APPENDIX L

Land use, soils and erosion assessment

Birriwa Solar and Battery Project

Land Use, Soils and Erosion Assessment

Prepared for ACEN Australia

July 2022

Birriwa Solar and Battery Project

Land Use, Soils and Erosion Assessment

ACEN Australia

J210553 Birriwa Solar and Battery Project - Land, Soils and Erosion

July 2022

Version	Date	Prepared by	Approved by	Comments
V1_draft	24 June 2022	Harry Savage	Michael Frankcombe	
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Executive Summary

ES1 Introduction

ACEN Australia Pty Ltd Ltd (ACEN), formerly known as UPC\AC Renewables Australia (UPC\AC) proposes to develop the Birriwa Solar and Battery Project; a large scale solar photovoltaic (PV) generation electricity facility along with battery storage and associated infrastructure (the project). The solar farm component of the project will have an indicative capacity of up to 600 megawatts (MW) and will include a centralised battery energy storage system (BESS) of up to 600 MW for a 2 hour duration. The BESS will enable energy from solar to be stored and then released during times of demand.

The project is in the localities of Birriwa and Merotherie, approximately 15 kilometres (km) south-west of the township of Dunedoo, in the Central West of New South Wales (NSW) (Figure 1.1). The project is within the Central-West Orana (CWO) Renewable Energy Zone (REZ), and is within the Mid-Western Regional Council local government area (LGA), with part of the access within Warrumbungle Shire Council LGA.

The project is a State significant development (SSD) under the *State Environmental Planning Policy (State and Regional Development) 2011*. Therefore, a development application for the project is required to be submitted under Part 4, Division 4.1 of the *NSW Environmental Planning and Assessment Act 1979* (EP&A Act). This Land Use, Soils and Erosion Assessment (LUSEA) report forms part of the Environmental Impact Statement (EIS).

ES2 Existing conditions

ES2.1 Soils and land capability

The Home Rule (hr) and Rouse (rs) soil landscapes are the most extensive land system present in the site area. It is modelled as host to Sodosol soils. Variation occurs in proximity to Barneys Reef in the presence of the Lees Pinch and Turill soil landscapes, associated with the Tenosol soil type. The erosion hazards discussed for all three soil landscapes highlight:

- erosion hazard is high when surface cover is low or flows are concentrated;
- importance of maintaining surface cover for erosion control;
- soils in drainage depressions are highly susceptible to gully erosion without adequate protection from high runoff; and
- severe gully erosion may occur where the sodic dispersible subsoils in drainage lines and depressions are exposed.

The fertility of all soil landscapes soil types is noted as low, supported by the inherent soil fertility mapping and subsequent low land and soil capability classes.

The soil chemistry results for samples obtained from the study area indicates that some soils present likely have dispersive characteristics that would present a high erosion risk, as indicated by the exchangeable sodium percentage and low Ca:Mg ratio. This is subject to the uncertainty of the low cation exchange capacity of the soils. The erosion risk is consistent with the presence of rilling and gullying within the study area as observed during the site inspection.

Utilising the *Land and Soil Capability Assessment Scheme* (OEH 2012) ('LSC Scheme') state scale mapping completed for NSW shows the study area is Classes 5 and 7, representing land with moderate-low capability to very low capability.

ES2.2 Agriculture

The project is predominantly located within the Mid-Western Regional LGA and has no strategic agricultural land mapped within the study area.

The primary agricultural productivity of the Mudgee Region–West and Mid-Western Regional LGA is livestock products and disposals (including domestic slaughtering and exports).

Indicative $/ha values for selected commodities were calculated utilising land use data from the 2015–16 agricultural census and agricultural productivity data from the *Australian Agricultural Census 2015-16* and Australian bureau of Statistics (ABS).

These indicative values provide a broad indication of land productivity for agricultural land use categories and the relative impacts on agricultural productivity associated with the project and range from $151.55–$262.78/ha for grazing and $311.76–$426.38/ha for cropping.

ES2.3 Erosion hazard

The soil erosion hazard has been assessed as high due to the presence of dispersive of subsoil. The rainfall and slope erosion hazard has been assessed as low where slopes are less than 12% and high where they exceed 12%. Potential impacts include tunnel erosion and severe gully erosion on and offsite, downstream sedimentation and the generation of highly turbid runoff.

The impacts are greatest during the construction phase when soils are disturbed and drainage and landforms are modified. These impacts can extend to the operational phase if drainage and landform designs inappropriate for dispersive soils are adopted, however, the erosion hazard can be minimised to an acceptable level via adoption of appropriate drainage, erosion and sediment control practices.

ES3 Assessment of impacts

A summary of the key potential social impacts and benefits identified are provided in Table ES1. The full assessment of potential impacts is provided in Section 5.

Table ES1 Key potential impacts

Impact/challenge	Mitigated impact
Construction soil impacts	**Low**
The soil disturbance during construction has the potential to result in the following impacts: • reduction in soil stability and increase susceptibility to erosion due to vegetation removal or soil exposure, especially as the subsoil is sodic and dispersive; • erosion of soil due to exposing soils, disturbing dispersive subsoils and concentration of flow; • loss of structure and water holding capacity due to mechanical compaction; • loss or degradation of topsoil material viable for use in rehabilitation; • introduction of salinity or sodicity into the topsoil material if soil is inadequately managed; • risk of exposing buried contaminants (pesticides and hydrocarbons); and • introduction of contaminants into soil material (eg hydrocarbons from plant). Implementing a management strategy that includes the development of a Soil and Water Management Plan (SWMP) that incorporates measures to ensure the preservation of soil resources will mitigate the impacts associated with soil disturbance during construction.	
Operation soil impacts	**Low**
Impacts to soils during operation 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; • tunnel erosion in cable trenches due to inadequately compacted and ameliorated dispersive subsoils; • exposure of dispersive soils in cut and fill batters and excavations; and • splash erosion of solar array footings due to inadequate soil surface cover under the arrays. Implementing a management strategy that includes the development of a Soil and Water Management Plan (SWMP) and project design that considers the limitation of the site's dispersive soils to ensure the preservation of soil resources will mitigate the impacts associated with soil disturbance during operation.	
Impacts to land and soil capability	**Low**
LSC mapping has determined the study area is mapped at the state scale as predominantly LSC Class 5 and minor areas of Class 7, which represent land with moderately-low to low capability for productive use without resulting in land degradation. The lands are currently used for cropping and cattle grazing. It is expected the LSC status of most of the project disturbances will be able to be re-established if the recommended management and mitigation measures are implemented.	

Table ES1 Key potential impacts

Impact/challenge	Mitigated impact
Impacts to agricultural productivity	**Medium**

Based on calculated agricultural values for the Mid-Western Regional LGA and Mudgee Region–West the development of the project would impact agricultural productivity through disturbing;

- the 1,330 ha of the study area, if fully developed, would encompass some 704.6 ha of land used for grazing and 602 ha for cropping, totalling 1,306.6 ha. Were this 1,306.6 ha to be developed (change of use) it would be valued between $363,462.89–$372,834.31 in annual productivity; or
- the 1,138 ha of the development footprint, if fully developed, would encompass some 572.0 ha of land used for grazing and 542.9 ha for cropping, totalling 1,115.0 ha. Were this 1,115.0 ha to be developed (change of use) it would be valued between $318,168.30–$319,564.66 in annual productivity.

Whilst this is a significant loss of agricultural land value based on annual productivity and an assumption of the entire study area being developed and unavailable for intensive agriculture such as cropping, the disruption to productivity will be primarily due to lack of access to the land, as opposed to a reduction of the land capability. Once the project reaches the end of its investment and operational life, the project infrastructure will be decommissioned and the study area returned to its pre-existing land use, namely suitable for grazing of sheep and cattle, or another land use as agreed by the project owner and the landholder at that time.

Additionally, during the project's operation the land could still be utilised for some agricultural practice even where developed, by utilising sheep for grazing which is estimated to achieve 50% of existing stocking rates for 50% of the year.

Construction impacts to erosion and sediment control	**Low**

Potential construction erosion and sediment control impacts include:

- off-site discharge of sediment and turbid run-off from the erosion of exposed soils particularly dispersive subsoils:
  - degradation of stock drinking water;
  - infilling of waterway pools; and
  - diversion of waterway flow due to sediment deposition and associated bed and bank erosion;
- erosion and subsequent sedimentation of creeks and waterways due inappropriately designed and constructed 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 land forms (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 run-off hydrograph due to an increase in impermeable surface such as roads, hardstands, roofs and solar arrays;
- tunnel erosion under or beside foundations for solar arrays, towers, light poles etc and along cable trenches due to dispersive soils; and
- dust emissions from unsealed roads, hardstands and exposed soils.

Implementing a management strategy that includes the development and implementation of suitable drainage, erosion and sediment control management strategies and minimising land disturbance will mitigate identified erosion and sedimentation impacts. Drainage and landform design will need to consider the dispersive subsoils present in the study area.

Table ES1 Key potential impacts

Impact/challenge	Mitigated impact
Operational erosion and sediment control impacts	**Low**
Potential operational erosion and sediment control impacts include: • offsite discharge of sediment and turbid run-off from on-going erosion from drainage, landform and infrastructure design not cognisant of dispersive subsoils; • increased maintenance costs for on-going stabilisation of landforms, roads, drains and cable trenches; • operation and maintenance of sediment control structures due to on-going erosion; • tunnel erosion under or beside foundations for solar arrays, towers, light poles etc and along cable trenches due to dispersive soils; and • dust emissions from unsealed roads, hardstands and exposed soils. Implementing a management strategy that includes the development and implementation of suitable drainage, erosion and sediment control management strategies and minimising land disturbance will mitigate identified erosion and sedimentation impacts. Drainage and landform design will need to consider the dispersive subsoils present in the study area.	

ES4 Evaluation of the project

The project design and situation within the study area to minimise the specific impacts relating to land and soils is limited due to the consistency of the study area in terms of soil type and associated usage, hazards and limitations, such as LSC and erosion hazard.

Cumulative impacts to adjacent land relevant to agriculture are expected to be minimal, with the only potential impact being associated with sediment deposition or erosion from the project, which can be suitably managed. Other impacts to adjacent agriculture are considered in other technical reports completed as part of the EIS, such as the Traffic Impact Assessment (Appendix H of the EIS) and Social Impact Assessment (Appendix O of the EIS).

ES4.1 Soils and land capability

Most of the site footprint is located conceptually on the Sodosol soil types. Sodosols are limited to generally very low agricultural potential with high sodicity leading to high erodibility, poor soil structure and low permeability and issues such as hard-setting topsoils and gully erosion, as evidenced on site. Despite the generally low relief of the study area, the possible risk from construction is very high due to dispersive nature of the subsoils and less-resilient nature of the topsoils. Soil management practices will be key to maintain suitable soil cover, minimise exposure of subsoils and maintain topsoil resources to ensure soil profiles are returned in a similar condition to minimise the exposure of erosion-prone subsoils and maintain soil productivity.

The land and soil capability of agricultural lands in the study area are unlikely to change from their current capability, provided appropriate management and mitigation measures are implemented.

ES4.2 Agriculture

The site suitability with respect to agriculture considers the inherent low LSC class in addition to the extensive amount of land utilised for agriculture within the LGA, of which the project is a very minor area. Project impacts to agriculture are primarily due to the loss of access to the land for usage in intensive cultivation such as cropping or cattle grazing for the duration of the project. These impacts are considered to be low due to the inherently poor land capability of the study area as well as the potential for ongoing agricultural practices, such as sheep grazing which is estimated to achieve 50% of existing stocking rates for 50% of the year.

Impacts to the inherent capability of the land and subsequent agriculture after project completion should be minimal if mitigation measures are utilised.

ES4.3 Erosion

The soil erosion hazard has been assessed as high due to the presence of dispersive of subsoil. The rainfall and slope erosion hazard has been assessed as low where slopes are less than 12% and high where they exceed 12%. Potential impacts include tunnel erosion and severe gully erosion on and offsite, downstream sedimentation and the generation of highly turbid runoff.

The impacts are greatest during the construction phase when soils are disturbed and drainage and landforms are modified. These impacts can extend to the operational phase if drainage and landforms design inappropriate for dispersive soils are adopted, however, the erosion hazard can be minimised to an acceptable level via adoption of appropriate drainage, erosion and sediment control practices that where possible, minimises concentration of flow, maintains or reinstates soil surface cover and minimises disturbance to dispersive subsoils.

Glossary

Item	Definition
ABS	Australian Bureau of Statistics
AC	Alternating current
ASC	The Australian Soil Classification scheme
Associated residents	Property owners within or near the study area, which ACEN has entered into access licence and option agreements with (landholder agreements) allowing it to lease the land for the construction, operation and decommissioning of the project
BESS	Battery energy storage system
BSAL	Biophysical Strategic Agricultural Land
CWO	Central-West Orana
CEMP	Construction Environment Management Plan
cm	Centimetre
CTMP	Construction Traffic Management Plan
CWMP	Construction Workforce Management Plan
DC	Direct current
Disturbance footprint	Land that would be disturbed for the construction and operation of the project, including access routes and transmission connections.
DPI	Department of Primary Industries
DPE	Department of Planning and Environment (formerly Department of Planning, Industry and Environment)
EIS	Environmental Impact Statement
EMM	EMM Consulting Pty Limited
EnergyCo	Energy Corporation of NSW
Environmental exclusion zones	Areas of higher environmental values within the study area excluded from the development footprint.
EPA	NSW Environment Protection Authority (EPA)
EP&A Act	NSW *Environmental Planning and Assessment Act 1979*
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
ESC	Erosion and sediment control
ESP	Exchangeable sodium percentage
ha	hectares
km	kilometre
kV	Kilovolt
LEP	Local Environmental Plan
LGA	Local government area
LSC	Land and soil capability

Item	Definition
MNES	Matters of national environmental significance
MW	Megawatts
Non-associated residences	Residences near the study area that are not the subject of an access licence and option agreement (landholder agreement).
NSW	New South Wales
PCT	Plant community type
PMST	Commonwealth Protected Matters Search Tool
PV	Photovoltaic
REZ	Renewable Energy Zone
SEARs	Secretary's Environmental Assessment Requirements
SIA	Social impact assessment
SRD SEPP	*State Environmental Planning Policy (State and Regional Development) 2011*
SSD	State significant development
Study area	The boundary of the project, which encompasses all operational components of the project where ACEN hold landholder agreements.
T-Link	Transmission link - NSW Energy Corporation's planned new 500/330kV transmission line, substation(s) and related infrastructure within the CWO REZ
TEC	Threatened ecological communities
The project	Birriwa Solar and Battery Project; a large scale solar photovoltaic generation facility along with battery storage and associated infrastructure. 'The project' refers to the project in its entirety; encompassing arrays of PV modules, power conversion units, BESS, connection infrastructure, road upgrades and ancillary infrastructure.
ACEN	ACEN Australia Pty Ltd – formally known as UPC\AC Renewables Pty Ltd

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1.1 Overview

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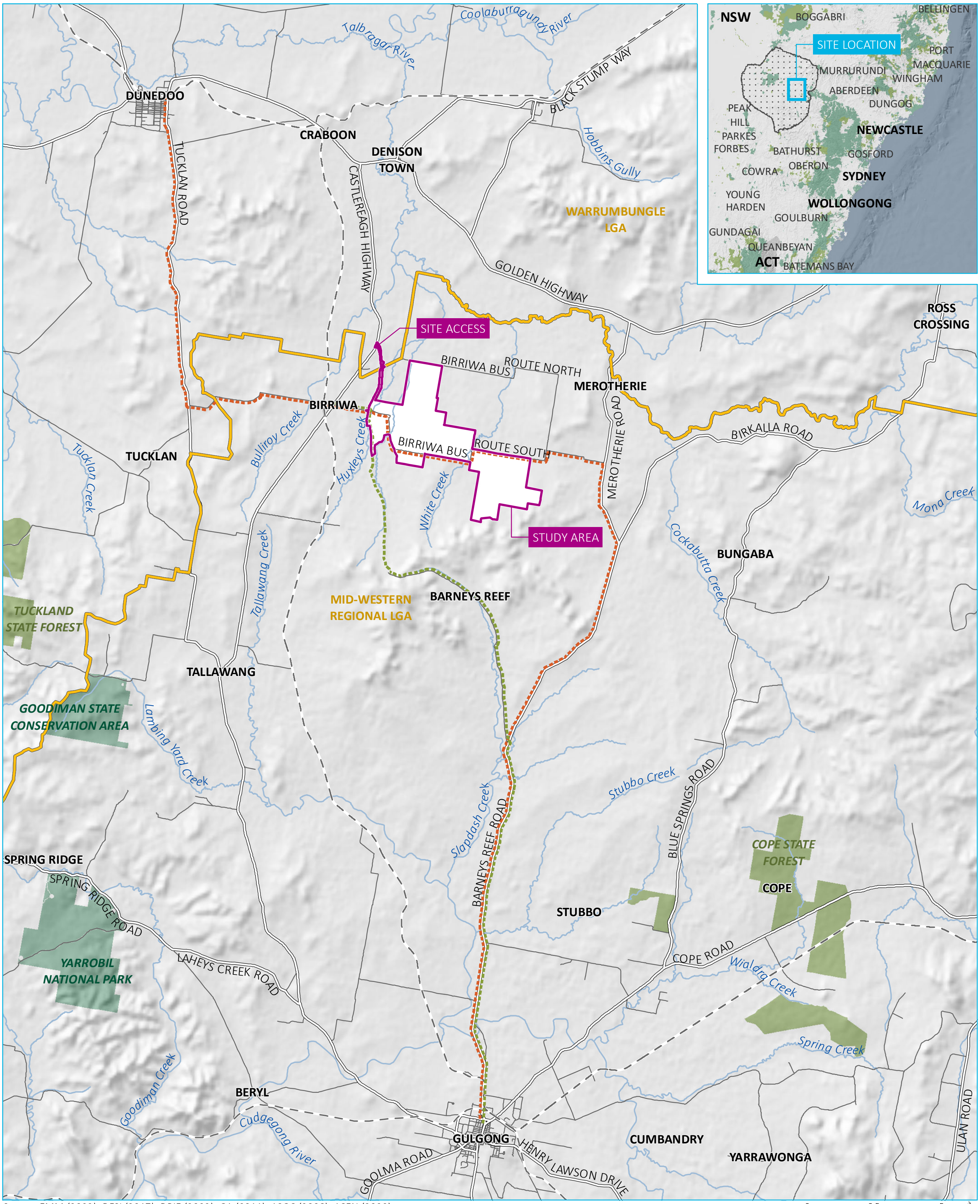

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Source: EMM (2022); DFSI (2017); DPIE (2022); GA (2011); ASGC (2006); ACEN (2022)

0 2.5 5 km
GDA 1994 MGA Zone 55
N

KEY

- Study area

Existing environment

- Rail line
- Major road
- Minor road
- Named watercourse
- Local government area
- Central West Orana Renewable Energy Zone (see inset)
- NPWS reserve
- State forest

Central West Cycle (CWC) Trail

- CWC main route - Gulgong to Dunedoo
- CWC alternate route - Slap Dash Creek side trail

Regional context

Birriwa Solar and Battery Project
LUSE Assessment Report
Figure 1.1

EMM
creating opportunities

1.2 Assessment approach and requirements

This LUSEA report supports the EIS for the project. It 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 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); and
- identify appropriate mitigation and management measures for the project.

This report is comprised of the following sections:

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

1.2.1 Secretary's Environmental Assessment Requirements

This LUSEA has been prepared in accordance with requirements of the NSW Department of Planning and Environment (DPE) which were set out in the Planning Secretary's Environmental Assessment Requirements (SEARs) for the project, issued on 5 November 2021. The SEARs identify matters which must be addressed in the EIS and essentially form its terms of reference. Table 1.1 lists individual requirements relevant to this LUSEA and where they are addressed in this report.

Table 1.1 LUSEA 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 8, EIS Section 2.2
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 3.4.5, 3.7 Soil characteristics described in Sections 3.4.8 Cumulative impact assessment detailed in EIS Section 6.14
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 *Land Use Conflict Risk Assessment Guide*; and • assessment of impact on agricultural resources and agricultural production on the site and region.	Land zoning considered in Section 3.5 and EIS Section 2.3 LUCRA completed in Section 5.3 Agricultural impact assessment in Section 5.1.4

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

1.2.2 DPE Draft Large-Scale Solar Energy Guidelines

DPE (formerly as the Department of Planning, Industry and Environment (DPIE)) released its *Draft Large-Scale Solar Energy Guideline* (DPIE 2021a) (Solar Guideline) for public exhibition in late 2021/early 2022. Once the Solar Guideline is finalised, an applicant of an SSD large-scale solar energy project must consider the Solar Guideline and prepare its EIS in accordance with the technical guidance. This applies to all applications where the SEARs are issued after the publication of the Solar Guideline. As the SEARs for this project were issued prior to the publication of the Solar Guideline, they are not applicable. However, the requirements of the Solar Guideline have been taken into consideration during the preparation of this LUSEA.

The Solar Guideline contains assessment requirements relating to agriculture, land and soils for solar energy projects. In particular, there is a section on Agriculture Impact Assessment Requirements in Appendix B, which is driven by the process identified in a flowchart replicated in Figure 1.2. The initial step involves an assessment of the land zoning, with assessment required where projects are located on rural zoned lands under the relevant Environmental Planning Instrument (EPI). Subsequently, assessment of the agricultural capability of the study area, utilising land and soil capability (LSC), biophysical strategic agricultural land (BSAL) or critical industry clusters (CICs), is required, with a soil survey required if the:

- subject land is mapped as LSC Class 1-4, BSAL or as a CIC; or
- immediately adjacent land is mapped as LSC Class 1-3, BSAL or as a CIC.

Neither of these conditions are relevant to the study area (refer Figure 3.4) and therefore a soil survey is not required under the Solar Guideline. Utilising the Appendix B assessment flowchart (Figure 1.2) only a Level 1 – Basic Assessment of project impacts to agricultural land would be required.

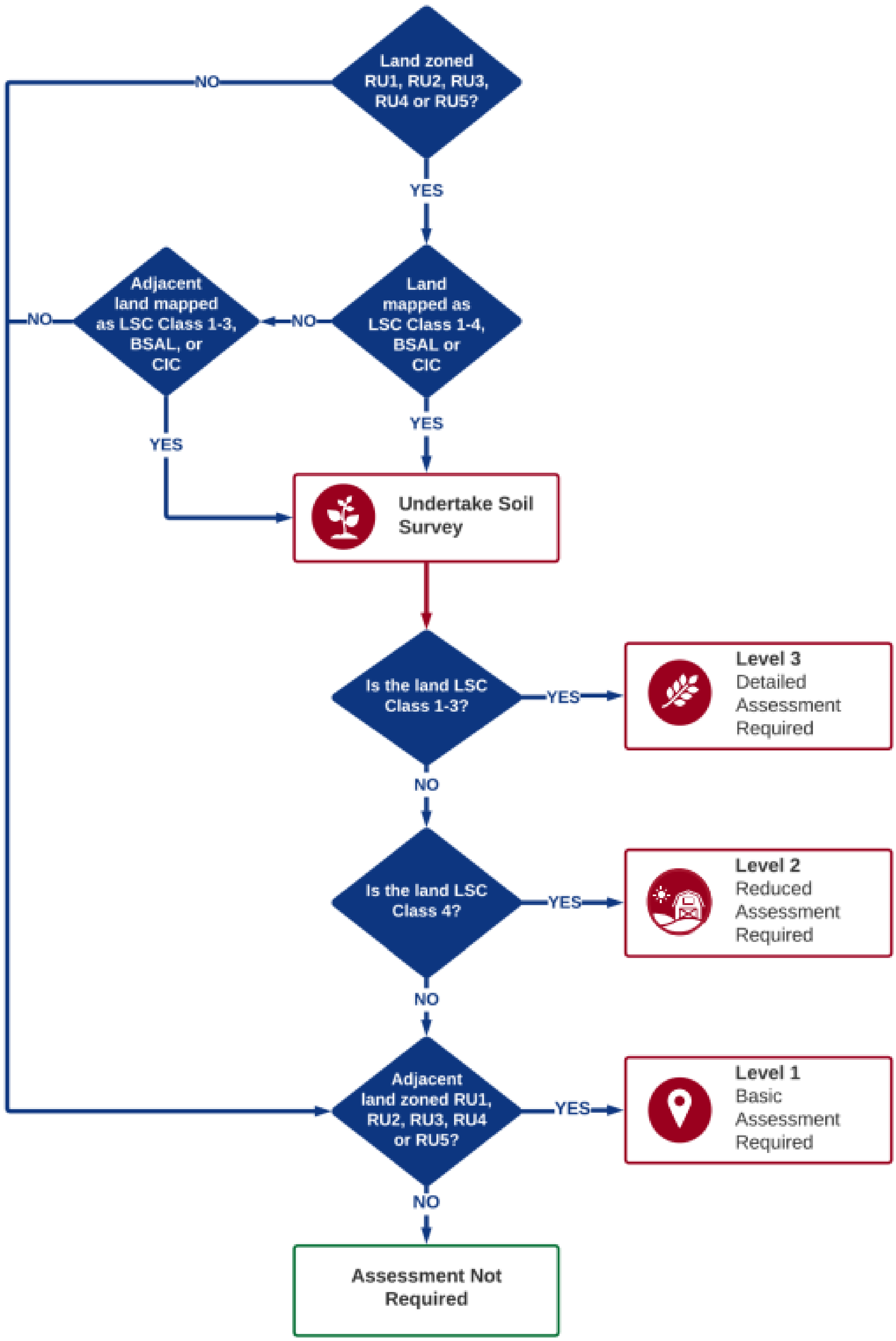


Figure 1.2 DPIE (2021a) draft solar guideline Appendix B assessment flowchart

2 Project description and setting

2.1 Project description

A full project description is provided in Chapter 3 of the EIS. The project will comprise the following key components:

- a network of approximately 1 to 1.4 million solar panels and associated mounting infrastructure;
- a BESS with a capacity of up to 600 MW and a storage duration of 2 hours;
- an onsite substation with a capacity of up to 500/330 kilovolt (kV);
- electrical collection and conversion systems, including inverter and transformer units, switchyard and control room;
- underground and aboveground cables;
- an operational infrastructure area, including demountable offices, amenities and equipment sheds;
- parking and internal access roads;
- a temporary construction compound (during construction and decommissioning only); and
- upgrade of the site access route from the Castlereagh Highway into the development footprint (Barneys Reef Road and part of Birriwa Bus Route South).

The study area, impact footprint and operational infrastructure areas are shown on Figure 2.1.

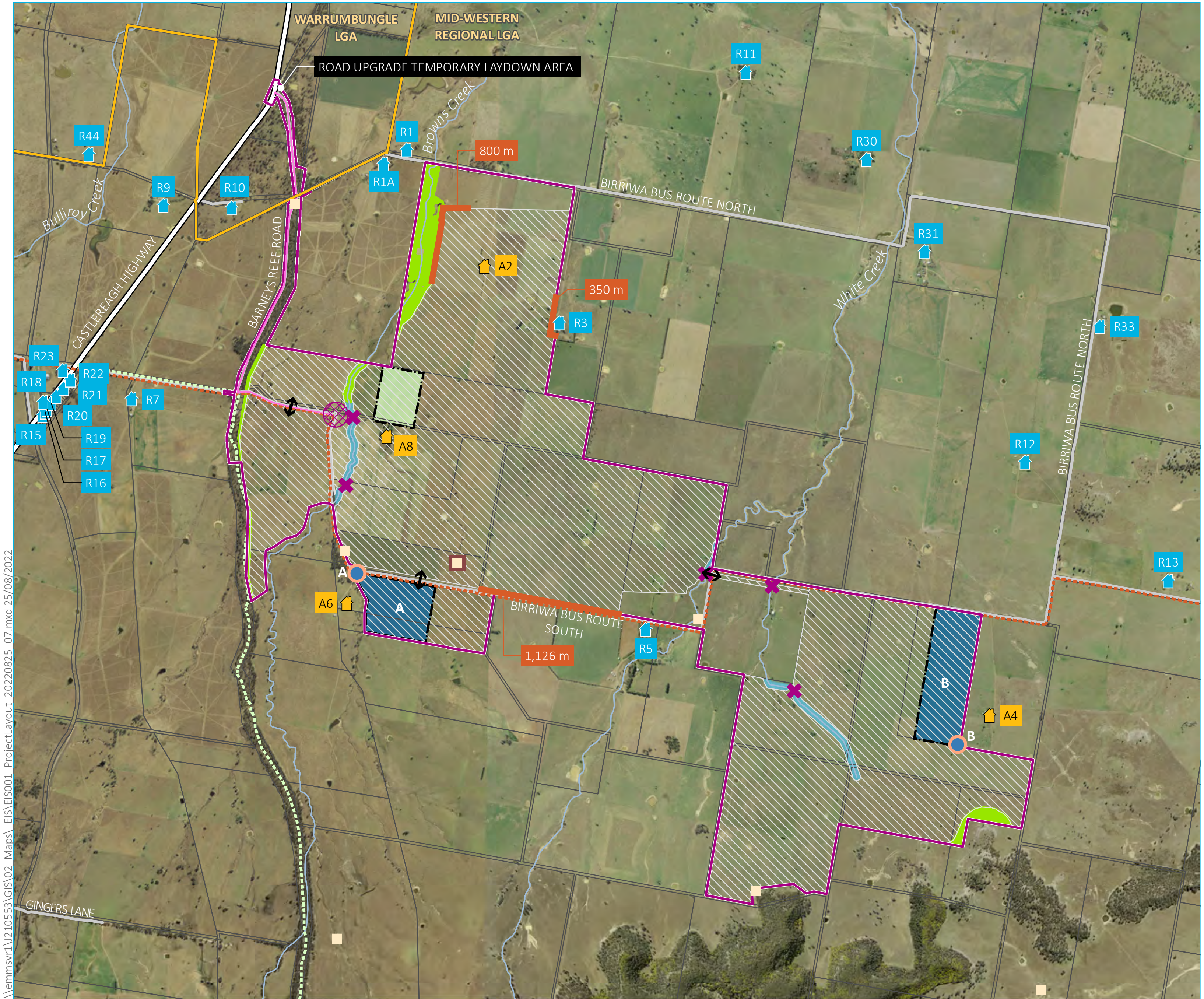
The project will connect to the proposed CWO REZ Merotherie Energy Hub. Details of the connection to the proposed Energy Hub are still being discussed with EnergyCo and are described further in Chapter 1 of the EIS.

2.2 The study area

The project will be developed within a study area of approximately 1,300 hectares (ha) and is comprised of 18 freehold land parcels (Figure 2.1). The properties within the study area are currently primarily used for sheep and cattle grazing as well as low intensity dry land cropping. There are four associated residences within close proximity to the study area (A2, A4, A6 and A8). There are 21 non-associated residences within 2 km of the study area, many of them in the township of Birriwa, and another 22 between 2 km and 5 km away (Figure 2.1).

The development footprint is the land within the study area that will be used for the operation of the project, which excludes certain areas of environmental or social constraint (Figure 2.1). The development footprint has been refined through an iterative design process throughout the preparation of the EIS and has been informed by the outcomes of community and stakeholder engagement and environmental, social and economic assessments.

The study area will be accessed via the Castlereagh Highway, Barneys Reef Road and Birriwa Bus Route South (Figure 2.1). From the project access point, private internal roads will be used to traverse the development footprint. A section of Barneys Reef Road and Birriwa Bus Route South will require upgrades to provide safe access to the development footprint during construction of the project.



KEY

- Study area

Impact footprint

- Development footprint
- Road upgrade corridor
- Restricted development area
- Potential public road crossing location

Project layout

- Potential creek crossing point (refer to inset below for indicative design)
- Proposed access point to the project
- Connection point (option A or B)
- Proposed operational infrastructure area including substation, operational facility and BESS (option A or B)
- Temporary construction compound
- Landscape screen planting

Existing environment

- Dwelling not associated with the project
- Dwelling associated with the project
- Aboriginal heritage site (to be salvaged)
- Aboriginal heritage site (to be avoided)
- Vegetation to be retained
- Major road
- Minor road
- Watercourse
- Cadastral boundary
- Local government area boundary

Central West Cycle (CWC) Trail

- CWC main route - Gulgong to Dunedoo
- CWC alternate route - Slap Dash Creek side trail

Source: EMM (2022); DFSI (2017, 2022); GA (2011); ACEN (2022)

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Project overview

Birriwa Solar and Battery Project
LUSE Assessment Report
Figure 2.1

EMM creating opportunities

3 Existing environment

3.1 Climate

Climate and rainfall data have been obtained from the Bureau of Meteorology (BoM) Dunedoo Post Office Station (No. 064009), where monitoring commenced in 1912. The study area has a warm temperate climate and is characterised by warm and persistently drier summers and cool and damp winters.

Long-term mean maximum and minimum annual temperature are 24.1°C and 9.7°C respectively, average annual rainfall is 613 mm/year and annual average pan evaporation rates between 1,600–1,800 millimetres per year (mm/year). Average monthly 9.00 am windspeeds range between 8.0–15.4 kilometres per hour (km/hr), being highest in January and lowest in July (BoM 2021a; BoM 2021b).

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

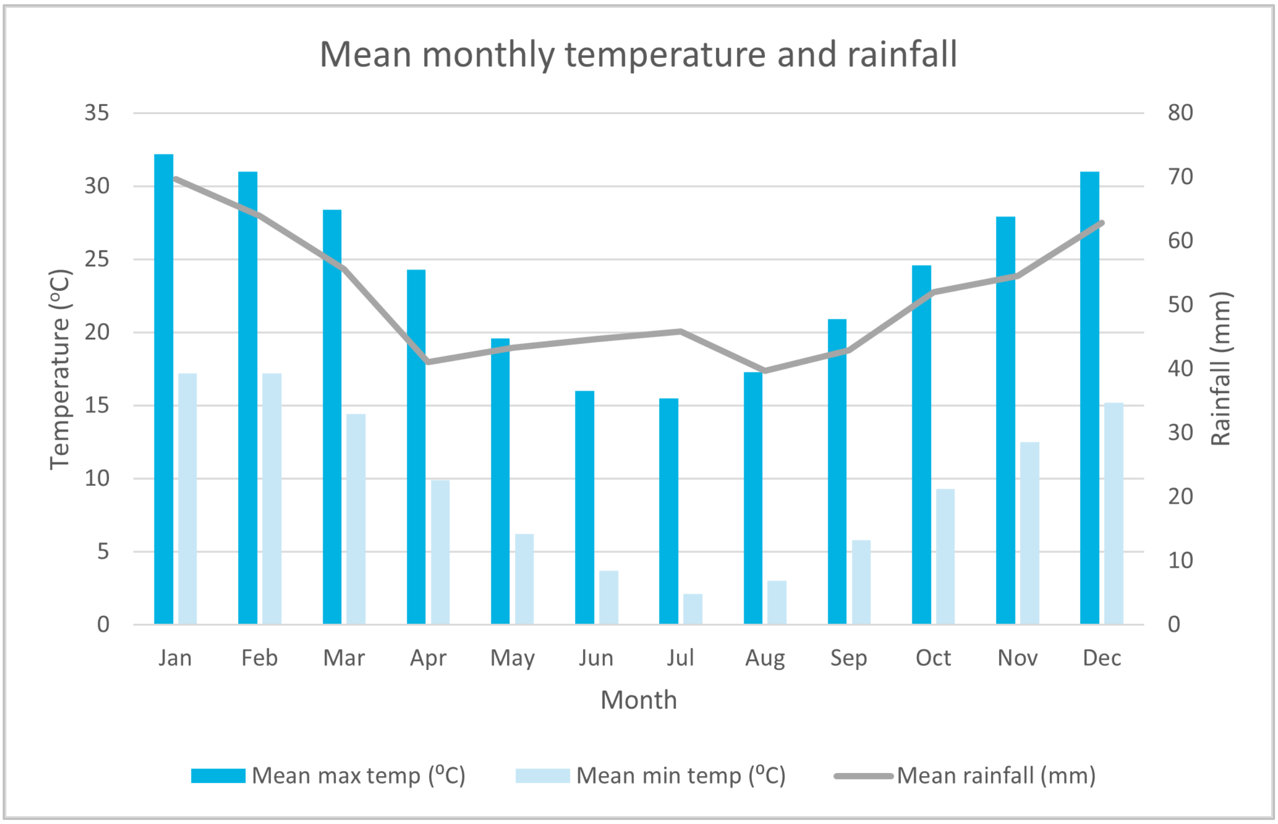


Figure 3.1 Mean monthly rainfall and mean wind speed (BoM 2021a)

3.2 Topography

The study area has relatively consistent relief, being predominantly plains in the north of the study area transitioning to rises in the central to southern area, with rising elevation to the hills of Barneys Reef just south of the study area, shown in Figure 3.2.

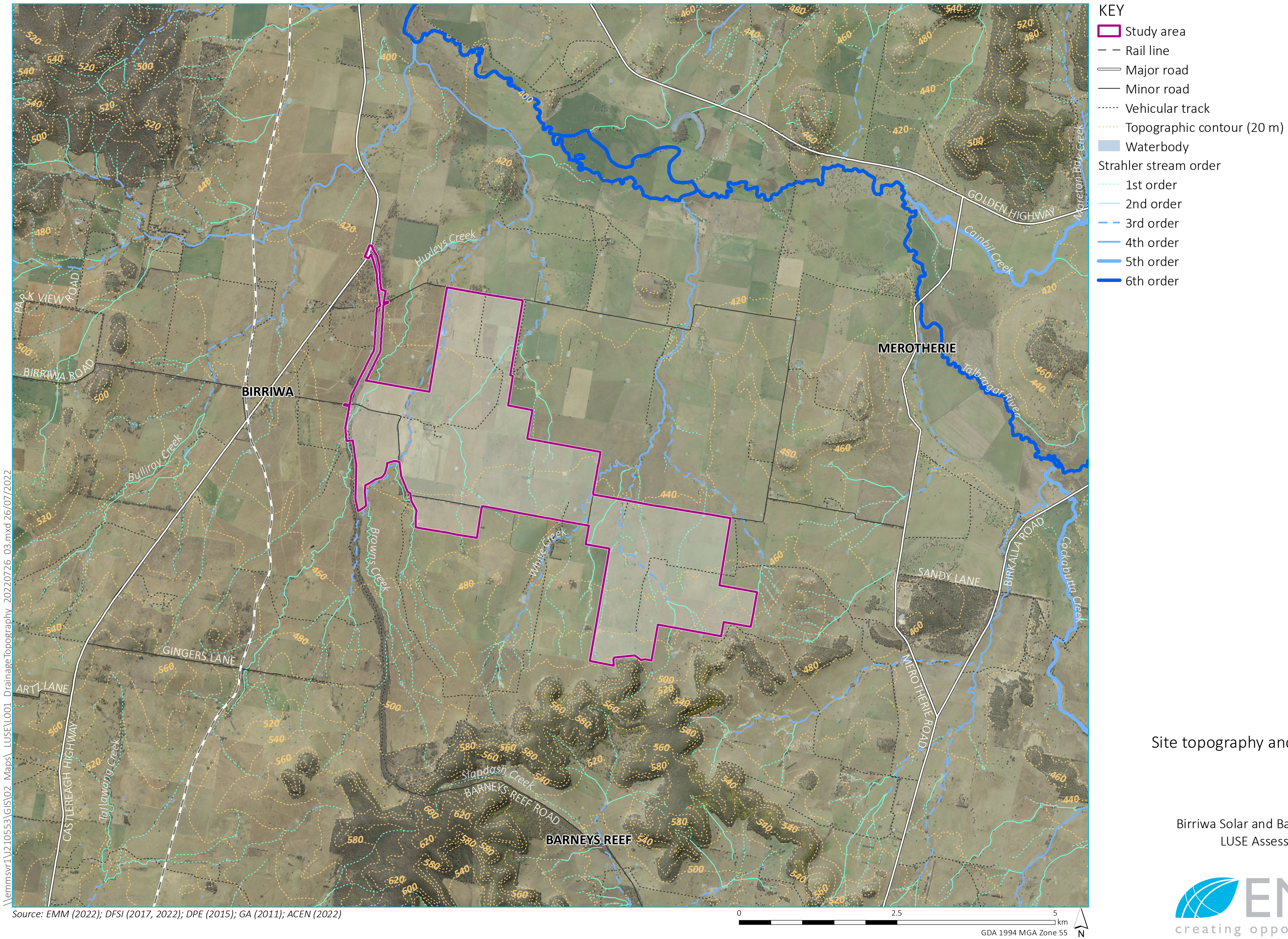
The central area is subdivided into an eastern and western area by White Creek running north-northeast, with a small associated ridge to the west of the Creek which falls away to the north from heights of around 480 meters (m) relative to Australian Height Datum (AHD). On the east of White Creek, the southern study area slopes consistently to the north at about 4% slope from a high of 500 mAHd at the base of Barneys Reef before levelling into gentler plains at 460 m AHD to 440 mAHD in the north. To the west of White Creek, the land slopes generally north-west at around 4% slope from the small ridge towards Browns Creek and level plains between Browns Creek and Huxleys Creek on the western boundary of the study area (NSW SS 2017a, NSW SS 2017b, NSW SS 2017c).

Spatial analysis of the study area slopes is detailed in Section 4.1.1i.

3.3 Surface water

The location of the proposed development falls within the Macquarie-Bogan River catchment. Three local waterways, Huxleys Creek, Browns Creek and White Creek, traverse the study area, flowing in a northerly direction into the Talbragar River. These waterways are identified as third order streams (with first and second order tributaries). All the three named tributaries flowing through the study area, and the Talbragar River, being specified as uncontrolled and outside water drinking catchments (Alluvium 2022a).

The moderately sloping nature of the catchment has resulted in relatively shallow flood depths across the site with deeper, faster moving flows in the creeks and narrow floodplain. In the majority of modelled flooding events, the flood depth in the major flow paths is generally over 1.0 m deep, with overland flow paths typically less than 0.25 m. There are pockets of trapped ponding distributed across the site, but these are associated with the existing farm dams (Alluvium 2022b).



Source: EMM (2022); DFSI (2017, 2022); DPE (2015); GA (2011); ACEN (2022)

Site topography and drainage

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Figure 3.2

EMM creating opportunities

3.4 Soils

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

- NSW Soil and Land Information System (SALIS) (DPIE 2021b), accessed through eSPADE (DPIE 2020a);
- *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); and
- *Soil Landscapes of Central and Eastern NSW* (DPIE 2020d).

3.4.1 Australian Soil Classification

The Australian Soil Classification scheme ('ASC', Isbell & NCST 2021) is a multi-category scheme with soil classes 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 site encompasses two soil orders; Sodosols and Tenosols (Figure 3.3), described in Table 3.1.

Of the soil classifications identified, the Sodosols have the highest erosion risk (particularly gully and tunnel erosion) and also the highest risk of generating turbid runoff. The soil chemistry of the site-specific soils discussed in Section 3.4.8. The Tenosol soil types, as poorly developed profiles, typically have lower constraints though they are often sandy with weak structure and therefore can be highly susceptible to erosion from concentrated flows.

Table 3.1 Summary of regional ASC soil mapping

Soil Type	ASC description [1]	Agricultural potential [2]
Sodosols (SO)	• Soils with strong texture contrast between A and sodic B horizons which are not strongly acid. • Soils other than Hydrosols with: – a clear or abrupt textural B horizon and 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 sodic and not strongly acid; and – soils with strongly sub-plastic upper B2t horizons are excluded.	• Typically have very low agricultural potential with high sodicity leading to high erodibility, poor structure and low permeability. • Subsoils are often dispersive and prone to gully and tunnel erosion. • Often hard- setting when dry and prone to crust formation. • Low to moderate chemical fertility and can be associated with soil salinity.
Tenosols (TE)	• Soils with generally only weak pedologic organisation apart from A horizons. • Excludes soils that have deep sandy profiles with a field texture of sand, loamy sand or clayey sand in 80% or more of the upper 1.0 m. • Typically very sandy with the surface soils often naturally acidic.	• Generally low or very low agricultural potential. • Typically very sandy with low chemical fertility, water holding capacity and structure. • Alluvial soils are often deep, fertile and have high agricultural potential.

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

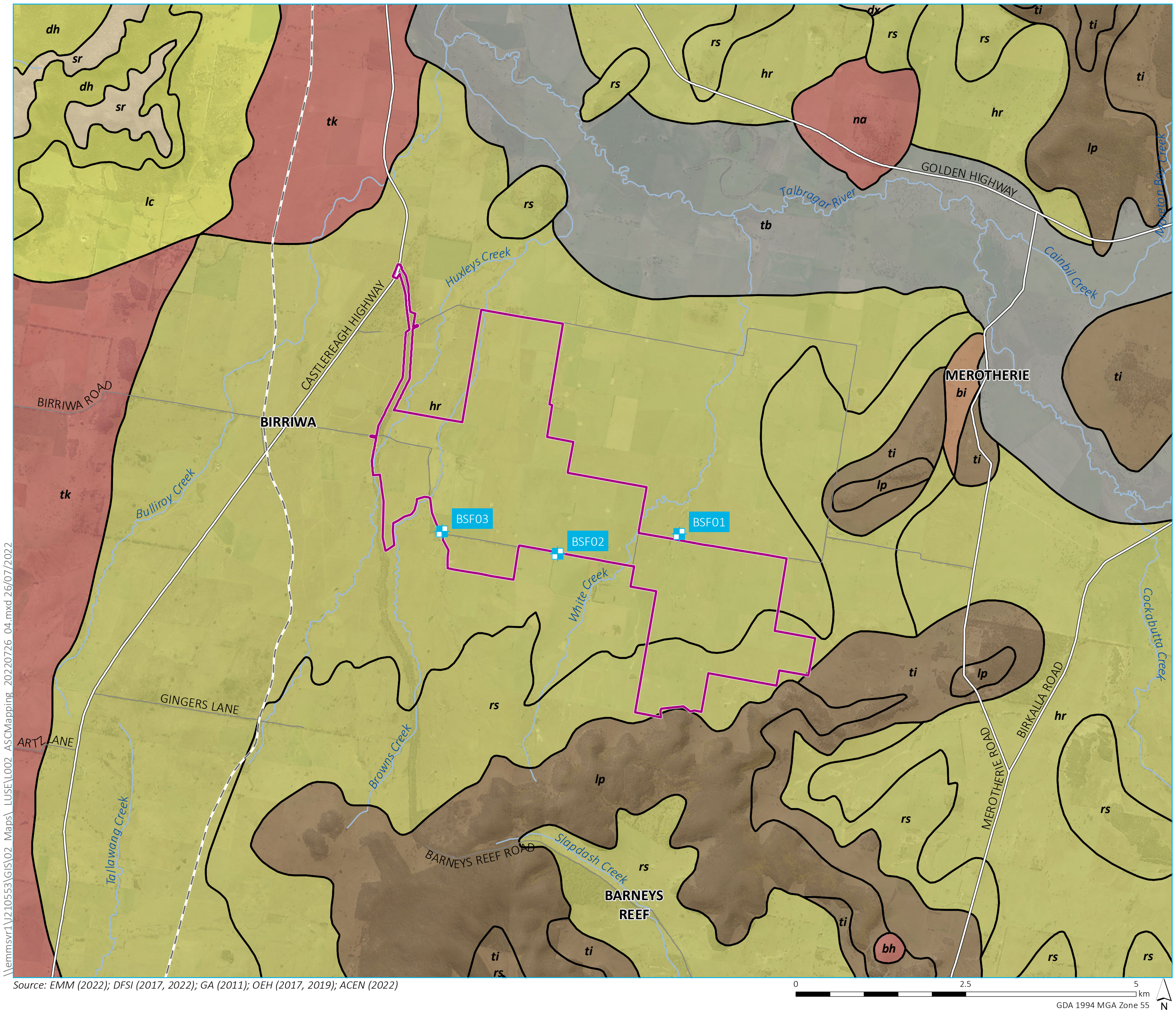
3.4.2 Great soil groups

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 study area are displayed in Table 3.2 with their corresponding ASC equivalents and associated soil landscapes and land resource areas.

Table 3.2 Regional soil mapping – great soil groups

Great soil groups	ASC equivalent	Soil landscape
Solodic soils (SC)	Sodosols	Home Rule (hr), Rouse (rs)
Earth sands (ES)	Tenosols	Lees Pinch (lp), Turill (ti)



Modelled ASC mapping

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Figure 3.3

creating opportunities

3.4.3 Soil landscapes

Soil Landscapes of Central and Eastern NSW mapping (DPIE 2020d) is a compilation of 40 soil landscape maps based on 1:100,000 and 1:250,000 topographic sheets, providing inventory of soil and landscape properties of the areas and identifying major soil and landscape qualities and constraints. Soil and topographic features are integrated into single units with relatively uniform land management requirements. The site is located on the Soil Landscapes of the Dubbo 1:250,000 Sheet (Murphy and Lawrie 2010).

The study area is predominantly located on the Home Rule soil landscape with areas of the Rouse soil landscape associated with the eastern and southern study area. Very small areas of the Lees Pinch and Turill soil landscapes are associated with proximity to Barneys Reef in the very southern study area. Soil landscapes are described in Table 3.3 with their dominant soil materials described in Table 3.4.

Table 3.3 Study area soil landscapes

Soil landscape	Landscape	Soils	Vegetation and land use	Limitations and degradation
Home Rule (hr)	604 km^2 rolling hills and low hills with steep rocky slopes and valley sides. Narrabeen sandstone, conglomerate sandstone, shale, conglomerate, mudstone, chert, coal and torbanite seams. Relief 60–240 m; slopes 15– 40%.	Shallow, sandy soils (Uc4.1; Uc1.43; Uc1; Uc2.21) with extensive rock outcrop, boulder debris slopes and sandstone cliffs. Other soils include grey or Yellow Earths (Gn2.84) and Yellow Podzolic Soils (Dy4.51) on lower slopes, shallow acid loams (Um5.51) on coal bearing strata, and Podzols (Uc2.22) on lower slopes.	A scribbly gum (*Eucalyptus haemastoma*) – narrow leaved stringybark (*Eucalyptus sparsifolia*) community is common. Land use includes native forest, timber, light grazing on native pastures.	Steep slopes; rock cliffs; very low fertility; very low waterholding capacity; high permeability. Existing minor sheet erosion; acid surface soils.
Rouse (rs)	335 km^2 undulating hills and low hills with granite outcropping as tors and sloping pavements. Gulgong Granite, biotite granite, adamellite, granodiorite. Relief 50– 90 m; slopes 5– 15% and 500– 1,000 m long.	Mainly shallow Siliceous Sands (Uc1.42) and Earthy Sands (Uc4.21) on mid-slopes and upper slopes. Yellow Soloths (Dy3.41) and yellow Solodic Soils (Dy3.43, Dy3.32) on lower slopes and in depressions. Deeper A2 horizons on lower slopes adjacent to main drainage lines. Other soils include bleached sands (Uc2.21), and Non-calcic Brown Soils and Red Earths on small areas of less siliceous rock.	Blakely's red gum (*Eucalyptus blakelyi*) – narrow-leaved red ironbark (*Eucalyptus crebra*) woodland community. Land use includes grazing on improved and native/volunteer pasture; some areas of cropping.	Very low fertility; acidic surface soils; low available waterholding capacity; seasonal waterlogging; sodic subsoils on lower slopes; high to very high erosion hazard under cultivation. Existing minor sheet and gully erosion, some areas of severe gully erosion.
Lees Pinch (lp)	604 km^2 rolling hills and low hills with steep rocky slopes and valley sides. Narrabeen sandstone, conglomerate sandstone, shale, conglomerate, mudstone, chert, coal and torbanite seams. Relief 60–240 m; slopes 15–40%.	Shallow, sandy soils (Uc4.1; Uc1.43; Uc1; Uc2.21) with extensive rock outcrop, boulder debris slopes and sandstone cliffs. Other soils include grey or Yellow Earths (Gn2.84) and Yellow Podzolic Soils (Dy4.51) on lower slopes, shallow acid loams (Um5.51) on coalbearing strata, and Podzols (Uc2.22) on lower slopes.	A scribbly gum (*Eucalyptus haemastoma*) – narrow leaved stringybark (*Eucalyptus sparsifolia*) community is common. Land use includes native forest, timber, light grazing on native pastures.	Steep slopes; rock cliffs; very low fertility; very low waterholding capacity; high permeability. Existing minor sheet erosion; acid surface soils

Table 3.3 Study area soil landscapes

Soil landscape	Landscape	Soils	Vegetation and land use	Limitations and degradation
Turill (ti)	317 km^2 undulating low hills with some sandstone outcrop. Narrabeen Sandstone, mudstone, and Jurassic shale and sandstone. Relief to 30–90 m; slopes 5–20%.	Yellow and brown Earthy Sands (Uc5.11; Uc5.2) and Siliceous Sands (Uc4.2; Uc1.21) on upper and midslopes. Red Podzolic Soils (Dr3.21) on lower slopes and flats. Yellow and Grey Podzolic Soils (Dy3.21; Dy3.21; Dy3.81) along larger drainage lines. Grey duplex soils (grey Solodic Soils) (Dg1.33) were observed in isolated swampy areas. Lateritic-type soils form ridges with gravelly Red Earths near junction with Goonoo (gn) Soil Landscape.	Dry sclerophyll woodland dominated by broad-leaved ironbark (*Eucalyptus fibrosa*), red ironbark (*Eucalyptus sideroxylon*) and narrow-leaved ironbark (*Eucalyptus crebra*). Groups or individuals of spotted iron gum (*Corymbia citriodora*) and kurrajong (*Brachychiton populneus*) grow on more fertile soils. Land use is grazing on native/volunteer pastures; some areas of improved pasture; uncleared native forest.	Low fertility and waterholding capacity; high to very erosion hazard under cultivation; some steep slopes. Salinity common on lower slopes and in depressions.Existing minor to moderate sheet erosion on the slopes, with minor gully erosion in drainage lines. Gully erosion can be severe in Soloths.

Table 3.4 Soil landscape – Soils

Soil	ASC description [1]	Limitations
Home rule (hr)		
Siliceous Sands	**Topsoil:** Loose brown to dark brown loamy sand; small angular stones of quartz and felspar; pH 6.0; to 10–35 centimetre (cm) depth. Clear change to– **Subsoil:** Bright brown to reddish-brown, loose clayey sand; small stones of quartz and orthoclase felspar; pH 7.0.	**Erosion hazard:** Erosion hazard is high when surface cover is low or flows are concentrated. Erosion control requires maintaining surface cover to minimise runoff and may require the construction of strategic earthworks in flow lines. Soils in drainage depressions are highly susceptible to gully erosion without adequate protection from high runoff. **Salinisation:** Low levels of soil salinity are apparent and common across the landscape. Landform elements affected include drainage lines, depressions, footslopes, lower slopes and more rarely, mid and upper slopes. **Foundation hazard:** Very sandy soils and loose sand of low wet bearing strength are limitations to foundations. Areas of salinity will affect foundations. **Landscape limitations:** The slopes are sufficient to be a moderate to high erosion hazard when surface cover is low. Soils on mid to upper slopes tend to be sandy and very permeable, while those in depressions have dense
Earthy Sands	**Topsoil:** Loose brown to dark brown loamy sand; small angular stones of quartz and felspar; pH 6.0; to 10–35 cm depth. Clear change to– **Subsoil:** Bright brown to reddish-brown, loose clayey sand; small stones of quartz and orthoclase felspar; pH 7.0.	
Yellow Solodic Soils/ Soloths	**Topsoil:** Hard-setting brown to dull yellowish-orange to dull yellowish-brown, massive sandy loam to fine sandy loam; pH 6.0–8.5; to 40 cm depth. **Subsoil:** Mottled dull yellowish-orange to bright yellowish-brown sandy clay; moderate structure, coarse columnar; pH 6.0–8.5; to 150 cm depth.	

Table 3.4 Soil landscape – Soils

Soil	ASC description [1]	Limitations
Bleached Sands	**Topsoil:** A1 horizon. Dark brown to dull brown sandy loam or loamy sand; weakly structured to single-grained. Clear boundary to– A2 horizon. Pale brown to bleached sandy loam or loamy sand, single-grained or massive. Sharp boundary to– **Subsoil:** B21 horizon. Yellowish-brown loamy sand to sandy loam with grey mottles; coherent and weakly structured; extends to 100 cm; cemented pans may be present.	sodic subsoils with very low permeability causing perched watertables in winter.
Rouse (rs)		
Siliceous Sands	**Topsoil:** Dark brown to brown loamy sand to clayey sand; very weak structure to massive single-grained; pH 6.0; extending to 20 cm depth. Clear change to— **Subsoil:** Bright brown to reddish-brown loamy sand to light sandy clay loam; massive and coherent; pH 6.0–8.0; extending to 50 cm depth. Gradual change to weathered granite or yellowish-brown, loamy sand to light sandy clay loam.	**Erosion hazard:** Erosion hazard is high under cropping and when surface cover is low or flows are concentrated. Erosion control requires soil conservation earthworks and/or the adoption of conservation farming practices. Soils in drainage depressions are highly susceptible to gully erosion without adequate protection from high runoff. Severe gully erosion may occur where the sodic dispersible subsoils in drainage lines and depressions are exposed. **Salinisation:** Low levels of soil salinity are apparent and common across the landscape. Landform elements affected include drainage lines, depressions, footslopes, lower slopes and more rarely, mid and upper slopes. **Foundation hazard:** Very sandy soils and loose sands of low wet bearing strength are limitations to foundations. Areas of salinity will affect foundations. **Landscape limitations:** The slopes are sufficient to be a moderate to high erosion hazard when surface cover is low. Soils on mid to upper slopes tend to be sandy and very permeable. Those in depressions have dense, sodic subsoils with very low permeability and cause perched watertables in winter.
Yellow Solodic Soils/ Solonths	**Topsoil:** A1 horizon. Hardsetting, brown to dull yellowish-orange to yellowish-brown coarse sandy loam; weakly structured; pH 6.5– 8.5; extending to 10–20 cm depth. A2 horizon. Massive pale, dull yellowish-brown sandy loam; extending to 20 to 30 cm depth. Clear change to– **Subsoil:** Yellowish-brown to dull yellowish-orange to bright yellowish-brown sandy clay loam; moderate coarse prismatic to columnar structure; pH 6.0–8.5.	

Table 3.4 Soil landscape – Soils

Soil	ASC description [1]	Limitations
Lees Pinch (lp)		
Shallow Siliceous Sands	**Topsoil:** Organically stained loamy sand; single-grained; pH 6.5; to 10–15 cm depth. Gradual change to– **Subsoil:** Grey clayey sand; single-grained; pH 5.5. Clear change to weathered sandstone at 15 to 50 cm.	**Erosion hazard:** Erosion hazard is high when surface cover is low or flows are concentrated. Erosion control requires maintaining surface cover to minimise runoff and may require the construction of strategic earthworks in flow lines. Soils in drainage depressions are highly susceptible to gully erosion without adequate protection from high runoff. **Salinisation:** Low levels of soil salinity are apparent and common across the landscape. Landform elements affected include drainage lines, depressions, footslopes, lower slopes and more rarely, mid and upper slopes. **Foundation hazard:** Very sandy soils and loose sand of low wet bearing strength are limitations to foundations. Areas of salinity will affect foundations. **Landscape limitations:** The slopes are sufficient to be a moderate to high erosion hazard when surface cover is low. Soils on mid to upper slopes tend to be sandy and very permeable, while those in depressions have dense sodic subsoils with very low permeability causing perched watertables in winter.
Shallow Acid Soils	**Topsoil:** A1 horizon. Gravelly, greyish-yellow brown fine sandy clay loam; weak structure; 10–20% stratified angular stones; pH 5.5; to 15 cm depth. **Subsoil:** Nil – oxidised coal parent material.	
Yellow Earths	**Topsoil:** A1 horizon. Hardsetting gravelly, greyish-yellow brown loam, fine sandy massive; 2–10% rounded and sub-angular stones of quartz and sedimentary origin; pH 7.5; to 32 cm depth. A2 horizon. Greyish-yellow brown sandy clay loam; massive; 2–10% stones; pH 6.0; to 66 cm depth. Gradual boundary to–change to– **Subsoil:** B21 horizon. Dull yellowish-orange light sandy clay loam; massive; 10–20% stones as in A1 but larger sizes; pH 5.5; to 86 cm depth. B22 horizon. Greyish-yellow sandy clay loam; massive; 2–10% dispersed stones as in A1 but larger; distinct, dark orange mottles; pH 5.5; to 115 cm depth.	
Turill (ti)		
Earth Sands	**Topsoil:** Brown clayey sand; loose; single-grained; pH 5.5; depth to 30 cm. Diffuse change to– **Subsoil:** Bright brown to reddish-brown clayey sand; single-grained; pH 6.0; becomes more orange to yellowish with depth.	**Erosion hazard:** Erosion hazard is high to very high for these soils under cultivation or when surface cover is low. The adoption of conservation farming practices such as minimising tillage, retaining stubble and pasture rotations is necessary to control erosion. Soil conservation earthworks may also be required

Table 3.4 Soil landscape – Soils

Soil	ASC description [1]	Limitations
Yellow Soloths	**Topsoil:** Dark brown sandy loam; loose; massive; pH 4.5. Overlies brown light sandy clay loam; bleached; massive; pH 5.5; depth to 30 cm. Clear change to — **Subsoil:** Yellowish-brown sandy clay; moderate structure; sometimes massive; distinct grey mottles (to 30%); pH 5.0.	in some situations. Drainage lines are susceptible to gully erosion because of sodic subsoils of the yellow Soloths. **Salinisation:** High levels of salinity are apparent and localised across the landscape. Soil salinity and its effects are generally confined to small isolated occurrences along drainage lines and depressions. **Foundation hazard:** Sandy soils on mid to upper slopes can have low wet bearing strength and areas of salinity will affect foundations. **Landscape limitations:** The long slopes with sufficient grade to cause erosion (5–20%) are a limitation to cropping. Seasonal waterlogging occurs frequently during winter and early spring.

3.4.4 Inherent soil fertility

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

Per the eSPADE database (DPIE 2020a) the state scale mapping completed for NSW shows that the soils of the study area have variable inherent soil fertility ranging from 'low' to 'moderately low' (Table 3.5).

Table 3.5 Inherent soil fertility

Inherent soil fertility	ASC	Description[1]
Low	Tenosols	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.
Moderately low	Sodosols	Soils with low fertilities that, generally, will only support vegetation suited to grazing with large inputs of fertiliser required to improve the soils and make them suitable for arable purposes.

1. Per Chapman (1978)

3.4.5 Land and soil capability

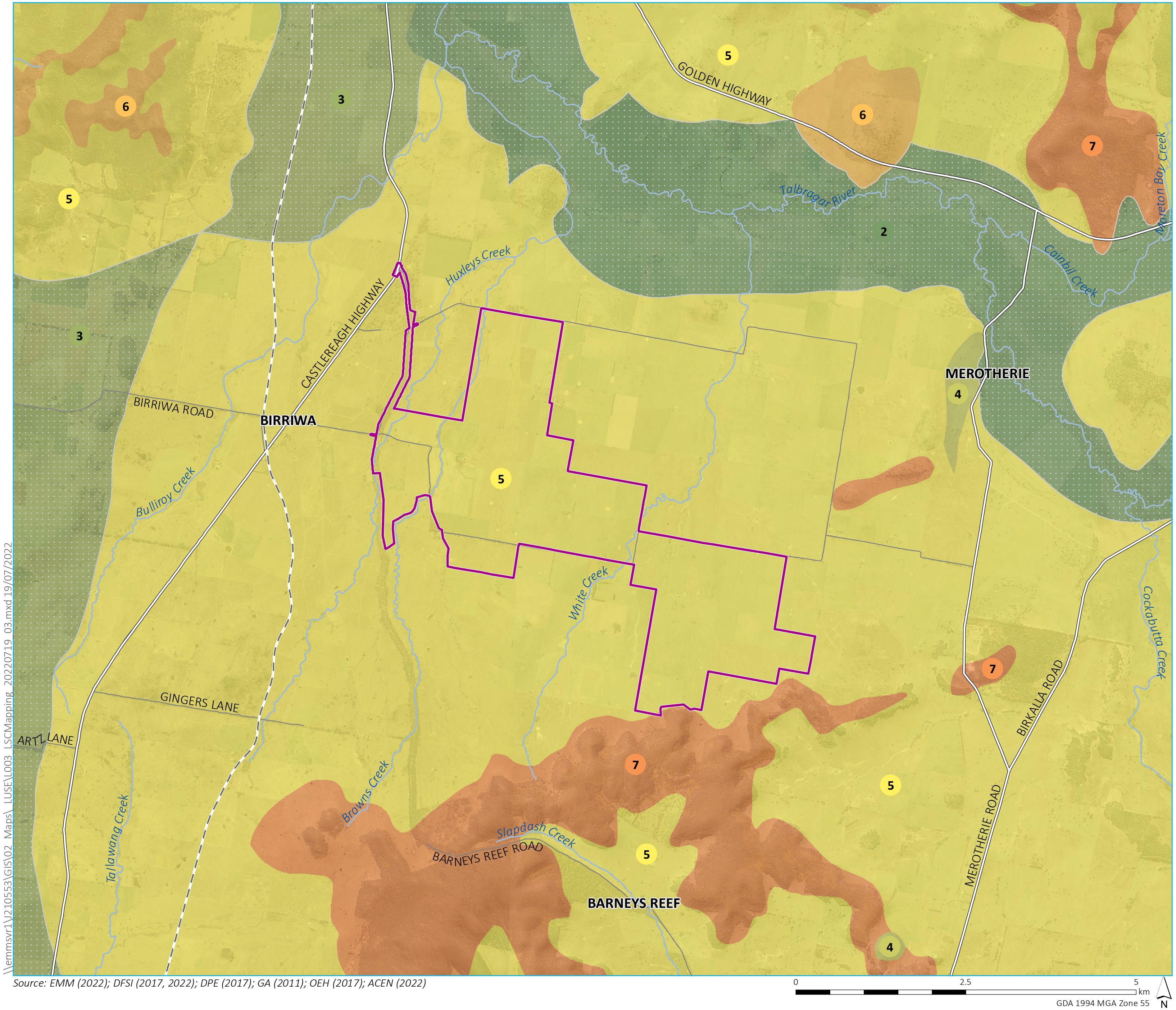
The *Land and Soil Capability Assessment Scheme* (OEH 2012) ('LSC Scheme') assesses the inherent physical capacity of the land to sustain a range of land uses (and management practices) in the long term without leading to degradation of soil, land, air and water resources. The LSC Scheme considers the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

The LSC classes present at a site can be determined at various scales, ranging from state, regional to farm scale, varying in accuracy according to the information and resolution associated with them. With reference to the eSPADE database (DPIE 2020a) and DPIE (2020c) the state scale mapping completed for NSW shows the study area is Classes 5 and 7, representing land with moderate-low capability to very low capability (Figure 3.4 and Table 3.6).

Table 3.6 Land and soil classifications mapped for the study area

LSC Class [1]	Description	ASC (Land system)
Class 5 – Moderate-low capability land	• 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.	Sodosol (Home Rule, Rouse) Tenosol (Turill)
Class 7 – Very low capability land	• 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 are not managed. • There should be minimal disturbance of native vegetation.	Tenosol (Lees Pinch)

1. Per OEH 2012



KEY

Study area

Existing environment

- Rail line
- Major road
- Minor road
- Named watercourse
- Biophysical Strategic Agricultural Land

Land and soil capability

- 2 | Slight but significant limitations
- 3 | Moderate limitations
- 4 | Moderate to severe limitations
- 5 | Severe limitations
- 6 | Very severe limitations
- 7 | Extremely severe limitations

Modelled LSC and BSAL mapping

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LUSE Assessment Report
Figure 3.4

EMM
creating opportunities

Source: EMM (2022); DFSI (2017, 2022); DPE (2017); GA (2011); OEH (2017); ACEN (2022)

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3.4.6 Acid sulphate soils

Acid sulphate soils (ASS) probability mapping has been completed along the NSW coast over 128 map sheets at 1:25,00 scale (Naylor *et al* 1998). The desktop assessment identified that there are no ASS or potential ASS in the study area, in accordance with the *Guidelines for the Use of Acid Sulfate Soil Risk Maps* (Naylor *et al* 1998). The NSW OEH Acids Sulphate Risk Map (OEH 2018) indicates that the nearest site with a high probability of ASS is approximately 285 km southeast of the study area and as such the study area is at little risk from ASS. Acid sulfate soils are typically found in coastal areas which does not apply to the study area.

3.4.7 Desktop review summary

A summary of the available land and soil mapping available from eSPADE (DPIE 2020a) characteristics and their associations is presented in Table 3.7.

Table 3.7 Regional soil mapping summary

Soil landscapes	Great soil groups	ASC	Inherent soil fertility	LSC class	Area (ha)
Home Rule (hr)	Solodic soils (SC)	Sodosols	Moderately low	5	1136.8
Rouse (rs)	Solodic soils (SC)	Sodosols	Moderately low	5	193.0
Turill (ti)	Earth sands (ES)	Tenosols	Low	5	0.1
Lees Pinch (lp)	Earth sands (ES)	Tenosols	Low	7	0.3

The Home Rule (hr) and Rouse (rs) soil landscapes are the most extensive land system present in the site area. It is modelled as host to Sodosol soils. Variation occurs in proximity to Barneys Reef in the presence of the Lees Pinch and Turill soil landscapes, associated with the Tenosol soil type. The erosion hazards discussed for all three soil landscapes highlight:

- erosion hazard is high when surface cover is low or flows are concentrated;
- importance of maintaining surface cover for erosion control;
- soils in drainage depressions are highly susceptible to gully erosion without adequate protection from high runoff; and
- severe gully erosion may occur where the sodic dispersible subsoils in drainage lines and depressions are exposed.

The fertility of all soil landscapes soil types is noted as low, supported by the inherent soil fertility mapping and subsequent low land and soil capability classes.

A lack of site-specific soil chemistry data results in uncertainty as to the exact hazards posed by the soils present on site. The Sodosols, as texture-contrast soils typically have lighter topsoils which have low resilience to disturbance, particularly with their noted hardsetting behaviour. The Sodosol subsoils are likely to be sodic or high in exchangeable magnesium which results in dispersive behaviour and high erosion potential. These soil types result in very fine sediment movement which is difficult to capture using tradition erosion and sediment controls (ESC) so prevention of erosion will be critical. The area of the site not mapped as Sodosols is covered by Tenosols, which are noted to have very high erosion potential due to their sandy, non-cohesive nature. However, their coarse nature does mean they are easier to control with typical ESC measures.

3.4.8 Site soil chemistry

During the site inspection conducted on 2 December 2021, opportunistic sampling of soils was undertaken at three sites (Birriwa Solar Farm (BSF) 1, BSF 2 and BSF 3) from across the study area (Figure 3.3) to determine soil characteristics and the potential for erosion to occur.

A National Association of Testing Authorities (NATA) and Australasian Soil & 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 3.8.

Table 3.8 Soil chemical analysis

Horizons	Analysis performed
Topsoil and subsoil	pH, EC (1:5), ECe, Cl- (1:5); exchangeable cations (Ca, Mg, Na, K, Al) and cation exchange capacity (NH4Cl or Ammonium Acetate); PSA (field texture and classification as per Northcote); exchangeable sodium percentage.

Detailed laboratory results are provided in Table 3.9. Interpretation of the laboratory analysis results is based predominantly on guidelines provided in:

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

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

Due to a lack of soil characterisation or classification it cannot be confirmed if the three sites described consist of the same soil type. The sites have been described separately according to variances in chemical characteristics, which reflect slightly different landform elements from which the samples were collect as shown in Figure 3.5.

i Soil chemical analysis results: sample sites BSF 1 and 3

Sites BSF 1 and 3 have similar soil pH, being medium acid in the topsoil (0–10 cm) and upper subsoil (10–30 cm), becoming mildly alkaline in the deeper subsoil (60–80 cm). The soil textures are sandy clay loams with occasional fine sandy textures and have very low salinity in the topsoil and upper subsoil with low salinity in the deeper subsoil. The soils have variable sodicity, with BSF01 being non-sodic in the topsoil and upper subsoil but strongly sodic in the lower subsoil and BSF03 being sodic in the topsoil and upper subsoil (potentially due to agriculture practices, such as ploughing, mixing the upper soil profile). The calcium:magnesium (Ca:Mg) ratio in both profiles is Ca low, though slightly higher in BSF03. The variability in sodicity is likely due to the generally low cation exchange capacity of both profiles, being generally around or less than 5 cmol(+)/kg, which can exacerbate variability in sodicity and other cation-dependent traits.

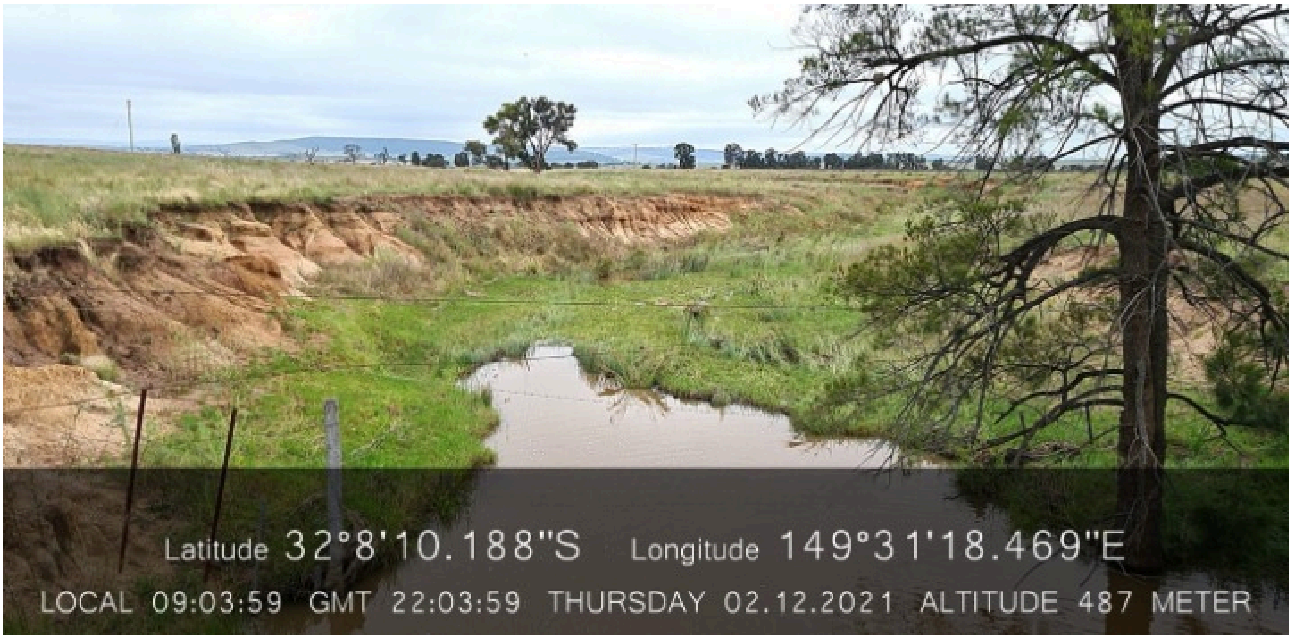
ii Soil chemical analysis results: sample site BSF 2

Site BSF 2 is more alkaline than the other sites (BSF 1 and BSF 3), being neutral in the topsoil (0–15 cm) and moderately alkaline in the upper subsoil (15–30 cm). The soil textures are a sandy clay loam topsoil with a clay loam subsoil. Salinity is similar across the site, being very low in the topsoil and low in the upper subsoil. BSF02 is non-sodic throughout, with a balanced Ca:Mg ratio and moderate to high cation exchange capacity.

iii Summary

The soil chemistry results for the submitted samples indicates that some soils (represented by BSF1 and BSF3) present within the study area likely have dispersive characteristics that would present a high erosion risk, as indicated by the exchangeable sodium percentage and low Ca:Mg ratio. This is subject to the uncertainty of the low cation exchange capacity of the soils. The erosion risk is consistent with the presence of rilling and gullying within the study area as observed during the site inspection (Photograph 3.1, Photograph 3.2 and Photograph 3.3).

Photograph 3.1 Gully erosion on site was common in areas of concentrated flow



Photograph 3.2 Soil exposure shows the susceptibility of the Sodosol subsoils to dispersion and erosion

Photograph 3.3 Soil exposure shows the susceptibility of the Sodosol subsoils to dispersion and erosion

Table 3.9 Soil profile chemistry data

Site	Depth (cm)	Particle size (%) [1]			Field texture [1]	pH (H_2O)	EC (dS/m)	EC rating[2]	ECe (dS/m)	Cl^- (mg/kg)	Exchangeable cations (meq/100 g)						ESP (%)	Sodicity (NS, S, SS)	Ca:Mg ratio
		Clay	Silt	Sand							Al^{+3}	Ca^{+2}	Mg^{+2}	K^+	Na^+	CEC			
BSF 1	0–10	30	15	55	SCL	5.8	0.02	VL	0.1	21.2	0.02	2.25	1.20	0.39	0.05	3.92	1.3	NS	1.88
BSF 1	10–30	30	15	55	FSCL	6.0	0.02	VL	0.2	18.6	0.01	2.98	1.83	0.30	0.07	5.19	1.3	NS	1.63
BSF 1	60–80	30	15	55	SCL	7.4	0.11	L	1.0	67.5	0.01	2.61	2.73	0.15	1.87	7.38	25.4	SS	0.95
BSF2	0–15	30	15	55	SCL	6.7	0.07	VL	0.6	28.1	0.01	8.68	2.01	1.84	0.11	12.60	0.8	NS	4.32
BSF2	15–30	35	30	35	CL	8.5	0.12	L	1.0	19.4	0.01	23.50	3.75	1.11	0.16	28.50	0.6	NS	6.26
BSF3	0–10	30	15	55	FSCL	6.0	0.03	VL	0.3	18.1	0.01	3.17	0.85	0.55	0.44	5.02	8.8	S	3.73
BSF3	10–30	30	15	55	SCL	5.9	0.02	VL	0.2	17.7	0.01	2.75	0.71	0.47	0.50	4.45	11.3	S	3.86

1. Calculated using hand field texture and classification as per Northcote texture classes.
2. Rayment & Lyons (2011) – very low salinity (VL), low salinity (L), moderately saline (M), highly saline (H), extremely saline (E)

3.5 Land use

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

The 2017 land use mapping utilises the standards of the Australian Collaborative Land Use Mapping Program 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 class which are broadly structured by the potential degree of modification and the impact to the 'natural state', essentially native land cover. In this system the primary and secondary classes relate to land use, the main use of the land defined by the management objectives of the land manager. The tertiary classes can include other information such as commodity groups, specific commodities, land management practices and vegetation information.

The ALUM classification features six primary classes, five primary classes of land use distinguished by increasing level of intervention or potential impact on the natural state, as well as water being included as the sixth primary class. These six primary classes are then subdivided. The six primary classes are detailed in Table 3.10.

Table 3.10 ALUM classification

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

Under the ALUM classification and mapping, the study 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, associated with Barneys Reef.

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.

A detailed breakdown of the ALUM classification of the study area and development footprint is contained in Table 3.11 and Table 3.12 respectively, and shown in Figure 3.5.

Table 3.11 Study area ALUM classification

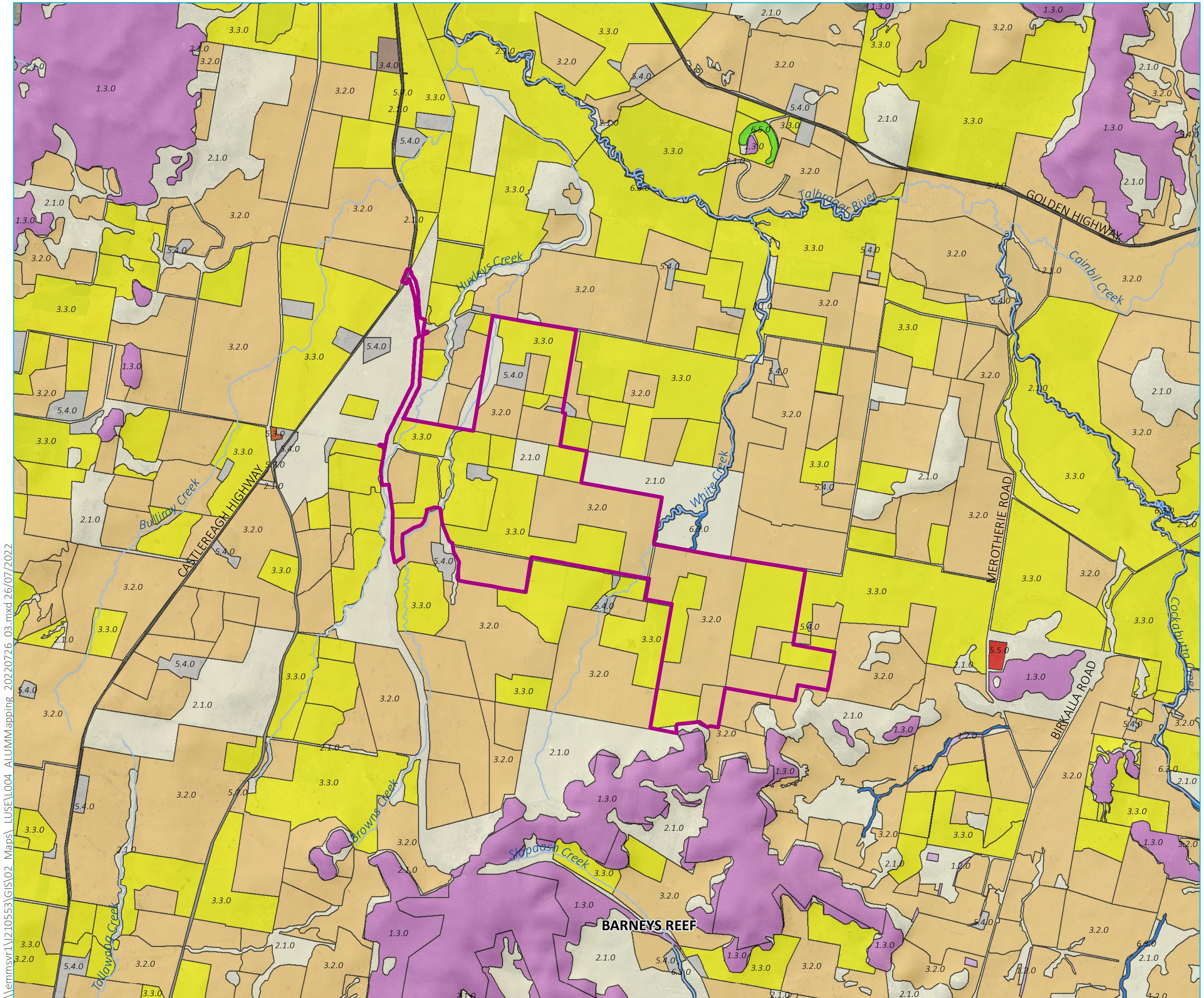
ALUM primary class	ALUM secondary class	ALUM tertiary class	Study area (hectares)
2	2.1.0 Grazing native vegetation	2.1.0 Grazing native vegetation	96.0
3	3.2.0 Grazing modified pastures	3.2.0 Grazing modified pastures	608.6
3	3.3.0 Cropping	3.3.0 Cropping	602.0
5	5.4.0 Residential and farm infrastructure	5.4.0 Residential and farm infrastructure	1.5
5	5.4.0 Residential and farm infrastructure	5.4.2 Rural residential with agriculture	21.8
5	5.7.0 Transport and communication	5.7.2 Roads	0.4
6	6.3.0 River	6.3.0 River	0.0017

Table 3.12 Development footprint ALUM classification

ALUM primary class	ALUM secondary class	ALUM tertiary class	Study area (hectares)
2	2.1.0 Grazing native vegetation	2.1.0 Grazing native vegetation	30.3
3	3.2.0 Grazing modified pastures	3.2.0 Grazing modified pastures	541.8
3	3.3.0 Cropping	3.3.0 Cropping	542.9
5	5.4.0 Residential and farm infrastructure	5.4.0 Residential and farm infrastructure	1.5
5	5.4.0 Residential and farm infrastructure	5.4.2 Rural residential with agriculture	21.8

3.6 Land zoning

The Mid-Western Regional Local Environmental Plan 2012 and Warrumbungle Local Environmental Plan (LEP) 2013 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 Mid-Western Regional or Warrumbungle Local Government Areas (LGAs). Land within the study area is zoned RU1, Primary Production with the exception of 0.85 ha which is zoned as RP2, classified road.



KEY

- Study area
- Named watercourse

Land use

- 1.2.0 Managed resource protection
- 1.3.0 Other minimal use
- 2.1.0 Grazing native vegetation
- 3.2.0 Grazing modified pastures
- 3.3.0 Cropping
- 3.4.0 Perennial horticulture
- 5.3.0 Manufacturing and industrial
- 5.4.0 Residential and farm infrastructure
- 5.5.0 Services
- 5.7.0 Transport and communication
- 6.3.0 River
- 6.5.0 Marsh/wetland

Source: EMM (2022); DFSI (2017, 2022); DPIE (2017); GA (2011); ACEN (2022)

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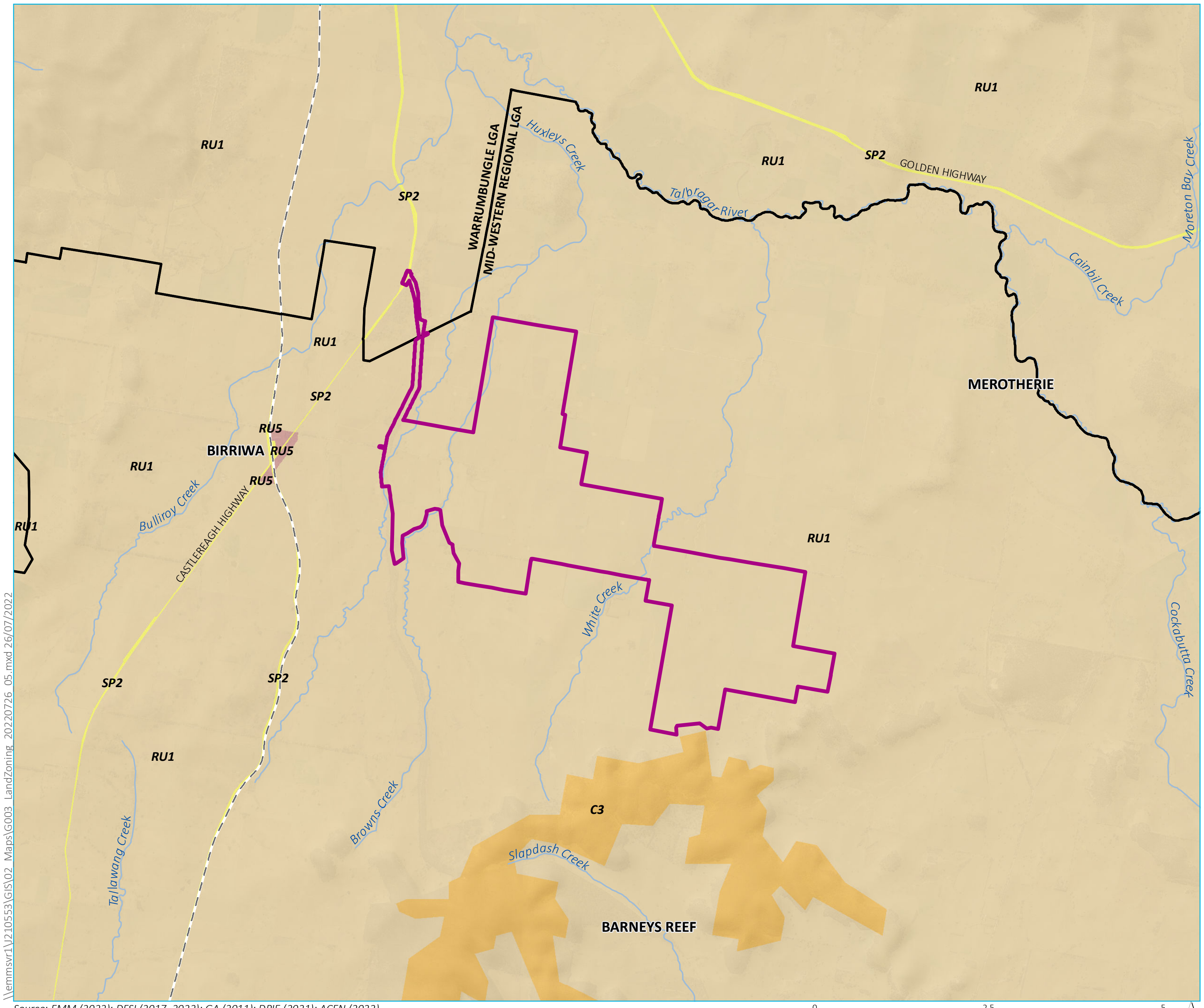
Australian land use and management (ALUM)

Birriwa Solar and Battery Project
LUSE Assessment Report
Figure 3.5

creating opportunities



Source: EMM (2022); DFSI (2017, 2022); GA (2011); DPIE (2021); ACEN (2022)

Land zoning

Birriwa Solar and Battery Project
LUSE Assessment Report
Figure 3.6

EMM creating opportunities

3.7 Agriculture

The project is predominantly located within the Mid-Western Regional LGA, with the northern end of the access road being located in the Warrumbungle LGA.

The assessment of project impacts to agricultural land has been determined with consideration for the DPE draft solar guidelines, as described in Section 1.2.2, as requiring a basic assessment. This consists of:

- LSC mapping or the results of a soil survey (if completed) to confirm land capability;
- consultation with neighbouring landholders to identify potential project impacts (if any) on immediately adjacent land;
- identify project impacts (if any) on immediately adjacent land;
- describe consultation undertaken; and
- consider measures to reduce impacts on neighbouring agricultural land.

Many of the required inputs have been described previously in Section 3, but other existing conditions relating to agriculture are described below.

3.7.1 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 study area is described below.

3.7.2 Biophysical Strategic Agricultural Land (BSAL)

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

The *State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) Amendment 2013* (the 2013 Mining SEPP amendment) requires certain types of developments to verify whether the proposed site is on Biophysical Strategic Agricultural Land (BSAL). The Interim protocol assists proponents and landholders to understand what is required to identify the existence of BSAL and outlines the technical requirements for the on-site identification and mapping of BSAL. While the Project is not classified as a mining Project under the Mining Act 1992, and thus the *State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007 (Mining SEPP)* is not applicable, the enclosed desktop BSAL review is provided to provide context on the agricultural significance of any present BSAL in the study area.

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

1. Soil Fertility – based on the regional scale Draft Inherent General Fertility of NSW (DPIE 2020b).
2. Land and Soil Capability – based on the regional scale Land and Soil Capability Mapping of NSW (Section 3.4.5, DPIE 2020c).

3. Access to reliable water supply, defined as:

   a) rainfall of 350 mm or more per annum (9 out of 10 years);

   b) a regulated river (maps show those within 150 m);

   c) a 5th order or higher unregulated river (maps show those within 150 m);

   d) an unregulated river which flows at least 95% of the time (maps show those within 150 m); or

   e) highly productive groundwater sources, as declared by the NSW Office of Water. These are characterised by bores having yield rates greater than 5 litres per second (L/s) and total dissolved solids (TDS) of less than 1,500 milligrams per litre (mg/L) and exclude miscellaneous alluvial aquifers, also known as small storage aquifers.

As BSAL land was systematically considered and avoided in ACEN's initial site selection, there is no BSAL mapped within the study area, though there is BSAL mapped land approximately 820 m north of the study area.

3.7.3 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 State Significant Agricultural Land (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; and
- 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.

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:

- land and soil capability (see Section 3.4.5) based on:
  - soil type;
  - slope;
  - landform position;
  - acidity;
  - salinity;
  - drainage;
  - rockiness; and
  - climate;

- inherent soil fertility (Section 3.4.4);
- pH – a soil pH of 5–8; and
- water availability – either more than 500 millimetres (mm) of rainfall per annum or land on highly productive groundwater sources.

The data utilised for the development of the SSAL mapping is predominantly regional-scale mapping or modelling and subject to associated data limitations.

There is no SSAL mapped within the study area, though there is some mapped land approximately 820 m north of the study area, associated with the mapped BSAL.

3.7.4 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 study area.

3.7.5 Agricultural water resources

i Drainage and surface water

Existing surface water conditions for the project are described in Section 3.3 as identified by Alluvium (2022a, 2022b). No agricultural water resources have been identified by Alluvium (2022a, 2022b).

ii Groundwater

No groundwater resources have been identified by Alluvium (2022a, 2022b).

3.7.6 Agricultural land uses

Data was collected in the 2015–2016 agricultural census for two areas relevant to the project, the 392,230 ha in the Mudgee Region–West area of the Mid-Western Regional LGA and the 875,240 ha of the entire Mid-Western Regional LGA. The land use for both areas is shown in Table 3.13.

Table 3.13 Agricultural land use

Land use	Mid-Western Regional LGA[1]		Mudgee Region–West [2]
	Area (ha)	Area of LGA (%)	Area (ha)
Cropping – dryland	30,942	3.54	19,646
Cropping – irrigated	720	0.08	*NR*
Horticulture – dryland	3,239	0.37	*NR*
Horticulture – intensive plant production	2	0.00	*NR*
Horticulture – irrigated horticulture	552	0.06	*NR*
Livestock – grazing modified pastures	203,983	23.31	148,444
Livestock – grazing native vegetation	302,042	34.51	148,382
Livestock – intensive animal production	503	0.06	*NR*
Livestock – irrigated pastures	1,089	0.12	*NR*
Livestock – land in transition	22	0.00	*NR*
Crops – total[3]	31,662	3.62	48,114
Agriculture – other	*NR*		24
Agriculture – total	**543,086**	**62.05**	**348,702**

1. ABARES 2021a, Catchment scale land use of Australia – update December 2020.
2. ABARES 2019, Australian Agricultural Census 2015-16 visualisations.
3. Crops includes broadacre, hay, silage and horticulture.

NR. no statistic recorded in dataset.

The Mid-Western Regional LGA lies within the Central West region of NSW, which has an agricultural sector dominated by grazing of modified pastures, occupying 38,100 square kilometres (km^2) or 54% of the 57,300 km^2 of the region's agricultural land (ABARES 2021b). As per ABARES 2021a, 58% of the MWR LGA land area is utilised for livestock production, with nature conservation utilising 31.15% and intensive uses and cropping being 3.69% and 3.62% respectively.

3.7.7 Agricultural production

In 2018–2019 the most important commodities in the Central West region (based on the gross value of agricultural production) were cattle and calves ($314 million) followed by wool ($238 million) and sheep and lambs ($212 million). These commodities together contributed 55 per cent of the total value ($1.4 billion) of agricultural production in the region (ABARES 2021b).

Agricultural productivity for selected commodities for the Mid-Western Regional LGA and Mudgee Region–West is presented in Table 3.14.

Table 3.14 Value of agricultural commodities – 2015–2016

Agricultural commodity	Mid-Western Regional LGA	Mudgee Region–West
	Gross value ($)[1]	Gross value ($)[2]
Total agriculture – all commodities	$90.45m	$93m
Livestock products – total	$18.28m	$20m
Livestock products – wool	$17.79m	*NR*
Livestock products – milk	$38,134	*NR*
Livestock products – eggs	$460,015	*NR*
Livestock slaughtered and other disposals – Total	$58.65m	$58m
Livestock slaughtered and other disposals - Sheep and lambs	$12.45m	*NR*
Livestock slaughtered and other disposals - Cattle and calves	$45.68m	*NR*
Livestock slaughtered and other disposals - Goats	$14,547	*NR*
Livestock slaughtered and other disposals - Poultry	$439,918	*NR*
Crops – broadacre – total	$6.55m	$9m
Horticulture – fruits, nuts, excluding grapes (human consumption)	$394,148	$1m
Horticulture –grapes	$786,280	$1m
Horticulture –vegetables (human consumption)	$22,847	*NR*
Hay – total	$5.75m	$6m
Crops – total[3]	$13.5m	$15m

1. ABS 2021, Value of Agricultural Commodities Produced, Australia, 2015-16.
2. ABARES 2019, Australian Agricultural Census 2015-16 visualisations.
3. All crops includes broadacre, hay, silage and horticultural produce.

NR. no statistic recorded in census dataset.

Consistent with the regional profile, the primary agricultural productivity of the Mudgee Region–West and Mid-Western Regional LGA is livestock products and disposals (including domestic slaughtering and exports).

Indicative $/ha values for selected commodities are given in 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 variation between recorded parameters for both agricultural productivity and land use for the Mudgee Region–West and Mid-Western Regional LGA.

Table 3.15 Indicative annual commodity value per hectare

Area	Commodity sector	Production value ($m)	Land use (ha)[1]	Value ($/ha)
Mid-Western Regional LGA	Livestock	$76.93	507,639	$151.55
	Cropping	$13.5	31,662	$426.38
Mudgee Region–West	Livestock	$78	296,826	$262.78
	Cropping	$15	48,114	$311.76

1. Per ABARES 2021a, Catchment scale land use of Australia – update December 2020 and ABARES 2019, Australian Agricultural Census 2015-16 visualisations (Table 3.13).

4 Erosion hazard analysis

The process for the assessment of erosion hazard in NSW is detailed in Section 4.4.1 of Landcom (2004). It is a two-part process that firstly considers the overall project erosion hazard in considering slope and rainfall erosivity (R-Factor). This is followed by a more detailed assessment where land soil loss classes (SLC) are determined using annual soil loss 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).

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

When a sodic soil (exchangeable sodium percentage >6%), or a magnesic soil (exchangeable magnesium percentage >20%) 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 (eg rock lining) applied to the soil surface.

4.1 Soil erosion hazard analysis

The erosion potential of a soil is determined by its physical and chemical properties and is expressed as its K-Factor (t.ha.h)/(ha.MJ.mm).

Rosewell (1993) provides an estimate of soil erosion risk based on the physical properties of the soil (Table 4.1) but not the chemical properties, even though the K-Factor is increased by 20% when a dispersive soil in encountered. Soils where the dominant cations are sodium or magnesium tend to be dispersive when wet.

Table 4.1 Rosewell (1993) soil erosion ranking

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

The modelled K-Factors for the study area, determined from the eSpade 2.1 database (DPIE 2020a), range from 0.04–0.07 t ha h $ha^{-1}MJ^{-1}mm^{-1}$, predominantly 0.05–0.07 t ha h $ha^{-1}MJ^{-1}mm^{-1}$, which indicate that the project soils have a high erosion potential. As described in Section 3.4, much of the project soils are Sodosols that are likely to have dispersive subsoils.

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.

While the construction of the arrays is unlikely to expose subsoils, the installation of driven piles, construction of roads, tracks and ancillary facilities will, and therefore, consideration of the erosion hazard posed by the dispersive subsoils is required. Landcom (2004) recommends increasing the K-Factor for dispersive soils by 10% but provides no scientific justification for this. Loch *et al.* (1998) measured and range of various sodic soils across NSW and QLD with K-Factors ranging from 0.056–0.106 t ha h $ha^{-1}MJ^{-1}mm^{-1}$. A K-Factor of 0.071 t ha h $ha^{-1}MJ^{-1}mm^{-1}$ has been adopted to determine the erosion hazard of project subsoils, indicating a high erosion potential.

4.1.1 Slope and rainfall erosivity erosion hazard analysis

The overall project water erosion hazard is determined using the process described in section 4.4.1 of Landcom (2004); however, as it does not consider the K-Factor, the erosion hazard can be considerably underestimated.

If a low erosion hazard is determined, no further delineation of erosion hazard is required. If a high erosion hazard is determined, then further assessment to determine the SLC is required.

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

i Rainfall erosivity

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

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

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

Where, S is the 0.5EY, 6-hour event in mm/h (Rosewell & Turner 1992). For the project S equals 7.51 mm/h (BoM 2020). The calculated R-Factor for the project is 1,393 $MJmmha^{-1}h^{-1}$.

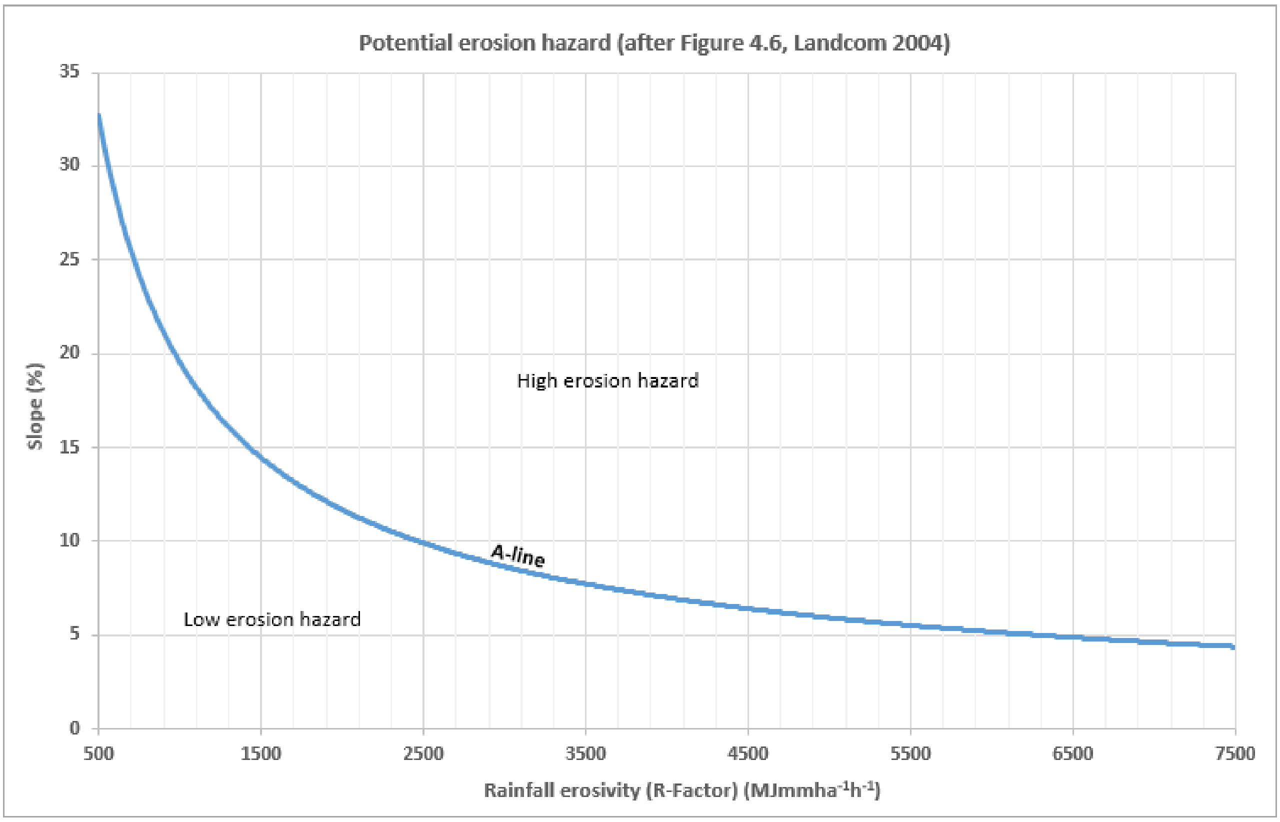


Figure 4.1 Assessment of potential erosion hazard (Landcom 2004)

Based on the application of the project R-Factor to the Landcom (2004) nomograph indicates that potential erosion hazard will be high for areas of the project where slopes exceed 15%.

ii Project slopes

Slope ranges and erosion hazard for the key project elements are provided in Table 4.2.

Table 4.2 is based on the proposed project layout options (A and B) provided by ACEN (Figure 2.1). The assessment of slope and associated erosion hazard is therefore limited on the assumption of the implementation of one of these options in the final project design.

Table 4.2 Slope ranges and erosion hazard for key project elements

Project element	Slope (min %)	Slope (max %)	Slope (mean %)	Erosion hazard
Study area	0.0	78.1	2.7	Low to high
Development footprint	0.00	52.5	2.6	Low to high
• Layout A	0.01	29.7	1.8	Low to high
• Layout B	0.01	29.0	2.9	Low to high
• Temporary laydown area	0.00	32.2	1.1	Low to high
Restricted development area	0.00	59.4	6.2	Low to high
Road upgrade corridor	0.07	36.5	4.8	Low to high

The project generally has a low erosion hazard based on mean slope, though there are areas of steep slopes that will present a high erosion hazard as per Figure 4.1 and Table 4.2. As such, further assessment of erosion hazard is necessary in accordance with Section 4.4.2 of Landcom (2004) to determine soil loss classes (Table 4.3).

4.1.2 Soil loss classes

Soil loss classes are determined calculating the annumichal 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 4.3 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

Adapted from Table 4.2 Landcom (2004)

Calculated indicative soil loss in t/ha/yr for slopes ranges from 1–40% for the project are provided in Table 4.4.

Table 4.4 Annual average soil loss t/ha/yr

Slope	1%	3%	5%	10%	12%	20%	25%	30%	40%
R-Factor (calculated)	1393	1393	1393	1393	1393	1393	1393	1393	1393
K-Factor (Landcom 2004)	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071
LS (Table A1 Landcom 2004 and USDA 1997)	0.19	0.65	1.19	2.81	3.70	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
C (Figure A5 Landcom 2004)	1	1	1	1	1	1	1	1	1
Soil loss t/ha/y	**24.4**	**83.6**	**153.0**	**361.3**	**475.8**	**941.2**	**1222.8**	**1491.6**	**2014.9**
SLC	**1**	**1**	**2**	**4**	**4**	**6**	**6**	**6**	**7**

Applying the calculated annual average soil loss to Table 4.3 results in a SLC ranging from 1 (very low) to 7 (extremely high). There appears to be change from moderate (SLC 4) to high erosion (SLC 5) at slopes between 10–20%, approximately 12%, whilst extremely high erosion hazard, SLC (7), applies to slopes greater than 30% (Table 4.5).

Table 4.5 Project SLC estimated slope and area

SLC	Erosion hazard	Estimated slope range	Study area (ha)
1–4	Very low to moderate	0–12%	1313.3
5 and 6	High and very high	12–30%	15.8
7	Extreme	>30%	1.1

The SLCs for key project elements are summarised Table 4.6 below.

Table 4.6 SLCs for key project elements

Project element	SLC (min)	SLC (max)
Study area	1	7
Development footprint	1	7
• Layout A	1	6
• Layout B	1	6
• Temporary laydown area	1	7
Restricted development area	1	7
Road upgrade corridor	1	7

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

The site is in rainfall zone 7 (Figure 4.2). Low and high rainfall erosivity periods for Zone 7 are provided in Table 4.7 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 4.7 Zone 7 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	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	L	L	L	L	L	L	L	L	L	L	H	H
6	H	H	H	H	H	H	L	L	L	L	L	L	L	L	L	L	L	L	H	H	H	H	H	H
7	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H

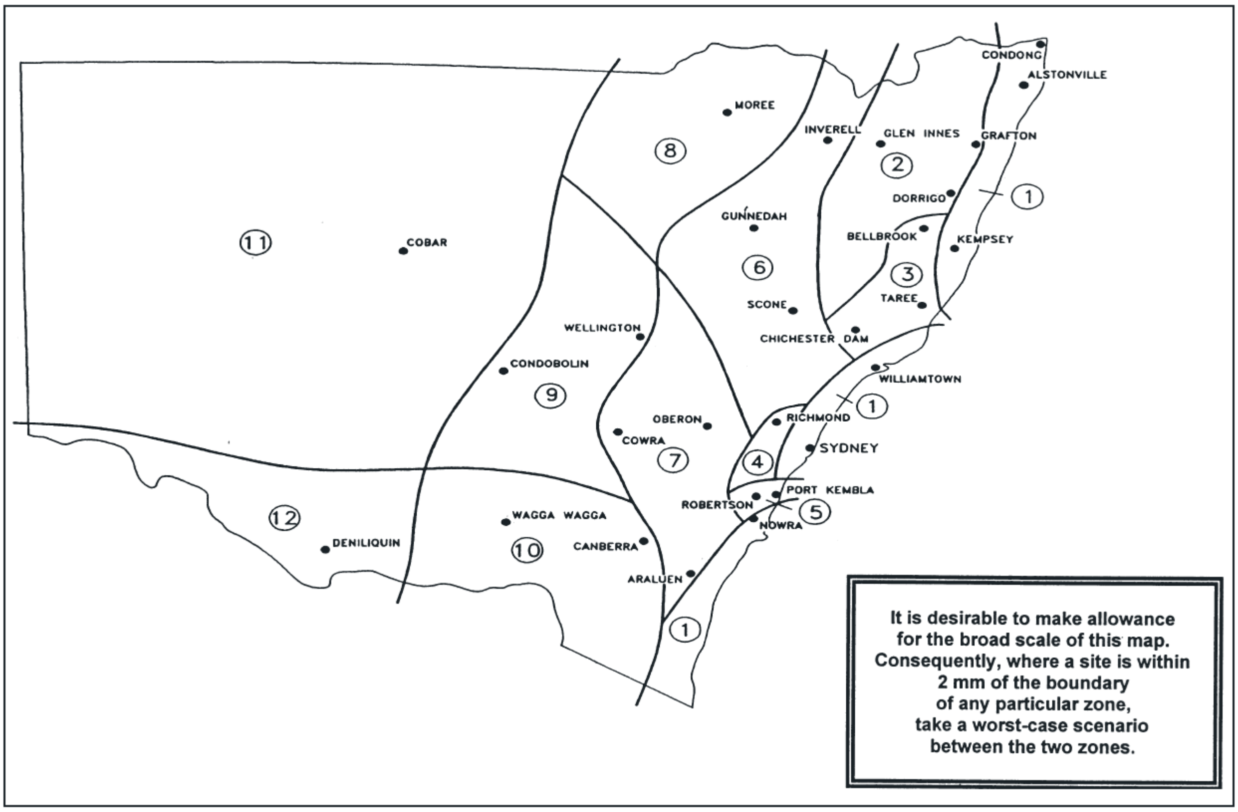


Figure 4.2 Rainfall zones

Source: Landcom (2004)

If scheduling of activities on highly sensitive land to occur during periods when rainfall erosivity is low is not possible or impractical, ideally ensure that any disturbed lands have C-Factors lower than 0.1 when the 3 day rainfall forecast predicts that rain is likely.

4.2 Summary

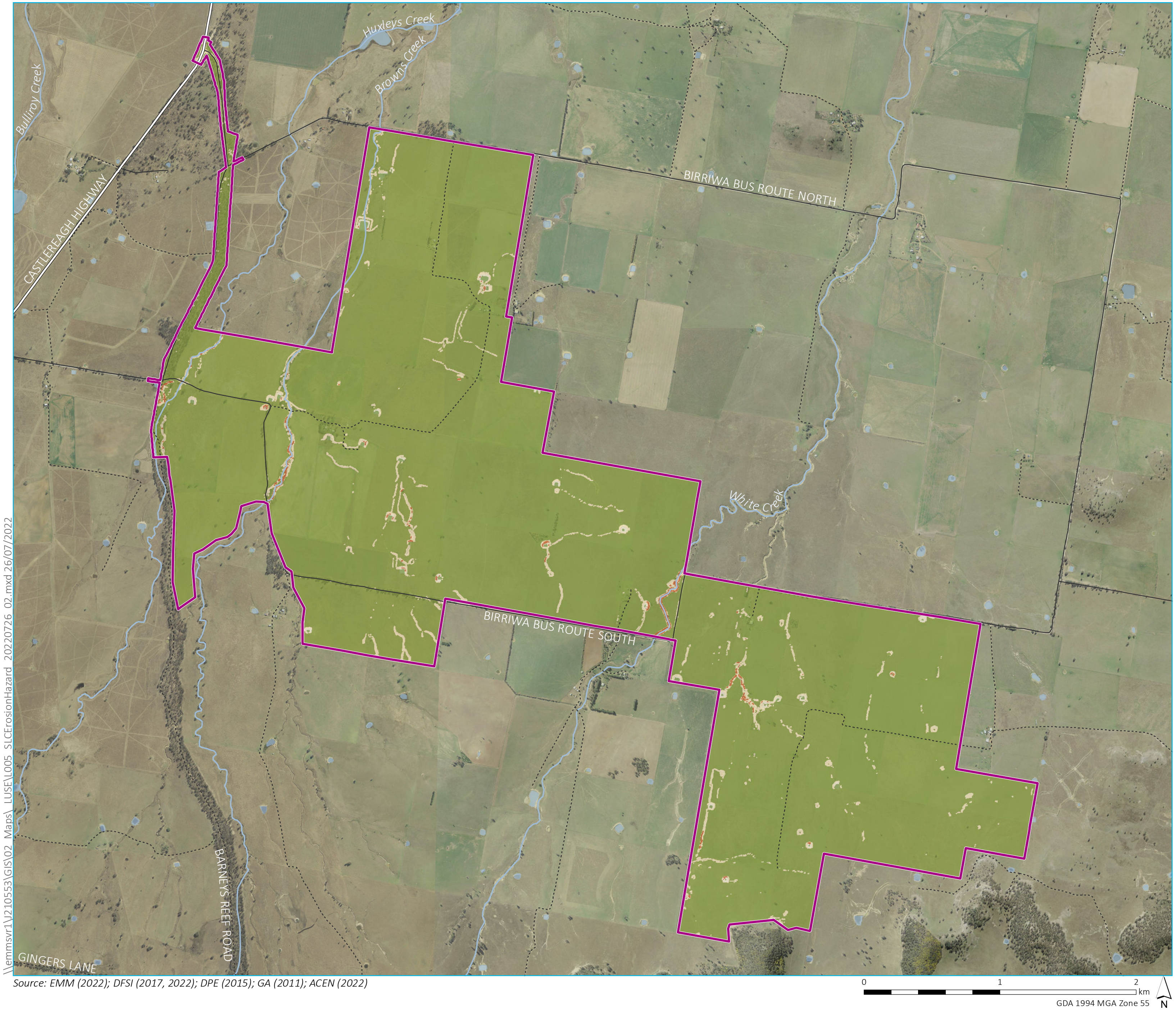
An assessment of erosion hazard has been completed as per Landcom (2004) which considers the overall project erosion hazard based on slope and rainfall erosivity (R-Factor) and subsequent determination of soil loss classes (SLC).

The erosion potential of soils of the study area, expressed as K-factor, is high due to the presence of dispersive soils. Assessment of rainfall erosivity indicates erosion hazard will be high for areas of the project where slopes exceed 15%, which aligns with the assessment of SLCs, indicating a change from moderate (SLC 4) to high erosion (SLC 5) at slopes between 10–20%, estimated to be 12%, while extremely high erosion hazard, SLC (7), applies to slopes greater than 30% (Figure 4.3).

The project generally has a low erosion hazard based on mean slope, though there are areas of steep slopes that will present a high erosion hazard, primarily associated with the incised waterways present on site, as seen in Figure 4.3. These areas are already being avoided by the project as restricted development areas, which would reduce areas likely to be subject to higher erosion potential.

Lands with SLCs ≥4 (where project slopes >12%) trigger increased erosion and sediment control management requirements as stipulated in Section 4.4.2 of Landcom (2004). Determination of SLCs indicates that special measures will be required to be implemented for areas where slopes are between 12–30% at certain times of the year, as per Table 4.7, and always on areas where slopes exceed 30%.

Further project specific management and mitigation measures are provided in Section 6.



KEY
- Study area
- Major road
- Minor road
- Vehicular track
- Named watercourse
- Waterbody

Project SLC erosion hazard
- SLC 1-4 (very low to moderate erosion hazard)
- SLC 5 & 6 (high to very high erosion hazard)
- SLC 7 (extremely high erosion hazard)

Soil loss class erosion hazard

Birriwa Solar and Battery Project
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Figure 4.3

EMM
creating opportunities

Source: EMM (2022); DFSI (2017, 2022); DPE (2015); GA (2011); ACEN (2022)

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5 Impact assessment

5.1 Land and soil capability

5.1.1 Construction soil impacts

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

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

i Soil mixing

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

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

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

ii Compaction

Topsoil degradation can result in organic matter reduction that can lead to soil density increases and subsequent compaction. 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 hard setting limitation described in Section 3.4.

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

5.1.2 Operation soils impacts

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

- erosion of soil resources due to excessive concentration of flow and inappropriate channel lining and flow energy dissipation;
- tunnel erosion in cable trenches due to inadequately compacted and ameliorated dispersive subsoils;
- exposure of dispersive soils in cut and fill batters and excavations; and
- splash erosion of solar array footings due to inadequate soil surface cover under the arrays.

5.1.3 Changes to project land and soil capability

As described in Section 3.4.5, indicative assessment of LSC utilising the eSPADE database (DPIE 2020a) and DPIE (2020c), LSC mapping has determined the study area is mapped at the state scale as predominantly LSC Class 5 and minor areas of Class 7, which represent land with moderately-low to low capability for productive use without resulting in land degradation. The lands are currently used for cropping and cattle grazing, predominantly grazing.

Lands where solar arrays and other permanent infrastructure such as the substation, electrical collection systems, switchyard, control room or management hub and roads have been constructed will not be able to be used for cropping or cattle grazing once constructed.

The land will not be available for cropping during the life of the project, though sheep grazing would be able to be undertaken depending on the height of arrays. However, the LSC status of lands subject to infrastructure with a small footprint or temporary disturbances will be able to be maintained or reinstated following appropriate landform design and rehabilitation.

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

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

5.1.4 Agricultural productivity impacts

Extrapolating from data contained in Sections 3.5, 3.7.6 and 3.7.7, the 1,330 ha of the study area, if fully developed, would encompass some 704.6 ha of land in the study area used for grazing and 602 ha for cropping, as per Table 3.11, totalling 1,306.6 ha. Were this 1,306.6 ha to be developed (change of use) it would be valued between $363,462.89–$372,834.31 in annual productivity based on calculated agricultural values for the Mid-Western Regional LGA and Mudgee Region–West respectively (Table 5.1).

Extrapolating from data contained in Sections 3.5, 3.7.6 and 3.7.7, the 1,138 ha of the development footprint, if fully developed, would encompass some 572.0 ha of land used for grazing and 542.9 ha for cropping, as per Table 3.12, totalling 1,115.0 ha. Were this 1,115.0 ha to be developed (change of use) it would be valued between $318,168.30–$319,564.66 in annual productivity based on calculated agricultural values for the Mid-Western Regional LGA and Mudgee Region–West respectively (Table 5.1).

Table 5.1 Estimated Project land value

Area	Commodity sector	Estimated land value ($/ha)	Area (ha)[1]	Project land value ($)
Study area				
Mid-Western Regional LGA	Livestock	$151.55	704.6	$106,782.13
	Cropping	$426.38	602	$256,680.76
	Total			**$363,462.89**
Mudgee Region–West	Livestock	$262.78	704.6	$185,154.79
	Cropping	$311.76	602	$187,679.52
	Total			**$372,834.31**
Development footprint				
Mid-Western Regional LGA	Livestock	$151.55	572.0	$86,686.60
	Cropping	$426.38	542.9	$231,481.70
	Total			**$318,168.30**
Mudgee Region–West	Livestock	$262.78	572.0	$150,310.16
	Cropping	$311.76	542.9	$169,254.50
	Total			**$319,564.66**

1. Per ABARES 2021a, Catchment scale land use of Australia – update December 2020 and ABARES 2019, Australian Agricultural Census 2015-16 visualisations.

Whilst this is a significant loss of agricultural land value based on annual productivity and an assumption of the entire study area 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 as discussed in Section 5.1.3. Additionally, the land could still be utilised for some agricultural practice even where developed, by utilising sheep for grazing which is estimated to achieve 50% of existing stocking rates for 50% of the year.

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

i Impacts to adjacent lands

Project impacts are anticipated to be limited primarily to the direct study area with minimal impact to adjacent lands. Consultation with landholders is also expanded in Section 6 of the social impact assessment (SIA), Appendix O of the EIS**.** Identified impacts to adjacent lands highlighted through consultation include:

- In November 2021, the owners of R5 indicated their concern about the cattle access within their property, located just south of Birriwa Bus Route South. The landholders currently use land within the study area just north of Birriwa Bus Route North for heavy vehicle manoeuvres to access the cattle yard. The landholders requested a [25 m] setback to the north of Birriwa Bus Route South to maintain heavy vehicle access to the cattle yard. ACEN agreed to an even larger setback to include mitigation for visual and noise impacts.

- A landholder who lives in the area has been renting a 365 ha portion of the site for the last 15 years. He has lamented the fact that he will no longer have access to this property for livestock grazing should the project go ahead.
- The owner of R13 uses a wool shed within the side. Based on consultation, the decision was made to exclude the lot containing the woolshed from the development footprint, which also reduced visual impacts for the dwelling of R5.
- Discussion with owners of R11 and R12 commented that the classification system was out of date, some of the land is a lot more productive than its class suggests.

5.2 Erosion and sediment control

5.2.1 Construction erosion and sediment control impacts

Potential construction erosion and sediment control impacts include:

- off-site discharge of sediment and turbid run-off from the erosion of exposed soils particularly dispersive subsoils:
  - degradation of stock drinking water;
  - infilling of waterway pools; and
  - diversion of waterway flow due to sediment deposition and associated bed and bank erosion;
- erosion and subsequent sedimentation of creeks and waterways due inappropriately designed and constructed 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 run-off hydrograph due to an increase in impermeable surface such as roads, hardstands, roofs and solar arrays;
- tunnel erosion under or beside foundations for solar arrays, towers, light poles etc and along cable trenches due to dispersive soils; and
- dust emissions from unsealed roads, hardstands and exposed soils.

5.2.2 Operational erosion and sediment control impacts

Potential operational erosion and sediment control impacts include:

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

Appropriate management and mitigation techniques are provided in Sections 7 and 8.

5.3 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 Appendix A. 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, Mid-Western Regional Council 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 5.2) and identifying the consequences of the potential conflict, which include:

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

Table 5.2 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 (Appendix A), 35 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 (eg noise, dust, visual and traffic);
- increased soil erosion and impacts to surface water resources; and
- risks associated with the project (eg security, safety, health and fire).

Under the unmitigated scenario (ie without the implementation of the proposed management strategies), the risk ranking matrix identified potential for 18 high-risk conflicts (ie those with a risk ranking score of greater than 10). Through the implementation of the proposed management strategies described in Appendix A, the number of high-risk conflicts reduced to seven, which reflects a reduction of greater than 60%.

Potential conflicts with a revised risk ranking of greater than 10 were limited to removal of agricultural land and subsequent reduction in productivity, visual amenity impacts 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 in the decommissioning and rehabilitation plan;
- should landscaping be implemented within the development footprint (ie to reduce the extent of potential visual amenity impacts experienced at R1, R1a and R5), the landscaping plan will include a program to monitor and report on the effectiveness of the proposed landscaping;
- the Construction Traffic Management Plan will include a complaint resolution and disciplinary procedure as a mechanism to address any issues identified by the local community and other roads users in relation to safety; and

- 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.

6 Management and mitigation of impacts

6.1 Land and soil capability

ACEN will adopt the following management strategies to address the identified LSC impacts:

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

6.2 Erosion and sediment control

ACEN will adopt drainage, erosion and sediment control management strategies to address the identified erosion and sedimentation impacts.

ACEN have planned the location of project infrastructure to utilise the existing topography where practicable, to avoid land reshaping during the construction phase and rehabilitation phase as far as possible, and to minimise land disturbance and the alteration of drainage patterns. The solar arrays will require minimal soil disturbance as they are mounted on driven piles. Cut and fill activities will be kept to a minimum for construction of the solar arrays.

As dispersive subsoils are present within the study area, the project design will need to:

- avoid concentration of flow and maintain sheet flow conditions where possible;
- avoid excavating drains in dispersive soils and locate roads, hardstands and pads to utilise the natural slope so that water drains away as required;
- maintain the velocity of flows below 0.3m/s or line concentrated flow paths as required;
- avoid the use of structures that pond water and can cause tunnel erosion such as check dams and channel banks in concentrated flows and benches on cut and fill batters;
- use back-push diversion banks in lieu of channel banks or excavated drains if it is necessary to divert flow;
- ameliorate dispersive soils particularly in cable trenches where there is a high risk of tunnel erosion; and
- use high efficiency sediment basins (Type A or B) with flow activated dosing systems to treat turbid runoff to protect downstream receivers where greater than 2,500m^2 of land is disturbed or the calculated annual average soil loss exceeds 150t/ha/y.

A project-specific detailed soil sampling program is recommended to be undertaken to identify erosion and agronomic soil constraints, particularly in the presence of dispersive soils.

Detailed management measures for erosion and sediment control are contained in Table 6.1.

6.3 Mitigation measure summary

Table 6.1 provides a summary of the mitigation measures for the project.

Table 6.1 Mitigation and management measures

Item	Measure
Land and soil capability	
LR1	Prior to the commencement of construction, a Soil and Water Management Plan (SWMP) will be prepared and will include management measures to cover: • erosion and sediment control; • soil management and preservation including stripping, handling, stockpiling and amelioration; • dispersive subsoils; • any cut and fill activities; and • drainage and landform design. The SWMP will be implemented during construction and operation of the project.
Erosion and sediment control	
LR2	As part of the CEMP, land disturbance processes will be developed to ensure unnecessary land disturbance does not occur, including provision for site inspection by the site Environmental Manager or delegate prior to disturbance, to identify any necessary drainage and erosion and sediment controls are planned and implemented as required.

7 Rehabilitation

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

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

It is expected that any drainage line causeways will remain for future use by landowners.

It is recommended that an appropriate LSC soil assessment is completed, so that the depth of topsoil and subsoil is understood. This can be used to guide minimum soil depths for rehabilitation works so that the pre-project LSC can be re-established, particularly in areas where hardstands, roads and sediment basins are removed.

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

8 Conclusion

8.1 Evaluation of the project

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

The project design and situation within the study area to minimise the specific impacts relating to land and soils is limited due to the consistency of the study area in terms of soil type and associated usage, hazards and limitations, such as LSC and erosion hazard.

The scale and nature of the project impacts are described in greater detail below.

8.1.1 Soil assessment

Most of the site footprint is located conceptually on the Sodosol soil types. Sodosols are limited to generally very low agricultural potential with high sodicity leading to high erodibility, poor soil structure and low permeability and issues such as hard-setting topsoils and gully erosion, as evidenced on site. Despite the generally low relief of the study area, the possible risk from construction is very high due to dispersive nature of the subsoils and less-resilient nature of the topsoils. Soil management practices will be key to maintain suitable soil cover, minimise exposure of subsoils and maintain topsoil resources to ensure soil profiles are returned in a similar condition to minimise the exposure of erosion-prone subsoils and maintain soil productivity.

The other prominent soil types of the area are Tenosols, poorly developed soils that typically have low clay content and are weakly structured, sandy soils. They are typically benign from a soil chemistry perspective, being typically non-saline and non-sodic with poor fertility. Their low clay content and poor structure should be considered in construction as they are susceptible to erosion due to their sandy, non-cohesive nature.

With reference to the eSPADE database (DPIE 2020a) and DPIE (2020c), the study area is mapped at the state scale as LSC Classes 5 and 7. These LSC classes represent land with moderately-low to low capability for productive use without resulting in land degradation.

The land and soil capability of agricultural lands in the study area are unlikely to change from their current capability, provided appropriate management and mitigation measures are implemented.

8.1.2 Agriculture

The site suitability with respect to agriculture considers the inherent low LSC class in addition to the extensive amount of land utilised for agriculture within the LGA, of which the project is a very minor area. Project impacts to agriculture are primarily due to the loss of access to the land for usage in intensive cultivation such as cropping or cattle grazing for the duration of the project. These impacts are considered to be low due to the inherently poor land capability of the study area as well as the potential for ongoing agricultural practices, such as sheep grazing which is estimated to achieve 50% of existing stocking rates for 50% of the year.

Impacts to the inherent capability of the land and subsequent agriculture after project completion should be minimal if mitigation measures are utilised.

Cumulative impacts to adjacent land relevant to agriculture are expected to be minimal, with the only potential impact being associated with sediment deposition or erosion from the project, which can be suitably managed. Other impacts to adjacent agriculture are considered in other technical reports completed as part of the EIS, such as the traffic impact assessment (Appendix H of the EIS) and social impact assessment (Appendix O of the EIS).

8.1.3 Erosion and sediment control

The soil erosion hazard has been assessed as high due to the presence of dispersive of subsoil. The rainfall and slope erosion hazard has been assessed as low where slopes are less than 12% and high where they exceed 12%. Of the study area, 1,313 ha slopes less than 12% and is therefore very low to moderate erosion hazard (SLC 1–4), whilst 15.8 ha is high to very high erosion hazard (SLC 5 & 6) and 1.1 ha is extremely high erosion risk (SLC 7). Potential impacts include tunnel erosion and severe gully erosion on and offsite, downstream sedimentation and the generation of highly turbid runoff.

The impacts are greatest during the construction phase when soils are disturbed and drainage and landforms are modified. These impacts can extend to the operational phase if drainage and landforms design inappropriate for dispersive soils are adopted, however, the erosion hazard can be minimised to an acceptable level via adoption of appropriate drainage, erosion and sediment control practices:

- minimising disturbance and maintaining topsoil and vegetative cover over dispersive subsoils;
- adopting a drainage design that maintains sheet flow conditions and minimises concentration of flow;
- installing solar arrays at a height that maintains adequate vegetative soil surface cover;
- utilising the natural landform topography and minimising cut and fill where practicable;
- ensuring pipeline and cable trenches are located on the contour where feasible and using trench breakers that extend outside the trenches into in-situ soils;
- treating disturbed dispersive soils with gypsum;
- locating sediment basins downstream of disturbed areas to capture eroded sediments and treat turbid runoff; and
- progressively stabilising and revegetating disturbed areas.

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Appendix A

Land use conflict risk assessment

A.1 LUCRA

Table A.1 LUCRA table

Identified potential conflict	Probability (P)	Consequence (C)	Risk ranking	Management strategy (method of control)	Revised risk ranking (P; C)	Performance target
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, appropriate wash down facilities will be available to clean vehicles and equipment prior to arrival and when leaving the work areas. 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, if implemented, sheep grazing would 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 general disturbance. 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.	5 (D; 4)	Effectiveness will be measured as part of the CEMP and OEMP.

Table A.1 LUCRA table

Identified potential conflict	Probability (P)	Consequence (C)	Risk ranking	Management strategy (method of control)	Revised risk ranking (P; C)	Performance target
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 (ie agriculture) upon decommissioning. The development footprint incorporates a mix of farms from within the local community, with potential for continuation of sheep grazing activities within the development footprint during operations, as well as continuation of farming activities on land surrounding the development footprint. Primary production can continue within the immediate surrounds. 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 formation of level pads for substations, PCUs and BESS infrastructure. A project decommissioning and rehabilitation plan will be prepared prior to the end of the project's operational life and will feature rehabilitation objectives and strategies for returning the development footprint to agricultural production.	11 (A; 5)	Rehabilitation objectives and strategies (including performance measures) will be established in the decommissioning and rehabilitation plan.
Reduced agricultural productivity of land under project infrastructure during operations.	A	5	11	The anticipated use of single axis tracking PV modules involves a typical row spacing of 8–12 m, which would result in a significant area of land within the project's development footprint that could still be utilised for sheep grazing during the project's operations. It is noted that resting the land within the development footprint from significant grazing pressure during operations may improve the future agricultural productivity potential of the land following decommissioning.	11 (A; 5)	Rehabilitation objectives and strategies (including performance measures) will be established in the decommissioning and rehabilitation plan.
Impacts on the operation of the project from neighbouring agricultural operations (eg dispersal of dust and/or agricultural products on to PV modules).	D	4	5	No significant impacts on the operation and functionality of the project are anticipated as a result of neighbouring agricultural operations. Standard maintenance of the PV modules and other project infrastructure will likely address any potential impacts generated by dust or spray drift from neighbouring agricultural and/or land management practices.	5 (D; 4)	No action required.

Table A.1 LUCRA table

Identified potential conflict	Probability (P)	Consequence (C)	Risk ranking	Management strategy (method of control)	Revised risk ranking (P; C)	Performance target
Construction noise and associated impacts on residents.	B	3	17	Construction noise impacts have been assessed as part of the noise and vibration impact assessment. The results of the construction noise modelling demonstrate predictions of compliance with the construction noise management levels (NMLs) for all assessment locations. Noise generated during construction will also be minimised through implementation of best practice requirements outlined in the *Interim Construction Noise Guideline* (DECC 2009). Construction noise management and mitigation will be addressed in the CEMP.	9 (D; 3)	Effectiveness will be measured as part of the CEMP, 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 *Interim Construction Noise Guideline* (DECC 2009). Any required mitigation measures will be identified in consultation with landholders and included in the CEMP for the project.	8 (C; 4)	Effectiveness will be measured as part of the CEMP, 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 and vibration impact assessment. To achieve compliance with operational noise criteria at all assessment locations, the following mitigation measures have been applied in the model: • no electrical infrastructure (i.e., transformers or inverters) to be installed within 250 m of the property boundary of R3; • no electrical infrastructure to be installed within 100 m of the property boundary of R5; and • the 1,200 MVA grid transformer, which will form part of the BESS, will be installed with a 6.5 m high barrier, positioned to reduce noise impacts on nearby sensitive receivers (ie non-associated residences). With the implementation of these measures, compliance with the *Noise Policy for Industry* (EPA 2017) criteria is predicted at all assessment locations.	2 (D; 5)	No action required.

Table A.1 LUCRA table

Identified potential conflict	Probability (P)	Consequence (C)	Risk ranking	Management strategy (method of control)	Revised risk ranking (P; C)	Performance target
Noise from increased vehicle movements on local roads during construction and associated impacts on residents and livestock.	B	3	**17**	Road traffic noise impacts have been assessed as part of the noise and vibration impact assessment. Project-related traffic on Castlereagh Highway is predicted to increase existing road traffic noise by more than 2 dB during construction; however, daytime traffic noise levels (LAeq,15hour) from light and heavy vehicle movements on Castlereagh Highway will remain below the minimum threshold for arterial roads under the *Road Noise Policy* (DECCW 2011). To reduce the project's impacts on the local road network, one dedicated access route will be utilised by all project-related vehicles when accessing the project from the Castlereagh Highway (ie Barneys Reef Road and Birriwa Bus Route South). Implementation of best practice requirements outlined in the *Interim Construction Noise Guideline* (DECC 2009) will also minimise noise impacts. Construction noise management and mitigation will be addressed in the CEMP.	9 (D; 3)	Effectiveness will be measured as part of the CEMP, which will include reference to relevant noise criteria.
Dust from vehicle movements along access roads and unsealed local roads.	B	4	**12**	ACEN will apply appropriate mitigation strategies to reduce potential dust generation by project-related vehicle movements during construction. Water truck(s) will be used during construction for dust suppression along internal, unsealed access roads and disturbed areas. 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 sheep moving across paddocks on-site once operational. If implemented, sheep grazing within the development footprint would be a continuation of an existing land use. No management strategy is proposed to address this potential conflict.	4 (C; 5)	No action required.
Visibility of project infrastructure from residences and the local road network.	B	2	**21**	The visibility of project infrastructure from eight viewpoints has been assessed as part of the visual impact assessment. The mitigation measures required to alleviate visual impacts are listed in the visual impact assessment and, subject to the outcomes of ongoing engagement with relevant landholders, may include vegetation screening within the development footprint to minimise visual amenity impacts at R1, R1a and R5.	**13 (C; 3)**	Any future landscaping plans will include a program to monitor and report on the effectiveness of the proposed landscaping.

Table A.1 LUCRA table

Identified potential conflict	Probability (P)	Consequence (C)	Risk ranking	Management strategy (method of control)	Revised risk ranking (P; C)	Performance target
Inadequacy of vegetation at screening project infrastructure during ongoing operations.	C	3	13	Any required vegetation screening would be installed in accordance with a detailed landscaping plan prepared in consultation with DPE, project landholders and affected landholders to the satisfaction of the Secretary. Vegetation screening would be planted prior to the commencement of operations and consist of vegetation species that facilitate the best possible outcome in terms of visual screening and would be designed to be effective at screening views of project infrastructure within three years of the commencement of construction. The plan would include a program to monitor and report on the effectiveness of the vegetation screening and include details of who would be responsible for monitoring, reviewing and implementing the plan. It would also detail the appropriate course of action should affected landholders or relevant agencies consider the planted vegetation screening to be inadequate.	9 (D; 3)	The landscaping plan will include a program to monitor and report on the effectiveness of the proposed landscaping.
Glare/reflectivity from PV modules and other project infrastructure.	D	4	5	Based on the findings of previous assessments prepared for PV solar energy facilities, glint and glare from the project's PV modules and other project infrastructure are not expected to significantly impact receptors within the vicinity of the development footprint or motorists travelling along the local and regional road network. The proposed landscaping would also reduce the visibility of PV modules and other project infrastructure at these locations, which would also mitigate any potential for glint or glare impacts. No management strategy is proposed to address this potential conflict.	5 (D; 4)	No action required.

Table A.1 LUCRA table

Identified potential conflict	Probability (P)	Consequence (C)	Risk ranking	Management strategy (method of control)	Revised risk ranking (P; C)	Performance target
Potential for night lighting from the project to impact neighbouring properties.	D	5	2	The project sits within the Dark Sky Region surrounding the Siding Spring Observatory. Developments within this area are required to apply good lighting design principles in accordance with the *Dark Sky Planning Guideline* (DPE 2016). The use of lighting will be minimised, using lights only as required for safety and security. Shield and orient lighting downward to eliminate any light spill. Any external lighting associated with the project will comply with AS/NZS 4282:2019 - Control of the Obtrusive Effects of Outdoor Lighting, or its latest version.	5 (D; 4)	Compliance will be measured as part of the CEMP and OEMP.
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 Construction Workforce Management Plan (CWMP). The CWMP will encourage positive workforce behaviour.	9 (D; 3)	The CWMP will include details on how the plan 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. The temporary construction site compound will be established in a fenced-off area within the development footprint. Chain mesh security fencing will be installed around the perimeter of the development footprint to control access.	5 (D; 4)	No action required.

Table A.1 LUCRA table

Identified potential conflict	Probability (P)	Consequence (C)	Risk ranking	Management strategy (method of control)	Revised risk ranking (P; C)	Performance target
Safety of children and cyclists due to increased vehicle movements along the local road network.	D	2	**14**	The project's CTMP and Driver Code of Conduct will be prepared prior to commencement of construction and will include: informing drivers about the school bus routes along Castlereagh Highway; • direction to avoid compression braking near residential receptors; • direction for trucks to avoid making trips during school hours; • direction to avoid trips during school zone times; • direction to not travel within 100 m of any school bus and not to overtake any school buses; • direction to not travel within 100 m of cyclists and not to overtake cyclists on Birriwa Bus Route South; and • responding to local climate conditions that may affect road safety such as fog, dust and wet weather.	**14 (D; 2)**	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.
Safety of horses, wildlife and livestock due to increased vehicle movements along the local road network.	D	2	**14**	Speed within the development footprint will be limited to 40 km/hr during construction and operations to minimise potential vehicle collisions with fauna within the development footprint. Temporary travel speed reduction may also be implemented on local roads as part of the CTMP.	**14 (D; 2)**	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.

Table A.1 LUCRA table

Identified potential conflict	Probability (P)	Consequence (C)	Risk ranking	Management strategy (method of control)	Revised risk ranking (P; C)	Performance target
Devaluation of neighbouring properties due to proximity to project infrastructure.	D	3	9	Where significant impacts to neighbouring landholders have been identified during the initial site investigations, the project has been refined and/or management and mitigation measures have been proposed to further reduce potential impacts. This includes the introduction of setbacks from neighbouring residences to reduce potential views of project infrastructure, paying particular attention to the most valued views from affected residences, or a significant reduction in the development footprint to reduce visual impacts. There are many factors that influence land values; however, inference can be drawn from one key factor, which is amenity and specifically, the impacts to the amenity of neighbouring properties and the locality. The EIS and supporting technical assessments have considered potential amenity impacts from the project's construction and operations. Construction impacts will be temporary in nature and are therefore considered unlikely to have a lasting impact on the amenity of the locality. The residual impacts associated with the ongoing operation of the project (ie after the implementation of proposed management and mitigation measures, such as landscaping) are predicted to be minimal. ACEN will also implement the following measures to reduce impacts to neighbouring properties and thus minimise potential risk of property devaluation: • buffer zones during construction works to minimise potential noise impacts at neighbouring residences; • a CTMP and Driver Code of Conduct to minimise potential impacts on the safety and serviceability of the local road network; and • a CWMP 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 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 to the council rates of neighbouring properties due to the change in land use within the development footprint.	D	3	9	The rating category for the land within the development footprint will likely need to change from 'farmland' to 'business' in accordance with the NSW *Local Government Act 1993*. This could result in some increase in land value and subsequent increases in rates; however, it is not anticipated that this will impact land value or council rates on neighbouring agricultural properties. No management strategy is proposed to address this potential conflict.	9 (D; 3)	No action required.

Table A.1 LUCRA table

Identified potential conflict	Probability (P)	Consequence (C)	Risk ranking	Management strategy (method of control)	Revised risk ranking (P; C)	Performance target
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 impact to the general public and neighbouring agricultural operations will be minimal or negligible. Location selection for project infrastructure (namely the PV modules, PCUs, substation and BESS infrastructure) and fencing within the study area will limit exposure to EMFs for the general public. Outside of exposure to EMFs, there are no known potential health impacts associated with proximity to the project infrastructure.	10 (E; 2)	No action required.
Increased vehicle movements along the local road network during construction and subsequent impacts on accessibility and commute times.	B	4	**12**	To reduce the project's impacts on the local road network, one dedicated access route will be utilised by all project-related vehicles when accessing the project from the Castlereagh Highway (ie Barneys Reef Road and Birriwa Bus Route South).	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 (eg 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 (eg temporary alternate construction vehicle access routes and/or 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 and are estimated to be an average of 20 daily vehicle movements which would generally all be light vehicle movements. 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.

Table A.1 LUCRA table

Identified potential conflict	Probability (P)	Consequence (C)	Risk ranking	Management strategy (method of control)	Revised risk ranking (P; C)	Performance target
Impact of vehicle movements on school bus route accessibility and commute times.	C	4	8	The project's CTMP and Driver Code of Conduct will be prepared prior to commencement of construction and will include: • informing drivers about the school bus routes along Castlereagh Highway; • direction for trucks to avoid making trips during school hours; • direction to avoid trips during school zone times; and • direction to not travel within 100 m of any school bus and not to overtake any school buses.	8 (C; 4)	The CTMP will include a complaint resolution and disciplinary procedure as a mechanism to address any issues identified by neighbouring landholders.
Potential conflicts between project-related construction vehicle movements and stock movements.	C	4	8	Project-related and nearby landholders may move stock between paddocks and across roads proposed to be utilised for access to the development footprint, therefore there is potential for conflict with project-related construction traffic movements. Potential stock crossing locations will be identified through further consultation with project-related and nearby landholders. Any required mitigation measures (eg direct line of communications between landholder and site construction manager and/or temporary traffic control at stock movement locations) will be identified in consultation with landholders and included in the CTMP for the project.	5 (D; 4)	The CTMP will include a complaint resolution and disciplinary procedure as a mechanism to address any issues identified by neighbouring landholders.
Soil erosion leading to land and water pollution.	C	3	13	Prior to the commencement of construction, a Soil and Water Management Plan (SWMP) will be prepared, which 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 SWMP, CEMP and OEMP.

Table A.1 LUCRA table

Identified potential conflict	Probability (P)	Consequence (C)	Risk ranking	Management strategy (method of control)	Revised risk ranking (P; C)	Performance target
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 SWMP. Infrastructure with the potential to cause pollution to waterways in the event of flooding (ie inverters and BESS components) will be located with a minimum 300 mm freeboard above the maximum 1% AEP flood level. Given the shallow depths across the development footprint, raising these small fill pads is highly unlikely to result in any adverse impacts off-site. The natural state of the draining flow paths will be maintained whenever possible. Internal access roads, where crossing watercourses, will be designed for the 10% AEP design flow and may include compacted rock causeways to provide low maintenance access with limited impact on the drainage line or culvert structures.	8 (C; 4)	Effectiveness will be measured as part of the SWMP, 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 via water trucked to the development footprint. Water contained within existing farm dams to be removed may be used for non-potable construction purposes, in accordance with harvestable rights provisions, 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, Mid-Western Regional Council and relevant agencies.	5 (D; 4)	No action required.
Potential loss of access to water within dams for livestock due to the project's construction.	B	3	**17**	Further consultation between project landholders and ACEN may be required in consideration of lease arrangements and legislative requirements for construction of replacement farm dams for stock watering. Water contained within existing farm dams to be removed may be used for non-potable construction purposes, in accordance with harvestable rights provisions, to minimise use of imported water where practicable. The income for the project landholders will serve to drought-proof their ongoing farming operations for the next generation of farmers. There are not expected to be any constraints on the current or potential agricultural uses of nearby land.	9 (D; 3)	No action required.

Table A.1 LUCRA table

Identified potential conflict	Probability (P)	Consequence (C)	Risk ranking	Management strategy (method of control)	Revised risk ranking (P; C)	Performance target
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) in consultation with Mid-Western Regional Council and DPE. 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. The WMP will be prepared prior to commencement of construction.	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. A primary means of planning and managing potential impacts to the local community (including availability of accommodation, infrastructure and services) will be through implementation of a CWMP or similar. ACEN will advocate with industry bodies such as EnergyCo for a strategic approach to understanding and managing cumulative impacts from REZ development on regional communities in regard to access to and use of infrastructure and services including accommodation. ACEN will also engage with other renewable energy proponents in the regional area in relation to a coordinated response to manage potential workforce impacts on services and facilities across the regional area.	5 (D; 4)	The CWMP will include details on how the plan will be managed and audited.
Impacts on land surrounding the project 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. The bushfire management plan for the project 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.

Table A.1 LUCRA table

Identified potential conflict	Probability (P)	Consequence (C)	Risk ranking	Management strategy (method of control)	Revised risk ranking (P; C)	Performance target
Impacts on the operation of the project 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 defendable 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; and • 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.

Information is based on draft technical assessments and will need to be updated in line with comments following ACEN review.