Agricultural Land Utility Assessment

Proposed BESS Facility

9010 Mitchell Highway, Apsley, NSW

ACENERGY

Cadeema

DOCUMENT INFORMATION

Prepared For:	ACEnergy
Prepared By:	Cadeema- Soil, Water & Environmental Consultants, Shepparton, Victoria
Project Name:	Agricultural Land Utility Assessment for BESS Facility
File Reference:	ACEnergy BESS Facility, Apsley, NSW
Job Reference:	C274
Project Duration:	March- April 2022

DOCUMENT CONTROL

Version	Date	Issue	Author	Reviewed/Approved
1.0	5 April 2022	Draft	Ahmed Alsabe	Cliff Dillon
2.0	12 April 2022	Draft	Ahmed Alsabe	Cliff Dillon
3.0	5 May 2022	Final	Ahmed Alsabe	Cliff Dillon

CONSULTANT INFORMATION

Cadeema - Soil, Water & Environmental Consulting

- A Scientific & Technical Consultancy Group
- Specialising in soil, water and environmental management
- Fields of environmental, agricultural, geotechnical, archaeology
- Undertaking site investigations, pre-development assessments, trouble-shooting, on-going monitoring, development planning and implementation management

ABN:	37 621 073 032
Phone:	0428291011
Email:	admin@cadeema.com.au
Web:	www.cadeema.com.au

TABLE OF CONTENTS

1 INTRODUCTION

In April 2022, ACEnergy proposed to construct a BESS (Battery Energy Storage System) facility at Glenara Park, 9010 Mitchel Highway (Lot 3 (DP1012686)) in Apsley (NSW) (*Appendix A - Locality Plan*) which is located approximately 11 km south of Wellington (*Appendix B - District Plan*). ACEnergy engaged Cadeema to undertake an Agricultural Land Utility Assessment of an approximately 6 ha area of land which had been selected for the purpose and which is referred to herein as '*the site*', (*Appendix C - Site Plans*) (*Image 1*).

Details of the proposed BESS facility are provided in the Environmental Impact Statement (EIS) (compiled and provided by others) elsewhere and in summary, the facility is proposed to be total 6 ha. It includes approximately 5.5 ha of potentially disturbed area, containing battery containers and associated infrastructure, along with approximately 0.5 ha area of overhead transmission facilities (*Appendix C - Site Plans*). The facility will include connection to existing high-voltage power lines located east of the site.

The project has SEARs (NSW Department of Planning, Industry and Environment (DPIE) Secretary's Environmental Assessment Requirements (SEARs) (Application Number SSD-35160796)) some of which are addressed in this Agricultural Land Utility Assessment. Specifically, the SEAR's addressed herein include the provision of '*a soil survey to determine the soil characteristics and consider the potential for erosion to occur*' along with the provision of sufficient information to facilitate an assessment (to be conducted by others and detailed in the EIS) of '*the impact on agricultural resources and agricultural productivity*'.

Image 1: *The site in March 2022 consisted of open grazing land sustaining weeds.*

The aim of this Agricultural Land Utility Assessment was to collect sufficient environmental information to ascertain the potential agricultural resource status of the site. Regulatory authorities require this information to consider the protection of existing and/or potential agricultural industries, the land on which these industries depend, on existing or potential agricultural resources, and any cumulative impacts on regional agricultural productivity. To quantify site agricultural resources, the consultants determined the Land and Soil Capability (LSC) (*Office of Environment and Heritage 2012*) of the site and the Biophysical Strategic Agricultural Land (BSAL) (*Office of Environment and Heritage 2013*) status across the site.

2 METHODOLOGY

As detailed above, this detailed Agricultural Land Utility Assessment involved the collection of relevant site environmental information to ascertain the potential agricultural resource status of the site and to determine, on a higher resolution scale than previously adopted, the Land and Soil Capability (LSC) (*Office of Environment and Heritage 2012*), and the Biophysical Strategic Agricultural Land (BSAL) (*Office of Environment and Heritage 2013*) status of the site.

This detailed Agricultural Land Utility Assessment included a desktop assessment of relevant publicly available information including environmental features on and surrounding the site. Two experienced soil, agricultural and environmental scientists undertook a detailed investigation of the site on Tuesday 29th March 2022 and this included an interview with the current landholder Mrs Jeanette Blackhall. The site inspection included assessment of site biophysical characteristics including geology, landform, geomorphology, soils, vegetation (including remnant vegetation), hydrology (natural surface water occurrence and movement), drainage (soil profile and surface), topography, agricultural utility, agricultural infrastructure, landscape context and general pertinent features relating to agricultural use on and adjoining the site. The soil investigations included detailed assessment of soil physical characteristics laterally across the site and vertically down the soil profile using mechanically excavated soil profile inspection pits (*Image 2*) and hand auger soil profile investigations (*Image 3*). Soil samples were collected for soil chemistry laboratory analysis to facilitate assessment of soil chemical characteristics. In addition, this Agricultural Land Utility Assessment also included accessing information on soil classification, landscape, groundwater, climatic variables and water supply.

Some areas on and adjoining the site consisted of agricultural shedding, public roadways and water storage dams which precluded detailed soil examination and whilst these areas were inspected and assessed, these areas are not likely to be utilised or altered as part of the proposed BESS facility and have therefore been termed Exclusion Zones (*Office of Environment and Heritage 2013*). To ensure a thorough assessment of the site, two locations were selected for detailed assessment and these, which included soil profile inspection pits and detailed soil chemistry analysis, have been termed Detailed Sites (*Office of Environment and Heritage 2013*). Whilst the site covers 6 ha, the inclusion of a surrounding buffer area takes the total area assessed to 10 ha. This equates to a Detailed Site every 5 ha. In addition, the land and soil was inspected at another 50 locations with a hand soil auger on an approximately 50 m grid; these inspection locations have been termed Check Sites (*Office of Environment and Heritage 2013*). As per the New South Wales Government Office of Environment and Heritage 2013 guidelines for the assessment of BSAL, this Agricultural Land Utility Assessment consisted of:

Exclusion Zones - infrastructure, excessive rock and/or excessive slope (topography)
Detailed Sites - 2 in total (1 per 5 ha); soil profile inspection pits & detailed soil chemistry analysis
Check Sites - 50 in total (5 per ha); undertaken with a hand soil auger

***Image 2** (left): The soil profile was examined and logged in 2 soil profile inspection pits excavated on the site.*
***Image 3** (right): The soil profile was also examined at approximately 50 locations across the site using a hand soil auger. Documentation of soil physical characteristics using these methods facilitated segregation of the soil into Soil Types and the mapping of the soils across the site.*

The site investigation, and in particular the soil physical and chemical characteristic assessments, facilitated segregation of the soils across the site into Soil Types. A soil profile description for each of the Soil Types is provided in the appendices (*Appendix D - Soil Profile Descriptions*) and this details the site soil physical characteristics. Ten soil samples were collected from the soil profile inspection pits at the 2 Detailed Sites and these were analysed in the laboratory for a range of agronomic soil chemical parameters and the results of this are provided in the appendices (*Appendix E - Soil Chemistry Analysis Results*). Further details on these soil investigations are provided in ensuing sections.

The New South Wales Government has a web based central resource for sharing and enabling environmental data in NSW (Sharing & Enabling Environmental Data (SEED)) (*SEED 2022*). Information and data on environmental features pertaining to the site were accessed from SEED and some of the maps covering the site sourced from SEED are provided in the appendices (*Appendix F – Geology, Topogrpahy, Landscape & Soil Maps*).

The collaboration and interpretation of the above-mentioned information in this Agricultural Land Utility Assessment facilitated the assessments detailed herein of the Land and Soil Capability (LSC) (*Office of Environment and Heritage 2012*) on the site, and of the Biophysical Strategic Agricultural Land (BSAL) (*Office of Environment and Heritage 2013*) status of the site. Details of the methodologies employed for these land and soil classifications are provided in ensuing sections.

3 SITE CONTEXT

3.1 Site Setting

The site forms part of a larger property called Glanara Park which is owned by Mrs Jeanette Blackhall and is located adjacent to the Mitchell Highway to the south of Wellington in central NSW in the district of Apsley (*Appendix B - District Plan*). Other areas of this property, including the homestead and agricultural shedding, are located approximately 250 m south of the site. The site is currently accessed from this property infrastructure. The site is located on cleared, gently undulating hills in an agricultural district used for grazing and cropping.

The Mitchell Highway forms the western boundary of the site and an agricultural fence line forms the northern boundary (*Appendix C - Site Plans*). The southern boundary of the site is part of a larger agricultural paddock. The east of the site consists of an incised earthen agricultural surface water run-off dam, rudimentary agricultural shedding is located in the southeast of the site, and a high-voltage power transmission line adjoins the eastern boundary of the site (*Appendix C - Site Plans*).

The site consists of a gentle slope (2%) and has a north-westerly aspect. A topographical plan of the site is provided in the appendices (*Appendix G - LSC & BSAL Maps*). A slightly lower area between gently undulating hills enters the site from the southeast and this enters the aforementioned incised earthen agricultural surface water catchment dam located in the northeast of the site (*Appendix C - Site Plans*). Excess surface water from south of the site appears to enter a slightly lower area which extends from south to north through the site and terminates in an earthen agricultural surface water catchment dam located immediately north of the north-western boundary of the site.

At the time of the site investigation, the site was being utilised for low intensity grazing of weeds by beef cattle. The property owner stated that the site had been tilled and utilised for dryland winter fodder crop production in the past. The site appeared to have low agricultural management intensity.

Whilst it appears that excess surface water run-off may enter and cross the site from surrounding more elevated areas, the site appeared to generally have good surface drainage and it appeared that excess surface water would readily leave the site. This would typically terminate in the dam adjacent to the north west boundary of the site. Whilst difficult to ascertain, excess surface water from the adjoining Mitchell Highway may enter the western parts of the site.

The site does not support any trees or shrubs, and no remnant or native understory or grasses were identified during this site inspection. Several rows of planted native trees are located along the Mitchell Highway north of the north-western corner of the site. These trees are approximately 10 years old and appear to be in good health. A significant remnant tree occurs approximately 100 m south of the southern boundary of the site in the centre of an agricultural paddock on the property. At the time of the site investigation the entire site supported a large variety of weed species which appeared to be predominantly in good health.

Further details on the site such as vegetation, surrounding land uses, groundwater and hydrology are detailed elsewhere in the EIS

3.2 Climate

The nearest Bureau Of Meteorology (BOM) weather station is located at Wellington (BOM Site No. 65034) approximately 9 km north of the site. Weather data from 1881 to 2021 indicates a long-term average annual rainfall approximating 615 mm, with the long-term 10th percentile dry year rainfall approximating 395 mm and the long-term 90th percentile wet year rainfall approximating 855 mm. Rainfall distribution throughout the year is relatively even however, rainfall over the winter months is approximately 25% below rainfall over the summer months. This is sufficient annual rainfall for adequate production of agricultural crops such as grain and fodder crops, and for agricultural pastures.

3.3 Soil Overview, Assessment & Classification

3.3.1 <u>Soil Assessment Process</u>

Soil physical characteristics across the site were documented and mapped using two soil profile inspection pits and approximately 50 soil profile hand auger investigations. The location of the two pits is detailed in the appendices (*Appendix C - Site Plans*) as are the pit GPS coordinates (*Appendix D - Soil Profile Descriptions*). The location of these pits was selected based on soil variations across the site and to provide representative examples of the site soil profiles. The two soil pits have been designated '*Soil Pit 1 West*' and '*Soil Pit 2 East*'.

The soil profile inspection pits were dug with an excavator to a depth of 1.0 m below the natural surface. The face of each soil pit was revealed with a hand soil pick and this facilitated identification of soil horizons and the subsequent detailed description of soil physical characteristics down the soil profile. A description of the soil profile for each of the Detailed Sites investigated is provided in the appendices (*Appendix D - Soil Profile Descriptions*).

Soil physical characteristics were also investigated in approximately 50 soil profile hand auger investigation locations which were spaced on an approximately 50 meet grid. A 100 mm diameter hand soil auger (*Image 3*) was used to expose the soil profile down to depths of between 30 and 80 cm below the natural surface. The depth investigated at each location depended on the depth to rock or to the highest clay content subsoil layer (horizon).

The combination of information from the soil pits, from the soil hand auger investigation locations and from surface features across the site facilitated classification of the soils into 3 distinct Soil Types.

3.3.2 <u>Geology</u>

The geology of the entire site is mapped as Ordovician sedimentary and mafic volcanic and volcaniclastic rocks (Osv). The site investigation indicated colluvium derived from Ordovician sedimentary rock along with variable and sporadic Ordovician sedimentary rock fragments and areas of Ordovician sedimentary bedrock outcrops.

3.3.3 <u>Soil Types</u>

The soil physical characteristics in the upper 50 cm of the soil profile across the site readily facilitated segregation of the soils into three distinct Soil Types. These characteristics include those most likely to influence agricultural production and the growth and function of typical horticultural or agricultural crop roots. Whilst a range of soil physical characteristics were considered (*Appendix D - Soil Profile Descriptions*), the most pertinent include amount of rock and the depth (thickness), texture, structure and drainage of the topsoil (A Horizon), of the initial (transitional) subsoil (B1 Horizon) and of the main subsoil (B2 Horizon) layers. This facilitated segregation of the soils into the three Soil Types:

- **Rocky Soil** = < 30 cm of rock and red clay loam overlying bedrock
- **Red Friable Soil** = 30 cm of gradational, friable red clay loam to light clay overlying medium clay
- **Brown Plastic Soil** = <10 cm of brown clay loam overlying dense, plastic, medium to heavy clay

These Soil Types are described in more detail in ensuing sections, along with the soil chemical characteristics. Whilst an appropriate assessment was made of the Rocky Soil, no Detailed Site or soil profile inspection pit were assigned to this Soil Type due to the inability to excavate and limited soil profile features. The Detailed Site and soil profile inspection pit designated Soil Pit 1 West was representative of the Brown Plastic Soil. The Detailed Site and soil profile inspection pit designated Soil Pit 2 East was representative of the Red Friable Soil.

Based on the consultant's soil science experience and a search of publicly available records, there is no record of acid sulphate soils on or in the vicinity of the site and the soils on the site are not susceptible to the development of acid sulphate conditions.

Based on the consultant's soil science experience and on the site biophysical features such as landform position, slope gradient, drainage and climate, along with soil physical and chemical characteristics, the soils on the site are not susceptible to significant erosion.

3.3.4 Soil Mapping

The soil physical characteristics unique to each Soil Type were readily identified in the field at the Check Sites with the 100 mm diameter hand soil auger and this method was used to map the three Soil Types across the site (*Appendix G - 2022 Soil Map*). As detailed on the soil map in the appendices, the three Soil Types cover the following areas:

- Rocky Soil = 10%
- Red Friable Soil = 60%
- Brown Plastic Soil = 30%

3.3.5 Corresponding Soil Classifications

SEED (*2022*) documents the site as consisting entirely of the Great Soil Group (GSG) Euchrozems which are described as red, strongly-structured clay soils with a somewhat lower clay content near the surface; resembling Krasnozems but more alkaline. SEED (*2022*) also documents the site as consisting entirely of the Australian Soil Classification (ASC) (*Isbell 2021*) Ferrosols which are described as soils which lack a strong texture contrast between the A and B Horizons, have high free iron oxide content B2 Horizons, and have vertic (high clay content (> 35%), cracking, slickensides and/or lenticular peds) properties. The Red Friable Soil identified on the site has characteristics approximating those of Euchrozems and Ferrosols.

When considering the Australian Soil Classification (ASC) (*Isbell 2021*), the three Soil Types identified on the site have the following ASC:

- Rocky Soil – Leptic Rudosol
- Red Friable Soil – Red Ferrosol
- Brown Plastic Soil – Brown Sodosol

4 ROCKY SOIL

4.1 Surface

The land surface of the Rocky Soil typically consists of a consistent extended 1% slope, a flat micro relief and an exposed north-north-westerly (340^{o}) aspect. The soil surface contains floating Ordovician sedimentary rock and boulders (5 to 100 cm diameter) and Ordovician sedimentary bedrock encompassing 30 to 40 % of the land surface. Where soil occurs on the surface, this is generally loose and friable. At the time of the site investigation, the Rocky Soil was utilised for dryland grazing of weeds and for rudimentary agricultural shedding. The Rocky Soil is not considered arable due to surface rock content (*Image 4*).

Image 4: *The Rocky Soil surface consists of 30-40% Ordovician sedimentary bedrock, boulders & rock.*

4.2 Soil Physics

As detailed in the appendices (*Appendix D - Soil Profile Descriptions*), the Rocky Soil consists of weakly structured, granular, friable, red-brown, sandy clay loam with variable (5 to 50%) Ordovician sedimentary rock and boulders (5 to 100 cm diameter). This material shows no Horizon development and overlies Ordovician sedimentary bedrock. The depth of soil over bedrock is highly variable ranging from nil to 30 cm and averaging 15 cm. The surface consists of 30 to 40 % Ordovician sedimentary bedrock (*Image 5*).

Image 5: *The Rocky Soil consists of friable red-brown sandy clay loam and Ordovician sedimentary rock.*

4.3 Soil Chemistry

No soil chemistry analysis was undertaken of the Rocky Soil due to excessive rock content and the limited prospects of agricultural utility. However, the surface soil layer excluding rock is likely to have chemical characteristics approximating those of the surface soil of the Red Friable Soil based on both soil types having very similar surface soil physical characteristics, the same geology and being located in similar locations in the landscape.

4.4 Key Soil Features

The Rocky Soil is a Leptic Rudosol (*Isbell 2021*) which occurs on an exposed gentle sloping hill (2% slope). Whilst not analysed in the laboratory, based on field observations, field pH assessments and laboratory analysis of the adjoining down slope Soil Type, soil pH levels ($CaCl_2$) are likely to approximate 5.0 to 7.0 and the soils are likely to have low salinity and sodicity levels. This Soil Type is well drained with a moderately permeable profile (*NCST 2009*) and the surface consists of 35% rock. Leptic Rudosols (*Isbell 2021*) are classified as having a relative fertility ranking of 1 which is low (*Office of Environment and Heritage 2013*).

The Rocky Soil has limited agricultural utility due to a large proportion of rock (including bedrock) occurring on the surface and within 0.3 m of the surface. This rock precludes tillage and limits the volume of soil available for plant root exploitation. The Rocky Soil potentially facilitates groundwater recharge. This Soil Type is not suitable for cropping and is only suitable for limited dryland grazing.

5 RED FRIABLE SOIL

5.1 Surface

The land surface of the Red Friable Soil typically consists of a consistent extended 2% slope, a flat micro relief and an exposed north-westerly (310º) aspect. The soil surface contains sporadic and rare (1 to 5%) Ordovician sedimentary rock fragments (0 to 50 mm diameter). The soil surface is generally loose and friable with approximately 40% surface crusting (slaking). No large rocks (> 100 mm diameter) or bedrock outcrops occur in this Soil Type. At the time of the site investigation, the Red Friable Soil was utilised for dryland grazing of weeds and had reportedly been tilled for dryland winter fodder crop production in the past (*Image 6*).

Image 6: *The Red Friable Soil occurs on a gentle slope with a relatively flat and even surface and, at the time of the site investigation, was being utilised for dryland grazing of weeds.*

5.2 Soil Physics

As detailed in the appendices (*Appendix D - Soil Profile Descriptions*), the Red Friable Soil consists of;

- Minimal rock throughout the profile

- Moderate to good depth (15 cm) of well structured, friable sandy clay loam topsoil (A Horizon)
- Gradational soil profile
- Gradual transition into a well structured, friable, light clay subsoil (B1 Horizon)
- Gradual transition into a moderately structured, semi-friable, medium clay subsoil (B2 Horizon)
- Good to moderate upper soil profile drainage (0-50 cm depth)
- Moderately structured, mottled, medium to heavy clay deeper subsoil the (B3 & B4 Horizon)
- Poor deeper soil profile drainage (50-100 cm depth)
- Adequate water and plant root soil profile penetration through A, B1 & 20 cm into B2 Horizons
- Typical effective root zone of 50 cm (*Images 7 and 8*)
- No physical or chemical barriers to plant root penetration or water infiltration in the upper 1.0 m

Images 7 (left) & 8 (right): *The gradational soil profile of the Red Friable Soil consists of 15 cm of red-brown, well structured, friable clay loam topsoil (A Horizon) overlying a transitional subsoil layer of red-brown, well structured, friable, light clay (B1 Horizon), which in turn overlies a dull red-brown, moderately structured, semi-friable, medium clay subsoil (B2 Horizon); deeper subsoil layers consist of medium to heavy clay with yellow colouration.*

5.3 Soil Chemistry

Five soil samples were collected from the soil profile of the Red Friable Soil from Soil Pit 2 East and these were analysed by the NATA accredited ALS Laboratories for typical agronomic soil parameters. The results are detailed in the appendices (*Appendix E - Soil Chemistry Analysis Results*) along with a detailed soil chemistry interpretation (*Appendix F - Soil Chemistry Interpretation*). The soil samples were collected from;

- Upper surface soil 0-5cm designated the A1 Horizon
- Surface soil 0-12 cm designated the A2 Horizon
- Initial subsoil 15-30 cm designated the B1 Horizon
- Subsoil 30-60 cm designated the B2 Horizon
- Deeper subsoil 60-100 cm designated the B3 Horizon

Whilst full details are provided in the detailed soil chemistry interpretation (*Appendix F - Soil Chemistry Interpretation*), the soil chemistry analysis results indicate:

- Soil pH (in water) of 6.2 to 8.9 increasing with depth
- Low soil salinity levels
- Adequate phosphorus and potassium levels
- Low nitrogen and sulphur levels
- Good cation exchange and calcium levels
- Very low soil sodicity
- Typical low and marginal soil organic matter levels
- Typical and adequate trace element levels
- No dispersion

5.4 Key Soil Features

The Red Friable Soil is a Red Ferrosol (*Isbell 2021*) which occurs on an exposed gentle sloping hill (2% slope). Soil pH levels ($CaCl_2$) ranged from 5.1 to 7.0 and increased with depth. Both soil salinity and soil sodicity were very low. This Soil Type does not contain bedrock within 1.0 m of the soil surface and the soil profile contains minimal rock (< 5%). Upper soil layers (< 50 cm depth) are likely to be moderately permeable whilst deeper soil layers are likely to be slowly permeable (*NCST 2009*). This soil type is considered to be moderately well drained (*NCST 2009*). Red Ferrosols (*Isbell 2021*) are classified as having a relative fertility ranking of 4 which is moderately high (*Office of Environment and Heritage 2013*).

Because this Soil Type has a good depth of soil suitable for plant root exploitation, the Red Friable Soil has a relatively high productivity potential and is suitable for a range of agricultural uses and a range of crops. The Red Friable Soil as an adequate depth of surface soil with a medium soil texture, adequate structure and acceptable drainage. The initial subsoil layers to a depth of 50 cm below the surface, whilst increasing in clay content, also have adequate structure and acceptable drainage. This provides a good depth of adequately drained soil to facilitate plant root proliferation and function. Whilst dependent on management and climatic variables, this Soil Type is likely to be suitable for fodder crops, field crops, pastures, forest trees, and for some vegetable and horticultural tree/vine crops.

6 BROWN PLASTIC SOIL

6.1 Surface

The land surface of the Brown Plastic Soil typically consists of a consistent extended 2% slope, a flat micro relief but pugged from cattle (biotic animal hole micro relief (*NCST 2009*)), an exposed north-westerly (310^{o}) aspect. The soil surface contains sporadic and rare (1 to 5%) Ordovician sedimentary rock fragments (0 to 50 mm diameter). The soil surface is predominantly crusted and slaked (80% crusting), yet is friable. No large rocks (> 100 mm diameter) or bedrock outcrops occur in this Soil Type. At the time of the site investigation, the Brown Plastic Soil was utilised for dryland grazing of weeds and had reportedly been tilled for dryland winter fodder crop production in the past (*Image 9*).

Image 9: *At the time of the site investigation, the Brown Plastic Soil sustained weeds utilised for dryland grazing by cattle however, plant growth was not as prolific on this Soil Type by comparison with the Red Friable Soil.*

6.2 Soil Physics

As detailed in the appendices (*Appendix D - Soil Profile Descriptions*), the Brown Plastic Soil has;

- Minimal rock throughout the profile
- A shallow depth (7 cm) of weekly structured, mostly friable sandy clay loam topsoil (A Horizon)
- Duplex soil profile
- Sharp transition into a thin (2 cm) poorly structured, slightly cemented, medium clay subsoil (B1 Horizon) (plough pan) presenting a slight physical barrier to water and roots
- Abrupt transition at 9 cm depth into a poorly structured, dense, tough, plastic (hard when dry, sticky when wet), medium to heavy clay subsoil (B2 Horizon) extending to depth (100+ cm)
- Moderate surface soil drainage (due to texture and slope)
- Poor soil profile drainage
- Restricted water and plant root soil profile penetration into/through 7+ cm B1 & B2 Horizons
- Typical effective root zone of 17 cm (*Images 10 and 11*)
- Apart from the aforementioned B1 Horizon no significant physical or chemical barriers to plant root penetration or water infiltration in the upper 1.0 m

Images 10 (left) & 11 (right): *The Plex Brown Plastic Soil consists of a shallow (7 cm) weekly structured, sandy clay loam topsoil (A Horizon) overlying a thin (2 cm) poorly structured, slightly cemented layer (B1 Horizon) which, at a depth of 9 cm, rapidly transitions into a poorly structured, dense, tough, plastic, medium to heavy clay subsoil (B2 Horizon) which extends to depth (100+ cm).*

6.3 Soil Chemistry

Five soil samples were collected from the soil profile of the Brown Plastic Soil from Soil Pit 1 West and these were analysed by the NATA accredited ALS Laboratories for typical agronomic soil parameters. The results are detailed in the appendices (*Appendix E - Soil Chemistry Analysis Results*) along with a detailed soil chemistry interpretation (*Appendix F - Soil Chemistry Interpretation*). The soil samples were collected from;

- Upper surface soil 0-5cm designated the A1 Horizon
- Surface soil 0-12 cm designated the A2 Horizon
- Initial subsoil 15-30 cm designated the B1 Horizon
- Subsoil 30-60 cm designated the B2 Horizon
- Deeper subsoil 60-100 cm designated the B3 Horizon

Whilst full details are provided in the detailed soil chemistry interpretation (*Appendix F - Soil Chemistry Interpretation*), the soil chemistry analysis results indicate:

- Soil pH (in water) of 6.8 to 9.8 increasing with depth
- Low surface soil salinity levels
- Elevated subsoil salinity levels
- Adequate potassium levels
- Low nitrogen, phosphorus and sulphur levels
- Good cation exchange capacities
- Low soil calcium levels
- Elevated surface soil sodicity
- Extremely elevated subsoil sodicity
- Typical low and marginal soil organic matter levels
- Typical and adequate trace element levels
- Dispersive soils, particularly in the subsoils

6.4 Key Soil Features

The Brown Plastic Soil is a Brown Sodosol (*Isbell 2021*) which occurs on an exposed gentle sloping hill (2% slope). Soil pH levels ($CaCl_2$) ranged from 5.1 to 8.2 and increased with depth. Soil salinity was low in the surface soil layers and was slightly to very elevated in the subsoil layers. Soil sodicity was slightly elevated in the surface soil layers and was extremely elevated in the subsoil layers. This Soil Type does not contain bedrock within 1.0 m of the soil surface and the soil profile contains minimal rock (< 5%). The soil profile is very slowly permeable and is poorly drained (*NCST 2009*). Brown Sodosols (*Isbell 2021*) are classified as having a relative fertility ranking of 2 which is moderately low (*Office of Environment and Heritage 2013*).

The limited depth of surface soil and high clay content, poorly structured, sodic and poorly drained subsoils limit the utility of this Soil Type for agricultural production and limit the productivity potential of the soil. However, this Soil Type has low to moderate productivity potential for a limited range of agricultural crops and pastures. Physical restrictions and impeded drainage, combined with salinity and sodicity, limit the volume of soil available for effective plant root proliferation and function. Whilst dependent on management and climatic variables, this Soil Type is likely to be suitable for fodder crops, field crops and pastures only.

7 LSC ASSESSMENT

7.1 LSC Scheme

To assist this assessment of site agricultural land utility, the New South Wales Government Office of Environment and Heritage land and soil capability (LSC) assessment scheme for NSW has been adopted (*Office of Environment and Heritage 2012*). This scheme considers the inherent land physical capacity to sustain a range of land uses and management practices in the long term without degradation to soil, land, air and water resources. The LSC assessment scheme uses land biophysical features such as landform position, slope gradient, drainage and climate, along with soil characteristics which determine land and soil hazards such as erosion, soil structure decline, soil acidification, salinity and waterlogging. Through assessment of each of these land features or hazards, the scheme assigns a rating between 1 (best, highest capability land) and 8 (worst, lowest capability land) with the final LSC class of the land based on the most limiting hazard. The LSC class provides an indication of land management practices that can be applied to the land without causing degradation to the land and environment on and adjoining the site. The aim of the scheme is to provide an indication of land use capability which can then tailor management aimed at the long-term sustainable use and management of land and soil resources (*Office of Environment and Heritage 2012*).

7.2 LSC Class 2012

Whilst predominantly undertaken on a broad scale, LSC assessment and mapping has been undertaken across the majority of NSW and is regularly updated and amended as higher resolution data becomes available and is incorporated (*Office of Environment and Heritage 2012*). The LSC map covering the site (*Appendix G - Initial LCA & BSAL Maps*) (*SEED*) indicates that the majority of the site is Land and Soil Capability Class 3 with a small area of Land and Soil Capability Class 6 in the southeast corner of the site.

The land mapped as LSC Class 6 on the site approximates the area coinciding with the Rocky Soil. An LSC Class 6 is described as having '*very severe limitations. Land incapable of sustaining many land use practices (e.g. cultivation, moderate to high intensity grazing and horticulture). Highly specialised practices can overcome some limitations for some high value products. Land often used for low intensity land uses (low intensity grazing)*' (*Office of Environment and Heritage 2012*). It is likely that this area of land was mapped as LSC Class 6 based on topography and rock.

The remaining areas of the site are mapped as LSC Class 3 which is described as having '*moderate limitations. Land capable of sustaining high impact land uses using more intensive, readily available and accepted management practices*' (*Office of Environment and Heritage 2012*). It is likely that this area of land was mapped as LSC Class 3 based on the Australian Soil Classification of Ferrosols (*SEED*).

7.3 LSC Assessment Process

A Land and Soil Capability (LSC) assessment was undertaken of the site based on the LSC assessment scheme (*Office of Environment and Heritage 2012*). The aforementioned information collected as part of this Agricultural Land Utility Assessment was used to determine the LSC classes on the site. The aforementioned Soil Type determination and associated soil mapping segregated the site into three Soil Types. A LSC class has been determined for each of these three soil mapping units (Soil Types).

In each case, the LSC class has been determined against eight decision tables which use landscape, soils and climatic data to identify risks in relation to soil erosion, structural decline, acidity, salinity, drainage, rockiness and mass movement (*Office of Environment and Heritage 2012*). The LSC class for each Soil Type has been determined by assessing each hazard individually and then combining these assessments to assign a LSC class based on the highest (most restrictive) hazard for that Soil Type.

7.4 Rocky Soil - LSC

Water Erosion – Slope is 2%; Location is Central Land Division of NSW = LSC Class 2.

Wind Erosion – Surface soil clay content > 13% clay; surface soil wind erodibility class is low; moderate exposure; moderate wind erosive power; average annual rainfall >500 mm = LSC Class 2.

Soil Structural Decline – Surface soil texture sandy clay loam; normal modifier; very low sodicity < 3%; fragile medium textured soil = LSC Class 3.

Soil Acidification – Great Soil Group Euchrozems; sandy clay loam surface soil; moderate to high soil buffering capacity; surface soil pH ($CaCl_2$) 5.1; average annual rainfall 550 - 700 mm = LSC Class 3.

Salinity – Moderate recharge potential; low discharge potential; low salt store = LSC Class 1.

Waterlogging – Typical waterlogging duration 0.25 - 2 months; return period every year; well drained (*NCST 2009*) = LSC Class 2.

Shallow Soil and Rockiness – Rock outcrop 30 - 50%; soil depth 25 - 75 cm = LSC Class 6.

Mass Movement – Rainfall > 500mm; no mass movement on site = LSC Class 1.

7.5 Red Friable Soil - LSC

Water Erosion – Slope is 2%; Location is Central Land Division of NSW = LSC Class 2.

Wind Erosion – Surface soil clay content > 13% clay; surface soil wind erodibility class is low; moderate exposure; moderate wind erosive power; average annual rainfall >500 mm = LSC Class 2.

Soil Structural Decline – Surface soil texture sandy clay loam; normal modifier; very low sodicity < 3%; fragile medium textured soil = LSC Class 3.

Soil Acidification – Great Soil Group Euchrozems; sandy clay loam surface soil; moderate to high soil buffering capacity; surface soil pH ($CaCl_2$) 5.1; average annual rainfall 550 - 700 mm = LSC Class 3.

Salinity – Low recharge potential; low discharge potential; low salt store = LSC Class 1.

Waterlogging – Typical waterlogging duration 0.25 - 2 months; return period every year; imperfectly drained (*NCST 2009*) = LSC Class 3.

Shallow Soil and Rockiness – Rock outcrop < 30%; soil depth > 100 cm = LSC Class 2.

Mass Movement – Rainfall > 500mm; no mass movement on site = LSC Class 1.

7.6 Brown Plastic Soil - LSC

Water Erosion – Slope is 2%; Location is Central Land Division of NSW = LSC Class 2.

Wind Erosion – Surface soil clay content > 13% clay; surface soil wind erodibility class is low; moderate exposure; moderate wind erosive power; average annual rainfall >500 mm = LSC Class 2.

Soil Structural Decline – Surface soil texture sandy clay loam; normal modifier; moderate sodicity 8.1 to 10.6%; moderately sodic clay loam surface soil = LSC Class 6.

Soil Acidification – Great Soil Group Euchrozems; sandy clay loam surface soil; moderate to high soil buffering capacity; surface soil pH ($CaCl_2$) 5.1; average annual rainfall 550 - 700 mm = LSC Class 3.

Salinity – Low recharge potential; low discharge potential; low salt store = LSC Class 1.

Waterlogging – Typical waterlogging duration < 3 months; return period every year; poorly drained (*NCST 2009*) = LSC Class 6.

Shallow Soil and Rockiness – Rock outcrop < 30%; soil depth > 100 cm = LSC Class 2.

Mass Movement – Rainfall > 500mm; no mass movement on site = LSC Class 1.

7.7 Site LSC Assessment Results

Based on the Land and Soil Capability assessment process detailed above, the three Soil Types on the site have the LSC Classes detailed in *Table 1*. The Rocky Soil (Leptic Rudosol) is a LSC Class 6 with the main limitations being the significant proportion of rock outcropping and in the surface soil (30 – 40%), and due to the shallow depth of soil over bedrock. The Red Friable Soil (Red Ferrosol) is a LSC Class 3 with the main limitations being the moderate risks of soil structural decline, soil acidification and waterlogging. The Brown Plastic Soil (Brown Sodosol) is a LSC Class 6 with the main limitations being the significant risk of soil structural decline from sodicity and the significant risk of waterlogging due to shallow surface soils and low permeability subsoils.

Table 1: Land and Soil Capability assessment results and Soil Type LSC Classes.

	Land and soil capability hazard								LSC Class
Soil Type	Water Erosion	Wind Erosion	Structural Decline	Soil Acidification	Salinity	Water -logging	Rock	Mass Movement	
Rocky Soil	2	2	3	3	1	2	6	1	**6**
Red Friable Soil	2	2	3	3	1	3	2	1	**3**
Brown Plastic Soil	2	2	6	3	1	6	2	1	**6**

The combination of the Rocky Soil and the Brown Plastic Soil cover 40% of the site and, based on a LSC Class 6 rating, present very severe limitations for agricultural production. These Soil Types are incapable of sustaining many land use practices (e.g. cultivation, moderate to high intensity grazing and horticulture) and require highly specialised practices to overcome some limitations for some high value products. These Soil Types would typically be used for low intensity land uses such as low intensity grazing (*Office of Environment and Heritage 2012*) which was being undertaken on the site at the time of the site investigation. However, it should be noted that dryland winter fodder cropping has also been practised on the Brown Plastic Soil but, based on the consultant's agricultural and soil experience with similar soils with similar limitations, yields for this land use are likely to be below average.

The Red Friable Soil which covers the remaining 60% of the site has a LSC Class 3 rating indicating moderate limitations for agriculture. This soil type is likely to be capable of sustaining high impact land uses using more intensive, readily available and accepted management practices (*Office of Environment and Heritage 2012*). This Soil Type, whilst being utilised for low intensity grazing at the time of the site investigation, would be suitable for agricultural fodder and grain crops, and agricultural pastures and has the potential for moderate to good productivity.

8 BSAL ASSESSMENT

8.1 Biophysical Strategic Agricultural Land

Biophysical strategic agricultural land (BSAL) is agricultural land with high quality natural resources capable of sustaining high levels of productivity (*Office of Environment and Heritage 2013*). BSAL typically has a rare combination of natural resources highly suitable for agriculture and is land with the best quality landforms, soil and water resources. BSAL is naturally capable of sustaining high levels of productivity and requires minimal management practices to maintain this high-quality. BSAL is typically fertile and generally lacks significant biophysical constraints (*Office of Environment and Heritage 2013*).

8.2 BSAL Assessment Process

To assist with this assessment of site agricultural land utility, the New South Wales Government Office of Environment and Heritage BSAL assessment process has been employed to determine if land on the site is BSAL (*Office of Environment and Heritage 2013*). The BSAL assessment process initially considers security of water supply. This is followed by consideration of landscape and soil criteria such as surface slope, rock, soil surface conditions, soil fertility, soil type, soil profile physical and chemical barriers to root penetration, soil drainage, soil pH and salinity. This detailed Agricultural Land Utility Assessment and the aforementioned information outlined here in provide sufficient information to undertake a BSAL assessment of the site.

8.3 BSAL Classification 2013

Whilst predominantly undertaken on a broad scale, BSAL assessment and mapping has been undertaken across selected areas of NSW; it is understood that this is regularly updated and amended as higher resolution data becomes available and is incorporated (*Office of Environment and Heritage 2013*). The BSAL map covering the site (*Appendix G - Topography & Initial LCA & BSAL Maps*) (*SEED*) indicates that the majority of the site is BSAL. It is likely that this classification has been based on the aforementioned LSC Classes and in particular the LSC Class 3 based on the Australian Soil Classification of Ferrosols (*SEED*). The land mapped initially mapped (*SEED*) as LSC Class 6 is excluded from the area designated BSAL.

8.4 Site BSAL Assessment

The site has an annual average rainfall approximating 615 mm and a long-term 10th percentile dry year rainfall approximating 395 mm. Therefore, the site has above 350 mm of annual rainfall in 9 out of 10 years. This verifies that the site has a reliable water supply. This satisfies the first criteria for BSAL (*Office of Environment and Heritage 2013*).

The next step in the BSAL assessment process is to consider land and soil criteria and in particular, soil constraints (*Office of Environment and Heritage 2013*). Because this site consists of three distinct Soil Types, a BSAL assessment has been undertaken for each Soil Type and initially, this soil criteria assessment process considers all three Soil Types; the Rocky Soil, the Red Friable Soil and Brown Plastic Soil. As the BSAL verification process is undertaken for each criteria, it is assumed that the Soil Type is BSAL unless otherwise noted.

1. **Surface Slope (1) -** Is the surface slope less than or equal to 10%? The surface slope in all three Soil Types is 2%.
2. **Rock Outcrop (2a) -** Is there < 30% rock outcrop? The Rocky Soil consists of 30 to 40 % outcropping bedrock and/or boulders. Therefore, the Rocky Soil is not BSAL (no further assessment of the Rocky Soil will be undertaken).

   Rock Outcrop (2b) - Is there < 30% rock outcrop? The remaining two Soil Types (the Red Friable Soil and the Brown Plastic Soil) consists of < 30% rock outcrop.
3. **Rock Fragments -** Does < 20% of the area have unattached rock fragments > 60 mm in diameter? The two remaining Soil Types contain < 6% unattached rock fragments < 30 mm in diameter.
4. **Gilgais -** Does < 50% of the area have gilgais >500mm deep? The two remaining Soil Types do not have any areas consisting of gilgais.
5. **Surface Slope (5) -** Is the surface slope less than 5%? The surface slope in the two remaining Soil Types is 2%.

6. **Rock Outcrops (6) -** Are there nil rock outcrops? The two remaining Soil Types have no rock outcrops.

7. **Fertility -** Does the soil have moderate fertility? The Red Friable Soil has a relative fertility ranking of 4 which is moderately high (*Office of Environment and Heritage 2013*); this fits the BSAL criteria. The Brown Plastic Soil has a relative fertility ranking of 2 which is moderately low (*Office of Environment and Heritage 2013*). Therefore, the Brown Plastic Soil is not BSAL (no further assessment of the Brown Plastic Soil will be undertaken).

8. **Effective Rootzone (Physical Barrier) -** Is the effective plant rooting depth to a physical barrier ≥ 750 mm? In the remaining Soil Type, the Red Friable Soil, there is no significant physical barrier to plant root soil profile penetration shallower than 750 mm.

9. **Soil Drainage -** Is soil drainage better than poor? The soil profile drainage in the Red Friable Soil is considered to be moderately well drained (*NCST 2009*).

10. **Soil pH -** Does the soil pH range from 5.0 to 8.9 (H_2O) or from 4.5 to 8.1 ($CaCl_2$) within the uppermost 600 mm of the soil profile? Four soil layers in the upper 600 mm of the Red Friable Soil type soil profile were assessed in the laboratory for pH and levels ranged from 6.2 to 7.3 (H_2O) and from 5.1 to 6.3 ($CaCl_2$) (*Appendix F- Soil Chemistry Interpretation*).

11. **Soil Salinity -** Is salinity (ECe) ≤ 4dS/m or are chlorides <800 mg/kg when gypsum is present, within the uppermost 600 mm of the soil profile? Four soil layers in the upper 600 mm of the Red Friable Soil type soil profile were assessed in the laboratory for Electrical Conductivity ($EC_{1:5}$) which ranged from 9 to 26 µS/cm (0.009 to 0.026 dS/m) which, when applying appropriate soil texture conversion factors, equates to Electrical Conductivity of the soil saturation extract (EC_e) of < 0.5 dS/m. Soil chloride levels in the same for soil layers were all < 10 mg/kg (*Appendix F- Soil Chemistry Interpretation*).

12. **Effective Rootzone (Chemical Barrier) -** Is effective rooting depth to a chemical barrier ≥ 75mm? There is no significant chemical barrier to plant root soil profile penetration shallower than 75 mm in the Red Friable Soil

13. **Contiguous Area -** Non-site criteria minimum area; Does the BSAL have a contiguous area of greater than or equal to 20 ha? The area of Red Friable Soil on the site approximates 7 ha and this occurs in two separate areas (*Appendix H - 2022 Soil Map*). Based on the site and soil investigations which formed part of this assessment, along with the BSAL Map, the LCA Map (*Appendix G - Topography, LCA & BSAL Maps*) and the Australian Soil Classification mapping (*SEED*) which details an extensive area of Ferrosols, it is likely that additional areas of BSAL occur adjoining and in the vicinity of the site. Whilst it is not possible to definitively state, it is likely that more than 20 ha of BSAL occurs on and in the vicinity of the site however, based on the soil mapping of this site, the BSAL is likely to be disjointed, not contiguous and irregularly shaped.

Based on this BSAL assessment process;

- The Rocky Soil is not BSAL because this Soil Type consists of > 30% rock outcrop
- The Brown Plastic Soil is not BSAL because this Soil Type has a relative fertility ranking of 2 which is moderately low and which is lower than a moderate fertility ranking (*Office of Environment and Heritage 2013*).
- The Red Friable Soil is BSAL as this Soil Type satisfies all the criteria detailed above to verify the presence of BSAL.

Whilst 7 ha of BSAL was verified on the site, there is likely to be additional areas of BSAL adjoining and/or in the vicinity of the site which is likely to equate to more than 20 ha of BSAL however, the area of BSAL is likely to be irregularly shaped and may not be contiguous.

9 SOIL IMPACTS & MITIGATION

9.1 Potential Impacts

Traffic and soil disturbance always has the potential to adversely impact soils in an agricultural setting such as this. Soil physical properties are most likely to be adversely impacted whilst soil chemical characteristics are only likely to be adversely impacted from mixing of soil layers which has the potential to relocate elevated salinity, pH and sodicity soils from lower to upper layers. It will therefore be important to minimise the mixing of soil layers and to target topsoil reinstatement where possible where excavation occurs. Adverse soil physical impacts may include traffic and infrastructure induced compaction, soil organic matter reduction and associated soil structural deterioration and/or erosion causing sediment mobilisation. It will be important to maintain and maximise vegetative cover where possible to help protect surface soil structure. It will also be important to minimise soil disturbance and excavation where practical.

Whilst the soils on this site are not particularly vulnerable to soil structural decline or erosion, there is potential for these adverse soil impacts to occur however, measures can be implemented to minimise adverse impacts. General strategies should include maximising vegetative cover to protect the soil surface, employing practices which maintain/increase soil organic matter levels, minimising soil disturbance (working/ploughing surface soils, excavating and/or exposing subsoil layers), minimising traffic and infrastructure induced compaction where practical, and the implementation of surface water management measures to minimise the risk of the collection and concentration of mobile surface water which has the potential to mobilise sediment and cause erosion.

9.2 Mitigation Plans

It is recommended that a Construction Erosion and Sediment Control Plan (ESCP), in accordance with Landcom (2004), is compiled as part of the detailed design stage. In addition to the ESCP which covers construction, it is recommended that a Soil and Water Management Plan (SWMP) is also compiled in accordance with Landcom (2004) to cover site development, operation and decommissioning. In addition to including all necessary measures from Landcom (2004), the ESCP and the SWMP should include and expand further upon the strategies and concepts detailed herein.

9.3 Mitigation Measures

As detailed above, a range of soil protection measures should be implemented in the planning, construction, operation and decommissioning of the site. Reference should be made to, and strategies should be included from, Landcom (2004). Soil protection measures can be expanded on and include more detail once detailed design is undertaken and as part of compilation of the ESCP and the SWMP. General soil management measures to minimise the risks of adverse impacts to soils on the site include;

- Minimise soil disturbance and excavation where possible
- Minimise mixing of soil layers where practical
- Retain and stockpile all disturbed or excavated soil
- Ameliorate any excavated and/or stockpiled soils in accordance with advice obtained from the NSW Soil Conservation Service
- Consider soil amelioration with lime and/or gypsum prior to reinstatement and/or as part of decommissioning
- Return stockpiled soil to its original location (where possible) as soon as reasonably practicable
- Ensure topsoil and subsoils are stockpiled separately and returned in order
- Minimise overworking of the surface soils (*in-situ*, in excavation, stockpiling and reinstatement)
- Reinstate topsoil where possible where excavation occurs
- Minimise vehicular traffic induced compaction where practical
- Minimise stock compaction by excluding livestock during construction, minimising stocking rates and/or minimising the risk of stock coinciding with wet topsoil conditions
- Minimise infrastructure induced compaction where possible (spread loads etc.)
- Maintain and maximise vegetative cover where possible to help protect surface soils
- Employ practices which maintain/increase soil organic matter levels such as maintaining grass cover where practical, minimising soil disturbance and the retention/incorporation of any cleared vegetation or organic matter as soon as reasonably practicable
- Avoid bare (fallow) soil surface where practical
- Whilst good weed control should be implemented, retention of less detrimental weeds may help maintain vegetal of cover and/or increase soil organic matter levels.
- Minimise the exposure of subsoil layers particularly to rainfall/surface water run-off impacts
- Implement excess surface water controls to minimise collection/concentration of mobile surface water
- Implement practices to minimise sediment mobilisation and/or sediment capture
- Minimise site activities and soil disturbance during wet weather conditions where possible
- Ensure that the sodic soils, which include all layers of the Brown Plastic Soil (to a depth of 1.0+m), are clearly identified and not mixed with other soils
- Regularly monitor soils for potential adverse impacts and if and when identified, implement appropriate mitigation or remediation actions
- Implement construction and/or site rehabilitation and revegetation in accordance with an appropriate landscape, revegetation or rehabilitation plan prepared by a suitably qualified professional
- Ensure rehabilitation is undertaken progressively to minimise the total disturbance area at any one time

- Prepare an appropriate decommissioning management plan which aims to minimise adverse soil impacts and aims to return the site to preconstruction land and soil capability (or better)
- The decommissioning management plan should determine soil conditions prior to decommissioning to ensure any existing soil conditions and/or adverse impacts, which may have changed/developed throughout the life of the development, are catered for

10 CONCLUSIONS

This comprehensive Agricultural Land Utility Assessment of the 6 ha site by appropriately qualified and experienced scientists collected data on, considered and assessed a range of biophysical and environmental features pertaining to the site. This included soil profile investigations, soil chemistry laboratory analysis and assessment of vegetation, infrastructure and water features on and adjoining the site. This information was used to assess the potential agricultural resource status of the site and to determine, on a higher resolution scale than previously adopted, the Land and Soil Capability (LSC) (*Office of Environment and Heritage 2012*), and the Biophysical Strategic Agricultural Land (BSAL) (*Office of Environment and Heritage 2013*) status of the site.

The land and the soils across the site were divided into three distinct Soil Types; namely the Rocky Soil (Leptic Rudosol), the Red Friable Soil (Red Ferrosol) and the Brown Plastic Soil (Brown Sodosol). The Rocky Soil had agricultural utility limitations in the form of excessive outcropping rock, excessive rock throughout the surface soil and a limited depth of soil over bedrock. The Brown Plastic Soil had agricultural utility limitations due to a limited depth of surface soil, sodicity, salinity, poorly structured medium to heavy clay subsoil layers and a propensity for poor drainage and water logging. As a consequence, these two soil types were classified as Land and Soil Capability Class 6 and did not satisfy the criteria to be designated Biophysical Strategic Agricultural Land.

The Red Friable Soil consisted of a moderate depth of appropriately textured and structured surface soil overlying relatively well structured permeable and friable initial subsoil layers which, in combination, provide a significant soil volume for plant root exploitation and function. Consequently, this soil has moderate agricultural utility, moderate soil productivity potential and is suitable for a range of agricultural crops and pastures. This soil was classified as a Land and Soil Capability Class 3 and the land on which this soil type occurred on the site was classified as Biophysical Strategic Agricultural Land. Approximately 60% of the site consists of BSAL covering an area approximating 7 ha. Whilst there is likely to be additional areas of BSAL adjoining and/or in the vicinity of the site which is likely to equate to more than 20 ha of BSAL, the area of BSAL is likely to be irregularly shaped and may not be contiguous.

11 REFERENCES

Bureau of Meteorology (2022), Monthly Rainfall, Wellington (D & J Rural). Accessed on 18 April 2022. http://www.bom.gov.au

Isbell, R.F. (2021), The Australian Soil Classification (ASC). R. F. Isbell and the National Committee on Soil and Terrain DOI: 10.1071/9781486314782; ISBN (paper): 978-1-4863-1477-5; ISBN (electronic): 978-1-4863-1479-9. Third Edition, CSIRO Publishing, CSIRO Division of Soils Technology, Melbourne.

Landcom (2004), Soils And Construction - Managing Urban Stormwater (Volume 1, 4th Edition, March 2004) (Blue Book), New South Wales Government.

NCST (2009) Australian soil and land survey field handbook, 3rd edition, National Committee on Soil and Terrain. CSIRO Publishing, Melbourne.

Office of Environment and Heritage (2012), The land and soil capability assessment scheme, second approximation, a general rule land evaluation system for New South Wales. Accessed on 18 April 2022. NSW Government Office of Environment & Heritage.
http://www.environment.nsw.gov.au/soils/20120394lsc2spubslandingpage.htm.

Office of Environment and Heritage (2013), Interim protocol for site verification and mapping of Biophysical Strategic Agricultural Land. Accessed on 16 April 2022. NSW Government Office of Environment & Heritage and the Office of Agricultural Sustainability & Food Security.
https://www.planning.nsw.gov.au/-/media/Files/DPE/Other/interim-protocol-for-site-verification-and-mapping-of-biophysical-strategic-agricultural-land-2013-04.pdf?la=en

SEED (2022), The central resource for sharing and enabling environmental data in NSW. Accessed on 18 April 2022. https://datasets.seed.nsw.gov.au

Water NSW (2022), River and groundwater data; Bell alluvial groundwater. Accessed on 20 April 2022.
https://waterinsights.waternsw.com.au/16567-bell-alluvial-groundwater/river-data#GW273147.2.2

12 APPENDICES

12.1 Appendix A - Locality Plan

12.2 Appendix B - District Plan

12.3 Appendix C - Site Plans

12.4 Appendix D - Soil Profile Descriptions

Site 1 Location - E 682938; N 6387138 Soil Pit 1 West - Brown Plastic Soil - Brown Sododol

Pit 1	Horizons		Depth (cm)		Texture	Colour		Consistence	Structure (Pedality)		Mottling		Carbonates			Coarse Fragments			Drainage	Rootzone	Samples
		Boundary	Start	Finish		Code	Munsell	% brittleness	Grade	Type	Colour	%	%	Type	R	%	Lith	Size		(cm)	Horizon(mm)
	A1		0	7	SCL	B	5YR 3/2	90	W	AC						1-5	Ord Sed	0-20mm	M-G	All	A1(0-50)
	B1	Sharp	7	9	SL-MC	B	5YR 3/3	0	W	CEM-AC						< 1	Ord Sed	0-10mm	P	10	A2(0-70)
	B2	Abrupt	9	30	M-HC	B-RB	2.5YR 3/3	0	W-M	COL-MA						< 1	Ord Sed	0-10mm	v P		B1(150-300)
	B3	Clear	30	60	M-HC	dRB	5YR 4/4	10	W-M	COL-MA	O R B	20				< 1	Ord Sed	0-10mm	v P		B2(300-600)
	B4	Gradual	60	100+	M-HC	RB	10R 3/6	30	M	SAB	O R B Y	40	15	P+N	S	1-5	Ord Sed	0-10mm	P	17cm total	B3(600-1000)

Site 2 Location - E 683180; N 6387035 Soil Pit 2 East - Red Friable Soil - Red Ferrosol

Pit 2	Horizons		Depth (cm)		Texture	Colour		Consistence	Structure (Pedality)		Mottling		Carbonates			Coarse Fragments			Drainage	Rootzone	Samples
		Boundary	Start	Finish		Code	Munsell	% brittleness	Grade	Type	Colour	%	%	Type	R	%	Lith	Size		(cm)	Horizon(mm)
	A1		0	15	SCL	B	5YR 3/2	100	M	G-AC						1-5	Ord Sed	0-50mm	M-G	All	A1(0-50)
	B1	Gradual	15	30	LC	RB	10R 3/6	70	M	f SAB						< 5	Ord Sed	0-10mm	M-G	All	A2(0-120)
	B2	Gradual	30	50	MC	dRB	5YR 4/4	40	M-S	SAB	O Y B R Mn	20				< 5	Ord Sed	0-10mm	M-P	20	B1(150-300)
	B3	Gradual	50	80	M-HC	YOB	5YR 4/6	20	M	SAB-COL	O Y B R Mn	60				< 5	Ord Sed	0-10mm	P		B2(300-600)
	B4	Gradual	80	100+	M-HC	YB	7.5YR 5/6	10	M	SAB	O Y B R Mn	80				< 5	Ord Sed	0-10mm	P	50cm total	B3(600-1000)

Site 3 Location - E 683168; N 6386933 Location 3 - Rocky Soil - Leptic Rudosol

	Horizons		Depth (cm)		Texture	Colour		Consistence	Structure (Pedality)		Mottling		Carbonates			Coarse Fragments			Drainage	Rootzone	Samples
		Boundary	Start	Finish		Code	Munsell	% brittleness	Grade	Type	Colour	%	%	Type	R	%	Lith	Size		(cm)	Horizon(mm)
	A1		0	15	SCL	RB	10R 3/4	100	W	G						40	Ord Sed	0-100cm	M-G	All	
	C2	Clear	15	15+	Rock	G	10YR 1/6	0								100	Ord Sed	bedrock		15cm total	

Soil Profile Description Key

HORIZON & DEPTH – Each soil layer is assigned a horizon and the depth in cm over which this horizon occurs is noted. The soil horizons are:

Symbol	Description
O	Organic layer
A1	Initial surface soil layer
A2	Bleached or different surface soil layer
B1	Transitional surface soil/subsoil layer (increasing clay content)
B2	Main subsoil layer (often highest clay content)
B3	Deeper subsoil layer (etc.)
C1	Significantly different (usually older) layer - weathered bedrock
C2	Bedrock

TEXTURE - Describes the amount of clay, sand and silt in the soil. This is designated:

Symbol	Description
G	Gravel
S	Sand
L	Loam
Z	Silt
C	Clay
	Sand may be: (prefix to 'S')
f	fine
c	course
	Clay may be: (prefix to 'C')
L	Light
M	Medium
H	Heavy
	Examples:
fSCL	Fine Sandy Clay Loam
ZLC	Silty Light Clay

COLOUR - The main background colour described using Munsell Soil Colour Chart notation and/or colours as described for Mottling (below).

MOTTLING – The colour of any mottling and the amount of this mottling as a % of the main background colour. Descriptions include:

Symbol	Description
d	dull/dark
lt	light
v	very
B	Brown
R	Red
Y	Yellow
O	Orange
G	Grey
W	White
Blk	Black
RB	Red-Brown
Mn	Manganese deposits

CONSISTENCE – Soil consistence is a field measurement of how plastic or brittle a soil is. An undisturbed piece of soil is subjected to a compressive shearing force and the subsequent aggregates are rated by those that have undergone brittle failure as opposed to those that have undergone plastic failure. From this, the soil is given a brittleness percentage. This measurement can be used to determine soil structure and strength, gypsum application rates and to predict the effectiveness of deep ripping. The higher the percentage, the more friable the soil.

PEDALITY - Grade and type of soil structure.

Symbol	Description	Symbol	Description
	Grades		**Types**
g	single grain	G	granular
w	weak	AB	angular blocky
m	medium	SAB	sub-angular blocky
s	strong	COL	columnar
sm	self mulching	PRI	prismatic
		AC	coherent
		V	massive
		f	fine

CARBONATES – The type and amount (percentage) of the soil layer that consist of natural lime (calcium carbonate $CaCO_3$) found in each soil layer and natural gypsum (Gyp) is also mentioned here if present.

Symbol	Description
	Types
P	Powdery
N	Nodulated
C	Concreitionary

COARSE FRAGMENTS – the amount (%), size and lithology (origin or type) of any coarse fragments (inclusions or rocks) found in each soil layer (Ord Sed = Ordovician sedimentary rock).

Symbol	Description
BS	Buckshot
Ca	Cambrian rock
Q	Quartz
GS	Green Stone basalt

DRAINAGE – subjective field observation of the permeability of the soil layer

Symbol	Description
G	Good
M	Moderate
P	Poor
v	very

ROOTZONE – The soil layers through which, or into which, typical agricultural crop roots will penetrate and function effectively are noted. This then facilitates calculation of the effective root zone which is noted in cm.

SAMPLES – The layers and depths from which soil samples are collected for laboratory analysis are noted.

12.5 Appendix E - Soil Chemistry Analysis Results

12.6 Appendix F - Soil Chemistry Interpretation

12.6.1 Red Friable Soil (Soil Pit 2 East)

pH – Soil pH levels (in water) were slightly acidic at 6.2 in the topsoils and gradually increased down the soil profile with subsoil levels ranging from 6.9 to 8.1. Similarly, **s**oil pH ($CaCl_2$) levels in surface soils were acidic (5.1) and subsoil levels this ranged from 5.6 to 7.0.

Salinity – Soil salinity levels were low. Salinity measured as Electrical Conductivity ($EC_{1:5}$) ranged from 9 to 26 µS/cm (0.009 to 0.026 dS/m) which, when applying appropriate soil texture conversion factors, equates to Electrical Conductivity of the soil saturation extract (EC_e) of < 0.5 dS/m. Soil chloride levels were also low and were all < 10 mg/kg. Similarly, soil levels of Total Soluble Salts were also low and ranged 29 to 88 mg/kg.

Nitrogen – Soil nitrogen levels were low in the surface soils and were very low in the subsoils. In the surface soils, nitrogen was low (nitrate nitrogen = 2.0 to 3.9 mg/kg; ammonium nitrogen = <20 mg/kg; total N = 1150 to 1230 mg/kg) and levels were very low in the subsoils (nitrate nitrogen = 0.3 mg/kg; ammonium nitrogen = <20 mg/kg; total N = 120 to 430 mg/kg).

Phosphorus - The available phosphorus (Olsen) levels in the surface soil were moderate (15.8 to 16.6 mg/kg Olsen P). As would be expected, levels in the subsoils were lower (2.7 to 6.2 mg/kg Olsen P). Total Phosphorus levels generally corresponded with available phosphorus levels; surface soils levels ranged from 459 to 516 mg/kg Total P; subsoils levels ranged from 199 to 436 mg/kg Total P.

Potassium – These soil types in this landscape typically contain sufficient natural inherent potassium for general agricultural production. Soil potassium levels in the surface soils were at good, adequate and optimum levels for agricultural production (500 to 600 mg/kg Skene K); Levels in subsoils were lower but still adequate (100 to 200 mg/kg Skene K).

Sulphur – Both Surface soil and subsoils sulphur levels were marginal to low (<10 mg/kg KCl 40 Sulphur). These soil sulphur levels are typical of these soil types under this land use.

Cation Exchange Capacity (CEC) - The cation exchange capacity of these soil layers correlated with soil texture with the higher clay content subsoils yielding higher CECs. Whilst the lower clay content surface soils had lower CEC levels (9.4 to 10.5 meq/100g), these levels are still adequate. In the subsoil layers which have higher clay contents, CEC levels ranged from 15.8 to 20.1 meq/100g. This indicates good CEC levels providing adequate capacity for the soils to retain nutrients and salts.

Calcium/Magnesium Ratio (Ca:Mg) - Soil calcium levels, as indicated by the ratio of calcium to magnesium, were good, particularly in the topsoil layers (Ca:Mg Ratio= 3.0). Whilst levels were lower in the subsoil is, levels were still adequate (Ca:Mg = 2.2 to 2.6). This is typical of these soil types in this landscape and indicates the soils have adequate calcium levels which will help maintain and promote beneficial soil structure.

Exchangeable Sodium Percentage (ESP) – Soil sodium levels (soil sodicity) measured as the Exchangeable Sodium Percentage (ESP) were all very low. ESP levels greater than 6 demarcate a sodic soil which indicates a propensity for soil structural decline due to dispersion. The surface soils had low sodium levels with ESP levels ranging from 1.1 to 1.2; levels were also low in the subsoils with ESP levels ranging from 1.1 to 2.6.

Organic Carbon – The soils were analysed for organic carbon which provides an indication of soil organic matter levels. Soil organic matter levels in the topsoil layers were low, marginal, typical of agricultural soil in this district and ranged from 1.9 to 2.8 %. As would be expected, subsoil organic matter levels were low and ranged from <0.5 to 0.8 %.

Trace Elements – The level in the soil of the trace elements listed hereunder were assessed based on the plant available amount present. This data should be used with caution because soil analysis for trace elements can be imprecise. Generally, the soils have typical trace element levels for these soil types in this district.

> **Copper –** Soil copper levels were typical, good and adequate ranging from <1.0 to 4.23 mg/kg with levels gradually decreasing with depth.
>
> **Zinc –** Soil zinc levels were low in the subsoils (<1.0 mg/kg) and levels were typical and marginal but adequate in the surface soils (1.09 to 1.34 mg/kg).
>
> **Manganese –** Soil manganese levels were typical and adequate ranging from 17 to 87 mg/kg.
>
> **Iron –** Soil iron levels were typical and adequate ranging from 11 to 112
>
> **Aluminium –** Soil aluminium levels were all low and not toxic (exchangeable aluminium < 0.1 mg/kg).
>
> **Boron –** Soil boron levels were adequate and not toxic ranging from < 0.2 to 0.3mg/kg.

Emerson Dispersion Class – There was no soil dispersion with slaking only in the two topsoil layers and in the B1 Horizon subsoil layer (Emerson Dispersion Class 6). Dispersion could only be induced on re-moulding and shaking in the two deeper subsoil layers (Emerson Dispersion Class 5). This indicates the soils are non-dispersive.

12.6.2 Brown Plastic Soil (Soil Pit 1 West)

pH - Soil pH levels (in water) were slightly acidic at 6.8 in the topsoil layers and levels increased with depth with strongly alkaline levels in the subsoil layers (9.1 to 9.8). These levels are likely to be exacerbated by the presence of calcium carbonate and sodium chloride. Similarly, **s**oil pH ($CaCl_2$) levels in the surface soil layers were acidic at 5.1 and levels in the subsoil layers ranged from 7.3 to 8.3.

Salinity – Soil salinity levels were low in the surface soil layers, gradually increased with depth, and were elevated in the subsoil layers. Surface soil salinity, measured as Electrical Conductivity ($EC_{1:5}$), ranged from 28 to 35 µS/cm (0.028 to 0.035 dS/m). In the surface soils, chloride levels ranged from 20 to 30 mg/kg and Total Soluble Salts ranged from 94 to 119 mg/kg. Soil salinity levels in the subsoil layers ranged from $EC_{1:5}$ of 68 to 860 µS/cm (0.068 to 0.860 dS/m), from Cl of 180 to 400 mg/kg, and from Total Soluble Salts of 230 to 2,920 mg/kg. This data indicates low soil salinity levels in the surface soils, slightly elevated levels in the initial (main) subsoil layer, and elevated soil salinity in the deeper subsoil layers (30+ cm depth).

Nitrogen – Soil nitrogen levels were low in the surface soils and were very low in the subsoils. In the surface soils, nitrogen was low (nitrate nitrogen = 2.6 to 4.0 mg/kg; ammonium nitrogen = <20 mg/kg; total N = 500 to 590 mg/kg); and levels were very low in the subsoils (nitrate nitrogen = 0.1 to 0.5 mg/kg; ammonium nitrogen = <20 mg/kg; total N = 110 to 340 mg/kg).

Phosphorus - The available phosphorus (Olsen) levels in the surface soil layers were low (5.7 to 6.3 mg/kg Olsen P). As would be expected, levels in the subsoil layers were very low (<1 mg/kg Olsen P). Total Phosphorus levels generally corresponded with available phosphorus levels with surface soil levels ranging from 206 to 217 mg/kg Total P and subsoil levels ranging from 67 to 242 mg/kg Total P.

Potassium – These soil types in this landscape typically contain sufficient natural inherent potassium for general agricultural production. Soil potassium levels in the surface soil layers were at good, adequate and optimum levels for agricultural production (300 to 400 mg/kg Skene K); Levels in the subsoil layers were low (<100 to 100 mg/kg Skene K).

Sulphur – Surface soil sulphur levels were marginal to low (<10 mg/kg KCl 40 Sulphur). Subsoil sulphur levels increased with depth and ranged from <10 to 104 mg/kg KCl 40 Sulphur. These soil sulphur levels are typical of these soil types under this land use.

Cation Exchange Capacity (CEC) - The cation exchange capacity of these soil layers correlated with soil texture with the higher clay content subsoils yielding higher CECs. Whilst the lower clay content surface soils had lower CEC levels (8.8 meq/100g), these levels are still adequate. In the subsoil layers which have higher clay contents, CEC levels ranged from 12 to 19 meq/100g. This indicates good CEC levels providing adequate capacity for the soils to retain nutrients and salts.

The Calcium/Magnesium Ratio (Ca:Mg) - Soil calcium levels, measured as the ratio of calcium to magnesium, were low. Levels in the topsoil layers were low (Ca:Mg Ratio = 1.0) and levels decreased with depth and were very low in the subsoil layers (Ca:Mg = 0.3 to 0.9). This data indicates low soil calcium levels which are likely to be adversely impacting soil structure.

Exchangeable Sodium Percentage (ESP) – Soil sodium levels (soil sodicity) were measured as the Exchangeable Sodium Percentage (ESP) where values greater than 6 demarcate a sodic soil which indicates a propensity for soil structural decline due to dispersion. Soil sodicity was slightly elevated in the surface soil layers (ESP = 8 to 11). Soil sodicity was extremely elevated in the subsoil layers (ESP = 32 to 48). This data indicates that this Soil Type is very sodic. This is likely to be exacerbated by the high clay content soil layers, the low soil profile permeability and the poor soil structure. These elevated soil sodicity levels are likely to be contributing to soil dispersion, structural decline, reduced profile permeability and to waterlogging.

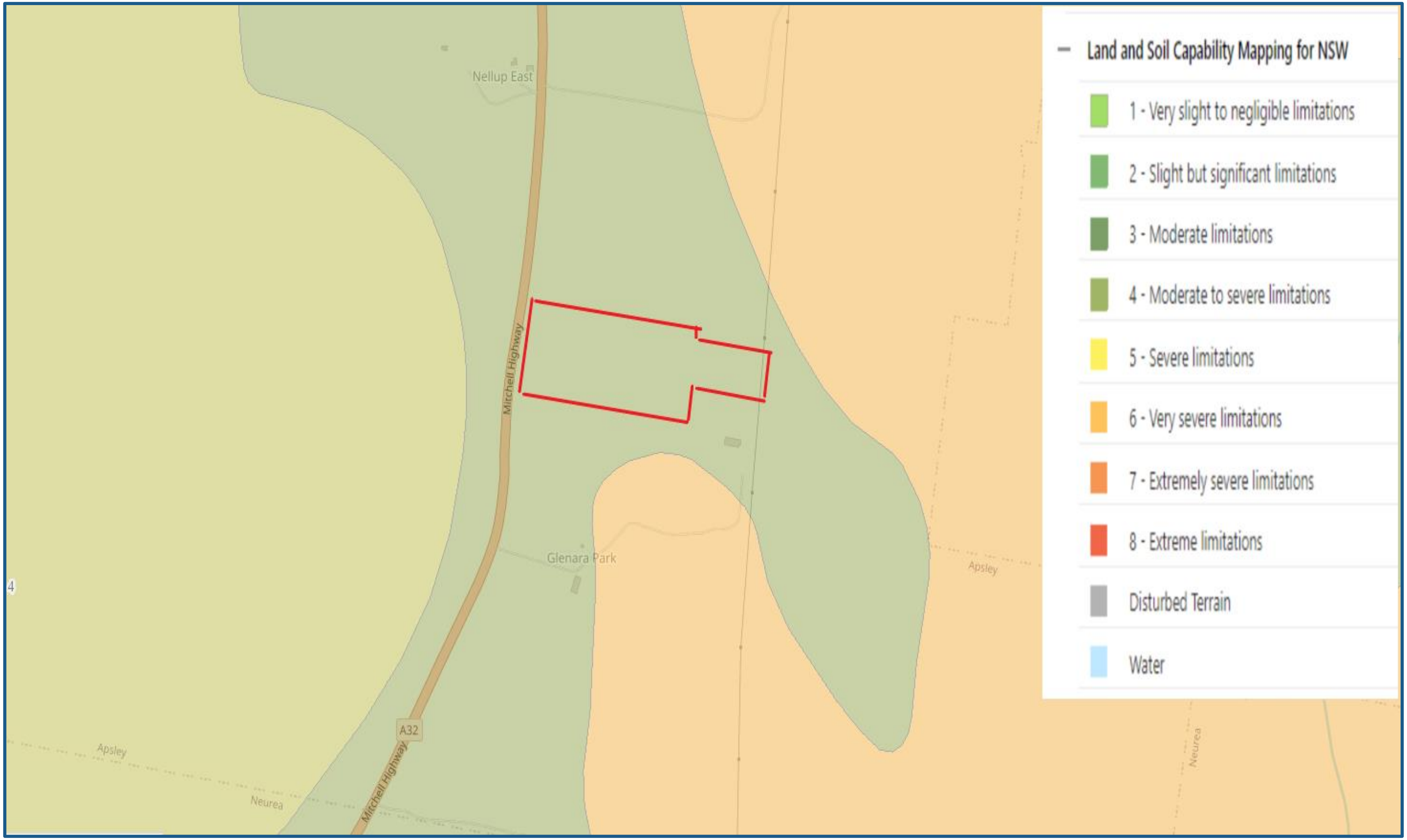
Organic Carbon – The soils were analysed for organic carbon which provides an indication of soil organic matter levels. Soil organic matter levels in the topsoil layers were low, marginal, typical of agricultural soil in this district and ranged from 2.2 to 2.4 %. As would be expected, subsoil organic matter levels were low and ranged from <0.5 to 0.6 %.

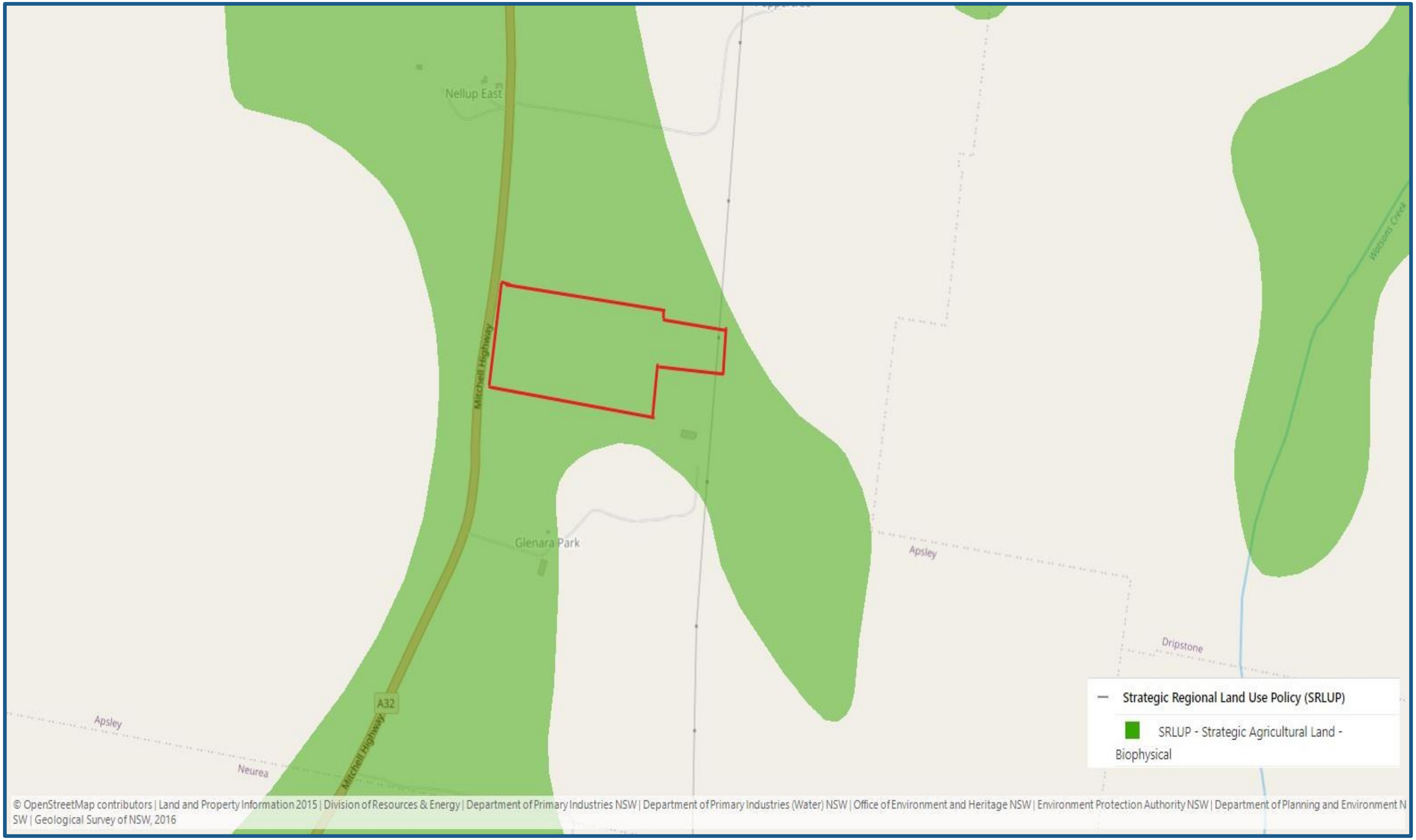
Trace Elements – The level in the soil of the trace elements listed hereunder were assessed based on the plant available amount present. This data should be used with caution because soil analysis for trace elements can be imprecise. Generally, the soils have typical trace element levels for these soil types in this district.

> **Copper -** Soil copper levels were typical, good and adequate ranging from 1.1 to 8.5 mg/kg with levels decreasing with depth.
>
> **Zinc -** Soil zinc levels were typical with low levels in the subsoils (<0.1 mg/kg) and adequate levels in the surface soils (1.3 to 3.3 mg/kg).
>
> **Manganese –** Soil manganese levels were typical and adequate ranging from 6 to 75 mg/kg.
>
> **Iron -** Soil iron levels were typical and adequate ranging from 10 to 94
>
> **Aluminium -** Soil aluminium levels were all low and not toxic (exchangeable aluminium < 0.1 mg/kg).
>
> **Boron –** Surface soil boron levels were adequate and not toxic ranging from 0.3 to 0.4 mg/kg; subsoils levels were slightly elevated and ranged from 1.5 to 7.5 mg/kg.

Emerson Dispersion Class – The upper A1 Horizon soil slaked and dispersed when re-moulded (Emerson Dispersion Class 3). The remaining topsoil (A2 Horizon) showed some dispersion (Emerson Dispersion Class 2). The subsoil low is displayed complete dispersion (Emerson Dispersion Class 1). This indicates dispersive soils.

12.7 Appendix G - Initial LCA & BSAL Maps




Nellup East
Mitchell Highway
Glenara Park
Apsley
Dripstone
Neurea
A32
Mitchell Highway
Watsons Creek
Strategic Regional Land Use Policy (SRLUP)
SRLUP - Strategic Agricultural Land - Biophysical
© OpenStreetMap contributors | Land and Property Information 2015 | Division of Resources & Energy | Department of Primary Industries NSW | Department of Primary Industries (Water) NSW | Office of Environment and Heritage NSW | Environment Protection Authority NSW | Department of Planning and Environment NSW | Geological Survey of NSW, 2016

12.8 Appendix H - 2022 Soil Map