: 1. Ratings as described in Section 4.1.4.

Table B.11 Site DWF07 – soil profile chemistry data

Depth (cm)	Particle size (%) ¹					pH (H ₂ O)	EC (dS/m)	EC rating ²	Cl ⁻ (mg/kg)	Exchangeable cations (cmol(+)/kg)						ESP (%)	Sodicity (NS, S, SS)	EAT Class	Ca:Mg ratio	Critical Aluminium levels ³
	Clay	Silt	Fine Sand	Coarse Sand	Gravel					Al ⁺³	Ca ⁺²	Mg ⁺²	K ⁺	Na ⁺	CEC					
0–10	64.6	12.1	14.8	8.3	0.3	6.82	0.09	VL	54.5	0.02	12.6	9.28	3.12	1.33	26.4	5.06	LS	3b	1.36	–
20–30	59.6	12.8	15.3	9.9	2.3	7.40	0.09	VL	37.1	0.02	8.4	6.63	1.37	1.43	17.8	8.03	S	2	1.26	–
80–90	44.4	24.0	17.3	13.6	0.7	9.18	0.19	L	31.6	0.02	5.9	3.87	0.87	2.96	13.6	21.70	SS	1	1.53	–

Notes: 1. Gravel (>2 mm), Coarse sand (0.2–2 mm), Fine sand (0.02–0.2 mm), Silt (2–20 µm), Clay (<2 µm)
2. Rayment & Lyons (2011) – very low salinity (VL), low salinity (L), moderately saline (M), highly saline (H), extremely saline (E)
3. Hazelton & Murphy (2016) – affects very sensitive plants (M), sensitive plants (H), tolerant plants (VH) and very tolerant plants (E).

Table B.12 **Site DWF07 – images**

Soil profile ¹	Landscape
	
Photograph B.7 DWF07 soil profile¹	Photograph B.8 DWF07 landscape

Notes: 1. Surface top left, 0.3 m increments.

B.1.5 Site DWF14

Table B.13 Site DWF14 – nutrient chemistry data

Depth (cm)	pH (H ₂ O)	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	(cmol+)/kg)	Rating							
0–10	6.99	–	–	–	–	–	–	–	–	1.46	VH	–	–	–	–	–	–

Notes: 1. Ratings as described in Section 4.1.4.

Table B.14 Site DWF14 – soil profile chemistry data

Depth (cm)	Particle size (%) ¹					pH (H ₂ O)	EC (dS/m)	EC rating ²	Cl ⁻ (mg/kg)	Exchangeable cations (cmol(+)/kg)						ESP (%)	Sodicity (NS, S, SS)	EAT Class	Ca:Mg ratio	Critical Aluminium levels ³
	Clay	Silt	Fine Sand	Coarse Sand	Gravel					Al ⁺³	Ca ⁺²	Mg ⁺²	K ⁺	Na ⁺	CEC					
0–10	69.3	9.5	14.5	6.1	0.6	6.99	0.14	VL	66.6	0.02	8.8	15.0	1.46	2.50	27.8	8.98	S	–	0.59	–
20–30	70.5	10.2	13.2	5.6	0.5	8.05	0.15	L	29.3	0.02	9.0	15.1	1.11	4.11	29.3	14.0	S	–	0.59	–

Notes: 1. Gravel (>2 mm), Coarse sand (0.2–2 mm), Fine sand (0.02–0.2 mm), Silt (2–20 µm), Clay (<2 µm)
2. Rayment & Lyons (2011) – very low salinity (VL), low salinity (L), moderately saline (M), highly saline (H), extremely saline (E)
3. Hazelton & Murphy (2016) – affects very sensitive plants (M), sensitive plants (H), tolerant plants (VH) and very tolerant plants (E).

Table B.15 **Site DWF14 – images**

Soil profile ¹	Landscape
	
Photograph B.9 DWF14 soil profile¹	Photograph B.10 DWF14 landscape

Notes: 1. Surface top left, 0.3 m increments.

B.2 Soil chemistry data – SPC01a

B.2.1 Site DWF15

Table B.16 Site DWF15 – nutrient chemistry data

Depth (cm)	pH (H ₂ O)	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	(cmol+)/kg	Rating							
0–10	5.66	–	–	–	–	–	–	–	–	0.98	H	–	–	–	–	–	–

Notes: 1. Ratings as described in Section 4.1.4.

Table B.17 Site DWF15 – soil profile chemistry data

Depth (cm)	Particle size (%) ¹					pH (H ₂ O)	EC (dS/m)	EC rating ²	Cl ⁻ (mg/kg)	Exchangeable cations (cmol(+)/kg)						ESP (%)	Sodicity (NS, S, SS)	EAT Class	Ca:Mg ratio	Critical Aluminium levels ³
	Clay	Silt	Fine Sand	Coarse Sand	Gravel					Al ⁺³	Ca ⁺²	Mg ⁺²	K ⁺	Na ⁺	CEC					
0–10	26.5	17.3	29.7	25.5	1.1	5.66	0.05	VL	37.7	0.13	3.3	2.0	0.98	0.22	6.7	3.33	LS	–	1.65	–
20–30	49.4	11.4	23.2	15.0	1.0	7.43	0.09	VL	58.0	0.02	7.1	7.0	0.73	2.31	17.2	13.5	S	–	1.01	–
50–60	–	–	–	–	–	8.92	0.46	M	361.0	0.02	12.0	9.4	0.69	4.86	27.0	18.0	SS	-	1.28	–

Notes: 1. Gravel (>2 mm), Coarse sand (0.2–2 mm), Fine sand (0.02–0.2 mm), Silt (2–20 µm), Clay (<2 µm)
2. Rayment & Lyons (2011) – very low salinity (VL), low salinity (L), moderately saline (M), highly saline (H), extremely saline (E)
3. Hazelton & Murphy (2016) – affects very sensitive plants (M), sensitive plants (H), tolerant plants (VH) and very tolerant plants (E).

Table B.18 Site DWF15 – images

Soil profile ¹	Landscape
	

Photograph B.11 DWF15 soil profile¹

Photograph B.12 DWF15 landscape

Notes: 1. Surface top left, 0.3 m increments.

B.3 Soil chemistry data – SPC02

B.3.1 Site DWF10

Table B.19 Site DWF10 – nutrient chemistry data

Depth (cm)	pH (H ₂ O)	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	(cmol(+)/kg)	Rating							
0–10	5.70	19.2	0.09	L	14.1	L	0.64	L	–	H	1.10	0.36	6.1	0.34	1.50	19.2	39.4

Notes: 1. Ratings as described in Section 4.1.4.

Table B.20 Site DWF10 – soil profile chemistry data

Depth (cm)	Particle size (%) ¹					pH (H ₂ O)	EC (dS/m)	EC rating ²	Cl ⁻ (mg/kg)	Exchangeable cations (cmol(+)/kg)						ESP (%)	Sodicity (NS, S, SS)	EAT Class	Ca:Mg ratio	Critical Aluminium levels ³
	Clay	Silt	Fine Sand	Coarse Sand	Gravel					Al ³⁺	Ca ⁺²	Mg ⁺²	K ⁺	Na ⁺	CEC					
0–10	7.1	3.2	16.0	72.1	1.6	5.70	0.07	L	25.9	0.02	3.5	0.5	0.80	0.11	4.9	2.15	NS	5	7.16	–
20–30	8.9	3.2	18.5	67.9	1.4	6.24	0.03	VL	6.8	0.08	3.4	0.5	0.59	0.16	4.7	3.39	LS	5	6.89	–
80–90	8.8	4.9	19.4	66.2	0.7	6.78	0.10	L	24.1	0.02	3.0	0.7	0.62	0.10	4.4	2.32	NS	5	4.26	–
110–120	16	8.6	22.7	47.1	5.6	7.69	0.08	L	37.1	0.02	5.1	2.1	0.29	0.14	7.7	1.85	NS	2	2.41	–

Notes: 1. Gravel (>2 mm), Coarse sand (0.2–2 mm), Fine sand (0.02–0.2 mm), Silt (2–20 µm), Clay (<2 µm)
2. Rayment & Lyons (2011) – very low salinity (VL), low salinity (L), moderately saline (M), highly saline (H), extremely saline (E)
3. Hazelton & Murphy (2016) – affects very sensitive plants (M), sensitive plants (H), tolerant plants (VH) and very tolerant plants (E).

Table B.21 **Site DWF10 – images**

Soil profile ¹	Landscape
	
Photograph B.13 DWF10 soil profile¹	Photograph B.14 DWF10 landscape

Notes: 1. Surface top left, 0.3 m increments.

B.4 Soil chemistry data – SPC03

B.4.1 Site DWF06

Table B.22 Site DWF06 – nutrient chemistry data

Depth (cm)	pH (H ₂ O)	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	(cmol(+)/kg)	Rating							
0–10	5.77	5.1	0.07	L	25.0	M	0.60	L	0.00	VH	1.03	0.52	4.6	0.68	0.48	29.6	49.6

Notes: 1. Ratings as described in Section 4.1.4.

Table B.23 Site DWF06 – soil profile chemistry data

Depth (cm)	Particle size (%) ¹					pH (H ₂ O)	EC (dS/m)	EC rating ²	Cl ⁻ (mg/kg)	Exchangeable cations (cmol(+)/kg)						ESP (%)	Sodicity (NS, S, SS)	EAT Class	Ca:Mg ratio	Critical Aluminium levels ³
	Clay	Silt	Fine Sand	Coarse Sand	Gravel					Al ³⁺	Ca ⁺²	Mg ⁺²	K ⁺	Na ⁺	CEC					
0–10	14.4	10.4	33.9	40.2	1.1	5.77	0.04	VL	19.8	0.08	4.6	1.1	1.08	0.26	7.1	3.65	LS	5	4.04	–
30–40	51.5	9.5	18.4	20.5	0.2	8.23	0.10	VL	76.8	0.02	5.8	4.7	0.66	1.90	13.0	14.50	S	2	1.24	–
60–70	46.7	9.3	21.3	19.2	3.5	8.88	0.91	H	1072	0.02	5.9	6.3	0.58	3.97	16.7	23.70	SS	4	0.94	–
90–100	47.5	13.4	23.4	13.9	1.8	8.73	1.37	VH	1477	0.02	6.8	7.1	0.49	4.68	19.0	24.60	SS	4	0.96	–

Notes: 1. Gravel (>2 mm), Coarse sand (0.2–2 mm), Fine sand (0.02–0.2 mm), Silt (2–20 µm), Clay (<2 µm)
2. Rayment & Lyons (2011) – very low salinity (VL), low salinity (L), moderately saline (M), highly saline (H), extremely saline (E)
3. Hazelton & Murphy (2016) – affects very sensitive plants (M), sensitive plants (H), tolerant plants (VH) and very tolerant plants (E).

Table B.24 Site DWF06 – images

Soil profile ¹	Landscape
	
Photograph B.15 DWF06 soil profile ¹	Photograph B.16 DWF06 landscape

Notes: 1. Surface top left, 0.3 m increments.

B.4.2 Site DWF11

Table B.25 Site DWF11 – nutrient chemistry data

Depth (cm)	pH (H ₂ O)	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	(cmol(+)/kg)	Rating							
0–10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	

Notes: 1. Ratings as described in Section 4.1.4.

Table B.26 Site DWF11 – soil profile chemistry data

Depth (cm)	Particle size (%) ¹					pH (H ₂ O)	EC (dS/m)	EC rating ²	Cl ⁻ (mg/kg)	Exchangeable cations (cmol(+)/kg)						ESP (%)	Sodicity (NS, S, SS)	EAT Class	Ca:Mg ratio	Critical Aluminium levels ³
	Clay	Silt	Fine Sand	Coarse Sand	Gravel					Al ⁺³	Ca ⁺²	Mg ⁺²	K ⁺	Na ⁺	CEC					
20–30	–	–	–	–	–	7.94	0.12	VL	74.5	0.02	6.1	7.9	0.62	2.75	17.3	15.9	SS	–	0.77	–
60–70	–	–	–	–	–	9.25	0.48	M	415	0.02	9.9	11.5	0.54	5.83	27.7	21.0	SS	–	0.86	–

Notes: 1. Gravel (>2 mm), Coarse sand (0.2–2 mm), Fine sand (0.02–0.2 mm), Silt (2–20 µm), Clay (<2 µm)
2. Rayment & Lyons (2011) – very low salinity (VL), low salinity (L), moderately saline (M), highly saline (H), extremely saline (E)
3. Hazelton & Murphy (2016) – affects very sensitive plants (M), sensitive plants (H), tolerant plants (VH) and very tolerant plants (E).

Table B.27 **Site DWF11 – images**

Soil profile¹



Photograph B.17 **DWF11 soil profile¹**

Landscape



Photograph B.18 **DWF11 landscape**

Notes: 1. Surface top left, 0.3 m increments.

Attachment C

Soil laboratory reports



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ANALYSIS REPORT SOIL

PROJECT NO: EW230824

Date of Issue: 14/04/2023

Customer: EMM Consulting

Report No: 1

Address: Suite 01 20 Chandos Street ST
LEONARDS NSW 2065

Date Received: 21/03/2023

Matrix: Soil

Attention: Harry Savage

Location: E220305-DWF

Phone: 0416 295 292

Sampler ID: Client

Fax:

Date of Sampling: 22/02/2023

Email: hsavage@emmconsulting.com.au

Sample Condition: Acceptable

Comments:

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

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

Signed: Anne Michie



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.

results you can rely on



ANALYSIS REPORT

PROJECT NO: EW230824

Location: E220305-DWF

CLIENT SAMPLE ID DEPTH					DWF01	DWF01	DWF01	DWF05
					0-10	20-30	80-90	0-10
Test Parameter	Method Description	Method Reference	Units	LOR	230824-1	230824-2	230824-3	230824-4
Sand	Calc	Texture	%	na	25	25	25	NA
Silt	Calc	Texture	%	na	30	30	30	NA
Clay	Calc	Texture	%	na	45	45	45	NA
pH (1:5 in H2O)	Electrode	R&L 4A1	pH units	na	6.27	8.13	8.29	7.37
pH (1:5 in CaCl2)	Electrode	R&L 4B2	pH units	na	5.36	7.02	7.95	6.89
Chloride Soluble	DA	DAP-06	mg/kg	5	32.7	24.7	2515	55.5
Electrical Conductivity	Electrode	R&L 3A1	dS/m	0.01	0.08	0.10	1.82	0.11
Total N (LECO)	LECO	R&L 7A5	mg/kg	50	NA	NA	NA	1408
E.C.e	Calc	R&L 3A1	dS/m	na	0.69	0.86	15.7	NA
Extractable Nitrate-N	DA	DAP-03	mg/kg	1	NA	NA	NA	15.9
Ammonium - N (Ex)	ExKCl/UV-Vis	PMS-22	mg/kg	2	NA	NA	NA	4.31
Phosphorus (Total)	HNO3/HClO4 ICP	ICP-03	mg/kg	40	NA	NA	NA	171
Organic Carbon (LECO)	LECO	R&L 6B3	%	0.2	NA	NA	NA	1.72
Phosphorus (Colwell)	Bicarb/UV-Vis	R&L 9B1	mg/kg	5	NA	NA	NA	8.28
Sulphate-Sulphur	KCl40/ICP	R&L 10D1	mg/kg	3	NA	NA	NA	22.8
Extractable Copper	DTPA/ICP	R&L 12A1	mg/kg	0.2	NA	NA	NA	1.42
Extractable Zinc	DTPA/ICP	R&L 12A1	mg/kg	0.2	NA	NA	NA	0.46
Extractable Manganese	DTPA/ICP	R&L 12A1	mg/kg	1	NA	NA	NA	17.1
Extractable Iron	DTPA/ICP	R&L 12A1	mg/kg	1	NA	NA	NA	9.48
Extractable Boron	Hot CaCl2/ICP	R&L 12C2	mg/kg	0.2	NA	NA	NA	1.25
Exchangeable Potassium	NH4Cl/ICP	R&L 15A1	mg/kg	10	287	412	298	NA
Exchangeable Calcium	NH4Cl/ICP	R&L 15A1	mg/kg	20	711	2156	2051	NA
Exchangeable Magnesium	NH4Cl/ICP	R&L 15A1	mg/kg	10	410	1624	1949	NA
Exchangeable Sodium	NH4Cl/ICP	R&L 15A1	mg/kg	10	113	876	2171	NA
Exchangeable Aluminium	KCl/ICP	R&L 15G1	mg/kg	2	<2.00	<2.00	<2.00	<2.00
Exchangeable Potassium	R&L 15A1	R&L 15A1	cmol/kg	na	0.74	1.06	0.76	NA



ANALYSIS REPORT

PROJECT NO: EW230824

Location: E220305-DWF

CLIENT SAMPLE ID					DWF01	DWF01	DWF01	DWF05
					0-10	20-30	80-90	0-10
DEPTH								
Test Parameter	Method Description	Method Reference	Units	LOR	230824-1	230824-2	230824-3	230824-4
Exchangeable Calcium	R&L 15A1	R&L 15A1	cmol/kg	na	3.56	10.8	10.3	NA
Exchangeable Magnesium	R&L 15A1	R&L 15A1	cmol/kg	na	3.42	13.5	16.2	NA
Exchangeable Sodium	R&L 15A1	R&L 15A1	cmol/kg	na	0.49	3.81	9.44	NA
Exchangeable Aluminium	Calculation	R&L 15J1	cmol/kg	na	0.02	0.02	0.02	0.02
ECEC	Calculation	PMS-15A1	cmol/kg	na	8.22	29.2	36.7	NA
Ca/Mg Ratio	Calculation	PMS-15A1	cmol/kg	na	1.04	0.80	0.63	NA
K/Mg Ratio	Calculation	PMS-15A1	cmol/kg	na	0.22	0.08	0.05	NA
Exchangeable Potassium %	Calculation	PMS-15A1	%	na	8.95	3.62	2.08	NA
Exchangeable Calcium %	Calculation	PMS-15A1	%	na	43.2	36.9	27.9	NA
Exchangeable Magnesium %	Calculation	PMS-15A1	%	na	41.6	46.3	44.2	NA
Exchangeable Sodium %	Calculation	PMS-15A1	%	na	5.98	13.0	25.7	NA
Exchangeable Aluminium %	Calculation	PMS-15A1	%	na	0.27	0.08	0.06	0.06
Exchangeable Potassium	ICP-OES	R&L 15C1	mg/kg	10	NA	NA	NA	456
Exchangeable Calcium	ICP-OES	R&L 15C1	mg/kg	20	NA	NA	NA	2402
Exchangeable Magnesium	ICP-OES	R&L 15C1	mg/kg	10	NA	NA	NA	880
Exchangeable Sodium	ICP-OES	R&L 15C1	mg/kg	10	NA	NA	NA	182
Exchangeable Potassium	R&L 15C1	R&L 15C1	cmol/kg	na	NA	NA	NA	1.17
Exchangeable Calcium	R&L 15C1	R&L 15C1	cmol/kg	na	NA	NA	NA	12.0
Exchangeable Magnesium	PMS-15C1	PMS-15C1	cmol/kg	na	NA	NA	NA	7.33
Exchangeable Sodium	R&L 15C1	R&L 15C1	cmol/kg	na	NA	NA	NA	0.79
ECEC	Calculation	PMS-15C1	cmol/kg	na	NA	NA	NA	21.3
Ca/Mg Ratio	Calculation	PMS-15C1	cmol/kg	na	NA	NA	NA	1.64
K/Mg Ratio	Calculation	PMS-15C1	cmol/kg	na	NA	NA	NA	0.16
Exchangeable Potassium %	Calculation	PMS-15C1	%	na	NA	NA	NA	5.48
Exchangeable Calcium %	Calculation	PMS-15C1	%	na	NA	NA	NA	56.3
Exchangeable Magnesium %	Calculation	PMS-15C1	%	na	NA	NA	NA	34.4



ANALYSIS REPORT

PROJECT NO: EW230824

Location: E220305-DWF

CLIENT SAMPLE ID					DWF01	DWF01	DWF01	DWF05
DEPTH					0-10	20-30	80-90	0-10
Test Parameter	Method Description	Method Reference	Units	LOR	230824-1	230824-2	230824-3	230824-4
Exchangeable Sodium %	Calculation	PMS-15C1	%	na	NA	NA	NA	3.71
Exchangeable Aluminium %	Calculation	PMS-15C1	%	na	NA	NA	NA	0.10
Total Cadmium	ICP-OES	AS4479.2	mg/kg	0.5	NA	NA	NA	<0.5
Total Chromium	ICP-OES	AS4479.2	mg/kg	0.5	NA	NA	NA	41.5
Total Copper	ICP-OES	PMS-09	mg/kg	0.5	NA	NA	NA	15.5
Total Iron	ICP-OES	PMS-09	mg/kg	0.5	NA	NA	NA	31400
Total Lead	ICP-OES	AS4479.2	mg/kg	0.5	NA	NA	NA	12.3
Total Manganese	ICP-OES	PMS-09	mg/kg	0.5	NA	NA	NA	526
Total Nickel	ICP-OES	AS4479.2	mg/kg	0.5	NA	NA	NA	29.0
Total Zinc	ICP-OES	PMS-09	mg/kg	0.5	NA	NA	NA	51.5
Total Potassium	ICP-OES	PMS-09	mg/kg	0.5	NA	NA	NA	7680
Texture	Field	Northcote	Class	na	LMC	LMC	LMC	SiCL
Total Calcium	ICP-OES	PMS-09	mg/kg	100	NA	NA	NA	4000
Total Magnesium	ICP-OES	PMS-09	mg/kg	50	NA	NA	NA	8010
Total Sodium	ICP-OES	PMS-09	mg/kg	40	NA	NA	NA	592
Total Sulphur	ICP-OES	PMS-09	mg/kg	40	NA	NA	NA	164
Total Aluminium	ICP-OES	PMS-09	mg/kg	100	NA	NA	NA	64200
Emerson Aggregate Test	Class	PMS-21	Number	na	NA	NA	NA	3b
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
Exchangeable Magnesium	ICP-OES	R&L 15D1	mg/kg	10	NA	NA	NA	NA
Exchangeable Sodium	ICP-OES	R&L 15D1	mg/kg	10	NA	NA	NA	NA
Gravel >2.0mm	Sieve	ASTMD422-63	%	na	NA	NA	NA	0.9
Coarse Sand 0.2-2.0mm	Sieve	ASTMD422-63	%	na	NA	NA	NA	11.4
Fine Sand 0.02-0.2mm	Sieve	ASTMD422-63	%	na	NA	NA	NA	21.2
Silt 0.002-0.02mm	Hydrometer	ASTMD422-63	%	na	NA	NA	NA	13.0



ANALYSIS REPORT

PROJECT NO: EW230824

Location: E220305-DWF

CLIENT SAMPLE ID					DWF01	DWF01	DWF01	DWF05
					0-10	20-30	80-90	0-10
DEPTH								
Test Parameter	Method Description	Method Reference	Units	LOR	230824-1	230824-2	230824-3	230824-4
Clay <0.002mm	Hydrometer	ASTMD422-63	%	na	NA	NA	NA	53.5



ANALYSIS REPORT

PROJECT NO: EW230824

Location: E220305-DWF

CLIENT SAMPLE ID DEPTH					DWF05	DWF05	DWF09	DWF09
					20-30	80-90	0-10	20-30
Test Parameter	Method Description	Method Reference	Units	LOR	230824-5	230824-6	230824-7	230824-8
Sand	Calc	Texture	%	na	NA	NA	NA	NA
Silt	Calc	Texture	%	na	NA	NA	NA	NA
Clay	Calc	Texture	%	na	NA	NA	NA	NA
pH (1:5 in H2O)	Electrode	R&L 4A1	pH units	na	9.01	8.95	6.73	8.30
pH (1:5 in CaCl2)	Electrode	R&L 4B2	pH units	na	8.11	8.32	5.71	7.53
Chloride Soluble	DA	DAP-06	mg/kg	5	14.6	1217	52.6	515
Electrical Conductivity	Electrode	R&L 3A1	dS/m	0.01	0.16	1.22	0.09	0.49
Total N (LECO)	LECO	R&L 7A5	mg/kg	50	NA	NA	1162	NA
E.C.e	Calc	R&L 3A1	dS/m	na	NA	NA	NA	NA
Extractable Nitrate-N	DA	DAP-03	mg/kg	1	3.06	69.2	6.11	2.09
Ammonium - N (Ex)	ExKCl/UV-Vis	PMS-22	mg/kg	2	2.40	2.76	9.40	5.34
Phosphorus (Total)	HNO3/HClO4 ICP	ICP-03	mg/kg	40	NA	NA	138	NA
Organic Carbon (LECO)	LECO	R&L 6B3	%	0.2	NA	NA	1.04	NA
Phosphorus (Colwell)	Bicarb/UV-Vis	R&L 9B1	mg/kg	5	NA	NA	29.2	NA
Sulphate-Sulphur	KCl40/ICP	R&L 10D1	mg/kg	3	NA	NA	12.3	NA
Extractable Copper	DTPA/ICP	R&L 12A1	mg/kg	0.2	NA	NA	1.86	NA
Extractable Zinc	DTPA/ICP	R&L 12A1	mg/kg	0.2	NA	NA	0.58	NA
Extractable Manganese	DTPA/ICP	R&L 12A1	mg/kg	1	NA	NA	43.5	NA
Extractable Iron	DTPA/ICP	R&L 12A1	mg/kg	1	NA	NA	63.1	NA
Extractable Boron	Hot CaCl2/ICP	R&L 12C2	mg/kg	0.2	NA	NA	0.94	NA
Exchangeable Potassium	NH4Cl/ICP	R&L 15A1	mg/kg	10	NA	NA	NA	NA
Exchangeable Calcium	NH4Cl/ICP	R&L 15A1	mg/kg	20	NA	NA	NA	NA
Exchangeable Magnesium	NH4Cl/ICP	R&L 15A1	mg/kg	10	NA	NA	NA	NA
Exchangeable Sodium	NH4Cl/ICP	R&L 15A1	mg/kg	10	NA	NA	NA	NA
Exchangeable Aluminium	KCl/ICP	R&L 15G1	mg/kg	2	<2.00	<2.00	<2.00	<2.00
Exchangeable Potassium	R&L 15A1	R&L 15A1	cmol/kg	na	NA	NA	NA	NA



ANALYSIS REPORT

PROJECT NO: EW230824

Location: E220305-DWF

CLIENT SAMPLE ID DEPTH					DWF05	DWF05	DWF09	DWF09
					20-30	80-90	0-10	20-30
Test Parameter	Method Description	Method Reference	Units	LOR	230824-5	230824-6	230824-7	230824-8
Exchangeable Calcium	R&L 15A1	R&L 15A1	cmol/kg	na	NA	NA	NA	NA
Exchangeable Magnesium	R&L 15A1	R&L 15A1	cmol/kg	na	NA	NA	NA	NA
Exchangeable Sodium	R&L 15A1	R&L 15A1	cmol/kg	na	NA	NA	NA	NA
Exchangeable Aluminium	Calculation	R&L 15J1	cmol/kg	na	0.02	0.02	0.02	0.02
ECEC	Calculation	PMS-15A1	cmol/kg	na	NA	NA	NA	NA
Ca/Mg Ratio	Calculation	PMS-15A1	cmol/kg	na	NA	NA	NA	NA
K/Mg Ratio	Calculation	PMS-15A1	cmol/kg	na	NA	NA	NA	NA
Exchangeable Potassium %	Calculation	PMS-15A1	%	na	NA	NA	NA	NA
Exchangeable Calcium %	Calculation	PMS-15A1	%	na	NA	NA	NA	NA
Exchangeable Magnesium %	Calculation	PMS-15A1	%	na	NA	NA	NA	NA
Exchangeable Sodium %	Calculation	PMS-15A1	%	na	NA	NA	NA	NA
Exchangeable Aluminium %	Calculation	PMS-15A1	%	na	0.06	0.06	0.06	0.06
Exchangeable Potassium	ICP-OES	R&L 15C1	mg/kg	10	179	132	NA	152
Exchangeable Calcium	ICP-OES	R&L 15C1	mg/kg	20	3176	1372	NA	1364
Exchangeable Magnesium	ICP-OES	R&L 15C1	mg/kg	10	1079	718	NA	1159
Exchangeable Sodium	ICP-OES	R&L 15C1	mg/kg	10	507	1384	NA	1023
Exchangeable Potassium	R&L 15C1	R&L 15C1	cmol/kg	na	0.46	0.34	NA	0.39
Exchangeable Calcium	R&L 15C1	R&L 15C1	cmol/kg	na	15.9	6.86	NA	6.82
Exchangeable Magnesium	PMS-15C1	PMS-15C1	cmol/kg	na	8.99	5.98	NA	9.66
Exchangeable Sodium	R&L 15C1	R&L 15C1	cmol/kg	na	2.20	6.02	NA	4.45
ECEC	Calculation	PMS-15C1	cmol/kg	na	27.6	19.2	NA	21.3
Ca/Mg Ratio	Calculation	PMS-15C1	cmol/kg	na	1.77	1.15	NA	0.71
K/Mg Ratio	Calculation	PMS-15C1	cmol/kg	na	0.05	0.06	NA	0.04
Exchangeable Potassium %	Calculation	PMS-15C1	%	na	1.67	1.76	NA	1.83
Exchangeable Calcium %	Calculation	PMS-15C1	%	na	57.6	35.7	NA	32.0
Exchangeable Magnesium %	Calculation	PMS-15C1	%	na	32.6	31.1	NA	45.3



ANALYSIS REPORT

PROJECT NO: EW230824

Location: E220305-DWF

CLIENT SAMPLE ID					DWF05	DWF05	DWF09	DWF09
					20-30	80-90	0-10	20-30
DEPTH								
Test Parameter	Method Description	Method Reference	Units	LOR	230824-5	230824-6	230824-7	230824-8
Exchangeable Sodium %	Calculation	PMS-15C1	%	na	8.00	31.3	NA	20.8
Exchangeable Aluminium %	Calculation	PMS-15C1	%	na	0.08	0.12	0.12	0.10
Total Cadmium	ICP-OES	AS4479.2	mg/kg	0.5	NA	NA	<0.5	NA
Total Chromium	ICP-OES	AS4479.2	mg/kg	0.5	NA	NA	34.6	NA
Total Copper	ICP-OES	PMS-09	mg/kg	0.5	NA	NA	12.7	NA
Total Iron	ICP-OES	PMS-09	mg/kg	0.5	NA	NA	28500	NA
Total Lead	ICP-OES	AS4479.2	mg/kg	0.5	NA	NA	10.4	NA
Total Manganese	ICP-OES	PMS-09	mg/kg	0.5	NA	NA	504	NA
Total Nickel	ICP-OES	AS4479.2	mg/kg	0.5	NA	NA	25.5	NA
Total Zinc	ICP-OES	PMS-09	mg/kg	0.5	NA	NA	36.0	NA
Total Potassium	ICP-OES	PMS-09	mg/kg	0.5	NA	NA	5020	NA
Texture	Field	Northcote	Class	na	LMC	MC	MC	SC
Total Calcium	ICP-OES	PMS-09	mg/kg	100	NA	NA	2180	NA
Total Magnesium	ICP-OES	PMS-09	mg/kg	50	NA	NA	4670	NA
Total Sodium	ICP-OES	PMS-09	mg/kg	40	NA	NA	891	NA
Total Sulphur	ICP-OES	PMS-09	mg/kg	40	NA	NA	157	NA
Total Aluminium	ICP-OES	PMS-09	mg/kg	100	NA	NA	58700	NA
Emerson Aggregate Test	Class	PMS-21	Number	na	4	6	3a	2
Exchangeable Potassium	ICP-OES	R&L 15D1	mg/kg	10	NA	NA	535	NA
Exchangeable Calcium	ICP-OES	R&L 15D1	mg/kg	20	NA	NA	1849	NA
Exchangeable Magnesium	ICP-OES	R&L 15D1	mg/kg	10	NA	NA	1308	NA
Exchangeable Sodium	ICP-OES	R&L 15D1	mg/kg	10	NA	NA	599	NA
Gravel >2.0mm	Sieve	ASTMD422-63	%	na	0.5	0.1	0.8	0.5
Coarse Sand 0.2-2.0mm	Sieve	ASTMD422-63	%	na	9.6	6.2	20.0	12.7
Fine Sand 0.02-0.2mm	Sieve	ASTMD422-63	%	na	17.6	17.0	21.2	17.2
Silt 0.002-0.02mm	Hydrometer	ASTMD422-63	%	na	11.7	8.1	10.9	7.8



ANALYSIS REPORT

PROJECT NO: EW230824

Location: E220305-DWF

CLIENT SAMPLE ID					DWF05	DWF05	DWF09	DWF09
					20-30	80-90	0-10	20-30
DEPTH								
Test Parameter	Method Description	Method Reference	Units	LOR	230824-5	230824-6	230824-7	230824-8
Clay <0.002mm	Hydrometer	ASTMD422-63	%	na	60.6	68.6	47.0	61.8



ANALYSIS REPORT

PROJECT NO: EW230824

Location: E220305-DWF

CLIENT SAMPLE ID					DWF09	DWF09	DWF07	DWF07
					50-60	80-90	0-10	20-30
DEPTH								
Test Parameter	Method Description	Method Reference	Units	LOR	230824-9	230824-10	230824-11	230824-12
Sand	Calc	Texture	%	na	NA	NA	NA	NA
Silt	Calc	Texture	%	na	NA	NA	NA	NA
Clay	Calc	Texture	%	na	NA	NA	NA	NA
pH (1:5 in H2O)	Electrode	R&L 4A1	pH units	na	8.45	8.01	6.82	7.40
pH (1:5 in CaCl2)	Electrode	R&L 4B2	pH units	na	7.88	7.85	6.02	6.61
Chloride Soluble	DA	DAP-06	mg/kg	5	2074	1975	54.5	37.1
Electrical Conductivity	Electrode	R&L 3A1	dS/m	0.01	1.54	2.00	0.09	0.09
Total N (LECO)	LECO	R&L 7A5	mg/kg	50	NA	NA	838	NA
E.C.e	Calc	R&L 3A1	dS/m	na	NA	NA	NA	NA
Extractable Nitrate-N	DA	DAP-03	mg/kg	1	2.74	2.73	8.38	7.14
Ammonium - N (Ex)	ExKCl/UV-Vis	PMS-22	mg/kg	2	5.99	3.12	10.9	3.12
Phosphorus (Total)	HNO3/HClO4 ICP	ICP-03	mg/kg	40	NA	NA	222	NA
Organic Carbon (LECO)	LECO	R&L 6B3	%	0.2	NA	NA	0.88	NA
Phosphorus (Colwell)	Bicarb/UV-Vis	R&L 9B1	mg/kg	5	NA	NA	21.3	NA
Sulphate-Sulphur	KCl40/ICP	R&L 10D1	mg/kg	3	NA	NA	18.2	NA
Extractable Copper	DTPA/ICP	R&L 12A1	mg/kg	0.2	NA	NA	2.90	NA
Extractable Zinc	DTPA/ICP	R&L 12A1	mg/kg	0.2	NA	NA	2.82	NA
Extractable Manganese	DTPA/ICP	R&L 12A1	mg/kg	1	NA	NA	25.4	NA
Extractable Iron	DTPA/ICP	R&L 12A1	mg/kg	1	NA	NA	61.7	NA
Extractable Boron	Hot CaCl2/ICP	R&L 12C2	mg/kg	0.2	NA	NA	1.16	NA
Exchangeable Potassium	NH4Cl/ICP	R&L 15A1	mg/kg	10	NA	NA	NA	NA
Exchangeable Calcium	NH4Cl/ICP	R&L 15A1	mg/kg	20	NA	NA	NA	NA
Exchangeable Magnesium	NH4Cl/ICP	R&L 15A1	mg/kg	10	NA	NA	NA	NA
Exchangeable Sodium	NH4Cl/ICP	R&L 15A1	mg/kg	10	NA	NA	NA	NA
Exchangeable Aluminium	KCl/ICP	R&L 15G1	mg/kg	2	<2.00	<2.00	<2.00	<2.00
Exchangeable Potassium	R&L 15A1	R&L 15A1	cmol/kg	na	NA	NA	NA	NA



ANALYSIS REPORT

PROJECT NO: EW230824

Location: E220305-DWF

CLIENT SAMPLE ID DEPTH					DWF09	DWF09	DWF07	DWF07
					50-60	80-90	0-10	20-30
Test Parameter	Method Description	Method Reference	Units	LOR	230824-9	230824-10	230824-11	230824-12
Exchangeable Calcium	R&L 15A1	R&L 15A1	cmol/kg	na	NA	NA	NA	NA
Exchangeable Magnesium	R&L 15A1	R&L 15A1	cmol/kg	na	NA	NA	NA	NA
Exchangeable Sodium	R&L 15A1	R&L 15A1	cmol/kg	na	NA	NA	NA	NA
Exchangeable Aluminium	Calculation	R&L 15J1	cmol/kg	na	0.02	0.02	0.02	0.02
ECEC	Calculation	PMS-15A1	cmol/kg	na	NA	NA	NA	NA
Ca/Mg Ratio	Calculation	PMS-15A1	cmol/kg	na	NA	NA	NA	NA
K/Mg Ratio	Calculation	PMS-15A1	cmol/kg	na	NA	NA	NA	NA
Exchangeable Potassium %	Calculation	PMS-15A1	%	na	NA	NA	NA	NA
Exchangeable Calcium %	Calculation	PMS-15A1	%	na	NA	NA	NA	NA
Exchangeable Magnesium %	Calculation	PMS-15A1	%	na	NA	NA	NA	NA
Exchangeable Sodium %	Calculation	PMS-15A1	%	na	NA	NA	NA	NA
Exchangeable Aluminium %	Calculation	PMS-15A1	%	na	0.06	0.06	0.06	0.06
Exchangeable Potassium	ICP-OES	R&L 15C1	mg/kg	10	192	179	NA	535
Exchangeable Calcium	ICP-OES	R&L 15C1	mg/kg	20	1328	1347	NA	1673
Exchangeable Magnesium	ICP-OES	R&L 15C1	mg/kg	10	1299	1208	NA	796
Exchangeable Sodium	ICP-OES	R&L 15C1	mg/kg	10	1298	1058	NA	329
Exchangeable Potassium	R&L 15C1	R&L 15C1	cmol/kg	na	0.49	0.46	NA	1.37
Exchangeable Calcium	R&L 15C1	R&L 15C1	cmol/kg	na	6.64	6.74	NA	8.37
Exchangeable Magnesium	PMS-15C1	PMS-15C1	cmol/kg	na	10.8	10.1	NA	6.63
Exchangeable Sodium	R&L 15C1	R&L 15C1	cmol/kg	na	5.64	4.60	NA	1.43
ECEC	Calculation	PMS-15C1	cmol/kg	na	23.6	21.9	NA	17.8
Ca/Mg Ratio	Calculation	PMS-15C1	cmol/kg	na	0.61	0.67	NA	1.26
K/Mg Ratio	Calculation	PMS-15C1	cmol/kg	na	0.05	0.05	NA	0.21
Exchangeable Potassium %	Calculation	PMS-15C1	%	na	2.08	2.10	NA	7.70
Exchangeable Calcium %	Calculation	PMS-15C1	%	na	28.1	30.8	NA	46.9
Exchangeable Magnesium %	Calculation	PMS-15C1	%	na	45.8	46.0	NA	37.2



ANALYSIS REPORT

PROJECT NO: EW230824

Location: E220305-DWF

CLIENT SAMPLE ID DEPTH					DWF09	DWF09	DWF07	DWF07
					50-60	80-90	0-10	20-30
Test Parameter	Method Description	Method Reference	Units	LOR	230824-9	230824-10	230824-11	230824-12
Exchangeable Sodium %	Calculation	PMS-15C1	%	na	23.9	21.0	NA	8.03
Exchangeable Aluminium %	Calculation	PMS-15C1	%	na	0.09	0.10	0.10	0.12
Total Cadmium	ICP-OES	AS4479.2	mg/kg	0.5	NA	NA	0.6	NA
Total Chromium	ICP-OES	AS4479.2	mg/kg	0.5	NA	NA	49.8	NA
Total Copper	ICP-OES	PMS-09	mg/kg	0.5	NA	NA	21.8	NA
Total Iron	ICP-OES	PMS-09	mg/kg	0.5	NA	NA	39500	NA
Total Lead	ICP-OES	AS4479.2	mg/kg	0.5	NA	NA	14.5	NA
Total Manganese	ICP-OES	PMS-09	mg/kg	0.5	NA	NA	615	NA
Total Nickel	ICP-OES	AS4479.2	mg/kg	0.5	NA	NA	35.0	NA
Total Zinc	ICP-OES	PMS-09	mg/kg	0.5	NA	NA	77.5	NA
Total Potassium	ICP-OES	PMS-09	mg/kg	0.5	NA	NA	3200	NA
Texture	Field	Northcote	Class	na	LC	LC	LC	LC
Total Calcium	ICP-OES	PMS-09	mg/kg	100	NA	NA	2910	NA
Total Magnesium	ICP-OES	PMS-09	mg/kg	50	NA	NA	6520	NA
Total Sodium	ICP-OES	PMS-09	mg/kg	40	NA	NA	557	NA
Total Sulphur	ICP-OES	PMS-09	mg/kg	40	NA	NA	122	NA
Total Aluminium	ICP-OES	PMS-09	mg/kg	100	NA	NA	72700	NA
Emerson Aggregate Test	Class	PMS-21	Number	na	6	6	3b	2
Exchangeable Potassium	ICP-OES	R&L 15D1	mg/kg	10	NA	NA	1215	NA
Exchangeable Calcium	ICP-OES	R&L 15D1	mg/kg	20	NA	NA	2520	NA
Exchangeable Magnesium	ICP-OES	R&L 15D1	mg/kg	10	NA	NA	1114	NA
Exchangeable Sodium	ICP-OES	R&L 15D1	mg/kg	10	NA	NA	307	NA
Gravel >2.0mm	Sieve	ASTMD422-63	%	na	0.4	0.9	0.3	2.3
Coarse Sand 0.2-2.0mm	Sieve	ASTMD422-63	%	na	11.8	17.5	8.3	9.9
Fine Sand 0.02-0.2mm	Sieve	ASTMD422-63	%	na	12.5	18.0	14.8	15.3
Silt 0.002-0.02mm	Hydrometer	ASTMD422-63	%	na	10.1	16.1	12.1	12.8



ANALYSIS REPORT

PROJECT NO: EW230824

Location: E220305-DWF

CLIENT SAMPLE ID					DWF09	DWF09	DWF07	DWF07
					50-60	80-90	0-10	20-30
DEPTH								
Test Parameter	Method Description	Method Reference	Units	LOR	230824-9	230824-10	230824-11	230824-12
Clay <0.002mm	Hydrometer	ASTMD422-63	%	na	65.2	47.5	64.6	59.6



ANALYSIS REPORT

PROJECT NO: EW230824

Location: E220305-DWF

CLIENT SAMPLE ID					DWF07	DWF14	DWF14	DWF10
					80-90	0-10	20-30	0-10
DEPTH								
Test Parameter	Method Description	Method Reference	Units	LOR	230824-13	230824-14	230824-15	230824-16
Sand	Calc	Texture	%	na	NA	NA	NA	NA
Silt	Calc	Texture	%	na	NA	NA	NA	NA
Clay	Calc	Texture	%	na	NA	NA	NA	NA
pH (1:5 in H2O)	Electrode	R&L 4A1	pH units	na	9.18	6.99	8.05	5.70
pH (1:5 in CaCl2)	Electrode	R&L 4B2	pH units	na	8.15	6.21	7.01	5.25
Chloride Soluble	DA	DAP-06	mg/kg	5	31.6	66.6	29.3	25.9
Electrical Conductivity	Electrode	R&L 3A1	dS/m	0.01	0.19	0.14	0.15	0.07
Total N (LECO)	LECO	R&L 7A5	mg/kg	50	NA	NA	NA	892
E.C.e	Calc	R&L 3A1	dS/m	na	NA	1.05	1.13	NA
Extractable Nitrate-N	DA	DAP-03	mg/kg	1	1.97	NA	NA	19.2
Ammonium - N (Ex)	ExKCl/UV-Vis	PMS-22	mg/kg	2	2.17	NA	NA	4.07
Phosphorus (Total)	HNO3/HClO4 ICP	ICP-03	mg/kg	40	NA	NA	NA	194
Organic Carbon (LECO)	LECO	R&L 6B3	%	0.2	NA	NA	NA	0.64
Phosphorus (Colwell)	Bicarb/UV-Vis	R&L 9B1	mg/kg	5	NA	NA	NA	14.1
Sulphate-Sulphur	KCl40/ICP	R&L 10D1	mg/kg	3	NA	NA	NA	6.11
Extractable Copper	DTPA/ICP	R&L 12A1	mg/kg	0.2	NA	NA	NA	0.34
Extractable Zinc	DTPA/ICP	R&L 12A1	mg/kg	0.2	NA	NA	NA	1.50
Extractable Manganese	DTPA/ICP	R&L 12A1	mg/kg	1	NA	NA	NA	19.2
Extractable Iron	DTPA/ICP	R&L 12A1	mg/kg	1	NA	NA	NA	39.4
Extractable Boron	Hot CaCl2/ICP	R&L 12C2	mg/kg	0.2	NA	NA	NA	0.36
Exchangeable Potassium	NH4Cl/ICP	R&L 15A1	mg/kg	10	NA	570	433	NA
Exchangeable Calcium	NH4Cl/ICP	R&L 15A1	mg/kg	20	NA	1764	1790	NA
Exchangeable Magnesium	NH4Cl/ICP	R&L 15A1	mg/kg	10	NA	1799	1811	NA
Exchangeable Sodium	NH4Cl/ICP	R&L 15A1	mg/kg	10	NA	574	946	NA
Exchangeable Aluminium	KCl/ICP	R&L 15G1	mg/kg	2	<2.00	<2.00	<2.00	<2.00
Exchangeable Potassium	R&L 15A1	R&L 15A1	cmol/kg	na	NA	1.46	1.11	NA



ANALYSIS REPORT

PROJECT NO: EW230824

Location: E220305-DWF

CLIENT SAMPLE ID					DWF07	DWF14	DWF14	DWF10
					80-90	0-10	20-30	0-10
DEPTH								
Test Parameter	Method Description	Method Reference	Units	LOR	230824-13	230824-14	230824-15	230824-16
Exchangeable Calcium	R&L 15A1	R&L 15A1	cmol/kg	na	NA	8.82	8.95	NA
Exchangeable Magnesium	R&L 15A1	R&L 15A1	cmol/kg	na	NA	15.0	15.1	NA
Exchangeable Sodium	R&L 15A1	R&L 15A1	cmol/kg	na	NA	2.50	4.11	NA
Exchangeable Aluminium	Calculation	R&L 15J1	cmol/kg	na	0.02	0.02	0.02	0.02
ECEC	Calculation	PMS-15A1	cmol/kg	na	NA	27.8	29.3	NA
Ca/Mg Ratio	Calculation	PMS-15A1	cmol/kg	na	NA	0.59	0.59	NA
K/Mg Ratio	Calculation	PMS-15A1	cmol/kg	na	NA	0.10	0.07	NA
Exchangeable Potassium %	Calculation	PMS-15A1	%	na	NA	5.26	3.79	NA
Exchangeable Calcium %	Calculation	PMS-15A1	%	na	NA	31.7	30.6	NA
Exchangeable Magnesium %	Calculation	PMS-15A1	%	na	NA	53.9	51.5	NA
Exchangeable Sodium %	Calculation	PMS-15A1	%	na	NA	8.98	14.0	NA
Exchangeable Aluminium %	Calculation	PMS-15A1	%	na	0.06	0.08	0.08	0.08
Exchangeable Potassium	ICP-OES	R&L 15C1	mg/kg	10	340	NA	NA	NA
Exchangeable Calcium	ICP-OES	R&L 15C1	mg/kg	20	1182	NA	NA	NA
Exchangeable Magnesium	ICP-OES	R&L 15C1	mg/kg	10	464	NA	NA	NA
Exchangeable Sodium	ICP-OES	R&L 15C1	mg/kg	10	680	NA	NA	NA
Exchangeable Potassium	R&L 15C1	R&L 15C1	cmol/kg	na	0.87	NA	NA	NA
Exchangeable Calcium	R&L 15C1	R&L 15C1	cmol/kg	na	5.91	NA	NA	NA
Exchangeable Magnesium	PMS-15C1	PMS-15C1	cmol/kg	na	3.87	NA	NA	NA
Exchangeable Sodium	R&L 15C1	R&L 15C1	cmol/kg	na	2.96	NA	NA	NA
ECEC	Calculation	PMS-15C1	cmol/kg	na	13.6	NA	NA	NA
Ca/Mg Ratio	Calculation	PMS-15C1	cmol/kg	na	1.53	NA	NA	NA
K/Mg Ratio	Calculation	PMS-15C1	cmol/kg	na	0.23	NA	NA	NA
Exchangeable Potassium %	Calculation	PMS-15C1	%	na	6.40	NA	NA	NA
Exchangeable Calcium %	Calculation	PMS-15C1	%	na	43.4	NA	NA	NA
Exchangeable Magnesium %	Calculation	PMS-15C1	%	na	28.4	NA	NA	NA



ANALYSIS REPORT

PROJECT NO: EW230824

Location: E220305-DWF

CLIENT SAMPLE ID DEPTH					DWF07	DWF14	DWF14	DWF10
					80-90	0-10	20-30	0-10
Test Parameter	Method Description	Method Reference	Units	LOR	230824-13	230824-14	230824-15	230824-16
Exchangeable Sodium %	Calculation	PMS-15C1	%	na	21.7	NA	NA	NA
Exchangeable Aluminium %	Calculation	PMS-15C1	%	na	0.16	0.16	0.16	0.16
Total Cadmium	ICP-OES	AS4479.2	mg/kg	0.5	NA	NA	NA	<0.5
Total Chromium	ICP-OES	AS4479.2	mg/kg	0.5	NA	NA	NA	1.1
Total Copper	ICP-OES	PMS-09	mg/kg	0.5	NA	NA	NA	<0.5
Total Iron	ICP-OES	PMS-09	mg/kg	0.5	NA	NA	NA	6530
Total Lead	ICP-OES	AS4479.2	mg/kg	0.5	NA	NA	NA	<0.5
Total Manganese	ICP-OES	PMS-09	mg/kg	0.5	NA	NA	NA	59.1
Total Nickel	ICP-OES	AS4479.2	mg/kg	0.5	NA	NA	NA	7.0
Total Zinc	ICP-OES	PMS-09	mg/kg	0.5	NA	NA	NA	<0.5
Total Potassium	ICP-OES	PMS-09	mg/kg	0.5	NA	NA	NA	361
Texture	Field	Northcote	Class	na	MC	MC	MC	S
Total Calcium	ICP-OES	PMS-09	mg/kg	100	NA	NA	NA	1250
Total Magnesium	ICP-OES	PMS-09	mg/kg	50	NA	NA	NA	122
Total Sodium	ICP-OES	PMS-09	mg/kg	40	NA	NA	NA	100
Total Sulphur	ICP-OES	PMS-09	mg/kg	40	NA	NA	NA	38.0
Total Aluminium	ICP-OES	PMS-09	mg/kg	100	NA	NA	NA	11900
Emerson Aggregate Test	Class	PMS-21	Number	na	1	NA	NA	5
Exchangeable Potassium	ICP-OES	R&L 15D1	mg/kg	10	NA	NA	NA	311
Exchangeable Calcium	ICP-OES	R&L 15D1	mg/kg	20	NA	NA	NA	702
Exchangeable Magnesium	ICP-OES	R&L 15D1	mg/kg	10	NA	NA	NA	58.8
Exchangeable Sodium	ICP-OES	R&L 15D1	mg/kg	10	NA	NA	NA	24.3
Gravel >2.0mm	Sieve	ASTMD422-63	%	na	0.7	0.6	0.5	1.6
Coarse Sand 0.2-2.0mm	Sieve	ASTMD422-63	%	na	13.6	6.1	5.6	72.1
Fine Sand 0.02-0.2mm	Sieve	ASTMD422-63	%	na	17.3	14.5	13.2	16.0
Silt 0.002-0.02mm	Hydrometer	ASTMD422-63	%	na	24.0	9.5	10.2	3.2



ANALYSIS REPORT

PROJECT NO: EW230824

Location: E220305-DWF

CLIENT SAMPLE ID					DWF07	DWF14	DWF14	DWF10
					80-90	0-10	20-30	0-10
DEPTH								
Test Parameter	Method Description	Method Reference	Units	LOR	230824-13	230824-14	230824-15	230824-16
Clay <0.002mm	Hydrometer	ASTMD422-63	%	na	44.4	69.3	70.5	7.1



ANALYSIS REPORT

PROJECT NO: EW230824

Location: E220305-DWF

CLIENT SAMPLE ID DEPTH					DWF10	DWF10	DWF10	DWF06
					20-30	80-90	110-120	0-10
Test Parameter	Method Description	Method Reference	Units	LOR	230824-17	230824-18	230824-19	230824-20
Sand	Calc	Texture	%	na	NA	NA	NA	NA
Silt	Calc	Texture	%	na	NA	NA	NA	NA
Clay	Calc	Texture	%	na	NA	NA	NA	NA
pH (1:5 in H2O)	Electrode	R&L 4A1	pH units	na	6.24	6.78	7.69	5.77
pH (1:5 in CaCl2)	Electrode	R&L 4B2	pH units	na	5.88	6.51	7.03	4.94
Chloride Soluble	DA	DAP-06	mg/kg	5	6.78	24.1	37.1	19.8
Electrical Conductivity	Electrode	R&L 3A1	dS/m	0.01	0.03	0.10	0.08	0.04
Total N (LECO)	LECO	R&L 7A5	mg/kg	50	NA	NA	NA	672
E.C.e	Calc	R&L 3A1	dS/m	na	NA	NA	NA	NA
Extractable Nitrate-N	DA	DAP-03	mg/kg	1	5.75	33.4	16.5	5.07
Ammonium - N (Ex)	ExKCl/UV-Vis	PMS-22	mg/kg	2	4.31	4.19	3.35	6.23
Phosphorus (Total)	HNO3/HClO4 ICP	ICP-03	mg/kg	40	NA	NA	NA	209
Organic Carbon (LECO)	LECO	R&L 6B3	%	0.2	NA	NA	NA	0.6
Phosphorus (Colwell)	Bicarb/UV-Vis	R&L 9B1	mg/kg	5	NA	NA	NA	25.0
Sulphate-Sulphur	KCl40/ICP	R&L 10D1	mg/kg	3	NA	NA	NA	4.57
Extractable Copper	DTPA/ICP	R&L 12A1	mg/kg	0.2	NA	NA	NA	0.68
Extractable Zinc	DTPA/ICP	R&L 12A1	mg/kg	0.2	NA	NA	NA	0.48
Extractable Manganese	DTPA/ICP	R&L 12A1	mg/kg	1	NA	NA	NA	29.6
Extractable Iron	DTPA/ICP	R&L 12A1	mg/kg	1	NA	NA	NA	49.6
Extractable Boron	Hot CaCl2/ICP	R&L 12C2	mg/kg	0.2	NA	NA	NA	0.52
Exchangeable Potassium	NH4Cl/ICP	R&L 15A1	mg/kg	10	NA	NA	NA	NA
Exchangeable Calcium	NH4Cl/ICP	R&L 15A1	mg/kg	20	NA	NA	NA	NA
Exchangeable Magnesium	NH4Cl/ICP	R&L 15A1	mg/kg	10	NA	NA	NA	NA
Exchangeable Sodium	NH4Cl/ICP	R&L 15A1	mg/kg	10	NA	NA	NA	NA
Exchangeable Aluminium	KCl/ICP	R&L 15G1	mg/kg	2	6.90	<2.00	<2.00	7.50
Exchangeable Potassium	R&L 15A1	R&L 15A1	cmol/kg	na	NA	NA	NA	NA



ANALYSIS REPORT

PROJECT NO: EW230824

Location: E220305-DWF

CLIENT SAMPLE ID					DWF10	DWF10	DWF10	DWF06
DEPTH					20-30	80-90	110-120	0-10
Test Parameter	Method Description	Method Reference	Units	LOR	230824-17	230824-18	230824-19	230824-20
Exchangeable Calcium	R&L 15A1	R&L 15A1	cmol/kg	na	NA	NA	NA	NA
Exchangeable Magnesium	R&L 15A1	R&L 15A1	cmol/kg	na	NA	NA	NA	NA
Exchangeable Sodium	R&L 15A1	R&L 15A1	cmol/kg	na	NA	NA	NA	NA
Exchangeable Aluminium	Calculation	R&L 15J1	cmol/kg	na	0.08	0.02	0.02	0.08
ECEC	Calculation	PMS-15A1	cmol/kg	na	NA	NA	NA	NA
Ca/Mg Ratio	Calculation	PMS-15A1	cmol/kg	na	NA	NA	NA	NA
K/Mg Ratio	Calculation	PMS-15A1	cmol/kg	na	NA	NA	NA	NA
Exchangeable Potassium %	Calculation	PMS-15A1	%	na	NA	NA	NA	NA
Exchangeable Calcium %	Calculation	PMS-15A1	%	na	NA	NA	NA	NA
Exchangeable Magnesium %	Calculation	PMS-15A1	%	na	NA	NA	NA	NA
Exchangeable Sodium %	Calculation	PMS-15A1	%	na	NA	NA	NA	NA
Exchangeable Aluminium %	Calculation	PMS-15A1	%	na	0.26	0.08	0.08	0.28
Exchangeable Potassium	ICP-OES	R&L 15C1	mg/kg	10	NA	NA	112	NA
Exchangeable Calcium	ICP-OES	R&L 15C1	mg/kg	20	NA	NA	1021	NA
Exchangeable Magnesium	ICP-OES	R&L 15C1	mg/kg	10	NA	NA	254	NA
Exchangeable Sodium	ICP-OES	R&L 15C1	mg/kg	10	NA	NA	32.7	NA
Exchangeable Potassium	R&L 15C1	R&L 15C1	cmol/kg	na	NA	NA	0.29	NA
Exchangeable Calcium	R&L 15C1	R&L 15C1	cmol/kg	na	NA	NA	5.11	NA
Exchangeable Magnesium	PMS-15C1	PMS-15C1	cmol/kg	na	NA	NA	2.12	NA
Exchangeable Sodium	R&L 15C1	R&L 15C1	cmol/kg	na	NA	NA	0.14	NA
ECEC	Calculation	PMS-15C1	cmol/kg	na	NA	NA	7.67	NA
Ca/Mg Ratio	Calculation	PMS-15C1	cmol/kg	na	NA	NA	2.41	NA
K/Mg Ratio	Calculation	PMS-15C1	cmol/kg	na	NA	NA	0.14	NA
Exchangeable Potassium %	Calculation	PMS-15C1	%	na	NA	NA	3.74	NA
Exchangeable Calcium %	Calculation	PMS-15C1	%	na	NA	NA	66.5	NA
Exchangeable Magnesium %	Calculation	PMS-15C1	%	na	NA	NA	27.6	NA





ANALYSIS REPORT

PROJECT NO: EW230824

Location: E220305-DWF

CLIENT SAMPLE ID					DWF10	DWF10	DWF10	DWF06
DEPTH					20-30	80-90	110-120	0-10
Test Parameter	Method Description	Method Reference	Units	LOR	230824-17	230824-18	230824-19	230824-20
Exchangeable Sodium %	Calculation	PMS-15C1	%	na	NA	NA	1.85	NA
Exchangeable Aluminium %	Calculation	PMS-15C1	%	na	0.56	0.16	0.29	1.09
Total Cadmium	ICP-OES	AS4479.2	mg/kg	0.5	NA	NA	NA	<0.5
Total Chromium	ICP-OES	AS4479.2	mg/kg	0.5	NA	NA	NA	16.0
Total Copper	ICP-OES	PMS-09	mg/kg	0.5	NA	NA	NA	4.0
Total Iron	ICP-OES	PMS-09	mg/kg	0.5	NA	NA	NA	13100
Total Lead	ICP-OES	AS4479.2	mg/kg	0.5	NA	NA	NA	4.9
Total Manganese	ICP-OES	PMS-09	mg/kg	0.5	NA	NA	NA	437
Total Nickel	ICP-OES	AS4479.2	mg/kg	0.5	NA	NA	NA	13.0
Total Zinc	ICP-OES	PMS-09	mg/kg	0.5	NA	NA	NA	12.3
Total Potassium	ICP-OES	PMS-09	mg/kg	0.5	NA	NA	NA	1380
Texture	Field	Northcote	Class	na	S	S	SCL	FSCL
Total Calcium	ICP-OES	PMS-09	mg/kg	100	NA	NA	NA	1130
Total Magnesium	ICP-OES	PMS-09	mg/kg	50	NA	NA	NA	793
Total Sodium	ICP-OES	PMS-09	mg/kg	40	NA	NA	NA	42.7
Total Sulphur	ICP-OES	PMS-09	mg/kg	40	NA	NA	NA	39.6
Total Aluminium	ICP-OES	PMS-09	mg/kg	100	NA	NA	NA	22500
Emerson Aggregate Test	Class	PMS-21	Number	na	5	5	2	5
Exchangeable Potassium	ICP-OES	R&L 15D1	mg/kg	10	232	243	NA	422
Exchangeable Calcium	ICP-OES	R&L 15D1	mg/kg	20	681	596	NA	915
Exchangeable Magnesium	ICP-OES	R&L 15D1	mg/kg	10	59.3	84.0	NA	136
Exchangeable Sodium	ICP-OES	R&L 15D1	mg/kg	10	36.9	23.6	NA	59.8
Gravel >2.0mm	Sieve	ASTMD422-63	%	na	1.4	0.7	5.6	1.1
Coarse Sand 0.2-2.0mm	Sieve	ASTMD422-63	%	na	67.9	66.2	47.1	40.2
Fine Sand 0.02-0.2mm	Sieve	ASTMD422-63	%	na	18.5	19.4	22.7	33.9
Silt 0.002-0.02mm	Hydrometer	ASTMD422-63	%	na	3.2	4.9	8.6	10.4



ANALYSIS REPORT

PROJECT NO: EW230824

Location: E220305-DWF

CLIENT SAMPLE ID					DWF10	DWF10	DWF10	DWF06
					20-30	80-90	110-120	0-10
DEPTH								
Test Parameter	Method Description	Method Reference	Units	LOR	230824-17	230824-18	230824-19	230824-20
Clay <0.002mm	Hydrometer	ASTMD422-63	%	na	8.9	8.8	16.0	14.4



ANALYSIS REPORT

PROJECT NO: EW230824

Location: E220305-DWF

CLIENT SAMPLE ID					DWF06	DWF06	DWF06	DWF11
DEPTH					30-40	60-70	90-100	20-30
Test Parameter	Method Description	Method Reference	Units	LOR	230824-22	230824-23	230824-24	230824-25
Sand	Calc	Texture	%	na	NA	NA	NA	25
Silt	Calc	Texture	%	na	NA	NA	NA	30
Clay	Calc	Texture	%	na	NA	NA	NA	45
pH (1:5 in H2O)	Electrode	R&L 4A1	pH units	na	8.23	8.88	8.73	7.94
pH (1:5 in CaCl2)	Electrode	R&L 4B2	pH units	na	6.98	8.25	8.22	6.86
Chloride Soluble	DA	DAP-06	mg/kg	5	76.8	1072	1477	74.5
Electrical Conductivity	Electrode	R&L 3A1	dS/m	0.01	0.10	0.91	1.37	0.12
Total N (LECO)	LECO	R&L 7A5	mg/kg	50	NA	NA	NA	NA
E.C.e	Calc	R&L 3A1	dS/m	na	NA	NA	NA	1.03
Extractable Nitrate-N	DA	DAP-03	mg/kg	1	1.47	1.39	2.42	NA
Ammonium - N (Ex)	ExKCl/UV-Vis	PMS-22	mg/kg	2	2.64	7.20	2.40	NA
Phosphorus (Total)	HNO3/HClO4 ICP	ICP-03	mg/kg	40	NA	NA	NA	NA
Organic Carbon (LECO)	LECO	R&L 6B3	%	0.2	NA	NA	NA	NA
Phosphorus (Colwell)	Bicarb/UV-Vis	R&L 9B1	mg/kg	5	NA	NA	NA	NA
Sulphate-Sulphur	KCl40/ICP	R&L 10D1	mg/kg	3	NA	NA	NA	NA
Extractable Copper	DTPA/ICP	R&L 12A1	mg/kg	0.2	NA	NA	NA	NA
Extractable Zinc	DTPA/ICP	R&L 12A1	mg/kg	0.2	NA	NA	NA	NA
Extractable Manganese	DTPA/ICP	R&L 12A1	mg/kg	1	NA	NA	NA	NA
Extractable Iron	DTPA/ICP	R&L 12A1	mg/kg	1	NA	NA	NA	NA
Extractable Boron	Hot CaCl2/ICP	R&L 12C2	mg/kg	0.2	NA	NA	NA	NA
Exchangeable Potassium	NH4Cl/ICP	R&L 15A1	mg/kg	10	NA	NA	NA	241
Exchangeable Calcium	NH4Cl/ICP	R&L 15A1	mg/kg	20	NA	NA	NA	1218
Exchangeable Magnesium	NH4Cl/ICP	R&L 15A1	mg/kg	10	NA	NA	NA	943
Exchangeable Sodium	NH4Cl/ICP	R&L 15A1	mg/kg	10	NA	NA	NA	633
Exchangeable Aluminium	KCl/ICP	R&L 15G1	mg/kg	2	<2.00	<2.00	<2.00	<2.00
Exchangeable Potassium	R&L 15A1	R&L 15A1	cmol/kg	na	NA	NA	NA	0.62



ANALYSIS REPORT

PROJECT NO: EW230824

Location: E220305-DWF

CLIENT SAMPLE ID					DWF06	DWF06	DWF06	DWF11
					30-40	60-70	90-100	20-30
DEPTH								
Test Parameter	Method Description	Method Reference	Units	LOR	230824-22	230824-23	230824-24	230824-25
Exchangeable Calcium	R&L 15A1	R&L 15A1	cmol/kg	na	NA	NA	NA	6.09
Exchangeable Magnesium	R&L 15A1	R&L 15A1	cmol/kg	na	NA	NA	NA	7.86
Exchangeable Sodium	R&L 15A1	R&L 15A1	cmol/kg	na	NA	NA	NA	2.75
Exchangeable Aluminium	Calculation	R&L 15J1	cmol/kg	na	0.02	0.02	0.02	0.02
ECEC	Calculation	PMS-15A1	cmol/kg	na	NA	NA	NA	17.3
Ca/Mg Ratio	Calculation	PMS-15A1	cmol/kg	na	NA	NA	NA	0.77
K/Mg Ratio	Calculation	PMS-15A1	cmol/kg	na	NA	NA	NA	0.08
Exchangeable Potassium %	Calculation	PMS-15A1	%	na	NA	NA	NA	3.56
Exchangeable Calcium %	Calculation	PMS-15A1	%	na	NA	NA	NA	35.1
Exchangeable Magnesium %	Calculation	PMS-15A1	%	na	NA	NA	NA	45.3
Exchangeable Sodium %	Calculation	PMS-15A1	%	na	NA	NA	NA	15.9
Exchangeable Aluminium %	Calculation	PMS-15A1	%	na	0.08	0.08	0.08	0.13
Exchangeable Potassium	ICP-OES	R&L 15C1	mg/kg	10	258	227	190	NA
Exchangeable Calcium	ICP-OES	R&L 15C1	mg/kg	20	1156	1175	1349	NA
Exchangeable Magnesium	ICP-OES	R&L 15C1	mg/kg	10	561	752	847	NA
Exchangeable Sodium	ICP-OES	R&L 15C1	mg/kg	10	436	912	1076	NA
Exchangeable Potassium	R&L 15C1	R&L 15C1	cmol/kg	na	0.66	0.58	0.49	NA
Exchangeable Calcium	R&L 15C1	R&L 15C1	cmol/kg	na	5.78	5.88	6.75	NA
Exchangeable Magnesium	PMS-15C1	PMS-15C1	cmol/kg	na	4.68	6.27	7.06	NA
Exchangeable Sodium	R&L 15C1	R&L 15C1	cmol/kg	na	1.90	3.97	4.68	NA
ECEC	Calculation	PMS-15C1	cmol/kg	na	13.0	16.7	19.0	NA
Ca/Mg Ratio	Calculation	PMS-15C1	cmol/kg	na	1.24	0.94	0.96	NA
K/Mg Ratio	Calculation	PMS-15C1	cmol/kg	na	0.14	0.09	0.07	NA
Exchangeable Potassium %	Calculation	PMS-15C1	%	na	5.08	3.48	2.57	NA
Exchangeable Calcium %	Calculation	PMS-15C1	%	na	44.3	35.2	35.5	NA
Exchangeable Magnesium %	Calculation	PMS-15C1	%	na	35.9	37.5	37.2	NA





ANALYSIS REPORT

PROJECT NO: EW230824

Location: E220305-DWF

CLIENT SAMPLE ID					DWF06	DWF06	DWF06	DWF11
DEPTH					30-40	60-70	90-100	20-30
Test Parameter	Method Description	Method Reference	Units	LOR	230824-22	230824-23	230824-24	230824-25
Exchangeable Sodium %	Calculation	PMS-15C1	%	na	14.5	23.7	24.6	NA
Exchangeable Aluminium %	Calculation	PMS-15C1	%	na	0.17	0.13	0.12	0.12
Total Cadmium	ICP-OES	AS4479.2	mg/kg	0.5	NA	NA	NA	NA
Total Chromium	ICP-OES	AS4479.2	mg/kg	0.5	NA	NA	NA	NA
Total Copper	ICP-OES	PMS-09	mg/kg	0.5	NA	NA	NA	NA
Total Iron	ICP-OES	PMS-09	mg/kg	0.5	NA	NA	NA	NA
Total Lead	ICP-OES	AS4479.2	mg/kg	0.5	NA	NA	NA	NA
Total Manganese	ICP-OES	PMS-09	mg/kg	0.5	NA	NA	NA	NA
Total Nickel	ICP-OES	AS4479.2	mg/kg	0.5	NA	NA	NA	NA
Total Zinc	ICP-OES	PMS-09	mg/kg	0.5	NA	NA	NA	NA
Total Potassium	ICP-OES	PMS-09	mg/kg	0.5	NA	NA	NA	NA
Texture	Field	Northcote	Class	na	LMC	LC	LC	LMC
Total Calcium	ICP-OES	PMS-09	mg/kg	100	NA	NA	NA	NA
Total Magnesium	ICP-OES	PMS-09	mg/kg	50	NA	NA	NA	NA
Total Sodium	ICP-OES	PMS-09	mg/kg	40	NA	NA	NA	NA
Total Sulphur	ICP-OES	PMS-09	mg/kg	40	NA	NA	NA	NA
Total Aluminium	ICP-OES	PMS-09	mg/kg	100	NA	NA	NA	NA
Emerson Aggregate Test	Class	PMS-21	Number	na	2	4	4	NA
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
Exchangeable Magnesium	ICP-OES	R&L 15D1	mg/kg	10	NA	NA	NA	NA
Exchangeable Sodium	ICP-OES	R&L 15D1	mg/kg	10	NA	NA	NA	NA
Gravel >2.0mm	Sieve	ASTMD422-63	%	na	0.2	3.5	1.8	NA
Coarse Sand 0.2-2.0mm	Sieve	ASTMD422-63	%	na	20.5	19.2	13.9	NA
Fine Sand 0.02-0.2mm	Sieve	ASTMD422-63	%	na	18.4	21.3	23.4	NA
Silt 0.002-0.02mm	Hydrometer	ASTMD422-63	%	na	9.5	9.3	13.4	NA



ANALYSIS REPORT

PROJECT NO: EW230824

Location: E220305-DWF

CLIENT SAMPLE ID					DWF06	DWF06	DWF06	DWF11
					30-40	60-70	90-100	20-30
DEPTH								
Test Parameter	Method Description	Method Reference	Units	LOR	230824-22	230824-23	230824-24	230824-25
Clay <0.002mm	Hydrometer	ASTMD422-63	%	na	51.5	46.7	47.5	NA





ANALYSIS REPORT

PROJECT NO: EW230824

Location: E220305-DWF

CLIENT SAMPLE ID DEPTH					DWF11	DWF15	DWF15	DWF15
					60-70	0-10	20-30	50-60
Test Parameter	Method Description	Method Reference	Units	LOR	230824-26	230824-27	230824-28	230824-29
Sand	Calc	Texture	%	na	45	NA	NA	25
Silt	Calc	Texture	%	na	15	NA	NA	30
Clay	Calc	Texture	%	na	40	NA	NA	45
pH (1:5 in H2O)	Electrode	R&L 4A1	pH units	na	9.25	5.66	7.43	8.92
pH (1:5 in CaCl2)	Electrode	R&L 4B2	pH units	na	8.41	4.80	6.20	8.12
Chloride Soluble	DA	DAP-06	mg/kg	5	415	37.7	58.0	361
Electrical Conductivity	Electrode	R&L 3A1	dS/m	0.01	0.48	0.05	0.09	0.46
Total N (LECO)	LECO	R&L 7A5	mg/kg	50	NA	NA	NA	NA
E.C.e	Calc	R&L 3A1	dS/m	na	4.13	0.43	0.77	3.96
Extractable Nitrate-N	DA	DAP-03	mg/kg	1	NA	NA	NA	NA
Ammonium - N (Ex)	ExKCl/UV-Vis	PMS-22	mg/kg	2	NA	NA	NA	NA
Phosphorus (Total)	HNO3/HClO4 ICP	ICP-03	mg/kg	40	NA	NA	NA	NA
Organic Carbon (LECO)	LECO	R&L 6B3	%	0.2	NA	NA	NA	NA
Phosphorus (Colwell)	Bicarb/UV-Vis	R&L 9B1	mg/kg	5	NA	NA	NA	NA
Sulphate-Sulphur	KCl40/ICP	R&L 10D1	mg/kg	3	NA	NA	NA	NA
Extractable Copper	DTPA/ICP	R&L 12A1	mg/kg	0.2	NA	NA	NA	NA
Extractable Zinc	DTPA/ICP	R&L 12A1	mg/kg	0.2	NA	NA	NA	NA
Extractable Manganese	DTPA/ICP	R&L 12A1	mg/kg	1	NA	NA	NA	NA
Extractable Iron	DTPA/ICP	R&L 12A1	mg/kg	1	NA	NA	NA	NA
Extractable Boron	Hot CaCl2/ICP	R&L 12C2	mg/kg	0.2	NA	NA	NA	NA
Exchangeable Potassium	NH4Cl/ICP	R&L 15A1	mg/kg	10	210	382	286	271
Exchangeable Calcium	NH4Cl/ICP	R&L 15A1	mg/kg	20	1972	668	1420	2407
Exchangeable Magnesium	NH4Cl/ICP	R&L 15A1	mg/kg	10	1379	243	842	1129
Exchangeable Sodium	NH4Cl/ICP	R&L 15A1	mg/kg	10	1342	51.2	532	1118
Exchangeable Aluminium	KCl/ICP	R&L 15G1	mg/kg	2	<2.00	11.5	<2.00	<2.00
Exchangeable Potassium	R&L 15A1	R&L 15A1	cmol/kg	na	0.54	0.98	0.73	0.69



ANALYSIS REPORT

PROJECT NO: EW230824

Location: E220305-DWF

CLIENT SAMPLE ID DEPTH					DWF11	DWF15	DWF15	DWF15
					60-70	0-10	20-30	50-60
Test Parameter	Method Description	Method Reference	Units	LOR	230824-26	230824-27	230824-28	230824-29
Exchangeable Calcium	R&L 15A1	R&L 15A1	cmol/kg	na	9.86	3.34	7.10	12.0
Exchangeable Magnesium	R&L 15A1	R&L 15A1	cmol/kg	na	11.5	2.03	7.02	9.41
Exchangeable Sodium	R&L 15A1	R&L 15A1	cmol/kg	na	5.83	0.22	2.31	4.86
Exchangeable Aluminium	Calculation	R&L 15J1	cmol/kg	na	0.02	0.13	0.02	0.02
ECEC	Calculation	PMS-15A1	cmol/kg	na	27.7	6.69	17.2	27.0
Ca/Mg Ratio	Calculation	PMS-15A1	cmol/kg	na	0.86	1.65	1.01	1.28
K/Mg Ratio	Calculation	PMS-15A1	cmol/kg	na	0.05	0.48	0.10	0.07
Exchangeable Potassium %	Calculation	PMS-15A1	%	na	1.94	14.6	4.27	2.57
Exchangeable Calcium %	Calculation	PMS-15A1	%	na	35.5	49.9	41.3	44.5
Exchangeable Magnesium %	Calculation	PMS-15A1	%	na	41.4	30.2	40.8	34.8
Exchangeable Sodium %	Calculation	PMS-15A1	%	na	21.0	3.33	13.5	18.0
Exchangeable Aluminium %	Calculation	PMS-15A1	%	na	0.08	1.91	0.13	0.08
Exchangeable Potassium	ICP-OES	R&L 15C1	mg/kg	10	NA	NA	NA	NA
Exchangeable Calcium	ICP-OES	R&L 15C1	mg/kg	20	NA	NA	NA	NA
Exchangeable Magnesium	ICP-OES	R&L 15C1	mg/kg	10	NA	NA	NA	NA
Exchangeable Sodium	ICP-OES	R&L 15C1	mg/kg	10	NA	NA	NA	NA
Exchangeable Potassium	R&L 15C1	R&L 15C1	cmol/kg	na	NA	NA	NA	NA
Exchangeable Calcium	R&L 15C1	R&L 15C1	cmol/kg	na	NA	NA	NA	NA
Exchangeable Magnesium	PMS-15C1	PMS-15C1	cmol/kg	na	NA	NA	NA	NA
Exchangeable Sodium	R&L 15C1	R&L 15C1	cmol/kg	na	NA	NA	NA	NA
ECEC	Calculation	PMS-15C1	cmol/kg	na	NA	NA	NA	NA
Ca/Mg Ratio	Calculation	PMS-15C1	cmol/kg	na	NA	NA	NA	NA
K/Mg Ratio	Calculation	PMS-15C1	cmol/kg	na	NA	NA	NA	NA
Exchangeable Potassium %	Calculation	PMS-15C1	%	na	NA	NA	NA	NA
Exchangeable Calcium %	Calculation	PMS-15C1	%	na	NA	NA	NA	NA
Exchangeable Magnesium %	Calculation	PMS-15C1	%	na	NA	NA	NA	NA



ANALYSIS REPORT

PROJECT NO: EW230824

Location: E220305-DWF

CLIENT SAMPLE ID DEPTH					DWF11	DWF15	DWF15	DWF15
					60-70	0-10	20-30	50-60
Test Parameter	Method Description	Method Reference	Units	LOR	230824-26	230824-27	230824-28	230824-29
Exchangeable Sodium %	Calculation	PMS-15C1	%	na	NA	NA	NA	NA
Exchangeable Aluminium %	Calculation	PMS-15C1	%	na	0.12	0.67	0.12	0.12
Total Cadmium	ICP-OES	AS4479.2	mg/kg	0.5	NA	NA	NA	NA
Total Chromium	ICP-OES	AS4479.2	mg/kg	0.5	NA	NA	NA	NA
Total Copper	ICP-OES	PMS-09	mg/kg	0.5	NA	NA	NA	NA
Total Iron	ICP-OES	PMS-09	mg/kg	0.5	NA	NA	NA	NA
Total Lead	ICP-OES	AS4479.2	mg/kg	0.5	NA	NA	NA	NA
Total Manganese	ICP-OES	PMS-09	mg/kg	0.5	NA	NA	NA	NA
Total Nickel	ICP-OES	AS4479.2	mg/kg	0.5	NA	NA	NA	NA
Total Zinc	ICP-OES	PMS-09	mg/kg	0.5	NA	NA	NA	NA
Total Potassium	ICP-OES	PMS-09	mg/kg	0.5	NA	NA	NA	NA
Texture	Field	Northcote	Class	na	SC	CL	LMC	LMC
Total Calcium	ICP-OES	PMS-09	mg/kg	100	NA	NA	NA	NA
Total Magnesium	ICP-OES	PMS-09	mg/kg	50	NA	NA	NA	NA
Total Sodium	ICP-OES	PMS-09	mg/kg	40	NA	NA	NA	NA
Total Sulphur	ICP-OES	PMS-09	mg/kg	40	NA	NA	NA	NA
Total Aluminium	ICP-OES	PMS-09	mg/kg	100	NA	NA	NA	NA
Emerson Aggregate Test	Class	PMS-21	Number	na	NA	NA	NA	NA
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
Exchangeable Magnesium	ICP-OES	R&L 15D1	mg/kg	10	NA	NA	NA	NA
Exchangeable Sodium	ICP-OES	R&L 15D1	mg/kg	10	NA	NA	NA	NA
Gravel >2.0mm	Sieve	ASTMD422-63	%	na	NA	1.1	1.0	NA
Coarse Sand 0.2-2.0mm	Sieve	ASTMD422-63	%	na	NA	25.5	15.0	NA
Fine Sand 0.02-0.2mm	Sieve	ASTMD422-63	%	na	NA	29.7	23.2	NA
Silt 0.002-0.02mm	Hydrometer	ASTMD422-63	%	na	NA	17.3	11.4	NA



ANALYSIS REPORT

PROJECT NO: EW230824

Location: E220305-DWF

CLIENT SAMPLE ID					DWF11	DWF15	DWF15	DWF15
					60-70	0-10	20-30	50-60
DEPTH								
Test Parameter	Method Description	Method Reference	Units	LOR	230824-26	230824-27	230824-28	230824-29
Clay <0.002mm	Hydrometer	ASTMD422-63	%	na	NA	26.5	49.4	NA

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Soils are air dried at 40°C and ground <2mm.

NB: LOR is the Lowest Obtainable Reading.

DOCUMENT END



Attachment D

Land and soil capability assessment

D.1 Water erosion assessment

Table D.1 outlines the assessment table for determining water erosion LSC classes which considers three major factors:

- slope length and gradient (%)
- soil erodibility (the presence of sodic soils or gully erosion)
- relevant NSW land division.

The LSC Scheme (OEH 2012) applies different criteria to the biophysical properties being assessed depending on their location in New South Wales (NSW). Under the *Crown Lands Act 1884* the state of NSW was divided into the three land division zones of Western, Central and Eastern (Figure D.1). In the water erosion assessment the Western Division is distinguished from the Eastern and Central divisions because of its drier climate, resulting in less protective groundcover. Assessment has been based on the criteria applicable to the Eastern and Central Land Division (Table D.1).

Table D.1 Slope class for each LSC class used to determine water erosion hazard

NSW land division	Slope class (%) for each LSC class							
	Class 1	Class 2	Class 3	Class 4 ¹	Class 5 ²	Class 6	Class 7	Class 8
Eastern and Central divisions	<1	1 to <3	3 to <10 or 1 to <3 with slope >500 m length	10 to <20	10 to <20	20 to <33	33 to <50	>50

Notes: 1. No gully erosion or sodic/dispersible soils are present.
2. Gully erosion and/or sodic/dispersible soils are present.
Sand bodies are classified as Class 1 for water erosion hazard



Figure D.1 NSW land divisions (OEH 2012)

Table D.2 outlines the results for water erosion LSC classes for each of the sites in the project area.

As detailed in Section 4.2, the soils encountered within the project area are commonly sodic and as such are Class 5 where slope is 10–20%.

Assessment of slope length, which where greater than 500 m impacts on LSC classes 2 and 3 where slopes are 1 to <3%, is based on assessment of available topography data. Determination of slope length for each site is based on the presence of relatively continuous (i.e. minimum directional changes) slope lengths of +/- 500 m anywhere up or down the relevant landform that intersects the soil investigation site.

Table D.2 Water erosion LSC classes for project area SPCs

Site ID	SPC	Slope length	Gully or sodic soils present? ¹	Slope (%)	Slope class (%)	Water erosion LSC class
SPC01 and 01a - Vertosols and Dermosols						
DWF01	1	>500	Yes	0.5	<1	1
DWF02	1	>500	Yes	0.3	<1	1
DWF04	1	>500	Yes	1	1 to <3	3
DWF05	1	>500	Yes	0.5	<1	1
DWF07	1	>500	Yes	0	<1	1
DWF09	1	>500	Yes	0.4	<1	1
DWF12	1	>500	Yes	0.5	<1	1
DWF13	1	>500	Yes	0	<1	1
DWF14	1	>500	Yes	0	<1	1
DWF15	1a	>500	Yes	0	<1	1
SPC02 - Arenosols						
DWF03	2	>500	No	0.5	<1	1
DWF10	2	>500	No	0.8	<1	1
SPC03 - Sodosols						
DWF06	3	>500	Yes	0.7	<1	1
DWF08	3	>500	Yes	0.5	<1	1
DWF11	3	>500	Yes	0	<1	1

Notes: 1. The presence of sodicity has been conservatively assumed in sites not submitted for laboratory analysis based on its occurrence in other profiles of the SPC that were subject to laboratory analysis. Bold text indicates those samples subject to laboratory analysis.

D.2 Wind erosion assessment

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

- wind erodibility class of surface soil
- wind erosion power
- exposure to wind
- average yearly rainfall.

D.2.1 Wind erodibility

Table D.3 outlines the assessment figure for determining wind erodibility hazard as an assessment of susceptibility of surface soil to wind erosion.

Table D.3 Wind erodibility hazard of surface soils (OEH 2012)

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

D.2.2 Wind erosive power

The NSW LSC wind erosion assessment utilises the erosive power of wind across NSW, according to a map in the LSC scheme, which is the only information provided for the wind erosive power parameter. As per Figure D.2, the site is located in the 'Low' wind erosive power.

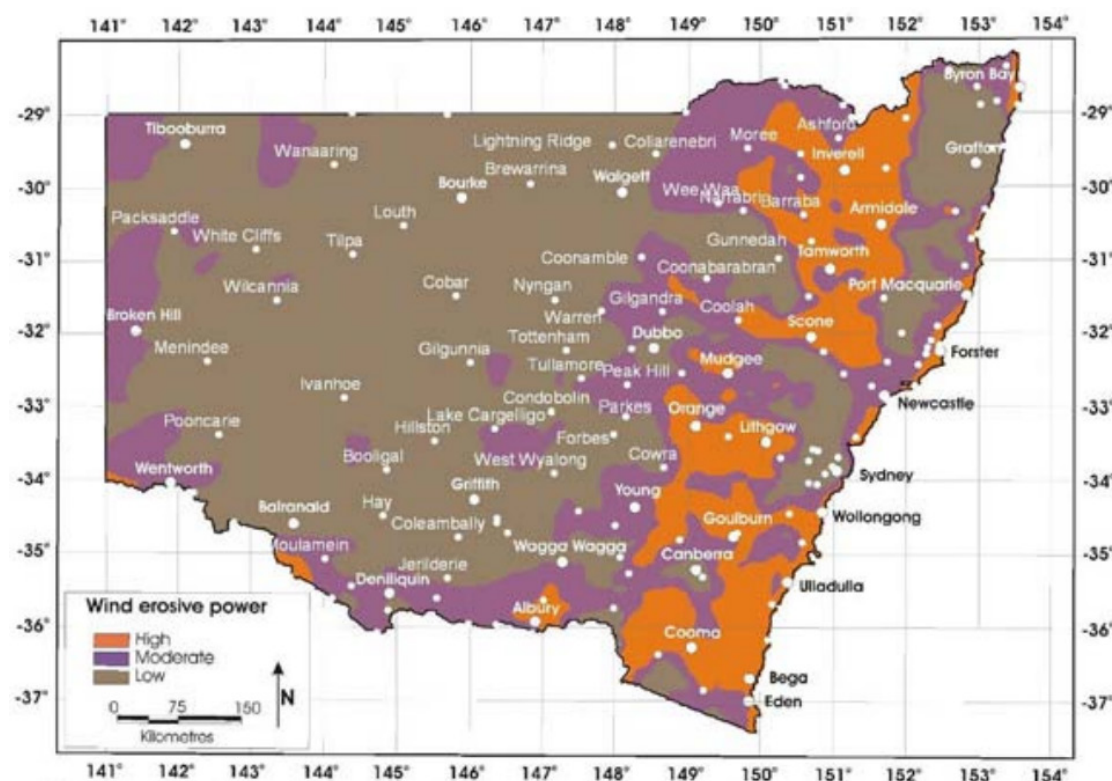


Figure D.2 NSW wind erosive power

Source: NSW Department of Trade and Investment, in OEH (2012)

D.2.3 Wind exposure

Table D.4 details the assessment for determining wind exposure. As per Section 3, utilising the BoM wind roses (BoM 2021a), the prevailing winds are north-easterly and south-westerly. For the purposes of the LSC wind erosion assessment, the wind exposure has considered that sites with aspects normal to the prevailing wind vector.

The topography of the region is largely flat with minimal features. Relief is localised and typically associated with geomorphic assemblages connected to alluvial deposition and aeolian processes that characterise the Riverine Plains. Tree canopy is also sparse and it can be concluded that there is little obstruction to winds and exposure is limited to minor, localised elevations (i.e. knolls, hillocks and gilgai).

Table D.4 Wind exposure hazard (OEH 2012)

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

D.2.4 Annual rainfall

As per Section 3, the average annual rainfall of the site is 447 mm.

D.2.5 Wind erosion LSC classes

Table D.5 outlines the assessment table for determining wind erosion LSC classes and has been shaded for the sections that do not apply to the site based on wind erosive power and average annual rainfall. Table D.6 outlines the results table for wind erosion LSC classes applied to the collected samples.

Table D.5 LSC class for wind erosion hazard (OEH 2012)

Wind erodibility class of surface soil	Wind erosive power	Exposure to wind	Average annual rainfall (mm)			
			>500	300–500	200 to <300	<200
Low	Low	Low	1	2	3	6
		Moderate	1	2	3	6
		High	2	3	4	7
	Moderate	Low	1	2	3	6
		Moderate	2	3	4	6
		High	3	4	5	7
	High	Low	2	3	4	6
		Moderate	3	4	5	7
		High	4	5	6	7
Moderate	Low	Low	2	3	4	7
		Moderate	3	4	5	7
		High	4	5	6	8
	Moderate	Low	2	3	4	6
		Moderate	3	4	5	7
		High	4	5	6	8

Table D.5 LSC class for wind erosion hazard (OEH 2012)

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

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

Table D.6 Wind erosion LSC classes for project area SPCs

Site ID	SPC	Site morphology	Landform Pattern	Relief modal slope	Surface soil texture	Erodibility class	Erosive power	Wind exposure	LSC class
SPC01 and 01a - Vertosols and Dermosols									
DWF01	1	Flat	Plain	Level plain	CLS	Low	Low	High	3
DWF02	1	Flat	Plain	Level plain	LC	Low	Low	High	3
DWF04	1	Flat	Plain	Gently undulating plains	LC	Low	Low	High	3
DWF05	1	Flat	Plain	Level plain	LMC	Low	Low	High	3
DWF07	1	Flat	Playa	Level plain	LC	Low	Low	High	3
DWF09	1	Flat	Plain	Level plain	LMC	Low	Low	High	3
DWF12	1	Flat	Plain	Level plain	LC	Low	Low	High	3
DWF13	1	Flat	Plain	Level plain	LMC	Low	Low	High	3
DWF14	1	Flat	Plain	Level plain	HC	Low	Low	High	3
DWF15	1a	Flat	Plain	Level plain	CLFS	Low	Low	High	3

Table D.6 Wind erosion LSC classes for project area SPCs

Site ID	SPC	Site morphology	Landform Pattern	Relief modal slope	Surface soil texture	Erodibility class	Erosive power	Wind exposure	LSC class
SPC02 - Arenosols									
DWF03	2	Flat	Prior Stream	Level plain	LKS	High	Low	High	6
DWF10	2	Flat	Plain	Level plain	LKS	High	Low	Moderate	5
SPC03 - Sodosols									
DWF06	3	Flat	Prior Stream	Level plain	SL	Moderate	Low	High	5
DWF08	3	Flat	Plain	Level plain	SL	Moderate	Low	High	5
DWF11	3	Flat	Plain	Level plain	SL	Moderate	Low	High	5

D.3 Soil structural decline assessment

The soil structure decline hazard LSC class requires the assessment of surface soils using three key characteristics:

- surface soil texture
- degree of sodicity
- degree of self-mulching.

The soil structural decline hazard assessment consists of applying a modifier to the surface soil field texture to determine a soil surface type with a corresponding LSC class, displayed in Table D.7. The modifier is determined by the sodicity or self-mulching characteristics of the surface soil, displayed in Table D.8. The final LSC assessment for soil structural decline is shown in Table D.9.

Table D.7 LSC class for soil structural decline hazard (OEH 2012)

Field texture (surface soils)	Modifier	Outcome – soil surface type	LSC class
Loose sand	Nil	Loose sand	1
Sandy loam	Nil	Fragile light textured surface soil	3
Fine sandy loam	Normal	Fragile light textured soil	3
	High levels of silt and very fine sand (>60%)	Fragile light textured soil – very hardsetting	4
Loam	Normal	Fragile medium textured soil	3
	Friable/ferric ¹	Friable medium textured soils – includes dark, friable loam soils	1
	High levels of silt and very fine sand	Fragile medium textured soil – very hardsetting	4
	Mildly sodic	Mildly sodic loam surface soil	4
	Moderately sodic	Moderately sodic loam surface soil	6
Clay loam	Normal	Fragile medium textured soil	3

Table D.7 LSC class for soil structural decline hazard (OEH 2012)

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

Notes:

1. The occurrence of friable or ferric surface soils is associated with (a) basaltic or basic parent materials and soils of the Ferrosols groups in the Australian Soil Classification or the Krasnozems and Euchrozem Great Soil Groups, and (b) the dark loam surface soils of the Chernozems and Prairie Soils on alluvial flats.
2. Loosely defined here as soils with over 8% organic carbon. These soils revert to the LSC class determined by the mineral component of the soils
3. Organosols have organic material layers over 0.4 m thick with minimum organic carbon of 12% if sands or 18% if clays (Isbell & NCST 2021).

Table D.8 Guidelines for evaluating some surface soil properties of clays (OEH 2012)

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

Table D.8 Guidelines for evaluating some surface soil properties of clays (OEH 2012)

Sodicity/size of soil structural units	Character of surface soil
High levels of exchangeable sodium (8–15%), often low exchangeable calcium relative to exchangeable magnesium (ratio <1:1). Peds/aggregates 20–50 mm in an air-* dry condition.	Moderately sodic surface soils
Very high levels of exchangeable sodium (>15%), often very low exchangeable calcium relative to exchangeable magnesium (ratio <0.5:1). Peds/aggregates >50 mm in an air-dry condition.	Strongly sodic surface soils

The chemical characteristics of sites not submitted for laboratory analysis have been conservatively assumed based on the chemical characteristics of the SPC profiles that were subject to laboratory analysis.

Table D.9 Soil structural decline LSC classes for project area SPCs

Site ID	SPC	Field texture (surface soils)	Modifier	Outcome – surface soil type	Soil structural decline LSC class
SPC01 - Vertosols and Dermosols					
DWF01	1	CLS	Mildly sodic	Mildly sodic clay loam surface soil	4
DWF02	1	LC	Mildly sodic	Mildly sodic/coarsely structured clay surface soil	4
DWF04	1	LC	Mildly sodic	Mildly sodic/coarsely structured clay surface soil	4
DWF05	1	LMC	Weakly self-mulching	Weakly self-mulching surface soil	3
DWF07	1	LC	Mildly sodic	Mildly sodic/coarsely structured clay surface soil	4
DWF09	1	LMC	Moderately sodic	Moderately sodic/coarsely structured clay surface soil	6
DWF12	1	LC	Mildly sodic	Mildly sodic/coarsely structured clay surface soil	4
DWF13	1	LMC	Mildly sodic	Mildly sodic/coarsely structured clay surface soil	4
DWF14	1	MHC	Moderately sodic	Moderately sodic/coarsely structured clay surface soil	6
DWF15	1a	CLFS	Normal	Fragile medium textured soil	3
SPC02 - Arenosols					
DWF03	2	LKS	Nil	Loose sand	1
DWF10	2	LKS	Nil	Loose sand	1
SPC03 - Sodosols					
DWF06	3	SL	Nil	Fragile light textured surface soil	3
DWF08	3	SL	Nil	Fragile light textured surface soil	3
DWF11	3	SL	Nil	Fragile light textured surface soil	3

D.4 Soil acidification assessment

The soil acidification hazard LSC class requires the assessment of three key characteristics:

- surface soil buffering capacity
- mean annual rainfall
- soil surface pH.

Buffering capacity of the soil surface can be determined through three different processes: The Great Soil Group, the surface soil texture, or the geology of the area. The buffering capacity of the soil surface was determined through an approximation from surface soil texture, shown in Table D.10.

Table D.10 Estimating buffering capacity based on surface soil texture (OEI 2012)

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

The following textures were not specifically listed in Table D.10, so the buffering capacity was assumed by using the equivalent clay percentages as per the standard soil texture triangle and the Yellow Book (NCST 2012).

Buffering capacity – Moderate:

- Sandy clay loam.

Buffering capacity – Very low:

- Loamy sand
- Clayey sand.

Table D.11 shows the assessment for soil acidification hazard and Table D.12 shows the results of the assessment for the project area SPCs. Soil surface pH shown in Table D.12 of sites not submitted for laboratory analysis have been averaged based on the laboratory pH results of the relevant SPC profiles.

Table D.11 Soil acidification LSC class assessment table (OEH 2012)

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

Notes: Based on natural pH status, buffering capacity and climate
Shading indicates criteria not applicable to the project.
* These lands usually have very low fertility.

Table D.12 **Soil acidification LSC classes for project area SPCs**

Site ID	SPC	Field texture (surface soils)	Buffering capacity of surface soil	pH of the natural soil surface		Soil acidification LSC class
				Lab pH (water)	Field pH	
SPC01 - Vertosols and Dermosols						
DWF01	1	CLS	M	6.27	7.0	3
DWF02	1	LC	VH	6.64	7.0	1
DWF04	1	LC	VH	6.84	7.0	1
DWF05	1	LMC	VH	7.37	7.5	1
DWF07	1	LC	VH	6.82	6.5	1
DWF09	1	LMC	VH	5.77	7.0	1
DWF12	1	LC	VH	6.84	7.5	1
DWF13	1	LMC	VH	6.84	7.0	1
DWF14	1	MHC	VH	6.99	6.5	1
DWF15	1a	CLFS	M	5.66	6.5	3
SPC02 - Arenosols						
DWF03	2	LKS	VL	5.7	6.5	4
DWF10	2	LKS	VL	5.7	6.0	4
SPC03 - Sodosols						
DWF06	3	SL	VL	5.77	7.0	4
DWF08	3	SL	VL	5.77	6.0	4
DWF11	3	SL	VL	5.77	7.0	4

Notes: Bold indicates verified lab pH whilst other values are reflective of the mean of the lab pH results for the relevant SPC.

D.5 Soil salinity assessment

The soil salinity hazard LSC class requires the assessment of three key characteristics:

- recharge potential
- discharge potential
- salt store.

A summary of these characteristics is detailed in Table D.13.

Table D.13 **A summary of salinity LSC notes from OEH 2012**

Factor	Notes	Example	Information source
Recharge potential	Recharge potential is the potential for water from rainfall, irrigation or streams to infiltrate past the plant root zone into the underlying groundwater system. This can occur over a whole landscape, or a component of the landscape, where water readily infiltrates soil, sediment or rock. Typically recharge areas have permeable, shallow and/or stony soils and fractured and/or weathered rock.	Recharge potential is highest where there is high rainfall relative to evaporation, low leaf area and plant water use, low water-holding capacity, and high permeability of the soils, regolith and rocks. Under natural conditions it relates to the climate, land use and hydrological characteristics of the catchment. It is exacerbated by land-use practices that disturb the vegetation cover or soil surface.	The value assigned for recharge potential is a qualitative assessment based on aerial photography, field observation and/or available literature, in particular soil landscape maps and reports.
Discharge potential	Discharge potential is the potential for groundwater to flow from the saturated zone to the land surface. It is a function of position in the landscape, depth to water table, groundwater pressure, soil type, substrate permeability and evapotranspiration. Discharge may occur as leakage to streams, evaporation from shallow water tables, or as springs and wet areas where water tables intersect the land surface or where narrow breaks occur in low permeability layers above confined aquifers.	Discharge potential is highest when recharge rates are greater than the amount of water that leaves the groundwater system through base flow and evapotranspiration. Typical discharge areas are low in the landscape and have high water tables, or higher in the landscape if sub-surface barriers impede groundwater flow.	The value assigned for discharge potential is a qualitative assessment based on aerial photography, field observation and/or available literature, in particular soil landscape maps and reports.
Salt store	Salt stores are high for many soils, regolith materials and rock types. This will depend on weathering characteristics, geological structures, rock and soil type, depth of the various materials and salt flux.	It is possible to have areas of low salt store and still have a salinity hazard due to evaporative concentration of salts at the soil surface. Conversely, areas of high salt store can have a lower hazard due to low rainfall. For example, in areas of low rainfall and low slope, salinity hazard can be low.	OEH (2012) provides a broad indication of salt stores throughout NSW. This map is generalised and local information should be used where available.

SPC01 and SPC03 were assigned low recharge potential due to their commonly poorly drained, slowly permeable profiles, low rainfall relative to evaporation and high water holding capacity of the soils. SPC02 soils had high recharge potential due to their deep, sandy profiles.

As discharge potential is primarily based on factors that are consistent across the project area, the project has been assessed as low to moderate due to the very level, low-relief nature of the project area. Discharge potential is generally low, but is moderate in the lower areas, such as minor depressions and relict streams.

Salt store was determined to be moderate for all SPCs, based on multiple factors including:

- the salt store map of NSW contained within the LSC scheme (Figure D.3, OEH 2013) indicating the project area is on an area of moderate to high salt store

- the presence of salinity in the soil chemistry
- high salt store, low salt export, moderate overall salinity risk observed in the hydrogeological landscapes.

Table D.14 shows the assessment for LSC salinity hazard according to the recharge potential, discharge potential and salt store of the project area. Table D.15 shows the results of the salinity hazard assessment for the project.

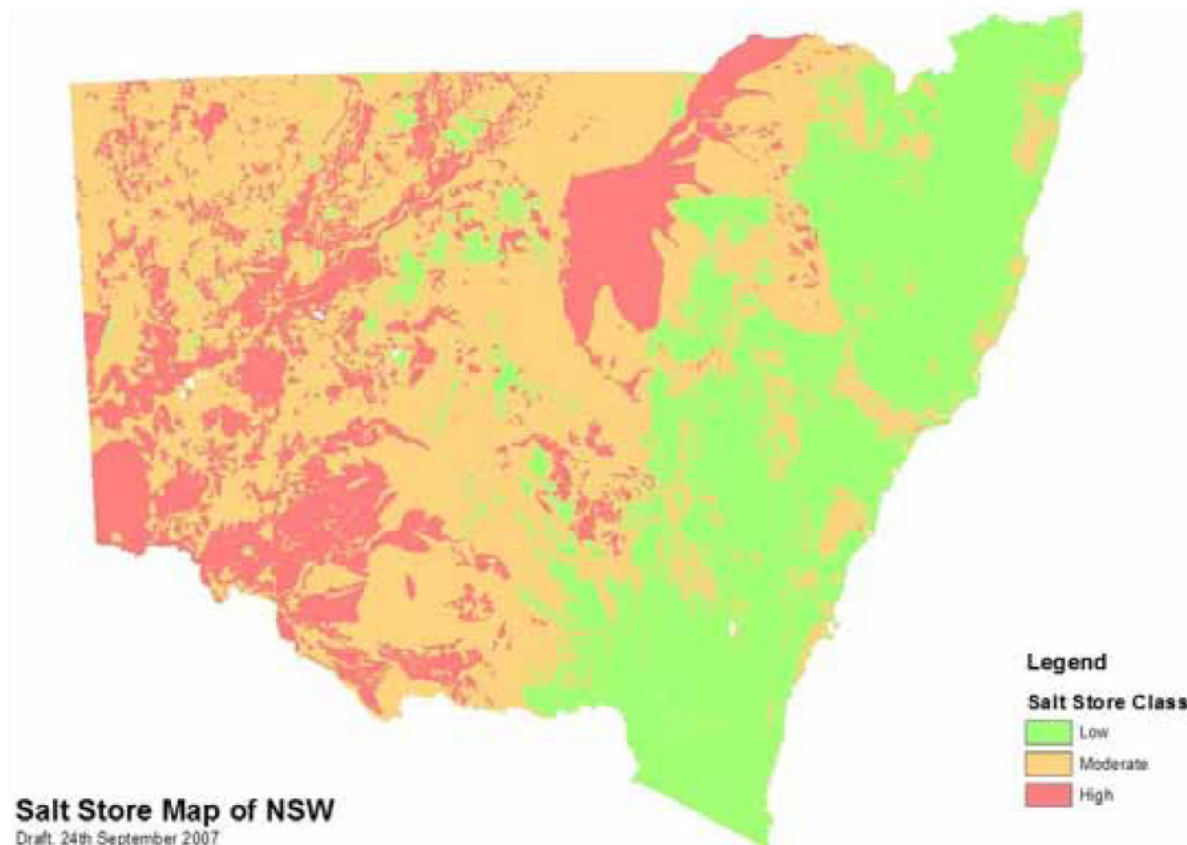


Figure D.3 NSW salt store map (OEH, 2012)

Table D.14 **LSC class for salinity hazard (OEI 2012)**

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

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

Table D.15 Soil salinity LSC classes for project area SPCs

Site ID	SPC	Site morphology	Landform pattern	Dominant mottle abundance	Profile drainage	Recharge potential	Discharge potential	Salt store	Soil salinity LSC class
SPC01 - Vertosols and Dermosols									
DWF01	1	Flat	Plain	2-10%	Imperfectly drained	Low	Moderate	Moderate	4
DWF02	1	Flat	Plain	<2%	Imperfectly drained	Low	Low	Moderate	3
DWF04	1	Flat	Plain	0	Imperfectly drained	Low	Moderate	Moderate	4
DWF05	1	Flat	Plain	2-10%	Imperfectly drained	Low	Low	Moderate	3
DWF07	1	Flat	Plain	0	Very poorly drained	Low	Moderate	Moderate	4
DWF09	1	Flat	Plain	2-10%	Imperfectly drained	Low	Moderate	Moderate	4
DWF12	1	Flat	Plain	0	Poorly drained	Low	Low	Moderate	3
DWF13	1	Flat	Plain	0	Poorly drained	Low	Moderate	Moderate	4
DWF14	1	Flat	Plain	2-10%	Poorly drained	Low	Moderate	Moderate	4
DWF15	1a	Flat	Plain	0	Poorly drained	Low	Low	Moderate	3
SPC02 - Arenosols									
DWF03	2	Flat	Plain	0	Well drained	Moderate	Low	Moderate	3
DWF10	2	Flat	Plain	0	Rapidly drained	Moderate	Low	Moderate	3
SPC03 - Sodosols									
DWF06	3	Flat	Plain	2-10%	Poorly drained	Low	Moderate	Moderate	4
DWF08	3	Flat	Plain	<2%	Very poorly drained	Low	Low	Moderate	3
DWF11	3	Flat	Plain	2-10%	Poorly drained	Low	Low	Moderate	3

D.6 Waterlogging assessment

The waterlogging LSC class requires the assessment of two key characteristics:

- soil profile drainage
- waterlogging duration.

The assessment criteria for determining the waterlogging LSC class is shown in Table D.16 and results of the waterlogging hazard assessment for the project are shown in Table D.17.

Waterlogging duration can be difficult to know without monitoring or local knowledge, and as such has been assumed based on observations of soil permeability, water holding capacity, drainage, presence of any waterlogging or springs and discussion with the landholders. The typical waterlogging duration was not known, but the presence of mottling and landscape position was used to assess soil profile drainage, the dominant influence on the waterlogging assessment and subsequently distinguish the likely degree of waterlogging (NCST 2009).

Table D.16 LSC class for waterlogging hazard (OEH 2012)

Typical waterlogging duration (months)	Return period	Typical soil drainage ¹	LSC class ²
0	Every year	Rapidly drained and well drained	1
0 – 0.25	Every year	Moderately well drained	2
0.25 – 2	Every year	Imperfectly drained	3
2 – 3	Every 2 to 3 years	Imperfectly drained	4
2 – 3	Every year	Imperfectly drained	5
>3	Every year	Poorly drained	6
Almost permanently	Every year	Very poorly drained	8

Notes: 1. NCST (2012) p.202-204.

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

Table D.17 Waterlogging LSC classes for project area SPCs

Site ID	SPC	Site morphology	Landform element	Dominant mottle abundance	Profile Drainage	Typical inundation (months)	LSC class
SPC01 - Vertosols and Dermosols							
DWF01	1	Flat	Plain	2-10%	Imperfectly drained	0	3
DWF02	1	Flat	Plain	<2%	Imperfectly drained	0	2
DWF04	1	Flat	Plain	0	Imperfectly drained	0–0.25	2
DWF05	1	Flat	Plain	2-10%	Imperfectly drained	0	3
DWF07	1	Flat	Playa	0	Very poorly drained	0.25–2	4
DWF09	1	Flat	Plain	2-10%	Imperfectly drained	0–0.25	3
DWF12	1	Flat	Plain	0	Poorly drained	0	3
DWF13	1	Flat	Plain	0	Poorly drained	0–0.25	3
DWF14	1	Flat	Plain	2-10%	Poorly drained	0	4
DWF15	1a	Flat	Plain	0	Poorly drained	0	3
SPC02 - Arenosols							
DWF03	2	Flat	Drainage Depression	0	Well drained	0	1
DWF10	2	Flat	Plain	0	Rapidly drained	0	1
SPC03 - Sodosols							
DWF06	3	Flat	Prior Stream	2-10%	Poorly drained	0–0.25	4
DWF08	3	Flat	Oxbow	<2%	Very poorly drained	0	4
DWF11	3	Flat	Plain	2-10%	Poorly drained	0	4

D.7 Shallow soils and rockiness assessment

The shallow soils and rockiness LSC class requires the assessment of two key characteristics:

- estimated percentage exposure of rocky outcrops
- average soil depth.

The assessment for determining the shallow soils and rockiness LSC class is shown in Table D.18. The depth of excavation has been recorded, but of the 15 investigation sites, a transitional 'B3' horizon was encountered in two sites, DWF06, DWF09, DWF11 at depths of 105, 80 and 90 cm respectively.

The final LSC classes of the sites where excavation depth did not extend to 100 cm BGL (but the horizon appeared to continue) have been based on the average soil depth for the deeper excavation sites of the relevant SPC with consideration for general refusal depths encountered.

Table D.18 LSC class for shallow soils and rockiness hazard (OEH 2012)

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

Notes:

1. Rock outcrop limitation from soil landscape report.
2. Based on rocky outcrop and soil depth.

Table D.19 **Shallow soils and rockiness LSC classes for project area SPCs**

Site ID	SPC	Excavated soil depth (cm)	Layer continuity ¹	Average SPC depth (cm)	Rocky outcrop (% coverage)	Soil depth category (cm) ²	LSC class
SPC01 - Vertosols and Dermosols							
DWF01	1	120	Layer continues	120	0	>100	1
DWF02	1	60	Check site (continues)	120	0	>100	1
DWF04	1	60	Check site (continues)	120	0	>100	1
DWF05	1	120	Layer continues	120	0	>100	1
DWF07	1	120	Layer continues	120	0	>100	1
DWF09	1	120	Layer continues	120	0	>100	1
DWF12	1	30	Check site (continues)	120	0	>100	1
DWF13	1	30	Check site (continues)	120	0	>100	1
DWF14	1	60	Check site (continues)	120	0	>100	1
DWF15	1a	60	Check site (continues)	120	0	>100	1
SPC02 - Arenosols							
DWF03	2	120	Layer continues	120	0	>100	1
DWF10	2	120	Layer continues	120	0	>100	1
SPC03 - Sodosols							
DWF06	3	120	Layer continues	120	0	>100	1
DWF08	3	60	Check site (continues)	120	0	>100	1
DWF11	3	120	Layer continues	120	0	>100	1

Notes:

1. RSA = rock stopped auger
2. Bold indicates where excavation depth has been extrapolated based on average SPC soil profile depth.

D.8 Mass movement assessment

The mass movement LSC class requires the assessment of three key characteristics:

- existing evidence of mass movement
- slope class
- average annual rainfall.

The assessment for determining the mass movement LSC class is shown in Table D.20 and the results of the assessment are shown in Table D.21.

Table D.20 LSC class for mass movement hazard (OEH 2012)

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

Note that scree or talus slopes go automatically into Class 8.

Table D.21 Mass movement LSC classes for project area SPCs

Site ID	Mass movement present	Slope class (%)	Mass movement LSC class
SPC01 - Vertosols and Dermosols			
DWF01	1	No	N/A
DWF02	1	No	N/A
DWF04	1	No	N/A
DWF05	1	No	N/A
DWF07	1	No	N/A
DWF09	1	No	N/A
DWF12	1	No	N/A
DWF13	1	No	N/A
DWF14	1	No	N/A
DWF15	1a	No	N/A
SPC02 - Arenosols			
DWF03	2	No	N/A
DWF10	2	No	N/A
SPC03 - Sodosols			
DWF06	3	No	N/A
DWF08	3	No	N/A
DWF11	3	No	N/A

D.9 SPC LSC assessment

Table D.22 LSC classes for project area SPCs

Site ID	LSC hazard								Final LSC class
	Water	Wind	Structure	Acidification	Salinity	Waterlogging	Shallow soils	Mass movement	
SPC01 - Vertosols and Dermosols									
DWF01	1	3	4	3	4	3	1	1	4
DWF02	1	3	4	1	3	2	1	1	4
DWF04	3	3	4	1	4	2	1	1	4
DWF05	1	3	3	1	3	3	1	1	3
DWF07	1	3	4	1	4	4	1	1	4
DWF09	1	3	6	1	4	3	1	1	6
DWF12	1	3	4	1	3	3	1	1	4
DWF13	1	3	4	1	4	3	1	1	4
DWF14	1	3	6	1	4	4	1	1	6
DWF15	1	3	3	3	3	3	1	1	3
SPC02 - Arenosols									
DWF03	1	6	1	4	3	1	1	1	6
DWF10	1	5	1	4	3	1	1	1	5
SPC03 - Sodosols									
DWF06	1	5	3	4	4	4	1	1	5
DWF08	1	5	3	4	3	4	1	1	5
DWF11	1	5	3	4	3	4	1	1	5

Attachment E

Land use conflict risk assessment

Activity	Identified potential conflict	Probability (P)	Consequence (C)	Risk ranking	Management strategy (method of control)	Revised risk ranking (P; C)	Performance target
Weed and pest management	Increased distribution of weeds during construction as a result of increased vehicle and pedestrian movements.	B	4	12	To manage the transfer of weeds and pathogens to and from work areas, suitable hygiene and washdown protocols will be implemented, including washdown and inspection of vehicles, plant and machinery when moving from areas with known populations of weed and pest species. The focus will be to minimise the transfer of soil and seed material. This will occur during vegetation clearing and construction. The project's construction environmental management plan (CEMP) and operational environmental management plan (OEMP) will include weed management protocols, such as measures for the identification, management and ongoing monitoring of weeds on-site. In addition, sheep grazing in the development footprint during operations will put pressure on any increases to weed levels while maintaining a multi-purpose land use throughout the life of the project.	5 (D; 4)	Effectiveness will be measured as part of the CEMP and OEMP.
	Increased presence of pest animals during construction as a result of increased food waste.	C	4	8	Pest animals may be encouraged by food sources from construction works and improved access roads potentially exacerbating movement. If pest control is considered necessary, it will generally involve a routine baiting program in consultation with the project landholders and neighbouring landholders. Other control methods such as shooting or trapping may also be used if deemed necessary or appropriate. Baiting programs would include methods to minimise the possibility of affecting non-target fauna species. The Biodiversity Management Plan (BMP) will detail pest management regimes to control foxes within the project area during construction and operations.	5 (D; 4)	Effectiveness will be measured as part of the CEMP, OEMP and BMP.
Agricultural land and productivity	Removal of agricultural land from production.	A	5	11	The project is considered to be a temporary and reversible change in land use and the land within the development footprint can be returned to its former use (i.e. agriculture) upon decommissioning. The development footprint is currently used for cattle and sheep grazing and cropping. Grazing is expected to continue in the project area outside the development footprint during both construction and operations, and may continue in portions of the development footprint during operations. In addition, it is anticipated that the development footprint will only require minimal site preparation and civil works (such as grading/levelling and compaction). No large areas of reshaping or excavation are anticipated, aside from digging of cable trenches and WTG foundations, and formation of level pads for substations and the accommodation facilities. Prior to the end of the project's operational life, rehabilitation objectives and strategies for returning the development footprint to agricultural production will be established.	11 (A; 5)	Rehabilitation objectives and strategies (including performance measures) will be established.
	Reduced agricultural productivity of land within development footprint during operations.	A	5	11	As WTGs will be placed relatively sparsely throughout the development footprint, a significant area of land within the development footprint could still be utilised for agricultural activities during operations. Prior to the end of the project's operational life, rehabilitation objectives and strategies for returning the development footprint to agricultural production will be established.	11 (A; 5)	Rehabilitation objectives and strategies (including performance measures) will be established.
Neighbouring agricultural operations	Impacts of the operation of the wind farm on neighbouring agricultural operations (e.g. aerial application of fertilisers and pesticides).	C	3	13	Spark Renewables will engage with local aerial agricultural operators regarding aircraft operations in the vicinity of the project including providing 'as constructed' location and height information of WTGs, meteorological monitoring masts and overhead transmission lines to local aircraft operators prior to construction. Engagement will be ongoing throughout operations.	8 (C; 4)	No action required.
Noise	Construction noise and associated impacts on residents.	B	3	17	Construction noise impacts have been assessed as part of the noise impact assessment. Noise generated during construction will be minimised through implementation of best practice requirements outlined in the <i>Interim Construction Noise Guideline</i> (DECC 2009). Noise impacts at the closest receiver (R049) have been assessed and identified construction noise impacts will be managed through the implementation of a Noise Management Plan (NMP) during construction.	9 (D; 3)	Effectiveness will be measured as part of the NMP, which will include reference to relevant noise criteria.
	Construction noise and associated impacts on livestock.	C	4	8	Potential construction noise impacts on livestock will be identified during further consultation with involved landholders and adjacent landholders. Noise generated during construction will also be minimised through implementation of several measures from the <i>Interim Construction Noise Guideline</i> (DECC 2009). Any required mitigation measures will be identified in consultation with landholders and included in the NMP for the project.	8 (C; 4)	Effectiveness will be measured as part of the NMP, which will include reference to relevant noise criteria.
	Operational noise and associated impacts on residents.	D	5	2	Operational noise impacts have been assessed as part of the noise impact assessment. All noise levels for non-associated receivers will be below the day, evening and night noise criterion outlined in the <i>Noise Policy for Industry</i> (NSW EPA 2017) and no mitigation measures are required.	2 (D; 5)	No action required.
	Noise from increased vehicle movements on local roads during construction and associated impacts on residents and livestock.	D	4	5	Road traffic noise impacts are expected to be limited. The project is proposed to be accessed along Kidman Way, McLennons Bore Road, Cadell Road, Fernbank Road, Wilson Road and Goolgumbula Road. There are only a limited number of receivers in the vicinity of these roads, and they are at separation distances of more than 175 m from these road corridors. Kidman Way is also the main connector road between Griffith and major centres to the south, and therefore already accommodates high levels of traffic.	5 (D; 4)	No action required.
Air quality	Dust from vehicle movements along access roads and unsealed local roads.	B	4	12	Spark Renewables will apply appropriate mitigation strategies to reduce potential dust generation by project-related vehicle movements during construction. Groundwater sourced from existing landholder bores will be used during construction for dust suppression along unpaved and disturbed areas and during the unloading and loading of dust generating materials. Dust suppression requirements during construction will take into consideration weather and the likelihood of extended dry periods which could exacerbate impacts.	8 (C; 4)	Effectiveness of mitigation strategies will be measured as part of the CEMP.
	Dust from sheep moving across paddocks on-site once operational.	C	5	4	No significant impacts on the operation and functionality of the project are anticipated as a result of dust from livestock moving across paddocks on-site once operational. No management strategy is proposed to address this potential conflict.	4 (C; 5)	No action required.
Visual amenity	Visibility of project infrastructure from residences and the local road network.	B	4	12	The visibility of project infrastructure from 25 public viewpoints and 22 private residences has been assessed as part of the landscape and visual impact assessment. With mitigation at R019, visual impacts on public and private viewpoints were assessed to be low and no additional mitigation is required.	12 (B; 4)	No action required.
	Blade flicker from WTGs.	C	4	8	Based on the findings of the blade flicker assessment, blade flicker from the WTGs is not expected to significantly impact receptors within the vicinity of the development footprint or motorists travelling along the local and regional road network.	5 (D; 4)	No action required.
	Potential for night lighting from the project to impact neighbouring properties.	C	4	8	Due to the relatively isolated location of the project, there are few existing sources of lighting in the night-time landscape. During operation, night lighting of ancillary infrastructure will only be required for security lighting at the substations and within the O&M facility. It is unlikely that the proposed night lighting will create a noticeable impact on the existing night-time landscape due to light sources being limited to a low brightness and siting of infrastructure to minimise visibility from existing residences and publicly accessible viewpoints. Shading and artificial light impacts will be minimised where possible through detailed design and lighting will be designed in general accordance with AS/NZS 4282:2019 Control of the obtrusive effects of outdoor lighting. If ongoing consultation with CASA and Air Services Australia determines that aviation hazard lighting is required for the project, aviation hazard lighting has the potential to extend the visual effect of the project to night-time and alter the character of the night landscape. Aviation hazard lighting will impact receptors that view the landscape at night. Mitigation measures will be implemented to reduce the impact of aviation hazard lighting.	5 (D; 4)	No action required.

Activity	Identified potential conflict	Probability (P)	Consequence (C)	Risk ranking	Management strategy (method of control)	Revised risk ranking (P; C)	Performance target
Security	Change in land use resulting in increased pedestrian and vehicle traffic on-site during the project's construction period and potential for theft and vandalism at neighbouring properties.	C	3	13	Construction workforce behaviour will be managed through the implementation of a Worker Code of Conduct, which will encourage positive workforce behaviour.	9 (D; 3)	The Worker Code of Conduct will include details on how the code will be managed and audited.
	Change in land use resulting in vandalism and theft of project infrastructure and construction materials.	C	4	8	Surveillance cameras and signs will be implemented to deter vandalism and theft. Project infrastructure will be located in fenced-off areas within the development footprint. Chain mesh security fencing will be installed around the substation areas to control access.	5 (D; 4)	No action required.
Safety	Safety of wildlife and livestock due to increased vehicle movements along the local road network.	D	3	9	Speed limits within the development footprint will be enforced during construction and operations to minimise potential vehicle collisions with fauna within the development footprint. Suitable speed limit reductions will be determined during preparation of the Biodiversity Management Plan (BMP). Temporary travel speed reduction may also be implemented on local roads as part of the Construction Traffic Management Plan (CTMP).	9 (D; 3)	The CTMP will include a complaint resolution and disciplinary procedure as a mechanism to address any issues identified by the local community and other road users.
Property values and council rates	Devaluation of neighbouring properties due to proximity to project infrastructure.	D	3	9	The impact to the amenity of neighbouring properties and the locality is a key factor influencing land values. The EIS and supporting technical assessments have considered potential amenity impacts from the project's construction and operations. Where significant impacts to neighbouring landholders have been identified, the project has been refined and/or management and mitigation measures have been proposed to further reduce potential impacts. This includes the introduction of a minimum setback of 2 km from the closest WTG to neighbouring residences to reduce potential views of, and noise from, project infrastructure. Construction impacts will be temporary in nature and are therefore considered unlikely to have a lasting impact on the amenity of the locality. Additionally, a review of relevant literature has determined that the visual impact of wind farms on the value of neighbouring properties is small and reduces over time (Brunner et al. 2024; Clean Energy Council 2013; Guo et al. 2024; NSW Department of Lands 2009). The residual impacts associated with the ongoing operation of the project are predicted to be minimal. Spark Renewables will also implement the following measures to reduce impacts to neighbouring properties and thus minimise potential risk of property devaluation: - in consultation with the landowner, supplementary tree planting at R019 to mitigate potential visual impacts - a NMP during construction works to minimise potential noise impacts at the closest residences - a CTMP and Driver Code of Conduct to minimise potential impacts on the safety and serviceability of the local road network - a Worker Code of Conduct to manage potential for adverse impacts to occur from the construction workforce.	9 (D; 3)	The CWMP will include details on how the plan will be managed and audited. The CTMP and NMP will include a complaint resolution and disciplinary procedure as a mechanism to address any issues identified by the local community.
Health	Potential health impacts due to proximity to project infrastructure.	E	2	10	As the strengths of electric and magnetic fields (EMFs) attenuate rapidly with distance, the ICNIRP reference level for exposure to the general public will not be exceeded and impacts to the general public and neighbouring agricultural operations will be negligible. Outside of exposure to EMFs, there are no potential health impacts based on the general public's proximity to project infrastructure have been identified.	10 (E; 2)	No action required.
Traffic	Increased vehicle movements along the local road network during construction and subsequent impacts on accessibility and commute times.	C	4	8	Impacts on accessibility and commute times along the local road network will be temporary and will be primarily experienced during the proposed public road upgrades on Kidman Way, McLennons Bore Road, Cadell Road, Fernbank Road, Wilson Road and Goolgumbula Road. Once these upgrades are complete, dedicated turning lanes will reduce the impact of turning vehicles on through traffic on Kidman Way.	8 (C; 4)	The CTMP will include a complaint resolution and disciplinary procedure as a mechanism to address any issues identified by the local community and other road users.
	Impacts on seasonal/campaign-based agricultural transport activities during construction (e.g. livestock or product cartage).	C	4	8	Potential seasonal/campaign-based agricultural transport activities will be identified during further consultation with project landholders and nearby landholders. Any required mitigation measures (e.g. revisions to construction scheduling) will be identified in consultation with landholders and included in the CTMP.	5 (D; 4)	The CTMP will include a complaint resolution and disciplinary procedure as a mechanism to address any issues identified by neighbouring landholders.
	Increased vehicle movements along the local road network during operation and subsequent impacts on accessibility and commute times.	D	4	5	Vehicle movements during operations will be much lower than during the project's construction. Impacts on accessibility and commute times as a result of the project operations traffic are predicted to be negligible.	5 (D; 4)	No action required.
Soil erosion	Soil erosion leading to land and water pollution.	C	3	13	The CEMP and OEMP will outline mitigation measures to be implemented during construction and operation of the project to minimise soil erosion risk (including erosion and sediment control measures).	5 (D; 4)	Effectiveness will be measured as part of the CEMP and OEMP.
Water	Change to surface water flows and water quality as a result of construction and operations of the project.	C	3	13	The best practice principles for stormwater and sediment control will be incorporated into the design, construction and operation phases of the project as part of the CEMP. Sensitive infrastructure (e.g. substations) will be located on high ground above 1% AEP event flood levels (or other suitable level of flood immunity as may be determined during detailed design), and avoid or otherwise divert local overland flow paths around infrastructure. Watercourse crossings will be designed and constructed to consider the appropriate level of serviceability and flood immunity required for the project and will consider local hydraulic conditions and minimise scour potential.	8 (C; 4)	Effectiveness will be measured as part of the CEMP and OEMP.
	Inadequate availability of sufficient water for neighbouring properties during construction and operation of the project.	D	4	5	The project will not impact licensed water users. The water needs of the project will be met mostly via existing landowner bores. Water contained within existing farm dams, where harvestable rights apply; and water reused from construction sediment basins and rainwater tanks collecting roof runoff may be used for non-potable construction purposes, to minimise use of imported water where practicable. Water supply arrangements for the project will be the subject of further consultation with the project landholders, neighbouring landholders, Murrumbidgee Council, Edward River Council and relevant agencies.	5 (D; 4)	No action required.
Local infrastructure and services	Inadequate availability of waste management facilities within the local community during construction and operations of the project.	C	3	13	A waste management plan (WMP) will be prepared prior to the commencement of construction. A key objective of the WMP will be to ensure that any use of local waste management facilities does not disadvantage local businesses and, more generally, the local community, by exhausting any available capacity at these facilities.	5 (D; 4)	The WMP will include a grievance mechanism through which any identified adverse impacts can be addressed.
	Inadequate availability of existing services and infrastructure in the local community.	C	4	8	Through the provision of additional economic stimulus, employment opportunities and benefits and investment in infrastructure and services, the net community benefit of the project is considered to be positive. Spark Renewables will pay access fees as part of its involvement in the South West REZ, which may also be used to provide additional capacity for local infrastructure and services. A temporary worker accommodation facility for non-local construction employees (where skills cannot be sourced locally) will be established as part of the early stages of the project's construction to accommodate up to 450 workers to mitigate potential workforce impacts on services and facilities across the regional area. Spark Renewables will continue to engage with Murrumbidgee Council and Edward River Council to identify potential service limitations and implement measures such as provision of an on-site medical personnel to reduce demand on local health services.	5 (D; 4)	No action required.

Activity	Identified potential conflict	Probability (P)	Consequence (C)	Risk ranking	Management strategy (method of control)	Revised risk ranking (P; C)	Performance target
Fire	Impacts on land surrounding the wind farm from structural fires generated from within the development footprint.	D	2	14	Fire emergency management procedures are proposed that include fire awareness, emergency response and evacuation, and monitoring and review procedures. A bushfire management plan will be prepared and will detail measures and procedures to prevent fires igniting during the construction, operation and decommissioning of the project.	14 (D; 2)	The bushfire management plan will be reviewed after incidents of bushfire or other fire as well as annually at the end of each bushfire season. The bushfire management plan will be amended after the review process, if required, to increase its effectiveness.
	Impacts on the operation of the wind farm from bushfires in the immediate vicinity of the project.	D	2	14	The key principles for bushfire prevention and protection for the project will be: - the provision of clear separation between structures and bushfire hazards in the form of fuel-reduced asset protection zones (APZs) and/or defensible space - appropriate access and egress for staff, contractors, visitors and emergency services - adequate water supply - suitable location of services and other infrastructure that pose potential ignition risk - suitable construction standards and design of buildings - suitable management plans for the provision and maintenance of mitigation measures as well as for appropriate emergency response. The key principles for fire prevention and protection listed above will be applied as fire protection and prevention measures during the construction, operation and decommissioning of the project. The project's bushfire management plan will detail the management measures to mitigate impacts on the operation of the project from bushfires.	14 (D; 2)	The bushfire management plan will be reviewed after incidents of bushfire or other fire as well as annually at the end of each bushfire season. The bushfire management plan will be amended after the review process, if required, to increase its effectiveness.
	Impact on aerial firefighting operations from presence of WTGs within the development footprint.	C	3	13	The Australasian Fire and Emergency Services Authorities Council's <i>Wind Farms and Bushfire Operations</i> (AFAC 2018) provides guidance on bushfire response in proximity to wind farms. Spark Renewables will consult with aerial firefighting operators to develop procedures for the safe operation of emergency aircraft in the vicinity of the project.	8 (C; 4)	The bushfire management plan will be reviewed after incidents of bushfire or other fire as well as annually at the end of each bushfire season. The bushfire management plan will be amended after the review process, if required, to increase its effectiveness.

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