HERA RESOURCES PTY LTD

ABN: 72 1389 929 99

Land and Soil Capability Assessment

Prepared by
SUSTAINABLE SOILS MANAGEMENT PTY LTD

November, 2021

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Federation Project

Land and Soil Capability Assessment

Prepared for:		
Hera Resources Pty Ltd ABN: 72 1389 929 99 Level17, 144 Edward St BRISBANE QLD 4000	Tel: Email:	07 3180 5000 office@aureliametals.com.au
Prepared by:		
Sustainable Soils Management Pty Ltd ABN: 67 105 201 581 5 Lawson St WARREN NSW 2824	Tel: Email:	(02) 68473367 admin@soilman.com.au
Ref No. Cr474		November, 2021

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SUMMARY

The soil assessment in this report covers the Federation Project (the Project), including the Federation Site, 17 km of linear infrastructure, a solar farm and a buffer around the proposed area disturbed by the Project. This assessment extends the land capability and soils assessment undertaken for the Federation Exploration Decline Program. The Project footprint is approximately 92 ha, of which 36 ha has been previously assessed as part of the Review of Environmental Factors for Exploration Decline Program, and is also incorporated in this report. The Soil Study Area, including buffer zones around disturbance areas covers 264 ha.

The assessment was based on profile descriptions in 26 pits, laboratory tests and used surface observations and published data to divide the land into 5 soil mapping units. The soil mapping units, which were variations on a soil theme of red, loamy, slightly acidic topsoil over more clayey subsoil with varying depth to unearthed rock. The whole profile had low salinity and low capacity to store nutrients as indicated by small cation exchange capacity. Cation ratios were generally desirable in the surface layers, but varied with depth. The soil had generally low nutrient status and soil organic carbon status was low. Laboratory tests found that the majority of samples tested in all Soil Mapping Units were dispersive, but some samples were stable.

The key differences between Soil Mapping Units were the depth to more than 50% gravel and the profile of cation ratios (Table S1).

Table S1. Soil properties that differentiate Soil Mapping Units.

Soil Mapping Unit	Key Properties	LSC Class	Area (ha)
Dermosol	• >1 m to more than 50% gravel. • Desirable cation ratios through profile.	4	61
Non-calcic Dermosol	• Average 75 cm to more than 50% gravel. • Cation ratios desirable in 0 to 5 cm layer, elevated calcium in 5 to 60 cm layer, elevated sodium in 60 to 90 cm layer.	5	76
Rudosol	• Average 20 cm to more than 50% gravel. • Desirable cation ratios through profile.	6	85
Acidic Rudosol	• Average 25 cm to more than 50% gravel. • Elevated aluminium through profile.	6	26
Tenosol	• Minimal soil.	7	16

The pattern of soil disturbance described in this report assumes that both the Federation Exploration Decline Program and the Project proceed. In this case, much of the soil disturbance would occur during the Federation Exploration Decline Program, while rehabilitation would occur when the Project is complete. The Project covered 88 ha of the disturbance footprint and included:

- The 41 ha Federation Site, which will contain a box cut, roads, infrastructure to support and underground mine, rock dumps and water retention ponds.
- A 14.3 km long Services Corridor covering 33 ha that would contain an access road, a water pipeline, a high voltage powerline corridor, and potentially a tailings pipeline.

- Access tracks to a communications tower, a quarry and access road to it covering 4 ha.
- An 8.7 ha solar farm and powerline corridor, constructed as part of the Project.

The Soil Study Area did not cover a borefield and 13.6 km of associated surface pipeline and tracks that covers 5 ha and would primarily be located on existing farm tracks.

An estimated 50 ha will be removed from agricultural production during the Project.

Topsoil in the Soil Study Area was assessed as being able to tolerate the planned disturbance and be used in rehabilitation to return to existing land capability provided the subgrade is loosened and topsoil replaced.

Disturbance by the Project and the Exploration Decline Program was estimated to remove a total of 47 ha of land with capability of LSC 4 to LSC class 6 from agricultural production during the life of the Project. This was estimated to be associated, with a theoretical loss of gross margin of $659/year (for the whole 47 ha of land with LSC class 4 to 6). However, most of the land, with the exception of a gravel quarry, should return to the existing production levels after the land is rehabilitated.

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1. INTRODUCTION

1.1. OVERVIEW

Hera Resources Pty Limited (Hera Resources) is a wholly owned subsidiary of Aurelia Metals Limited (Aurelia). Hera Resources currently own and operate the Hera Mine located approximately 80 km south-east of Cobar and approximately 5 km south of the township of Nymagee in western NSW (Figure 1.1). Aurelia also owns and operates the Peak Gold Mine (PGM) near Cobar in western NSW.

Hera Resources is evaluating the development of the Federation Project (the Project), a proposed underground metalliferous mine development. The Project comprises underground mining activities and surface infrastructure at the Federation Site, amendments at Hera Mine to facilitate processing of ore from the Federation Site, and a Services Corridor connecting the Federation Site with Hera Mine. The Federation Site is located approximately 15 km south of the Nymagee township and 10 km south of the Hera Mine.

1.2. PROJECT SUMMARY

The Project, as shown in Figure 1.2 comprises:

- The establishment and operation of underground gold and metalliferous mining activities, with supporting surface infrastructure, mining approximately 6.95 million tonnes (Mt) of ore over a period of 12 to 14 years, referred to as the Federation Site.
- Amendments at the Hera Mine to facilitate mining and processing of Federation ore, including new process plant and disposal of tailings in the Hera Mine tailings storage facility (TSF).
- Services Corridor between the Federation Site and Hera Mine, including powerline, water pipeline, access track, and potentially a tailings pipeline.
- A borefield through the Hera/Federation Project Area that would be linked by above ground polyethylene pipe to supply water.

The majority of ore produced would be sent to Hera Mine for processing. However up to 200 ktpa would be transported to PGM during the initial four years of processing (total of 750 kt over this period), whilst the new processing plant at Hera Mine is being commissioned and ramped up.

H:\Projects-SLR\660-SnWOL\660.30090.00000 Federation Project Approvals\06 SLR Data\01 CAD\GIS\GIS\SLR660300090_EIS_G1_LocalityPlan_001.mxd

Scale: 1:600,000 at A4
Coordinate System: GDA 1994 MGA Zone 55

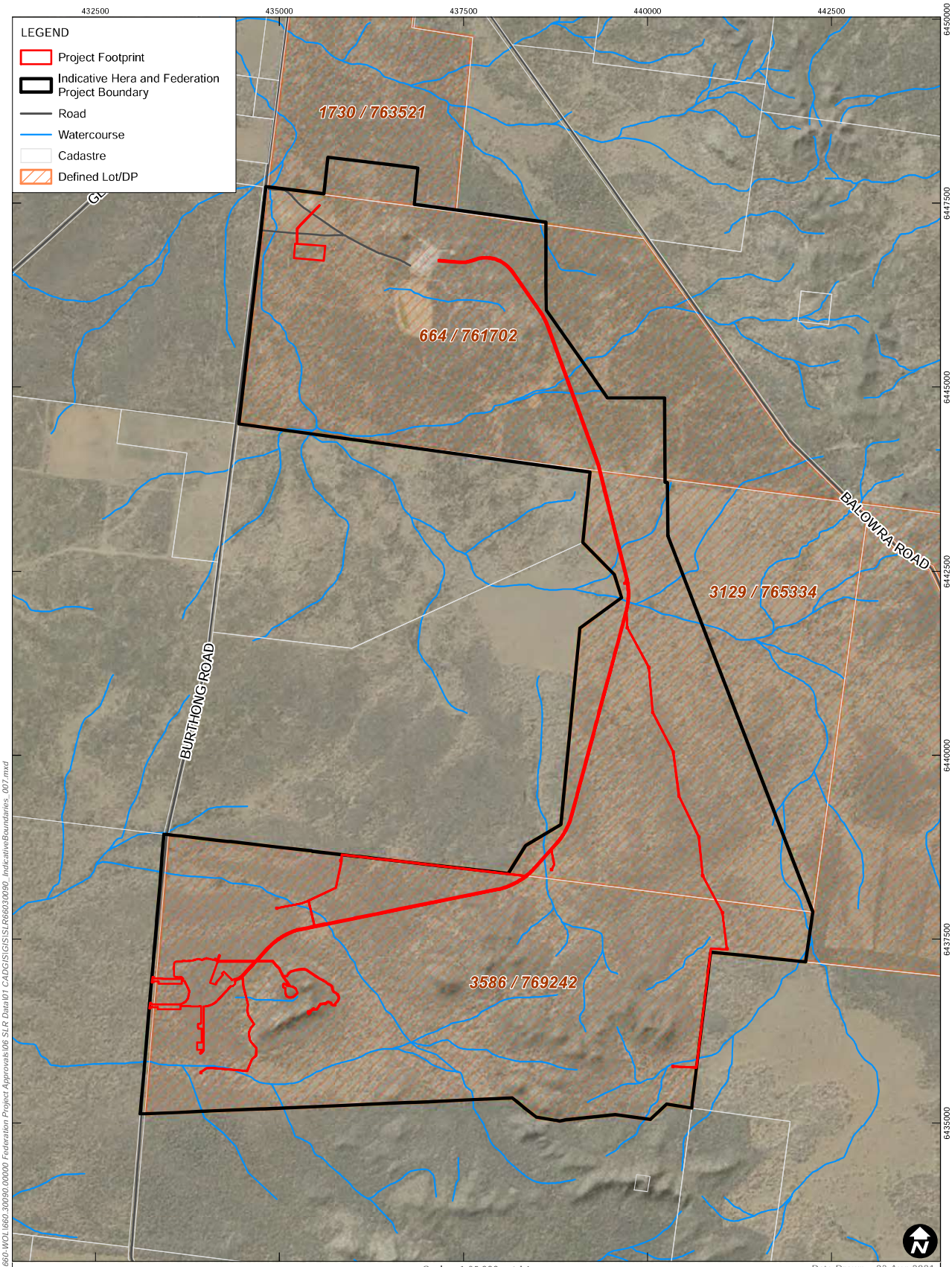
Date Drawn: 16-Nov-2021
Project Number: 660.30090.00000

Data Source: Basedata NSW SS, 2019, Geoscience Australia
Aerial imagery supplied by © Department of Customer Service 2020

SLR

FEDERATION PROJECT LOCATION PLAN

FIGURE 1.1



Indicative Hera and Federation Project Boundary

FIGURE 1.2

Hera Mine and Federation Site would be connected by a Services Corridor. The nominated width of the corridor is 23 m with an approximate length of 14.3 km. Clearing of existing vegetation would be required to install the proposed services infrastructure, including a power transmission line, water pipeline, access track and potentially a tailings slurry pipeline. The access track would be used for maintenance and inspection but not ore haulage.

The Federation Site would be expanded from that of the Exploration Decline Program, and include access to a communications tower and quarry.

A new solar farm (8.1 ha) at Hera Mine is proposed, and would be 200 m south of the existing heavy vehicle access road. The solar farm would be connected to the gas fired power plant at Hera Mine via a new transmission line. The new solar plant would increase power production to meet the additional requirements of the Federation Site, as well as the anticipated increase in demand at the Hera Mine from increased processing plant capacity. (Figure 1.2).

1.3. TRANSITIONAL PERIOD

It is anticipated that approval for the Federation Project will be obtained in early 2023. Prior to the construction and operation of the Federation Project, an Exploration Decline Program will be undertaken. This activity will be undertaken under a separate approval to that being sought for the Federation Project. The main objectives of the Exploration Decline Program are to further define the mineral resources associated with the Federation deposit, including permitting drilling of exploration drill holes from underground.

Key components of the Exploration Decline Program include:

- Establishment of a Surface Infrastructure Area required to support the exploration decline.
- Development of a box cut, portal, exploration decline, two ventilation rises and one escapeway.
- Transportation to and storage of waste rock within the Surface Infrastructure Area, with subsequent transport of waste rock to Hera Mine.
- Establishment and use of an approximately 14.8 km surface pipeline to transfer water from the exploration decline to Hera Mine.
- Exploration drilling from the exploration decline.
- Extraction of one or more bulk samples together totalling no more than 20,000 t and transportation of that material to the Hera Mine processing plant via Burthong Road.

It is anticipated that the Exploration Decline Program will commence in November 2021 with the Surface Infrastructure Area established and waste rock being generated from the decline. It is anticipated that ore from the bulk sample will be mined and processed between the third quarter of 2022 and first quarter of 2023. Based on the current schedule for the Federation Project, there will be a transitional period between Exploration Decline Program activities, mining operations at Hera Mine, and Federation Project construction and operations. Following approval of the Federation Project:

- construction of Federation Project infrastructure (including the new process plant) would commence in the first half of 2023

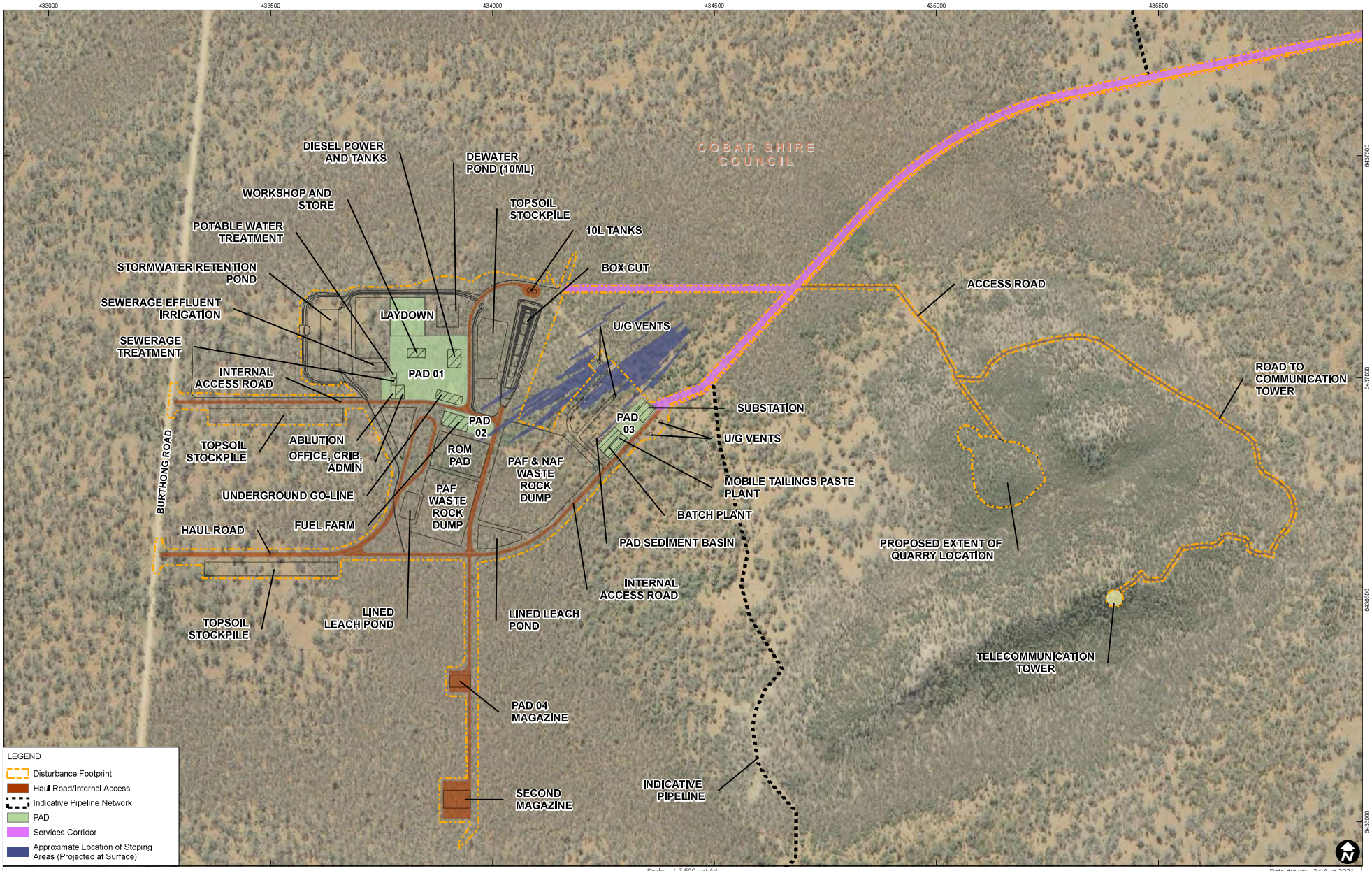
- Exploration Decline Program activities would transition into mining operations at the Federation Site
- Hera Mine operations may continue over a period of 6 to 12 months.

From early 2024, it is anticipated that all activities would be related to the Federation Project operations. The operational workforce numbers would be transitioned from Hera Mine operations to Federation Project operations.

1.4. TERMINOLOGY

The following terminology is used in this assessment.

- Proponent - Hera Resources Pty Ltd (Hera Resources), a wholly owned subsidiary of Aurelia Metals Ltd (Aurelia).
- The Project – The proposed development of an underground mine at the Federation Site, which would include activities at The Federation site, the Hera Mine Site and the Services Corridor as described in Section 1.2.
- Federation Site – Land to be disturbed to service mining of the Federation deposit as shown in Figure 1.3.
- Project Soil Disturbance Footprint – Land to be disturbed by the Project including land disturbed by the Exploration Decline Program, consequently the focus of the Environmental Impact Statement (EIS).
- Soil Study Area – the disturbance footprint of the Federation Site, a Services Corridor between the Hera Mine Site and the Federation Site, a proposed solar farm and powerline corridor within the Hera Mine Site. Includes alternative locations for access to communications tower and solar farm. The Soil Study Area excludes the borefield footprint.



Scale: 1:7,500 at A4
Coordinate system: GDA 1994 MGA Zone 55

Date drawn: 24-Aug-2021
Project number: 660.30090.00000

Data Source: Basedata NSW SS, 2019
Aerial imagery supplied by © Department of Customer Service 2020

SLR

FEDERATION SITE PLAN

FIGURE 1.3

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1.5. SPECIFIC ISSUES ADDRESSED IN THIS REPORT

The Planning Secretary's Environmental Assessment Requirements (SEARs) for the Project were issued by the Department of Planning, Industry and Environment (DPIE) on 17 August 2021. The SEARs identify matters which must be addressed in the Environment Impact Statement (EIS) and essentially form its terms of reference. Table 1.1 list individual SEARs relevant to this assessment and where they are addressed.

Table 1.1. Soil and land - related SEARs.

Key Issues	**Where addressed**
Land and Soils	
- the likely impacts of the development on the soils and land capability of the site and surrounds, and a description of the mitigation and management measures to prevent, control or minimise impacts of the development;	Sections 8, 9 and 10
- whether the soils in the area of the project are potentially contaminated or are acid forming (i.e., acid sulphate soils) and if so, identification of best practice mitigation measures and strategies or remedial and/or disposal actions that would be required/undertaken if applicable in accordance with relevant guidance/standards;	Acid Sulphate - Section 5 Contaminated soil - SLR Environment report
- the likely agricultural impacts of the development, including biosecurity risks;	Section 9
- the likely impact of the development on landforms (topography), including the long-term geotechnical stability of any new landforms on site; and	Rehabilitation Strategy Report (SLR)
- the compatibility of the development with other land uses in the vicinity of the development in accordance with the requirements of Clause 12 of State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007, paying particular attention to the agricultural land use in the region;	Section 9

2. LAND AND SOIL CAPABILITY ASSESSMENT METHODS

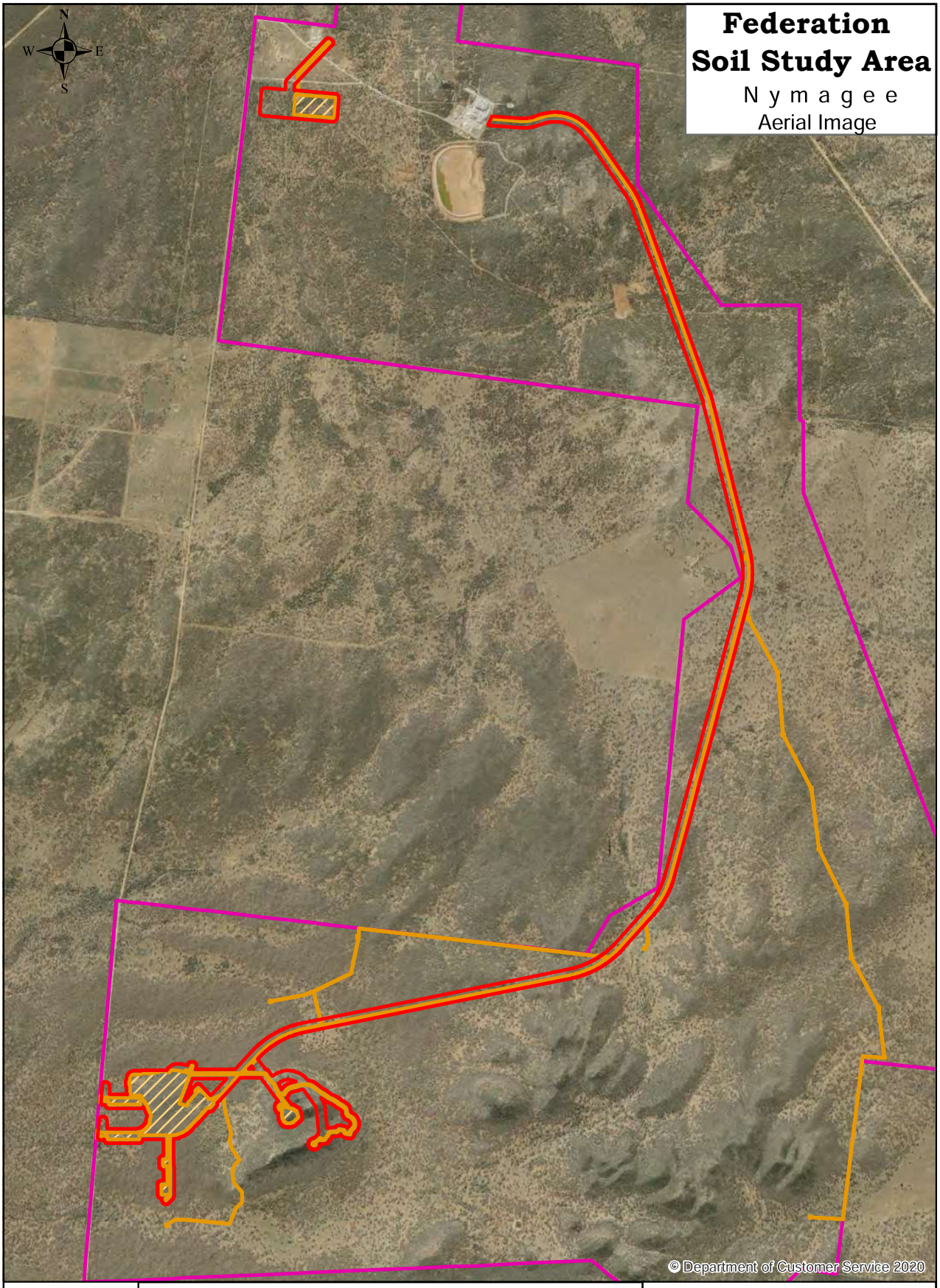
2.1. SOIL STUDY AREA EXTENT

The Soil Study Area of 264 hectares (ha) was based on the footprint in Figure 1.2, but the soil assessment buffered the footprint in the following ways:

- A 40 m buffer around the planned disturbance footprint to allow for minor inaccuracies and some modification to the footprint;
- An alternative access route to the communications tower;
- Extension of the footprint of solar farm 300 m eastwards to include land that appeared to be less susceptible to sporadic inundation.

The Soil Study Area consisted of 17 km of linear infrastructure of the Services Corridor, access tracks and power line corridor and 88 ha for the Federation Mine Site, solar farm and buffer (Figure 2.2). It includes the Soil Study Area of Exploration Decline Program assessed in Sustainable Soil Management (2021). The Soil Study Area excludes the borefield and associated pipelines laid on surface (see example in Figure 2.1), however this disturbance is expected to have minimal impact on soils.

Figure 2.1. Existing water pipe installation in Hera Mine Lease.



Certification

Draft/Uncontrolled Document
Unless Signed & Dated

Soil Study Area
Project Footprint
Federation Hera Project Area

Scale: 1:50,000 on A4 0 0.25 0.5 1 1.5 Km

Job Code: Cr474
Map Printed: 2021
Contact: Sustainable Soils Management
Phone : (02) 68 473367
Roads: Geoscience Australia
Drainage Lines: NSW Spatial Services

Datum: WGS 84
Projection: UTM

SSM Sustainable Soil Management

Figure 2.2

2.2. OVERVIEW OF SOIL ASSESSMENT PROCESS

The first step in the Land and Soil Capability (LSC) assessment was to conduct a soil and landscape assessment to divide the Soil Study Area into Soil Mapping Units, which are zones with consistent soil type and landscape properties. Each Soil Mapping Unit was then assigned an LSC class according to the criteria in Office of Environment and Heritage (2012).

The soil and landscape assessment was undertaken as a stratigraphic survey of soil within the Soil Study Area (Hewitt *et al.*, 2008). A stratigraphic soil survey is one in which properties at each location are assumed to be broadly correlated with the position in the landscape and broad scale variables such as geology and slope. Soil properties between each site observed are then expected to vary with covariates such as slope, soil colour or geology. These covariates are then used to map Soil Mapping Unit boundaries.

The following steps were undertaken to complete the LSC assessment for this report:

- a desktop review and assessment of existing information relating to soils and landforms in the Soil Study Area (Section 3).
- a field soil survey that consisted of excavation of 26 soil test pits supported by 3 observations of surface properties, field description of soil properties and laboratory analysis of selected samples to assess the range and distribution of soil properties across the Soil Study Area as Land Types (Section 4).
- A desktop assessment of the risk of Acid Sulphate Soil (Section 5).
- use of a subset of results from the soil survey to assess LSC across the Soil Study Area (Section 6).
- use of soil type distribution and LSC to assess the properties of disturbed soil (Section 7), the impact of the Project on agricultural soil resources with recommended soil management and mitigation measures (Section 8), recommended management of disturbed soil (Section 10), and an estimate of impact of the Project on agricultural production (Section 9).

2.3. DESKTOP ASSESSMENT

The desktop assessment reviewed a range of soil and landscape information across the Soil Study Area. Layers included: aerial image, published soil landscapes and their properties, geology, radiometrics (natural radiation emitted by the soil) and the shape of the land surface as indicated by selected indices.

The desktop assessment procedure was:

i. Overlay the Project boundaries on regional (1:250,000 scale) soil and landscape properties.

ii. Map land shape calculated from a 5 m resolution digital elevation model generated from photogrammetry data from NSW Spatial Services.

2.4. FIELD SURVEY

2.4.1. Sample Site Selection

Sample sites were selected using different strategies for the broad Federation Site and solar farm, and the narrow, essentially linear, Services Corridor.

In both cases, the aim was to sample sites that represent the range of selected covariates across the area assessed. Consequently, the sampling pattern in the broad areas starts as a grid, then sites are moved so that they are representative of the covariates. Similarly, sites along the linear features started at 1.2 km apart, then were moved to represent the range in covariates.

The 70 ha of the Federation Site (including 40 m buffer) was sampled with 7 pits and 2 observation sites giving a sampling intensity of 8 ha per site. The 20 ha of the solar farm site (including 40 m buffer) was sampled with 5 pits giving a sampling density of 4 ha per pit. Both these sampling intensities are appropriate for producing maps at a scale of 1:25,000 (Schoknecht *et al.,* 2008).

The sampling intensity of 14 pits and 1 observation site over 17 km Services Corridor and access roads is considered medium to low intensity and appropriate for producing maps at a scale of 1:50,000 (Soil Science Australia, Queensland Branch, 2013).

The location of sample sites is shown in Figure 4.1.

2.4.2. Survey Observations and Methods

Soil properties in the Soil Study Area were assessed by examining soil profiles in backhoe pits dug at least 1.0 m deep or to refusal when rock was encountered. The relatively shallow depth for this investigation was due to the small size of the excavator that was used to minimise the damage to vegetation. Locations of the pits were recorded using a handheld Garmin GPS, giving position accuracy of 5 m radius.

Selected soil properties in each pit were described according to the 'Australian Soil and Land Field Survey Handbook' (NCST, 2009). The soil properties described were:

- Depth of each horizon.
- Texture.
- Field pH using a kit based on the specifications of Raupach and Tucker.
- Dispersion.
- Root density.
- Proportion of soil occupied by gravel.
- Main colour and degree of mottling.
- Grade and type of structure and primary ped size.
- Size and type of concretions.
- Effervescence as an indication of the proportion of soft carbonates.

- Permeability and drainage were assessed for the profile as a whole.
- Nature of surface 2 cm of soil, i.e., whether or not soil was hard setting.

Additional measurements taken were:

- Potential rooting depth for annual field crops was estimated from structure, texture, and pH.
- Volume of Readily Available Water (RAW) was calculated from rooting depth and standard estimates of available water for each texture class.
- Salinity was estimated by measuring the electrical conductivity of a suspension of 1 volume of soil in 5 volumes of water.
- SOILpak score according to McKenzie (1998).

Each profile was classified to Suborder level of the Australian Soil Classification of Isbell (2002).

These properties were recorded on field sheets and entered into a custom soil database. Data was extracted from this database to estimate LSC class and used to construct logs of profile properties.

2.5. LABORATORY TESTING

Laboratory testing of 21 pits selected from the total 26 pits was undertaken to determine whether the average soil in the Soil Study Area had properties that encourage or constrain plant growth as well as assisting in the classification of soil types and the determination of LSC classes.

Soil samples were collected from standard depths of 0 to 5 cm, 5 to 15 cm, 15 to 30 cm, 30 to 60 cm, and 60 to 100 cm for all sites unless the depth range covered the boundary between the A and B horizons of duplex profiles. In duplex soil where a sample range covered the A to B horizon boundary, the depth range was shortened and only one horizon was sampled.

Samples were tested by Incitec Pivot Laboratories which has NATA accreditation in accordance with ISO/IEC 17025, and ASPAC accreditation using the methods of Rayment and Lyons (2010).

The soil properties measured assess soil fertility, presence of toxic soil chemistry and the chemical indicators of likely soil structure. These were:

0 to 5 and 5 to 15 cm only:

- Soil colour and texture.
- Organic carbon.
- Colwell phosphorus.
- Phosphorus Buffer Index.
- KCl sulphur.
- DTPA copper.
- DTPA zinc.
- DTPA manganese.
- DTPA iron.

- Hot $CaCl_2$ boron.
- Emerson Class.

All depths:

- Cations of Calcium, Magnesium, Potassium, Sodium and Aluminium.
- pH (1:5 water), pH (1:5 $CaCl_2$), electrical conductivity (1:5 water).
- Chloride anion
- Nitrate nitrogen and ammonium nitrogen.
- Ratios calculated from the measured properties were: Exchangeable Calcium Percentage, Exchangeable Magnesium Percentage, Exchangeable Potassium Percentage, Exchangeable Sodium Percentage, Exchangeable Aluminium Percentage, Calcium to Magnesium ratio and Electrochemical Stability Index were calculated. In addition, ECe (electrical conductivity of saturated extract) corrected for sparingly soluble sulphate according to Shaw (1999) was calculated.

All depths from 10 sites to represent the 4 dominant Soil Mapping Units:

- Particle size analysis (PSA) was conducted using the hydrometer method for 10 sample sites that were primarily in the area of greatest planned disturbance. These samples are described as PSA sites. The proportion of clay, silt, fine sand, and coarse sand was reported for these samples. PSA data was used in calculating the soil erodibility factor as described in Section 2.7.2.

2.6. ACID SULPHATE SOIL ASSESSMENT

The risk of Acid Sulphate was assessed in two ways. The first was to compare the location of the Soil Study Area with the ASRIS Atlas of Australian Acid Sulphate Soils.

The second was to compare soil properties in the Soil Study Area with soil properties associated with Acid Sulphate Soil. In this case, the task was to report on the presence or absence of a combination of both saline soil and abundant moisture, which are required for Acid Sulphate Soil to develop.

2.7. SOIL STRIPPING AND RESTORATION OF LAND CAPABILITY

Two sets of soil properties relevant to disturbance during the mine life were assessed at each detailed soil sampling site. The 'soil stripping suitability' rates the suitability of soil for use as topdressing material (topsoil) during Project rehabilitation. The 'soil erodibility factor' is an estimate of the susceptibility of agricultural soil to water erosion.

2.7.1. Soil Stripping Suitability

The suitability of soil for use during rehabilitation was determined while assessing soil pits using the physical assessment method of Elliot and Veness (1981) as presented in NSW Minerals Council (2007) and shown in Figure 2.3.

Inputs to the Elliot and Veness (1981) flowchart were calculated for all horizons to 50 cm by translating field and laboratory measured properties using the conversions below:

Step 1 Structure grade: Medium or strong structure grade has more than 30% peds, weak structure grade has less than 30% peds, massive structure has no peds (NCST, 2009).

Step 2 Coherence wet: None or partial field slaking indicates some wet coherence, complete slaking indicates no wet coherence.

Step 3 Mottle: Layers were classified as mottled if there was more than 5% mottle and the mottle type was not biological.

Step 4 Macrostructure: Dimensions classified as greater than 10 cm if both the primary and secondary ped size were larger than 10 cm.

Step 5 Force to disrupt peds: Not assessed because of wide range of subsoil moisture content during field assessment.

Step 6 Texture: Texture and the proportion of coarse fragments and segregations were extracted from the field soil descriptions.

Step 7 pH: pH_{H20} from field pH estimates.

Step 8 salinity: From measured electrical conductivity of 1:5 suspension converted to electrical conductivity of saturated extract using texture dependant factors.

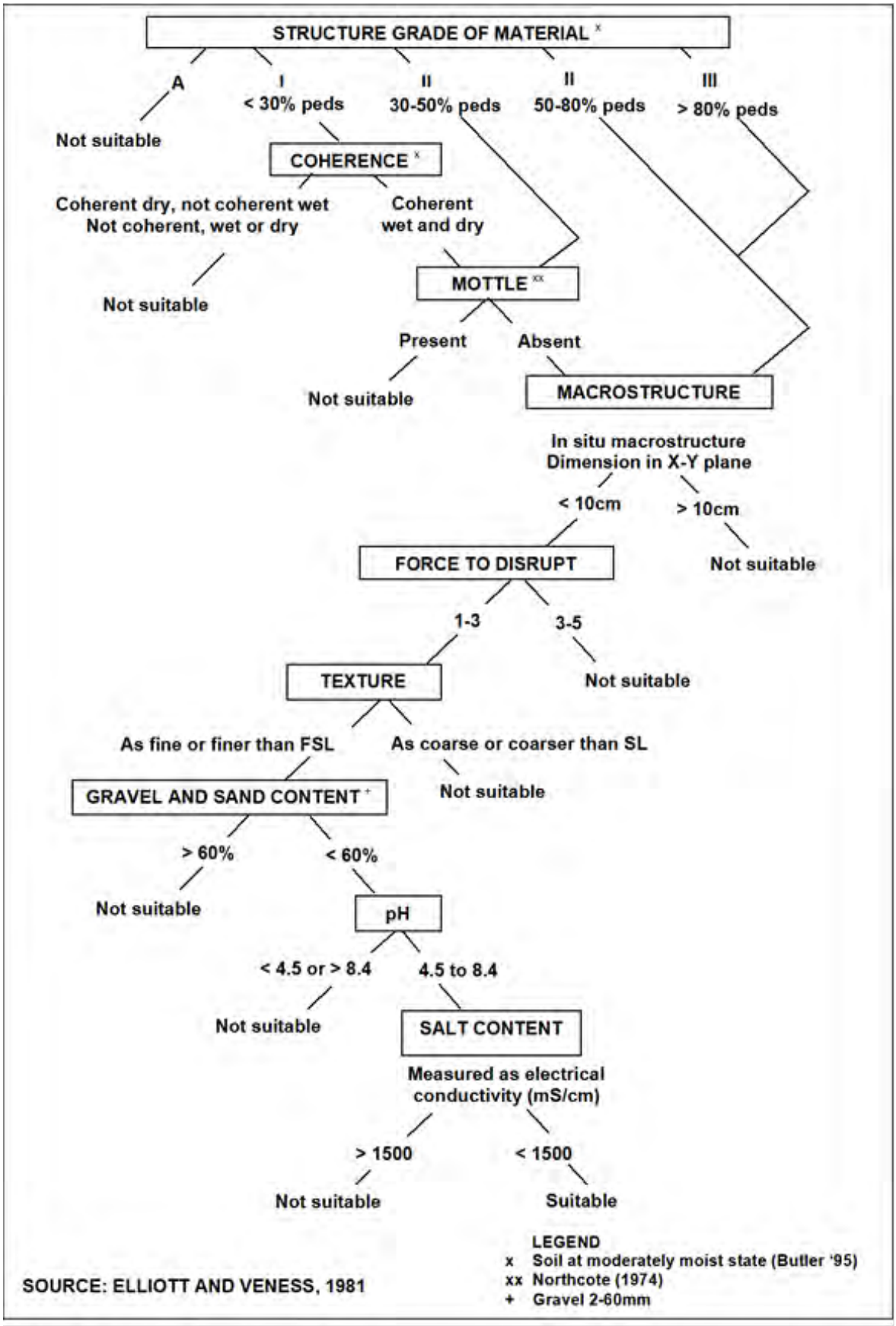


Figure 2.3. Flowchart for selection of topsoiling material.

2.7.2. Soil Erodibility Factor (K)

The soil erodibility factor (K, (t/ha)/(MJ mm ha^{-1} h^{-1})) was estimated for 10 sites for which particle size analysis was measured by using the equation:

$$100K = (2.1 * M^{1.14} * (10^{-4}) * (12-a) + 3.25 * (b-2) + 2.5 * (c-3) * 0.1317 \quad (1)$$

Where M is (percentage of silt + very fine sand) * (100 – percent clay), a is the percentage of organic matter, b is a soil structure class, and c is a profile permeability class (equation 3 in Wischmeier and Smith, 1978). Wischmeier and Smith (1978) state that this equation provides data for the nomograph in their report, which is reproduced by Landcom (2004) to estimate K. The 0.1317 factor is used to convert US units to SI units (Yang *et al.*, 2018).

The inputs used were: organic matter obtained by multiplying organic carbon of 0 to 5 cm layer by 1.72; soil texture estimated in the field or laboratory measured particle size for selected samples, surface soil structure and profile permeability described in the field.

Rosewell (1993) indicates that sites with a K value less than 0.02 have soil with low erodibility, K between 0.02 and 0.04 indicates moderate erodibility, and K greater than 0.04 indicates high erodibility.

2.8. SOIL MAPPING UNIT BOUNDARIES

Properties of the 0 to 5 cm soil layer were relatively consistent across the Soil Study Area, while there was a larger variation in the 15 to 90 cm soil properties. This challenge was overcome by using a combination of digital soil mapping and conventional soil mapping. The first step of digital soil mapping was to divide the 29 soil observations into 4 Soil Mapping Units. The second was to predict the Soil Mapping Unit using covariates from the Digital Elevation Model, Radiometrics Total Count and Multinominal Logistic Regression (Malone *et al.,* 2017). The Soil Mapping Unit boundaries were placed manually over the Soil Mapping Units predicted in this way.

2.9. LAND CAPABILITY ASSESSMENT

The land and soil capability was determined according to criteria in *Land and Soil Capability Assessment Scheme: second approximation* (OEH, 2012). Capability assessment is based on slope, wind hazard, soil pH, surface structural stability, salinity, rock outcrop, waterlogging potential, and existing erosion (OEH, 2012) and is described in more detail in Section 6.

The LSC class was determined for each Land Type from the calculated value for each profile description within the Land Type. This process is described in more detail in Section 6.

3. REGIONAL LANDSCAPE PROPERTIES AND CLIMATE

3.1. OVERVIEW OF SOIL STUDY AREA

The Soil Study Area is an erosional landscape that drains from east to west, and has small hills that are generally 30 m or less. This landscape is covered by woodland dominated by White Cypress, Poplar Box and Mallee, and is used for rangeland grazing of sheep and goats.

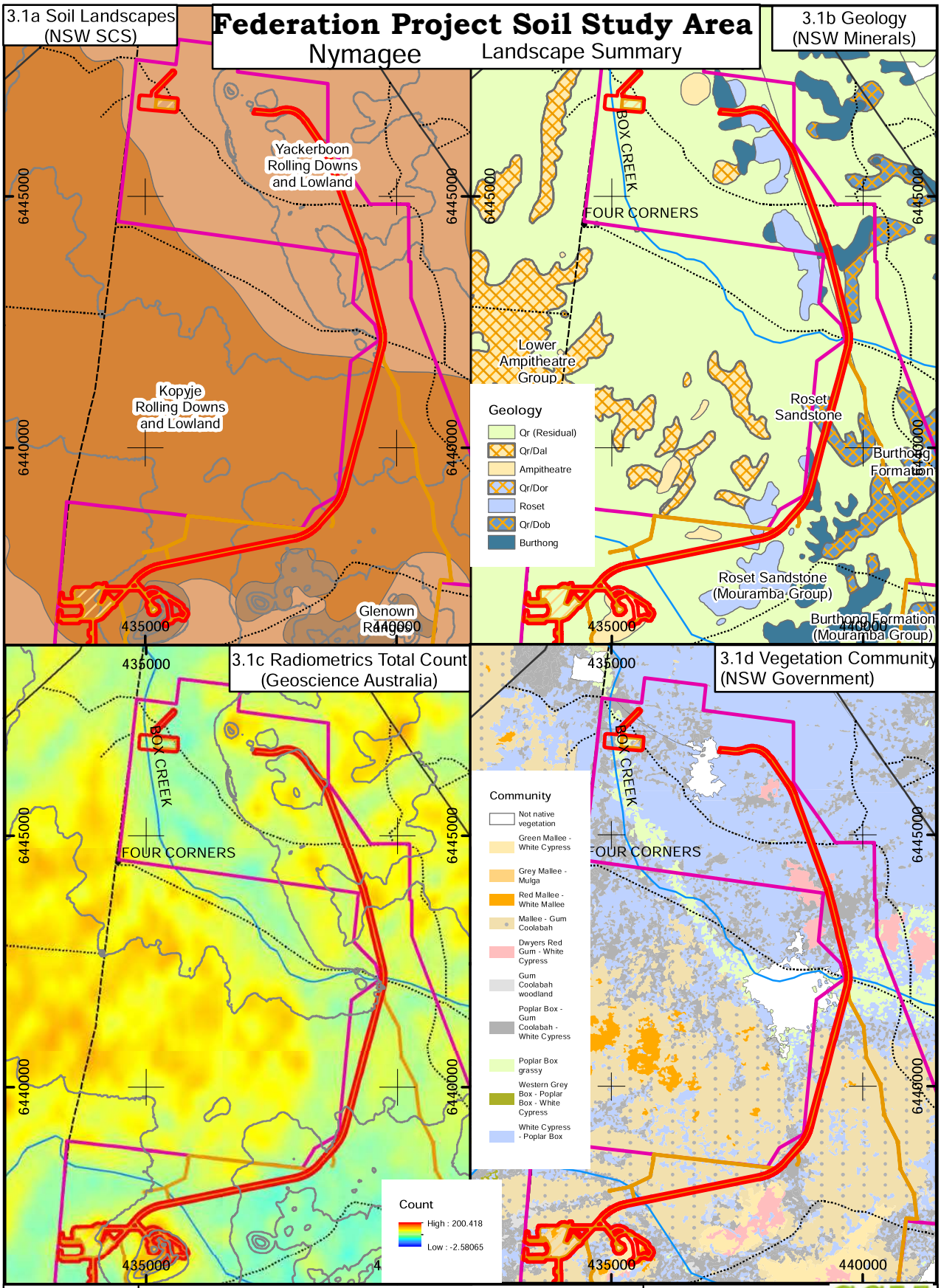
3.2. LANDSCAPE PROPERTIES

Walker (1991) mapped the northern half of the Soil Study Area as Yackerboon Rolling Downs and Lowlands **Land System**, and most of the southern half of the Soil Study Area as Kopyje Land Systems with undulating land surface (Figure 3.1a). Lithosols (shallow rocky soil) dominate in the Kopyje Land System, while red earths (ASC of Calcarosols and Red Kandosols, Murphy *et al.*, 2007) dominate in the Yackerboon Land System. Walker mapped the area of the quarry and communication tower as Glenown Land System, in which the dominant soil is shallow sandy soil.

The dominant **geology** in the Soil Study Area is Quaternary residual material (Qr) that has either been washed down the hills (colluvium) or been deposited by wind (eluvium). Rock outcrops in the Soil Study Area have a range of geology, consisting of fine sandstone from the Burthong group (dark blue in Figure 3.1b) coarser sandstone in the Roset Sandstone (light blue), or interbedded siltstone and sandstone of the Lower Ampitheatre Group (orange in Figure 3.1b).

The total **radiometrics count** indicates that there was more radiation naturally emitted from the erosional areas (hills) than the valleys. However, total count appeared to be lower in the Roset Sandstone than in the Lower Ampitheatre or Burthong Group (Figure 3.1c).

The NSW State Vegetation Type Map (State Vegetation Type Map | NSW Environment, Energy and Science)indicated that the northern half of the Soil Study Area was dominated by the White Cypress Poplar Box community (blue in Figure 3.1d). There was a relatively thin strip of Poplar box grassy woodland near the path of Box Creek. The southern half of the Soil Study Area was dominated by Mallee-Gum Coolabah woodland, with strips of woodland containing White Cypress and Bimble Box along drainage lines in the southern half of the Soil Study Area. Small patches of Red Mallee-White Mallee are mapped in the Federation Site and on the footslopes of the hills hosting the communications tower.


Federation Project Soil Study Area
Nymagee Landscape Summary
3.1a Soil Landscapes (NSW SCS)
3.1b Geology (NSW Minerals)
3.1c Radiometrics Total Count (Geoscience Australia)
3.1d Vegetation Community (NSW Government)
Yackerboon Rolling Downs and Lowland
Kopyje Rolling Downs and Lowland
Glenown Range
BOX CREEK
FOUR CORNERS
Lower Ampitheatre Group
Roset Sandstone
Burthong Formation
Roset Sandstone (Mouramba Group)
Burthong Formation (Mouramba Group)
Geology
Qr (Residual)
Qr/Dal
Ampitheatre
Qr/Dor
Roset
Qr/Dob
Burthong
Community
Not native vegetation
Green Mallee - White Cypress
Grey Mallee - Mulga
Red Mallee - White Mallee
Mallee - Gum Coolabah
Dwyers Red Gum - White Cypress
Gum Coolabah woodland
Poplar Box - Gum Coolabah - White Cypress
Poplar Box grassy
Western Grey Box - Poplar Box - White Cypress
White Cypress - Poplar Box
Count
High : 200.418
Low : -2.58065
6445000
6440000
435000
440000
Certification
Draft/Uncontrolled Document Unless Signed & Dated
Soil Study Area
Project Footprint
Federation Hera Project Area
20 m Contour
Road Class
Secondary Road
Minor Road
Track
0 0.5 1 2 3 4 Kilometres
Job Code: Cr474
Map Printed: 2021
Roads: NSW Minerals and Energy
Watercourses: Geoscience Australia
SSM Sustainable Soil Management
Contact: Sustainable Soils Management
Phone : (02) 68 473367
Datum: WGS 84
Projection: UTM
Figure 3.1

3.3. LAND SHAPE PROPERTIES

The **elevation** surface shows that there is more than a 90 m relief from the proposed location of the communication tower to Burthong Road (Figure 3.2). Although the drainage lines generally flow from east to west across the Soil Study Area, there are separate catchments with dendritic drainage patterns in the northern and southern half of the Soil Study Area. The Digital Elevation Model predicts that there is a drainage line through the southern half of the Solar Farm (Figure 3.2a).

The **slope** surface in Figure 3.2b indicates that hills near the Soil Study Area have small crests and concave slopes (steep near the crest and slope becoming continually flatter down the slope). The alignment selected for the Services Corridor is generally flatter than 5% slope except for a short section near the Hera Mine Site.

Multi-resolution Valley Bottom Flatness (Gallant *et al.,* 2011) separates erosional and depositional parts of the landscape. In landscapes like the Soil Study Area, soil is expected to be deeper in depositional areas (crimson in Figure 3.2c) than erosional areas (green in Figure 3.2c). Depositional Areas account for a small proportion of the Soil Study Area, so it is likely that shallow soil will be common.

Geomorphons (Jasiewicz *et al.,* 2012) aim to separate undulating landscapes into components that relate to conventional description of land shape. The Geomorphons fitted to the Soil Study Area show that the majority of the Federation Site is on the slopes of the hill to the east (Figure 3.2d). The Geomorphons also show that the depositional plains along the Services Corridor are narrow except the plain around Box Creek. In contrast the solar farm is classified as "Plains".

The background information indicates that the Soil Study Area is expected to contain a mixture of shallow stony soil in elevated areas, and deep red soil on footslopes and in plains. A range in soil pH is expected. The geology indicates that the soil is likely to be sandy or loamy rather than clayey. The pattern of White Cypress north of Box Creek and Mallee south of the creek may point to differences in soil properties. The land shape properties and vegetation distribution indicate that the solar farm is either on the floodplain of Box Creek or very close to it. The land shape surfaces indicate that the majority of the Soil Study Area is in an erosional rather than depositional part of the landscape. This is consistent with the common occurrence of shallow soil predicted in the Land Systems map. The land shape surfaces were used in Digital Soil Mapping to aid in generating Soil Mapping Unit boundaries.

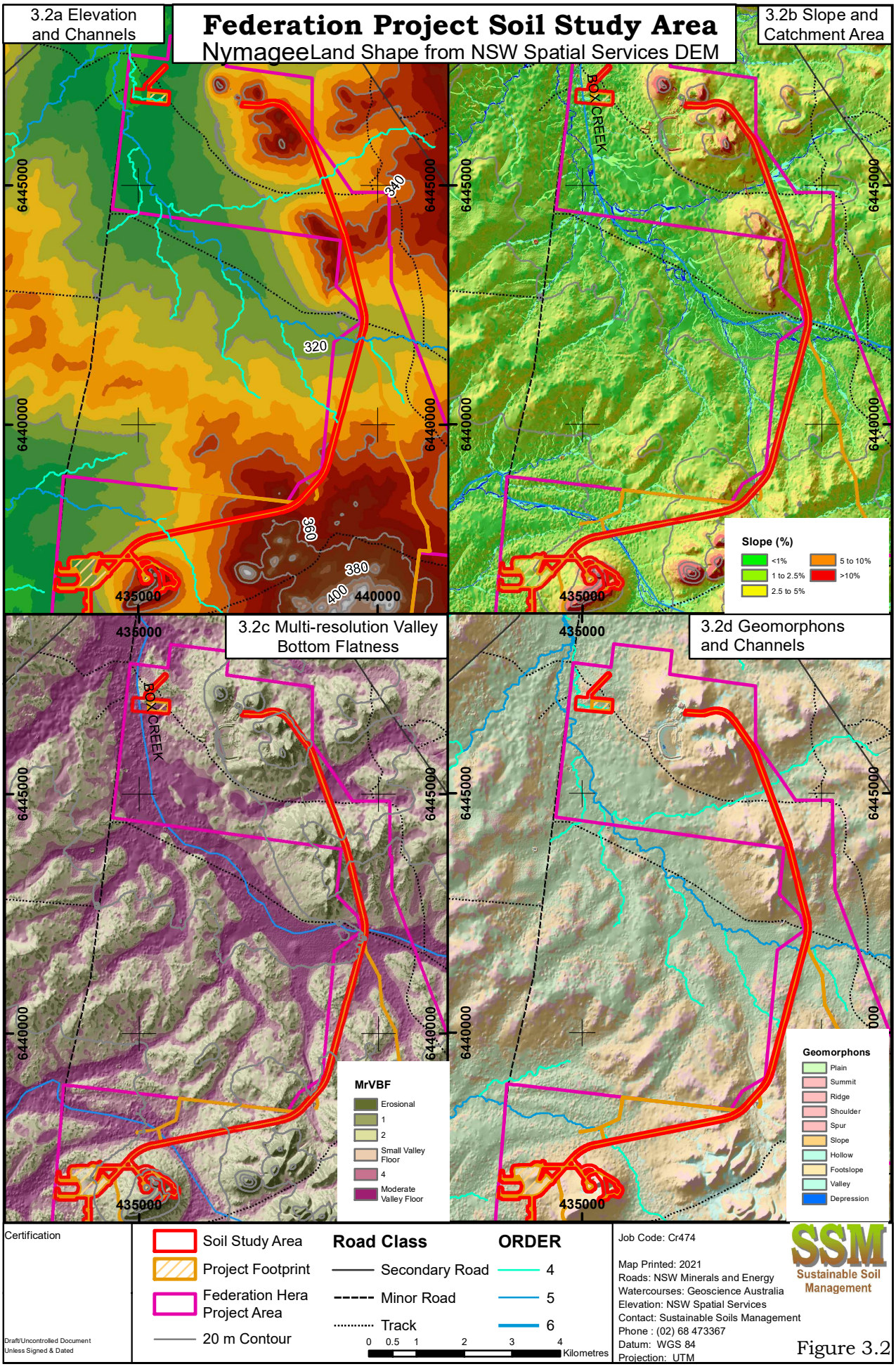

Federation Project Soil Study Area
NymageeLand Shape from NSW Spatial Services DEM
3.2a Elevation and Channels
3.2b Slope and Catchment Area
3.2c Multi-resolution Valley Bottom Flatness
3.2d Geomorphons and Channels
BOX CREEK
6445000
6440000
435000
440000
320
340
360
380
400
Slope (%)
<1%
1 to 2.5%
2.5 to 5%
5 to 10%
>10%
MrVBF
Erosional
1
2
Small Valley Floor
4
Moderate Valley Floor
Geomorphons
Plain
Summit
Ridge
Shoulder
Spur
Slope
Hollow
Footslope
Valley
Depression
Certification
Draft/Uncontrolled Document
Unless Signed & Dated
Soil Study Area
Project Footprint
Federation Hera Project Area
20 m Contour
Road Class
Secondary Road
Minor Road
Track
ORDER
4
5
6
0 0.5 1 2 3 4
Kilometres
Job Code: Cr474
Map Printed: 2021
Roads: NSW Minerals and Energy
Watercourses: Geoscience Australia
Elevation: NSW Spatial Services
Contact: Sustainable Soils Management
Phone : (02) 68 473367
Datum: WGS 84
Projection: UTM
SSM
Sustainable Soil Management

Figure 3.2

3.4. CLIMATE

The Soil Study Area receives an average 400 mm of annual rainfall with a relatively consistent average of around 33 mm/month (Figure 3.3, downloaded for 32.20°S, 146.30°E from Silo Data Drill). https://www.longpaddock.qld.gov.au/silo/point-data/ on 5/11/2020). Monthly rainfall is highly variable, with the standard deviation being greater than monthly average rainfall for 5 months of the year. Average evapotranspiration is much greater than rainfall for 8 months of the year, and less than double average rainfall for the period from May to August.

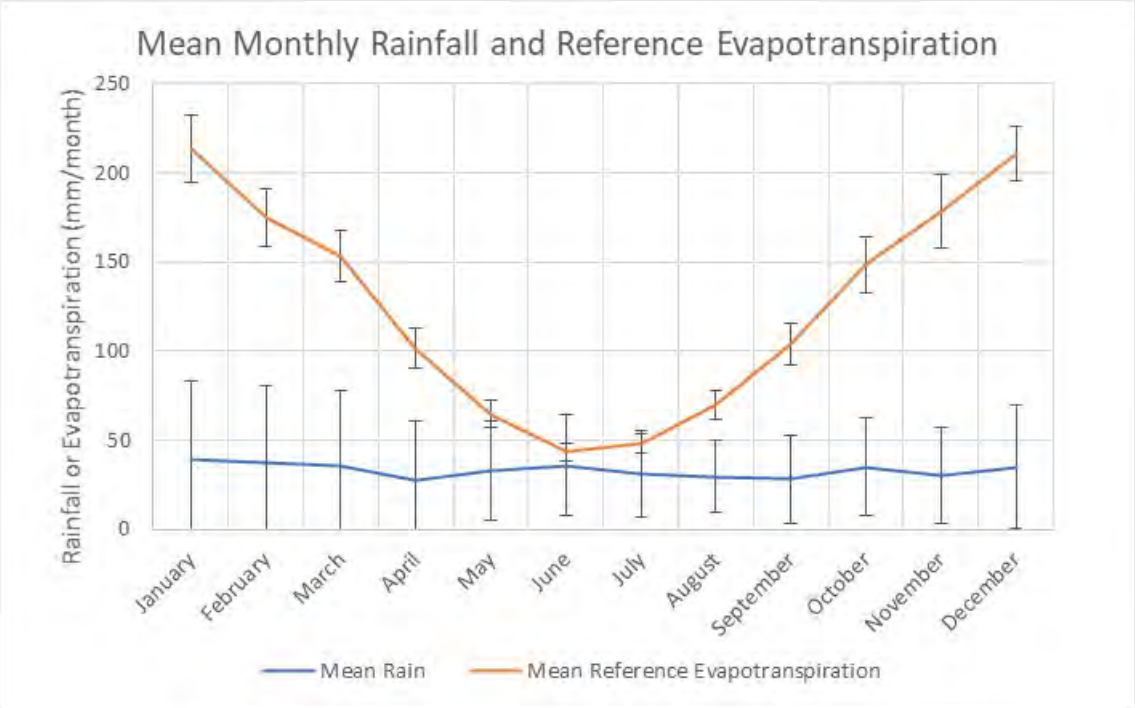


Figure 3.3. Average and standard deviation of rainfall and potential evapotranspiration for period from 1890 to 2020 at the Soil Study Area.

There is a 19°C difference between the 15°C average maximum temperature in June and July, and the 34°C average maximum temperature in January (Figure 3.4). Average minimum temperatures are 15°C cooler than maximum in the summer and 10°C cooler in winter. Frosts occur from May to September, and occur on an average 10 days in July. Maximum temperature is greater than 40 °C on an average of 1 to 2.4 days/month from December to February.

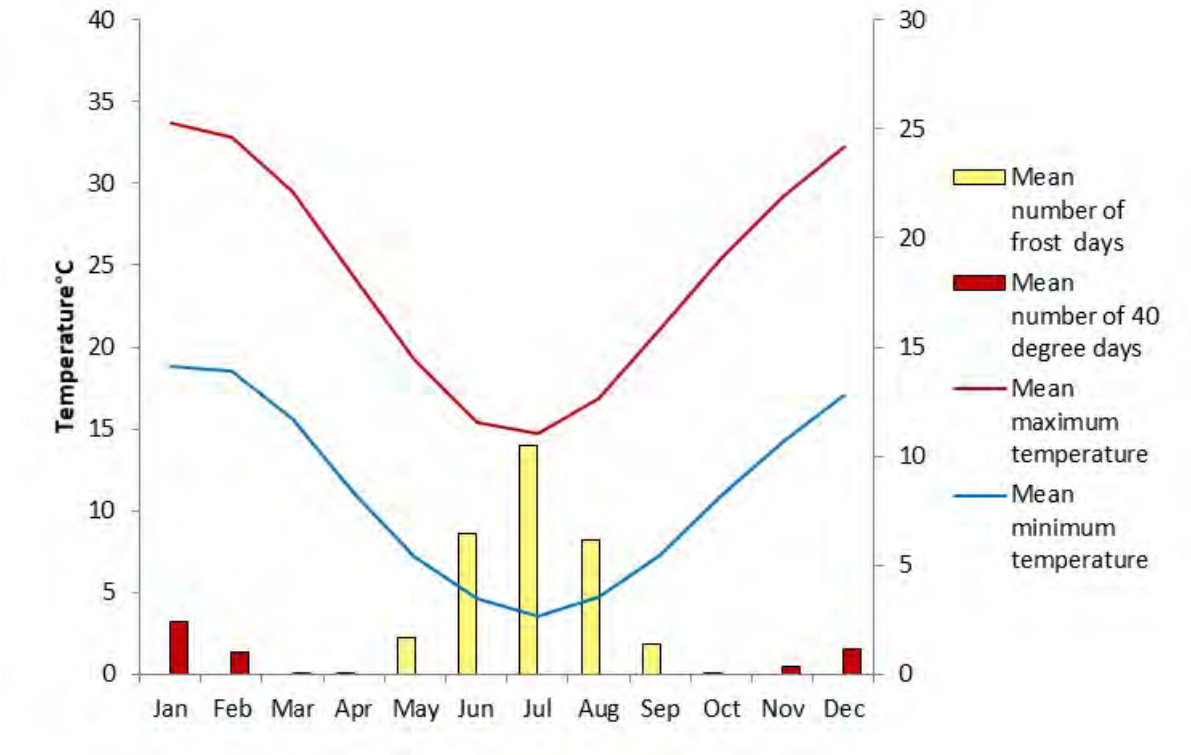


Figure 3.4. Average temperatures for period from 1890 to 2020 at the Soil Study Area.

The combination of temperature and rainfall results in a hot, arid steppe climate class, as per the Köppen-Geiger climate classification (Peel *et al.,* 2007).

4. SOIL DISTRIBUTION

4.1. OVERVIEW OF SOIL PROPERTIES

Surface soil properties were consistent across the Soil Study Area. The majority of topsoil layers were described as dark reddish brown sandy clay loam with subangular blocky structure. Cryptogam crust, a thin biological crust of lichens, mosses, liverworts, cyanobacteria, green algae and fungi, was common. Laboratory measured pH in the 0 to 5 cm layer was slightly acidic at 6.5. Soil salinity was consistently low across the Soil Study Area. The Soil Study Area was separated into 5 Soil Mapping Units based on depth to layer with more than 50% gravel and pH trend. These Soil Mapping Units are described in terms of Australian Soil Classification (ASC) Order and a descriptor.

4.2. DESCRIPTION OF SOIL MAPPING UNITS

The Soil Mapping Units reflected variations from the soil theme across the Soil Study Area of red, non-saline, slightly to moderately acidic clay loam to light clay with large variation in gravel content and depth to rock. The resulting Soil Mapping Units (Figure 4.1) are:

- **Dermosol** Soil Mapping Unit was red with sandy clay loam topsoil trending to light clay with depth. Most pits had more than 1 m of soil, which appears to have been deposited during multiple cycles.
- **Non-Calcic Dermosol** Soil Mapping Unit had red clay loam topsoil over red light clay subsoil. It was found in footslopes of hills in the Soil Study Area and was constrained by low pH, elevated exchangeable aluminium, low nutrient levels and moderate rootzone depth.
- **Rudosol** Soil Mapping Unit had red sandy clay loam topsoil, but layers with more than 50% gravel were encountered at an average depth of 20 cm. Rudosol occurred over the slopes and crests of hills in the Soil Study Area.
- **Acidic Rudosol** Soil Mapping Unit was characterised by shallow depth to layers with more than 50% gravel and an acidic layer that extends from at least 5 to 30 cm. The Acidic Rudosol Soil Mapping Unit occurred on hills and parent material was logged as fine sandstone.
- **Tenosol** Soil Mapping Unit occupied the hill area of the telecommunications tower and gravel pit and access tracks. There was a thin layer of soil on this land.

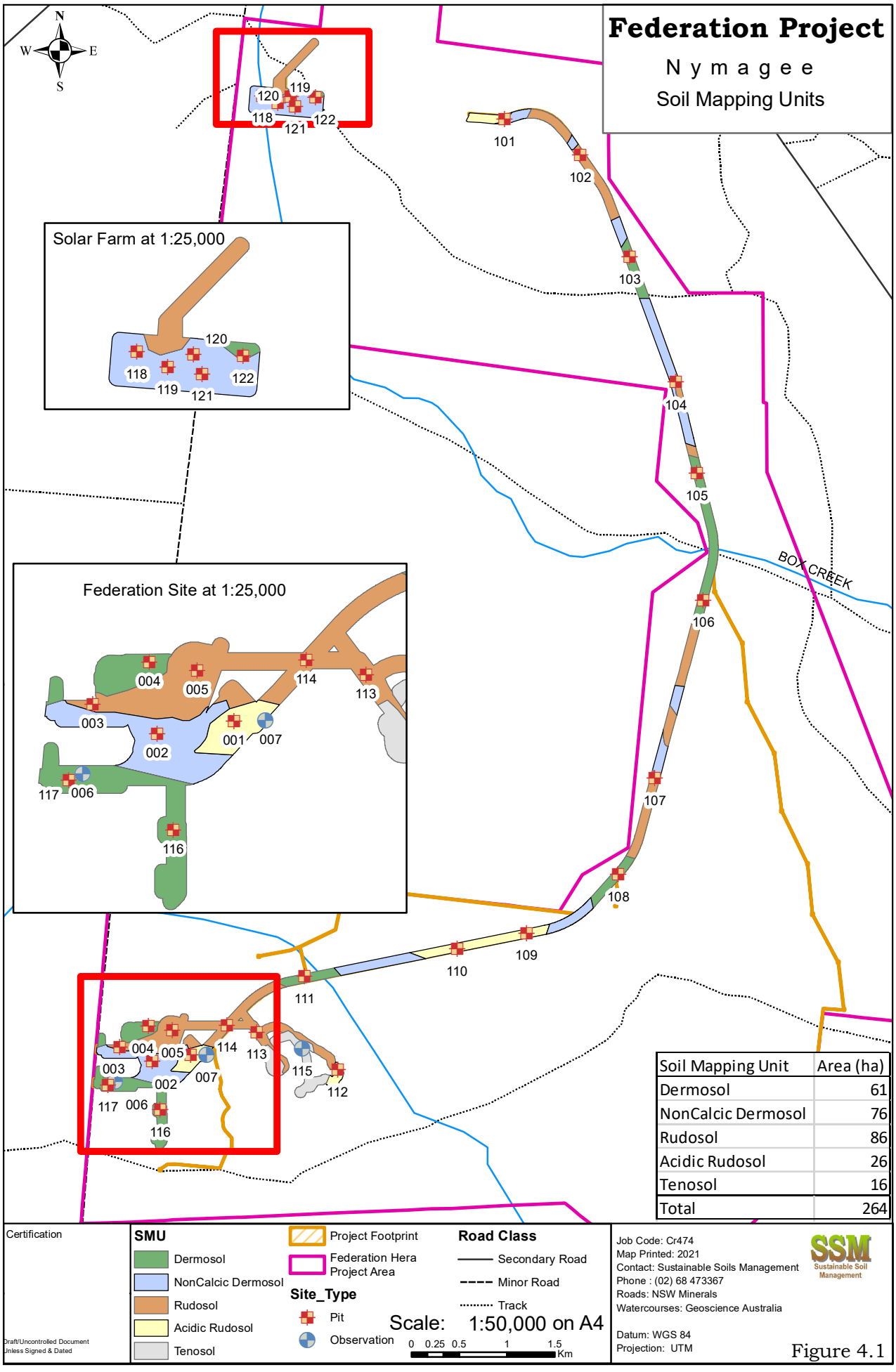
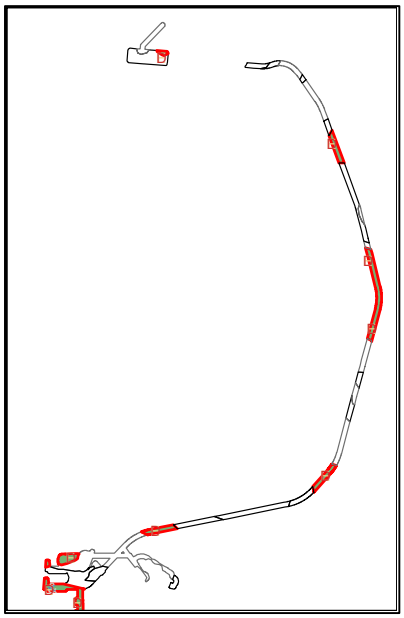

Federation Project
N y m a g e e
Soil Mapping Units
N
W
E
S
Solar Farm at 1:25,000
Federation Site at 1:25,000
BOX CREEK
101
102
103
104
105
106
107
108
109
110
111
112
113
114
115
116
117
118
119
120
121
122
001
002
003
004
005
006
007
Soil Mapping Unit | Area (ha)
Dermosol | 61
NonCalcic Dermosol | 76
Rudosol | 86
Acidic Rudosol | 26
Tenosol | 16
Total | 264
Certification
SMU
Dermosol
NonCalcic Dermosol
Rudosol
Acidic Rudosol
Tenosol
Project Footprint
Federation Hera Project Area
Site_Type
Pit
Observation
Road Class
Secondary Road
Minor Road
Track
Scale: 1:50,000 on A4
0 0.25 0.5 1 1.5 Km
Draft/Uncontrolled Document Unless Signed & Dated
Job Code: Cr474
Map Printed: 2021
Contact: Sustainable Soils Management
Phone : (02) 68 473367
Roads: NSW Minerals
Watercourses: Geoscience Australia
Datum: WGS 84
Projection: UTM
SSM
Sustainable Soil Management

Figure 4.1

4.2.1. **Dermosol** *(9 pits, 1 observation site, 7 sets of laboratory chemical analyses, 4 sets of particle size analysis over 60 ha).*

The Dermosol profiles were consistently red with clay loam or sandy clay loam topsoil over light clay subsoil. Effervescence to 1N HCl was detected deeper than 80 cm in 2 of the 9 pits tested. These were near the drainage lines in Figure 4.1. Weathered rock was encountered in 1 of the 9 pits tested. Gravelly layers occurred in 2 of the profiles, supporting interpretation that there have been a mix of erosional and depositional phases in the development of the Dermosol profiles.



Representative Soil Test Pit Profile Description: Dermosol.

Soil Test Pit: OF106	
	
Soil Test Pit OF106	**Landscape view, soil test pit OF106**
Australian Soil Classification Order	Dermosol (9)
Australian Soil Classification Sub-order	Red (9)
Representative Soil Test Pits	OA004, OF103, OF105, OF106, OF108, OF111, OF116, OF117, OF122
Observation site	OA006
Depth to 50% gravel	Generally greater than 1 m
Drainage	Moderately well drained
Erodibility Factor	All 4 PSA sites highly erodible
Stripping Suitability Depth	75 cm (range 35 to 135 cm). Limited by gravel layers.

The pH profile of the Dermosol Soil Mapping Unit was neutral from the surface to 30 cm, slightly alkaline to 60 cm, then returning to neutral in the 60 to 90 cm layer (Figure 4.2). Chloride concentration as a measure of salinity was very low throughout the profile. Cation Exchange Capacity (CEC) was low throughout the profile. Exchangeable Calcium Percentage (ECaP) was desirably high throughout the profile, and Exchangeable Sodium Percentage (ESP) and Exchangeable Aluminium Percentage (EAlP) were desirably low. Exchangeable Magnesium Percentage (EMgP) was a little higher than desirable (Hazelton and Murphy, 2011).

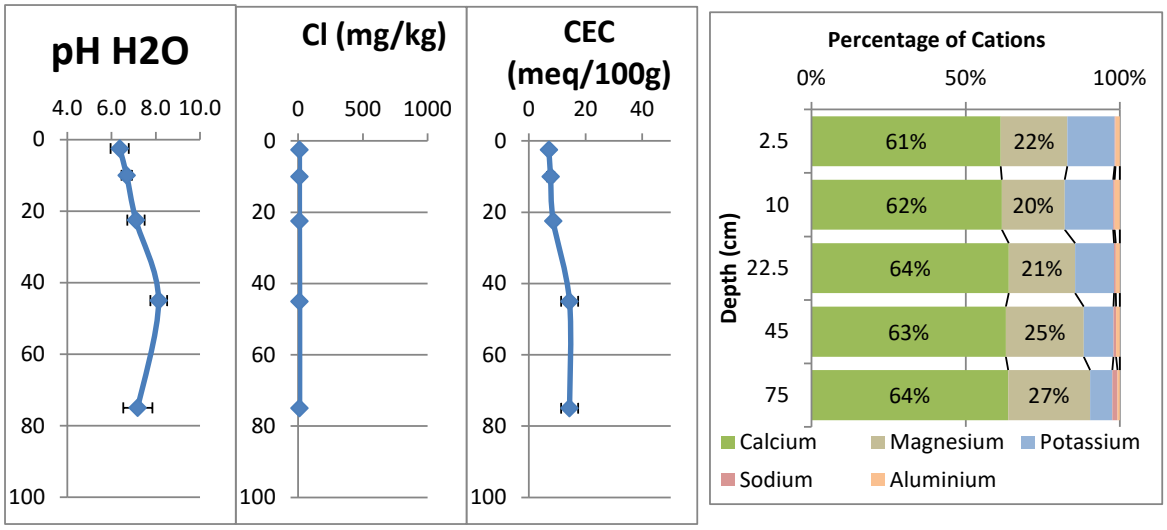


Figure 4.2. Summary of chemical properties Dermosol Soil Mapping Unit.

The clay content of the 4 sites tested for Particle size analysis (PSA) was around 25% for the surface to 30 cm, and increased to 50% of the fine earth fraction in the 60 to 90 cm layer (Figure 4.3). Fine sand, which tends to be associated with hardsetting soil, dominated the fine earth fraction for surface to 30 cm layer while clay dominated deeper in the profile.

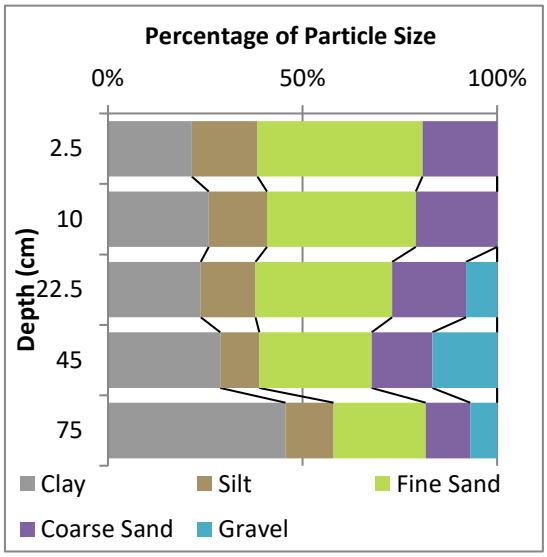


Figure 4.3. Particle Size of samples from Dermosol Soil Mapping Unit.

Topsoil organic carbon was 0.8%, (s.d. 0.2%), nitrate N was 2.3 mg/kg, (s.d. 1.7), available P was 7.3 mg/kg (s.d. 2.4) and sulphate sulphur was 1.7 mg/kg (s.d. 0.5). Soil organic carbon was low as were the nutrients tested.

Micronutrient levels were: Zinc 0.4 mg/kg, (s.d. 0.2), Copper 0.9 mg/kg, (s.d. 0.3), Manganese 14.7 mg/kg (s.d. 3.9) Iron 18.8 mg/kg (s.d. 5), and Boron 0.8 mg/kg (s.d. 0.2). Zinc concentration was moderately low, and the remaining micronutrients were at adequate concentrations.

Emerson tests indicate that most samples from Dermosol Soil Mapping Unit partly dispersed in water (Figure 4.4).

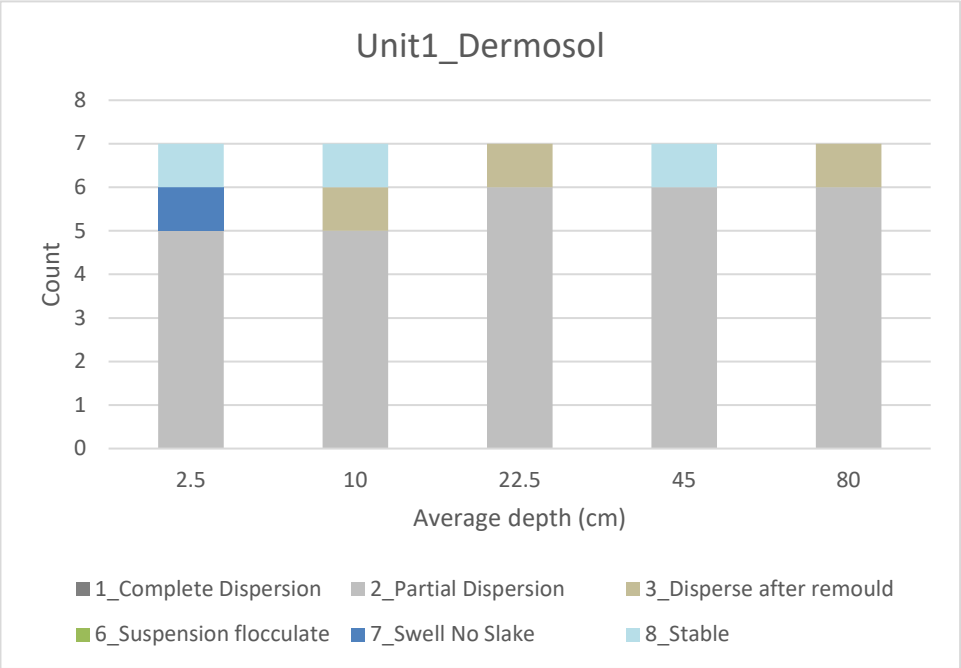
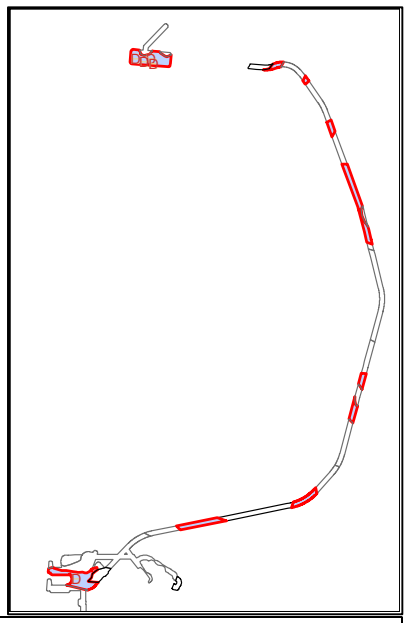


Figure 4.4. Soil stability from Emerson Aggregate Test on samples from Dermosol Soil Mapping Unit.

The Dermosol profiles had moderate waterholding capacity because there was a metre of soil above the weathered rock and the pH was close to neutral, but the soil was deficient in macronutrients and tended to disperse.

4.2.2. **NonCalcic Dermosol** (*5 pits, 3 sets of laboratory chemical analyses, 2 sets of particle size analysis over 76 ha*).

The NonCalcic Dermosol profiles were also consistently red and had clay loam topsoil over light clay subsoil. No effervescence to 1N HCl was detected in any layer tested in any pit. Weathered rock or greater than 50% gravel was encountered in 5 of the 6 profiles assessed. The NonCalcic Dermosol pits tended to be in footslopes rather than on plains.



Representative Soil Test Pit Profile Description: NonCalcic Dermosol.

Soil Test Pit: OF117	
	
Soil Test Pit OF118	**Landscape view, soil test pit OF118**
Australian Soil Classification Order	Dermosol (5)
Australian Soil Classification Sub-order	Red (5)
Representative Soil Test Pits	OA002, OF118, OF119, OF120, OF121
Depth to 50% gravel	Average 75 cm
Drainage	Moderately well drained (2), Well Drained (3)
Erodibility Factor	Both PSA sites were moderately erodible
Stripping Suitability Depth	60 cm (range 35 to 140 cm). Limited by coarse fragments

The pH profile of the NonCalcic Dermosol Soil Mapping Unit was slightly acidic to 15 cm, moderately acidic to 30 cm, then increased to neutral in the 30 to 90 cm layer (Figure 4.5). Chloride concentration as a measure of salinity was low throughout the profile. CEC was low to 60 cm and moderate to 90 cm. ECaP was desirably high in the 0 to 5 cm layer, then decreased to undesirably low below 30 cm, while ESP was higher than desirable in the 30 to 60 cm layer. EAlP was high enough to restrict the growth of many plants in the 5 to 60 cm layers. EMgP was a little higher than desirable in the 0 to 5 cm layer, and doubled through the profile.

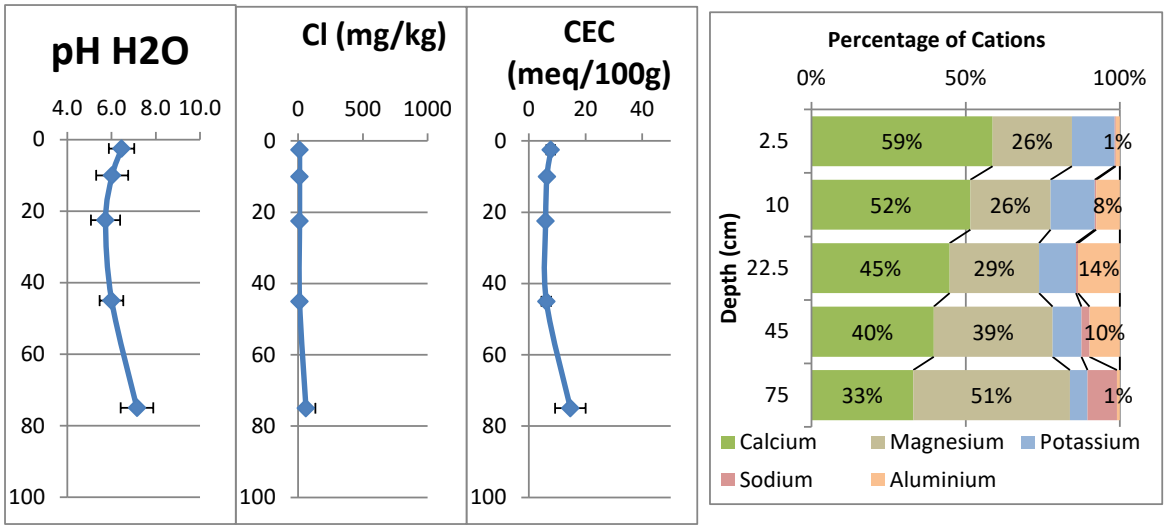


Figure 4.5. Summary of chemical properties in NonCalcic Dermosol Soil Mapping Unit.

The clay content of the 2 tested sites was around 22% for the surface to 5 cm, and increased steadily to 30% in the 30 to 60 cm layer and 35% in the 60 to 90 cm layer (Figure 4.6). Fine sand, which tends to be associated with hardsetting soil, dominated the fine earth fraction for the surface 60 cm, but clay tended to dominate the 60 to 90 cm layer.

Topsoil organic carbon was 1.3%, (s.d. 0.5%), nitrate N was 2.5 mg/kg, (s.d. 1.8), available P was 6.8 mg/kg (s.d. 1.7) and sulphate sulphur was 1.8 mg/kg (s.d. 0.5). The organic carbon concentration was moderate, while the macronutrients tested were lower than optimum.

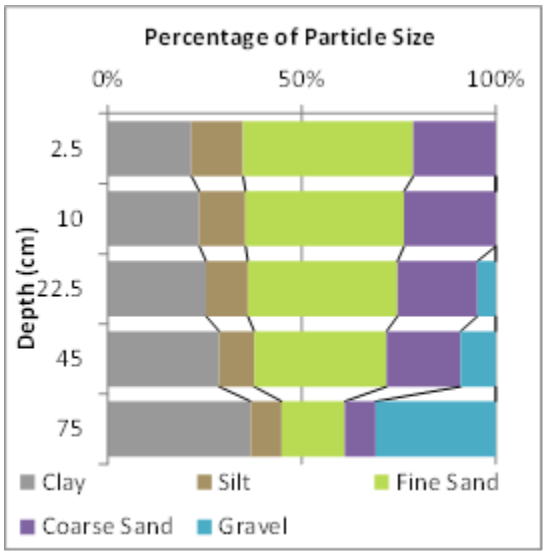


Figure 4.6. Particle Size of samples from NonCalcic Dermosol Soil Mapping Unit.

Micronutrient levels were: Zinc 0.7 mg/kg, (s.d. 0.2), Copper 1 mg/kg, (s.d. 0.4), Manganese 29.7 mg/kg (s.d. 17.1) Iron 24.3 mg/kg (s.d. 10.4), and Boron 1.2

mg/kg (s.d. 0.4). Zinc concentration was moderately low, and the remaining micronutrients were at adequate concentrations.

Emerson tests indicated that samples from the 2 NonCalcic Dermosol sites in the Solar Farm partly dispersed in water (Figure 4.7). However, soil tested from the surface to 30 cm from OA002 in the Federation Site was stable in water.

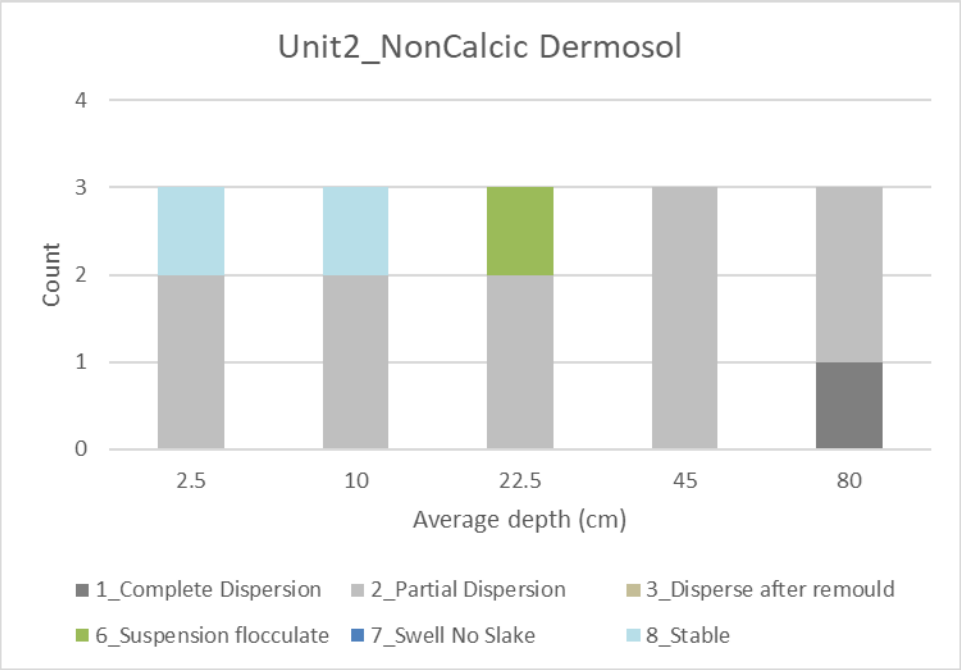
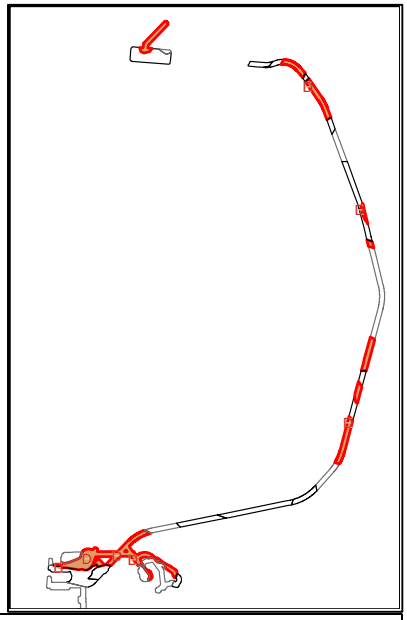


Figure 4.7. Soil stability from Emerson Aggregate Test on samples from NonCalcic Dermosol Soil Mapping Unit.

The NonCalcic Dermosol profiles had moderate waterholding capacity because there was an average 75 cm above weathered rock. Soil pH tended to be acidic, which was associated with elevated EAlP and the soil was deficient in macronutrients and tended to disperse. These soil properties will constrain the vegetation that grows in the NonCalcic Dermosol.

4.2.3. **Rudosol** (*7 pits, 6 sets of laboratory chemical analyses, 2 sets of particle size analysis over 85 ha).*

The Rudosol profiles were consistently red and had sandy clay loam topsoil and varied subsoil development. No effervescence to 1N HCl was detected in any layer tested in any pit. Weathered rock or greater than 50% gravel was encountered all profiles assessed. The Rudosol pits tended to be on the slopes of hills and the weathered rock encountered was generally logged as mudstone rather than sandstone.



Representative Soil Test Pit Profile Description: Rudosol.

Soil Test Pit: OF107	
	
Soil Test Pit OF107	**Landscape view, soil test pit OF107**
Australian Soil Classification Order	Dermosol (1), Tenosol (5), Rudosol (2)
Australian Soil Classification Sub-order	Red (1), Red-Orthic (5), Leptic (2)
Representative Soil Test Pits	OA003, OA005, OF102, OF104, OF107, OF113, OF114
Observation site	OF115
Depth to 50% gravel	Average 20 cm
Drainage	Poorly Drained (1), Imperfectly drained (1), Moderately well drained (1), Well drained (4)
Erodibility Factor	Both PSA sites highly erodible
Stripping Suitability Depth	15 cm (range 10 to 50 cm). Limited by coarse fragments

The average pH profile of the Rudosol Soil Mapping Unit was neutral from the surface to 60 cm, then slightly alkaline from 60 to 90 cm (Figure 4.8). However, pH varied more in the Rudosol than in the Dermosol Soil Mapping Units. Chloride concentration as a measure of salinity was very low throughout the profile. CEC was low to 30 cm them moderate from 30 to 90 cm. ECaP was desirably high throughout the profile, and ESP and EAlP were desirably low. EMgP was a little higher than optimum in the surface to 30 cm layers, then increased with depth.

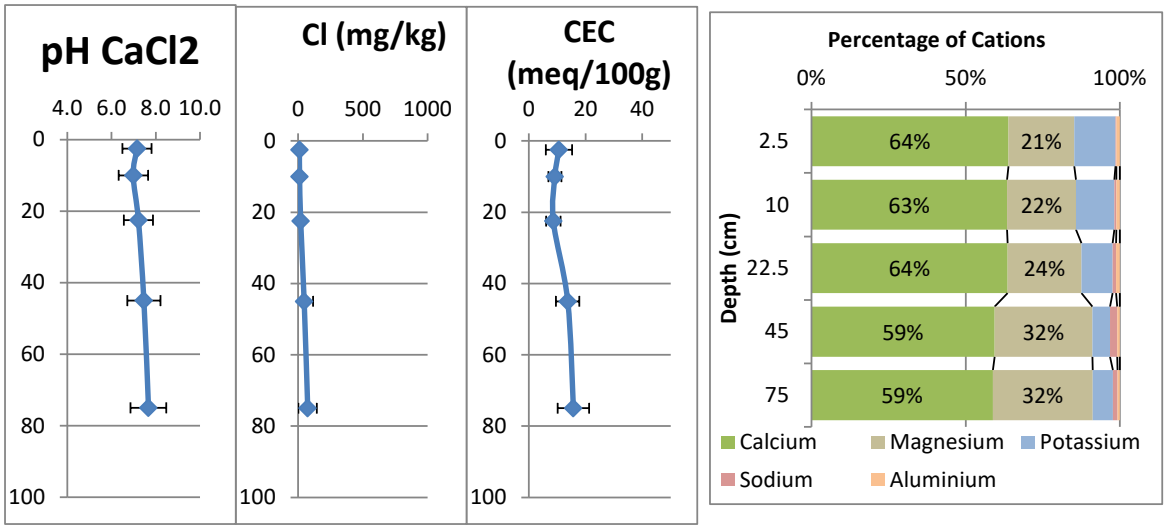


Figure 4.8. Summary of chemical properties in Rudosol Soil Mapping Unit.

The clay content of the 2 sites tested was around 25% for the surface to 30 cm, then increased to 35% in the 30 to 90 cm layers (Figure 4.9). Fine sand, which tends to be associated with hardsetting soil, dominated the fine earth fraction for the surface 30 cm, but clay tended to dominate the 60 to 90 cm layer.

Topsoil organic carbon was 1.3%, (s.d. 0.6%), nitrate N was 4.7 mg/kg, (s.d. 2.2), available P was 7 mg/kg (s.d. 2.1) and sulphate sulphur was 2.3 mg/kg (s.d. 0.5). The organic carbon concentration was moderate, while concentrations of the macronutrients tested were lower than optimum.

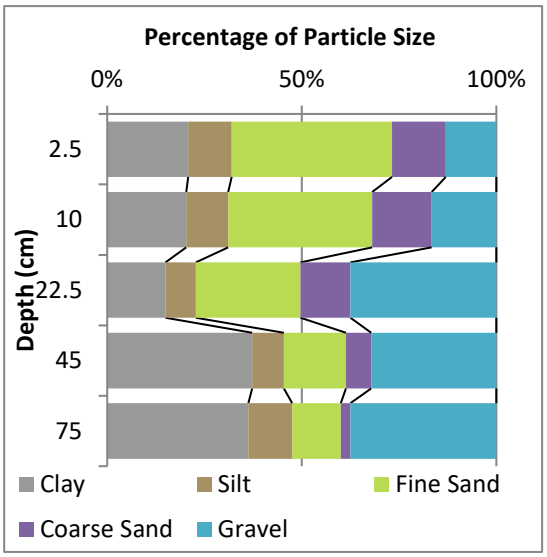


Figure 4.9. Particle Size of samples from Rudosol Soil Mapping Unit.

Micronutrient levels were: Zinc 0.3 mg/kg, (s.d. 0.1), Copper 0.6 mg/kg, (s.d. 0.2), Manganese 16.6 mg/kg (s.d. 10.7) Iron 9.5 mg/kg (s.d. 4.4), and Boron 1.4 mg/kg (s.d. 0.6). Zinc concentration was deficient, and the remaining micronutrients were at adequate concentrations.

Emerson tests indicate that surface to 30 cm samples from the Rudosol Soil Mapping Unit were evenly split between samples that spontaneously dispersed in water and those that did not (Figure 4.10). All the stable samples were taken from the Federation Site, while the dispersive samples were taken from the Services Corridor.

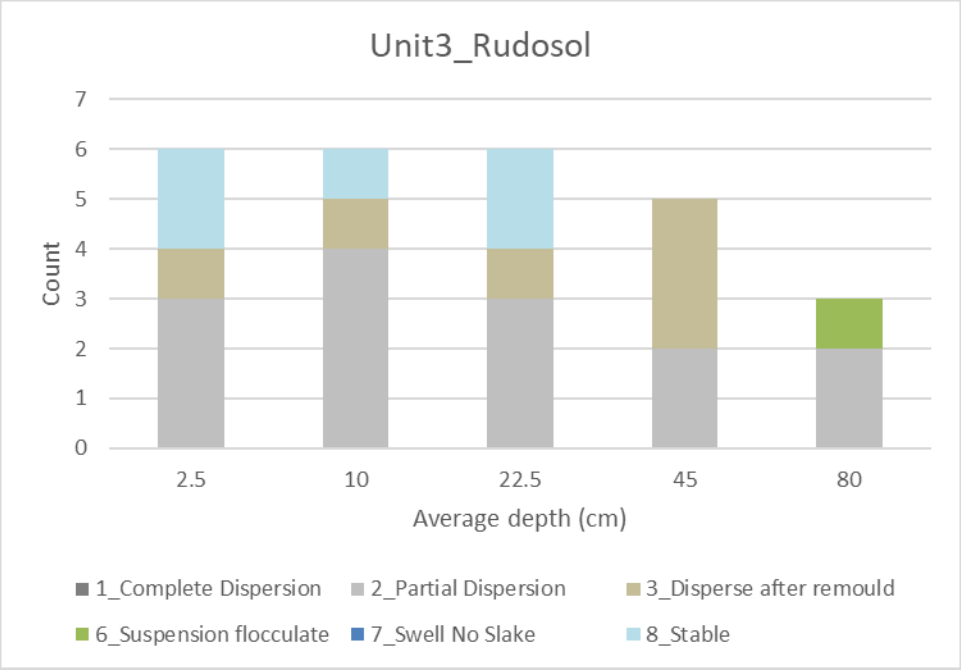
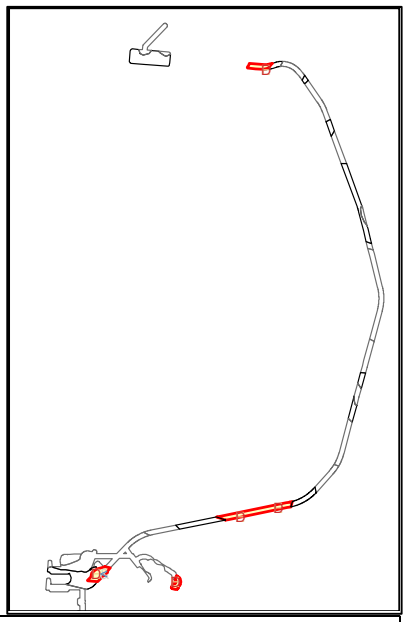


Figure 4.10. Soil stability from Emerson Aggregate Test on samples from Rudosol Soil Mapping Unit.

The Rudosol profiles had small waterholding capacity because there was an average 20 cm soil above layers with more than 50% gravel. The soil chemistry contained no indicators of harm to plant growth, but nutrient levels were low. These soil properties will constrain the vegetation that grows in the Rudosol.

4.2.4. **Acidic Rudosol** (*5 pits, 5 sets of laboratory chemical analyses, 2 sets of particle size analysis over 26 ha*)**.**

Three of the five Acidic Rudosol profiles were red, while the remaining 2 were black, they had sandy loam to light clay surface soil with minimal subsoil development. No effervescence to 1N HCl was detected in any layer tested in any pit. Weathered rock or greater than 50% gravel was encountered in all profiles assessed. The Acidic Rudosol pits tended to be on the slopes of hills and the weathered rock encountered was generally logged as very fine sandstone.



Representative Soil Test Pit Profile Description: Acidic Rudosol.

Soil Test Pit: OF109	
	
Soil Test Pit OF109	**Landscape view, soil test pit OF109**
Australian Soil Classification Order	Tenosol (5)
Australian Soil Classification Sub-order	Red-Orthic (4), Black-Orthic (1)
Representative Soil Test Pits	OA001, OF101, OF109, OF110, OF112
Observation site	OA007
Depth to 50% gravel	Average 25 cm
Drainage	Imperfectly Drained (2), Moderately well drained (1), Well Drained (2)
Erodibility Factor	50% of PSA sites moderately erodible, 50% highly erodible
Stripping Suitability Depth	30 cm (range 15 to 50 cm). Limited by coarse fragments

The average pH profile of the Acidic Rudosol Soil Mapping Unit was slightly acidic in the surface 5 cm, then strongly acidic in the 5 to 30 cm layer, returning to neutral in the 30 to 90 cm layer (Figure 4.11). This pH trend was consistent in the surface 30 cm, while pH in deeper layers was variable. Chloride concentration as a measure of salinity was very low throughout the profile. CEC was low to 60 cm then moderate from 60 to 90 cm. ECaP was lower than optimum through the profile, and EAlP was high enough to limit the range of plants that can grow on this soil. ESP was desirably low and EMgP was a higher than optimum throughout the profile.

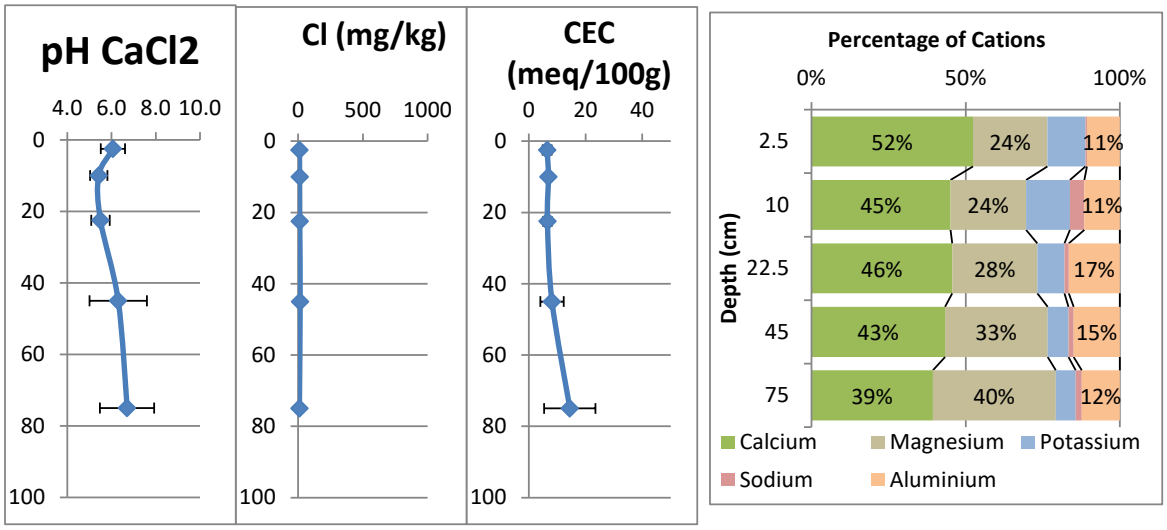


Figure 4.11. Summary of chemical properties in Acidic Rudosol Soil Mapping Unit.

The clay content of the 2 sites tested increased from 15% of the fine earth fraction in the 0 to 5 cm layer to 60% in the 60 to 90 cm layer (Figure 4.12). Fine sand, which tends to be associated with hardsetting soil, dominated the fine earth fraction for the surface 30 cm, but clay tended to dominate in deeper layers.

Topsoil organic carbon was 1.4%, (s.d. 0.7%), nitrate N was 2.7 mg/kg, (s.d. 1.7), available P was 8.4 mg/kg (s.d. 3.3) and sulphate sulphur was 2.6 mg/kg (s.d. 1.5). The organic carbon concentration was moderate, while concentrations of the macronutrients tested were lower than optimum.

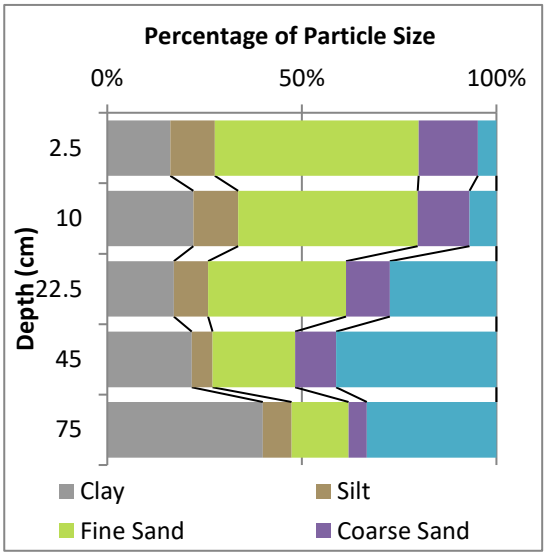


Figure 4.12. Particle Size of samples from Acidic Rudosol Soil Mapping Unit.

Micronutrient levels were: Zinc 2 mg/kg, (s.d. 2.9), Copper 0.7 mg/kg, (s.d. 0.3), Manganese 48.8 mg/kg (s.d. 58.5) Iron 13.4 mg/kg (s.d. 5), and Boron 0.8 mg/kg (s.d. 0.2). Zinc concentration was generally adequate as were the remaining micronutrients.

Emerson tests indicated that soil stability in the Acidic Rudosol Soil Mapping Unit ranged from water stable for 40% of sites to dispersive in the remaining 60% (Figure 4.13). The stable samples were taken from the Federation Site, while this dispersive samples were taken from the Services Corridor.

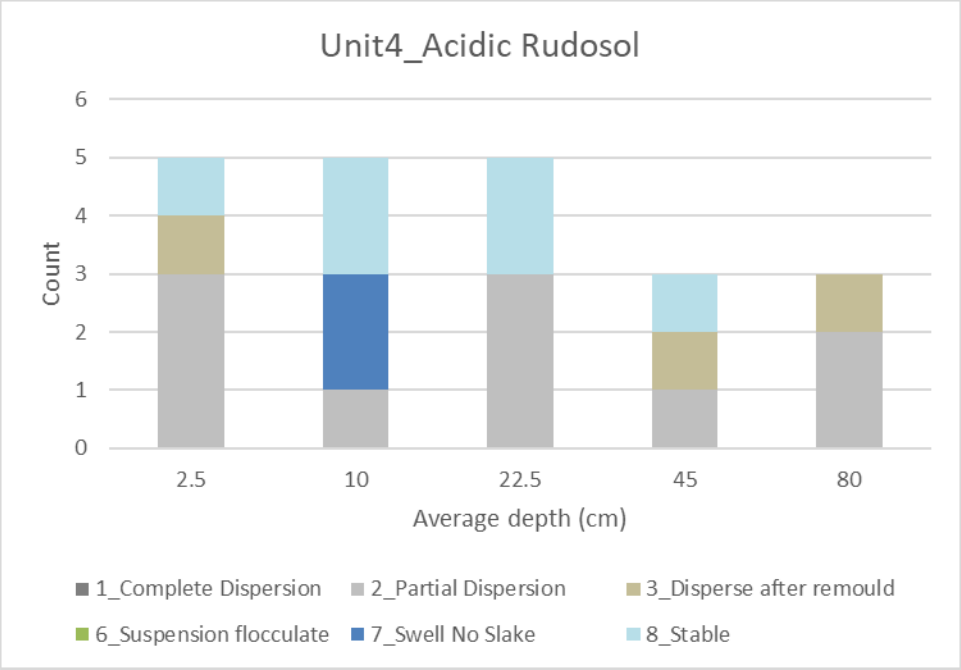
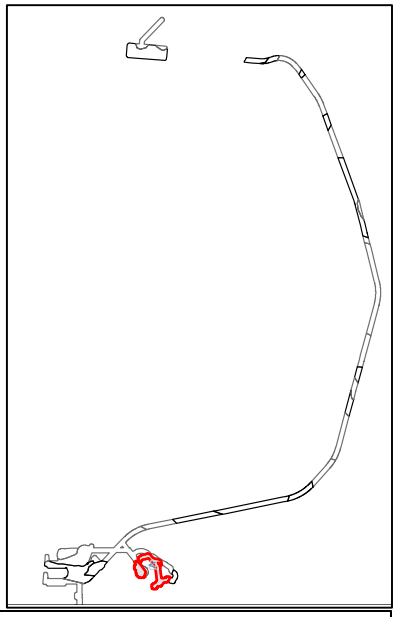


Figure 4.13. Soil stability from Emerson Aggregate Test on samples from Acidic Rudosol Soil Mapping Unit.

The Acidic Rudosol profiles had small waterholding capacity because there was an average of 20 cm of soil above layers with more than 50% gravel. The soil chemistry indicates that high exchangeable aluminium, associated with acidic soil will constrain the plants growing on this soil to plants that can tolerate the aluminium. These soil properties will severely constrain the vegetation that grows in the Acidic Rudosol.

4.2.5. **Tenosol** (*1 observation over 16 ha*).

The Tenosol Soil Mapping Unit was characterised by a surface lag of cobbles and rock outcrop. This was found on areas with slope steeper than 10% (Figure 3.2b) around the hill east of the Federation Site. No soil properties were described as there was little soil to sample.



Representative Soil Test Pit Profile Description: OF115.

Observation: OF115	
	
	Landscape view, soil test pit OF115
Australian Soil Classification Order	Tenosol (1)
Australian Soil Classification Sub-order	Not assessed
Representative Soil Test Pits	None
Observation site	OF115
Depth to 50% gravel	Surface
Drainage	Not assessed
Erodibility Factor	Not assessed
Stripping Suitability Depth	Not assessed

5. ACID SULPHATE SOIL ASSESSMENT

The Soil Study Area is overlaid on the ASRIS Atlas of Australian Acid Sulphate Soils in Figure 5.1, which shows that there is extremely low probability of Acid Sulphate Soil in the Soil Study Area.

McKenzie *et al.* (2004) state that acid sulphate soils are *"derived from saline soil or sediment that have an accumulation of iron sulphides and whose stability is maintained by waterlogged or strongly reducing conditions".*

The Soil Study Area is lacking 2 of the 3 criteria required for Acid Sulphate Soil to develop in that the whole profile was close to oven dry when inspected in 2020, and dry below 30 cm in 2021 (Appendix I), and the soil inspected had very low salinity (Figures 4.2, 4.5, 4.8, 4.11).

Consequently, Acid Sulphate Soil was not detected in the soil inspected in the Soil Study Area.

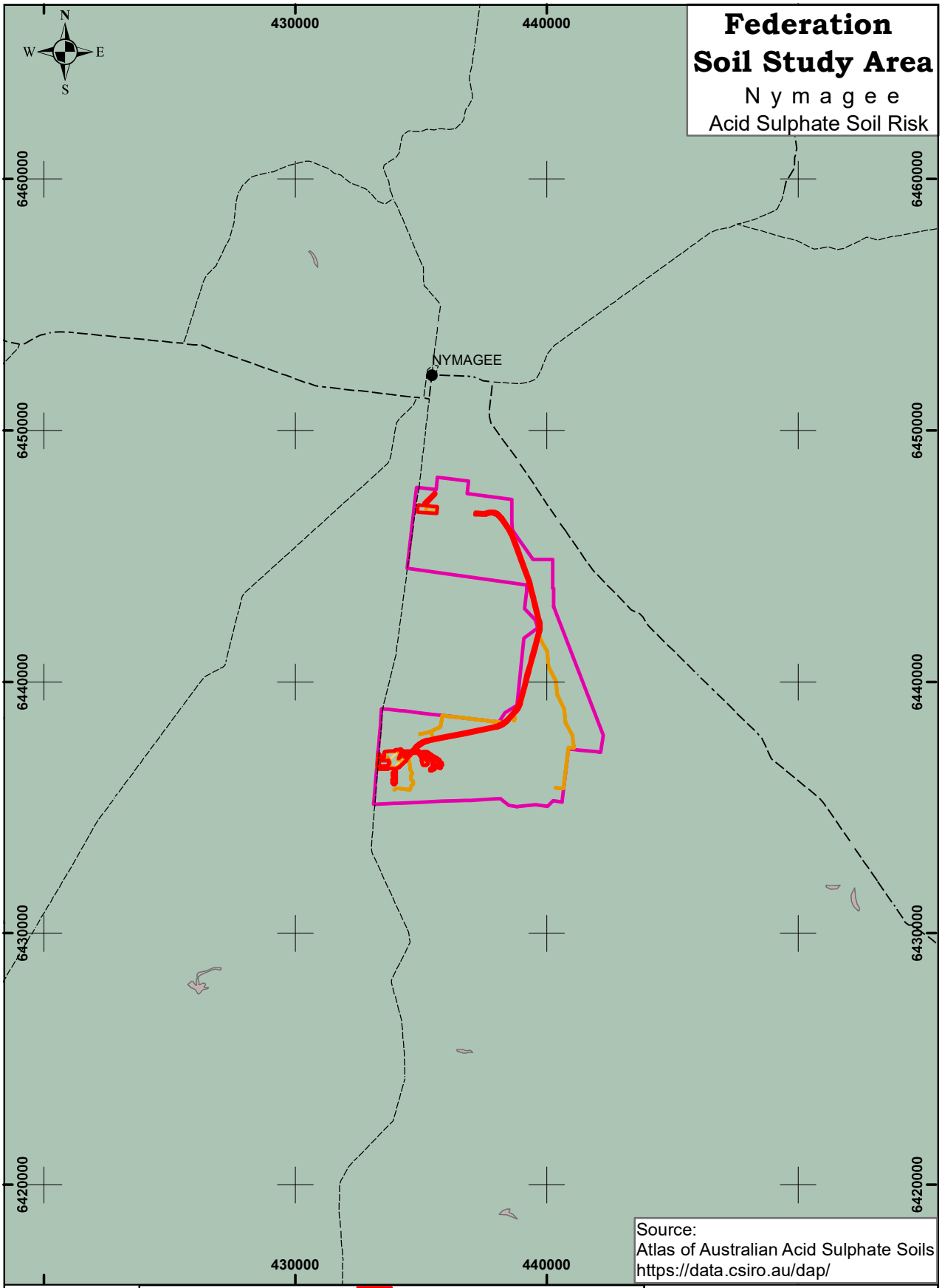

Federation
Soil Study Area
N y m a g e e
Acid Sulphate Soil Risk
N
W
E
S
430000
440000
6460000
6450000
6440000
6430000
6420000
NYMAGEE
Source:
Atlas of Australian Acid Sulphate Soils
https://data.csiro.au/dap/
Certification
PROBCLASS, CONFIDENCE
High Probability/Very Low Confidence
Extremely Low Probability/Very Low Confidence
Soil Study Area
Project Footprint
Federation Hera Project Area
LOCALITY
8
Road Class
3
4
Scale: 1:200,000 on A4
0 1 2 4 6 Km
Job Code: Cr474
Map Printed: 2021
Contact: Sustainable Soils Management
Phone : (02) 68 473367
Roads: NSW Minerals
Datum: WGS 84
Projection: UTM
SSM
Sustainable Soil Management
Draft/Uncontrolled Document
Unless Signed & Dated

Figure 5.1

6. LAND AND SOIL CAPABILITY ASSESSMENT

6.1. LAND AND SOIL CAPABILITY ASSESMENT PROCESS

The LSC assessment classifies land into one of eight land and soil capability classes. These classes give an indication of the intensity of use the land can withstand without suffering land and soil degradation (Table 6.1).

Table 6.1. Land and Soil Capability Classes – general definitions (OEH, 2012).

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

The LSC classes of the Soil Study Area were assessed in accordance with the land and soil capability assessment scheme – second approximation (OEH, 2012).

The LSC assessment scheme is a two-step process. The first step is to assess the LSC based on each of 8 individual hazards (water erosion, wind erosion, soil structure decline, soil acidification, salinity, waterlogging, shallow soils, and mass movement) at each of the 27 sites assessed. For each of these hazards the area around each site was assigned an LSC class from 1 (least hazard) to 8 (greatest). The second step is to determine the final LSC for each site from the highest class assigned to any hazard for that site (Figure 6.1).

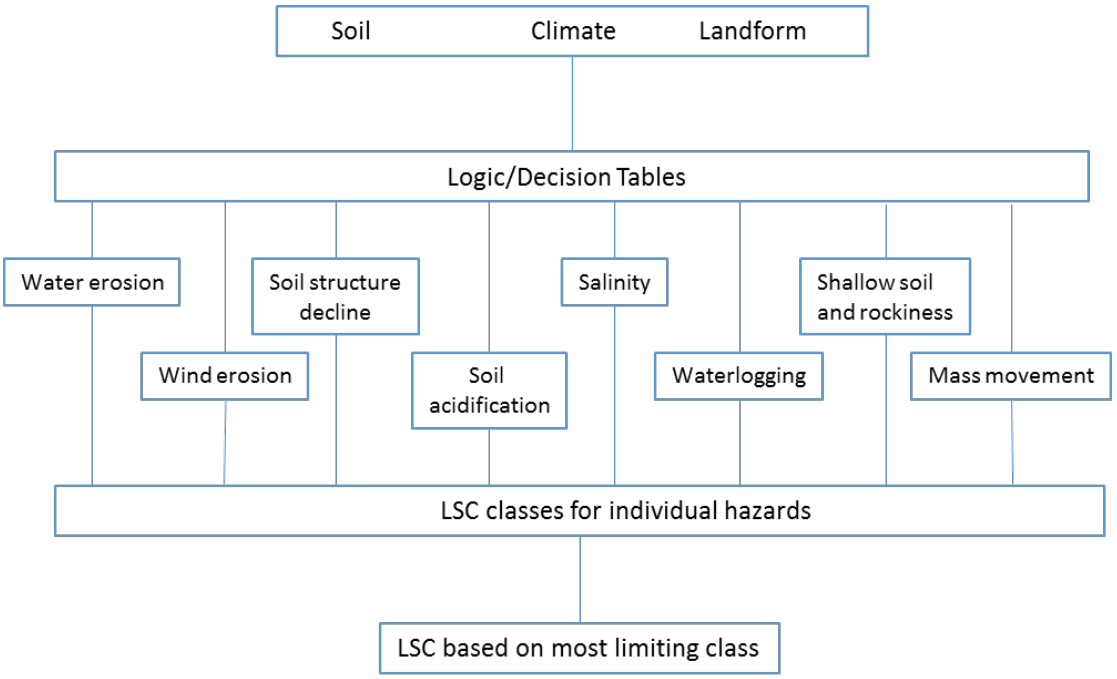


Figure 6.1. Biophysical information used to determine LSC class (from OEH, 2012).

The assessment of LSC classes for the Soil Study Area was based on data collected during the field survey, laboratory analysis of soil samples and is supplemented with information collected during the desktop assessment.

6.1.1. Assessment of Individual Hazards

Methods used to assess each of the hazards are summarized below.

6.1.1.1. Water erosion hazard

Assessment of water erosion hazard is based on slope and a lookup table in OEH (2012). This was applied on two scales. The slope calculated from a digital elevation model for each site, and the value input to Table 4 of OEH (2012) for Western Division of NSW, to give LSC class of the site described.

6.1.1.2. Wind erosion hazard

Calculation of wind erosion hazard considers average rainfall, wind erosivity, site exposure to prevailing wind and soil erodibility to wind. These factors were

combined to determine the wind erosion hazard following Tables 5 and 6 in OEH (2012):

- Soil was divided into three erodibility classes based on surface soil texture in the pits described, ranging from low for loam to clay texture, to high for loamy sand.
- Wind erosive power at this locality is moderate (Figure 6, OEH, 2012).
- Site morphology was divided into three site exposure classes, ranging from low for sheltered locations to high for hilltops, cols, or saddles.
- The average rainfall of 400 mm (Section 3.3) is associated with sufficient groundcover to reduce erosion compared to drier areas in Western NSW.

6.1.1.3. Soil structure decline

The soil structural decline hazard is determined by properties of the surface soil. The assessment considers surface soil texture, degree of hardsetting and presence of organic matter (Table 7, OEH, 2012).

Soil texture and relevant soil structure observations were determined at each site.

6.1.1.4. Soil acidification hazard

Acidification hazard is based on a combination of buffering capacity of the soil (surface soil texture), rainfall and pH of the surface soil. Assessment of the acidification hazard is a three-step process:

- Soil buffering capacity was estimated from field assessed topsoil texture (Table 10, OEH, 2012).
- Surface soil pH_{H2O} was taken from 0 to 15 cm samples analysed in a laboratory.
- Average annual rainfall of 400 mm (Section 3.3) was in the lowest rainfall class used.

These parameters were input to Table 12 (OEH, 2012) to give soil acidification hazard class.

6.1.1.5. Salinity hazard

There are three factors in estimating salinity hazard. They are: recharge potential, which is minimal in the low rainfall in the Soil Study Area; discharge potential, which was assessed from observed vegetation and groundwater levels; and salt store, which was estimated from the subsoil salinity. These factors were input to Table 13 in OEH (2012).

6.1.1.6. Waterlogging hazard

Waterlogging hazard is based on the NCST (2009) drainage classes observed during the field survey. The waterlogging hazard class was based on Table 14 in OEH (2012) with one modification. The modification was that poorly drained sites could be either LSC Class 5 if the site was judged to be not waterlogged most years or LSC Class 6 if it appeared that the site was waterlogged in most years.

6.1.1.7. Shallow soils and rockiness hazard

Shallow soils and rockiness hazard was based on field observations of soil depth and observed rock outcrop. The hazard was determined from Table 15 in OEH (2012) with the soil depth being classed as depth to 90% coarse fragments.

6.1.1.8. Mass movement hazard

Mass movement hazard was based on existing observed mass movement, slope class and rainfall. The hazard was determined from Table 16 in OEH (2012).

6.1.2. Determine Land and Soil Capability Class

The LSC class was determined by allocating an LSC class to each Soil Mapping Unit in Figure 4.1. This was based on the LSC class of each of the 27 sites assessed in the Soil Study Area. The LSC class was calculated for each site as the maximum LSC class of each of the 8 hazards described above. The Soil Mapping Unit LSC class was calculated from the average LSC class of the sites in that Soil Mapping Unit.

6.2. LSC ASSESSMENT RESULTS

The Land and Soil Capability assessment resulted in 61 ha or 23% of the Soil Study Area being rated as suitable for restricted cultivation (LSC Class 4) and the remainder rated as unsuitable for cultivation (Figure 6.2). Seventy six ha (24% of the Soil Study Area) was rated as having severe limitations for cropping. (LSC Class 5). One hundred and twelve ha (43% of the Soil Study Area) was rated as suitable only for low impact agricultural uses such as grazing or forestry. (LSC Class 6). The remaining 16 ha (6% of the Soil Study Area) has little agricultural potential. (LSC Class 7).

The distribution of LSC was strongly dissected because Soil Mapping Units and LSC class were controlled by position on hills, slopes and valleys, with the rolling hills presenting large variations. In essence, LSC class 4 occurred in depositional areas or valley floors, while the LSC class became more restrictive (higher LSC class) with distance uphill slopes.

The pattern of LSC class is generally consistent with the large scale LSC map of NSW shown as background in Figure 6.2, but has more detail, consistent with the smaller scale of this assessment.

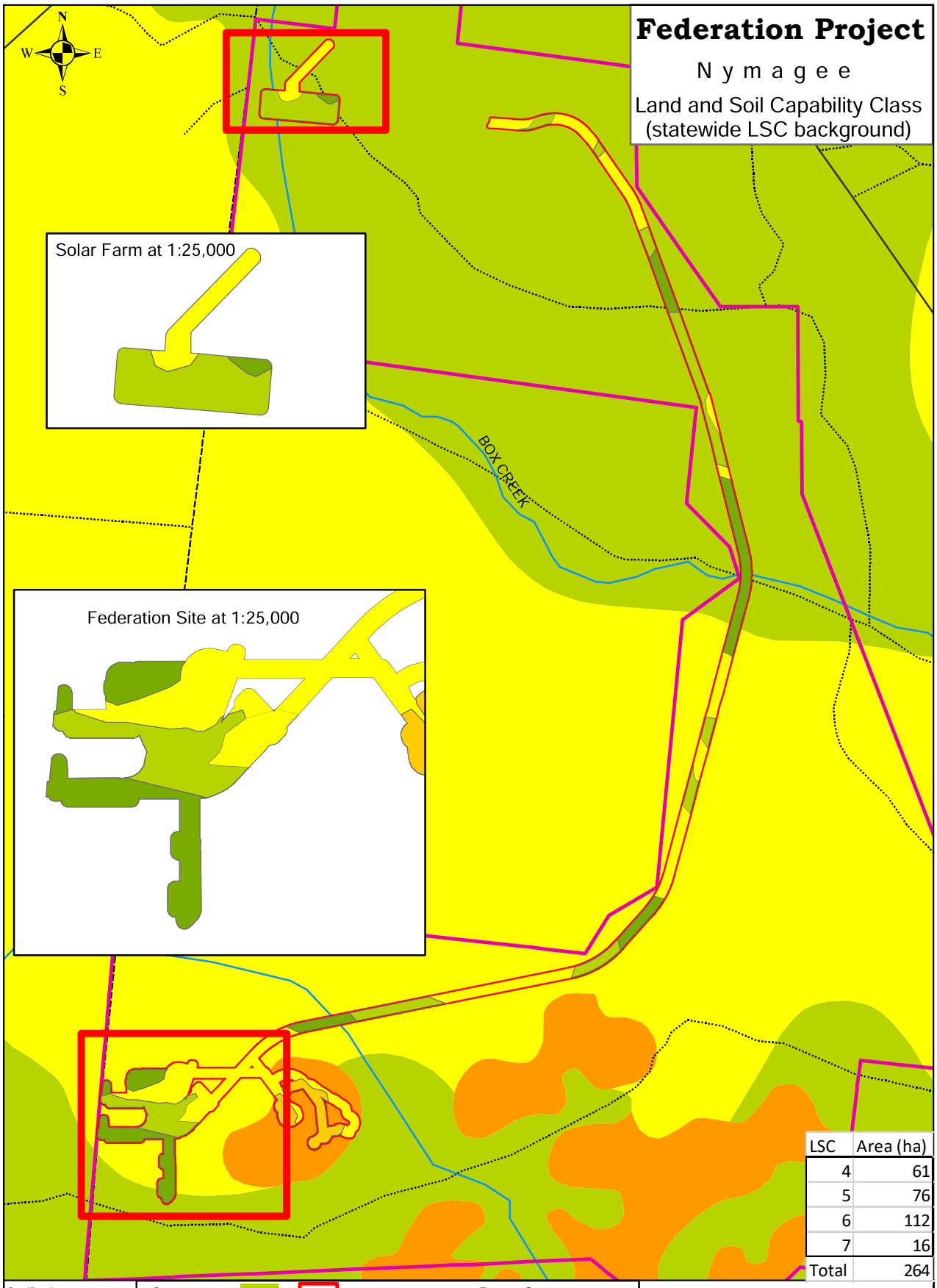

Federation Project
N y m a g e e
Land and Soil Capability Class
(statewide LSC background)
N
W
E
S
Solar Farm at 1:25,000
Federation Site at 1:25,000
BOX CREEK
LSC | Area (ha)
4 | 61
5 | 76
6 | 112
7 | 16
Total | 264
Certification
Capability
2
3
4
5
6
7
8
Soil Study Area
Federation Hera Project Area
Road Class
Secondary Road
Minor Road
Track
Scale: 1:50,000 on A4
0 0.25 0.5 1 1.5 Km
Draft/Uncontrolled Document Unless Signed & Dated
Job Code: Cr474
Map Printed: 2021
Contact: Sustainable Soils Management
Phone : (02) 68 473367
Roads: NSW Minerals
Watercourses: Geoscience Australia
Datum: WGS 84
Projection: UTM
SSM
Sustainable Soil Management

Figure 6.2

6.2.1. Summary of Individual Hazards

Shallow soil depth was the hazard that most strongly limited LSC class, with 5 of the 27 sites being rated as LSC class 7, 7 being rated as LSC class 6 and a further 7 being rated as LSC class 4 on the basis of shallow soil depth (Figure 6.3).

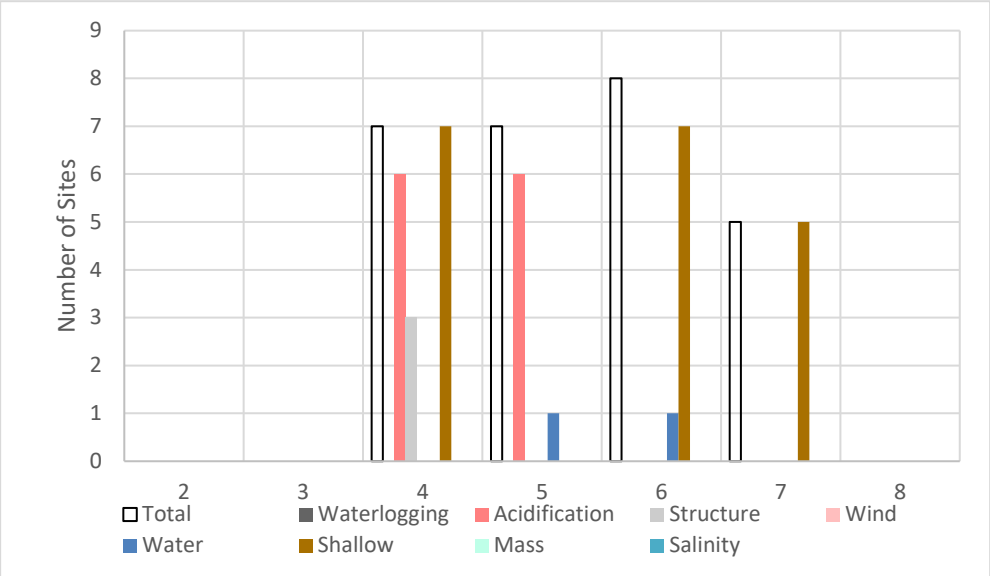


Figure 6.3. Hazard that limits Land and Soil Capability in each LSC class.

Acidification was the second most limiting hazard, but was a smaller constraint than shallow soil, limiting a total of 6 sites to LSC class 5. The acidification hazard arose because of existing low pH combined with coarse texture and low CEC which provide limited buffering capacity against pH change.

Note that for sites with more than one hazard having the same rating, all were included in Figure 6.3.

6.2.2. Limiting Hazard within Soil Mapping Units

Acidity was the most limiting hazard for the Dermosol and NonCalcic Dermosol Soil Mapping Units, while shallow soil depth was the most limiting hazard for the Rudosol, Acidic Rudosol and Tenosol Soil Mapping Units (Table 6.2).

Table 6.2. Average LSC class for each of the 8 hazards assessed for each Soil Mapping Unit in the Soil Study Area. (Grey shading indicates the most limiting hazard.)

Map Unit	Water	Wind	Structure	Acidifi-cation	Salinity	Water-logging	Shallow	Mass	LSC
Dermosol	2.0	2.1	2.9	4.1	1.0	1.9	4.0	1.0	4
NonCalcic Dermosol	2.7	2.0	3.0	4.8	1.0	1.5	4.3	1.0	5
Rudosol	2.9	2.6	3.4	3.9	1.0	1.7	6.0	1.7	6
Acidic Rudosol	3.4	3.0	2.6	5.0	1.0	2.2	5.6	1.0	6
Tenosol	2	3	4	4	1	1	7	1	7

6.3. LSC ASSESSMENT CONCLUSIONS

The LSC rating of the Soil Study Area as being predominantly LSC classes 5 and 6 is consistent with the historic landuse of the Soil Study Area of extensive grazing.

Although the overall LSC class indicates that the land has relatively low potential agricultural productivity, the low rating of LSC class 2 to 3 for the water and wind erosion hazards means that the land should be able to withstand the planned disturbance from the Federation Project provided care is taken to minimise concentration of water flow.

7. PROPERTIES OF DISTURBED SOIL

The Project would require stripping of soil for use is subsequent rehabilitation, which is more disruptive to soil than agricultural practices. Properties of this stripped soil are described below.

The depth of soil suitable for stripping was essentially inversely proportional to the LSC class (Table 7.1). This is because the most limiting LSC hazard was shallow soil depth (Table 6.2) and the dominant limitation to soil stripping depth was depth to coarse fragments (Table 7.1).

Table 7.1. Depth of soil suitable for use as topsoil during rehabilitation (Stripping Depth) of Soil Mapping Units within Soil Study Area using Elliot and Veness (1981) criteria.

Soil Mapping Unit	Average Stripping Depth (cm)	Stripping Depth Range (cm)	Dominant Limitation	Surface Soil Erodibility of tested sites
Dermosol	75	35 to 135	Coarse fragments in gravel layers	Highly erodible
NonCalcic Dermosol	60	35 to 140	Coarse fragments of weathered rock	Moderately erodible
Rudosol	15	10 to 50	Coarse fragments of weathered rock	Highly erodible
Acidic Rudosol	30	15 to 50	Coarse fragments of weathered rock	50% moderately erodible, 50% highly erodible
Tenosol	Essentially zero		Rock outcrop	Not assessed

The depth of soil suitable for stripping is most relevant in the Federation Site. The pattern of stripping suitability in this area is complex (Figure 7.1) as the depth to coarse fragments is shallower in locally high areas than low areas and drainage lines, which are also depositional areas, that run from east to west across the Federation Site.

The soil was moderately to highly erodible (Table 7.1). This means that even though the Soil Study Area experiences relatively low rainfall, care would be required to minimise erosion of disturbed soil.

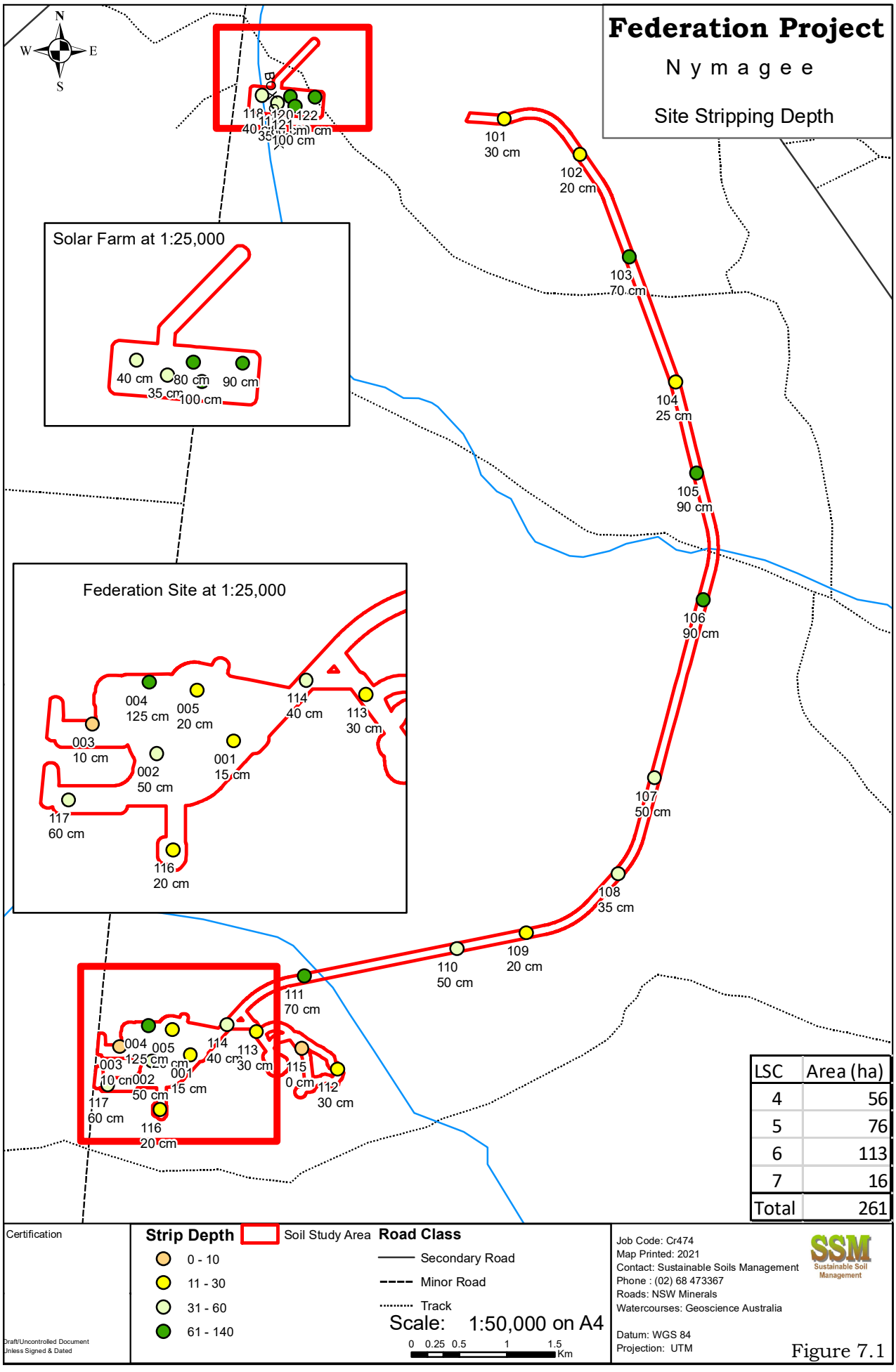

Federation Project
Nymagee
Site Stripping Depth
N
W
E
S
Solar Farm at 1:25,000
40 cm
80 cm
90 cm
35 cm
100 cm
Federation Site at 1:25,000
004
125 cm
005
20 cm
114
40 cm
113
30 cm
003
10 cm
002
50 cm
001
15 cm
117
60 cm
116
20 cm
101
30 cm
102
20 cm
103
70 cm
104
25 cm
105
90 cm
106
90 cm
107
50 cm
108
35 cm
109
20 cm
110
50 cm
111
70 cm
115
0 cm
112
30 cm
LSC | Area (ha)
4 | 56
5 | 76
6 | 113
7 | 16
Total | 261
Certification
Draft/Uncontrolled Document
Unless Signed & Dated
Strip Depth
0 - 10
11 - 30
31 - 60
61 - 140
Soil Study Area
Road Class
Secondary Road
Minor Road
Track
Scale: 1:50,000 on A4
0 0.25 0.5 1 1.5
Km
Job Code: Cr474
Map Printed: 2021
Contact: Sustainable Soils Management
Phone : (02) 68 473367
Roads: NSW Minerals
Watercourses: Geoscience Australia
Datum: WGS 84
Projection: UTM
SSM
Sustainable Soil Management

Figure 7.1

8. POTENTIAL IMPACT OF PROJECT ON SOIL RESOURCES

This section focuses on managing soil disturbance as a result of disturbing land during the Project, and describes components of the soil rehabilitation process, namely:

- An assessment of the suitability of soil for stripping and use in construction of soil profiles on land disturbed by the Project (Section 7).
- A description of the location and area of planned disturbance during The Project.
- A summary of the planned soil construction and rehabilitation practises in disturbed land.
- An estimate of the volume of soil available beneath the disturbance footprint and required to construct the planned landform.
- An estimate of the post-Project LSC and the change in LSC associated with The Project.

The remainder of this section describes a scenario where the Federation Site is disturbed to conduct the Exploration Decline Program, additional land is disturbed for the Project, which is completed, then the whole of the EIS Disturbance Footprint is rehabilitated. This process will compare LSC and agricultural productivity before the Exploration Decline Program with that during and after the Project.

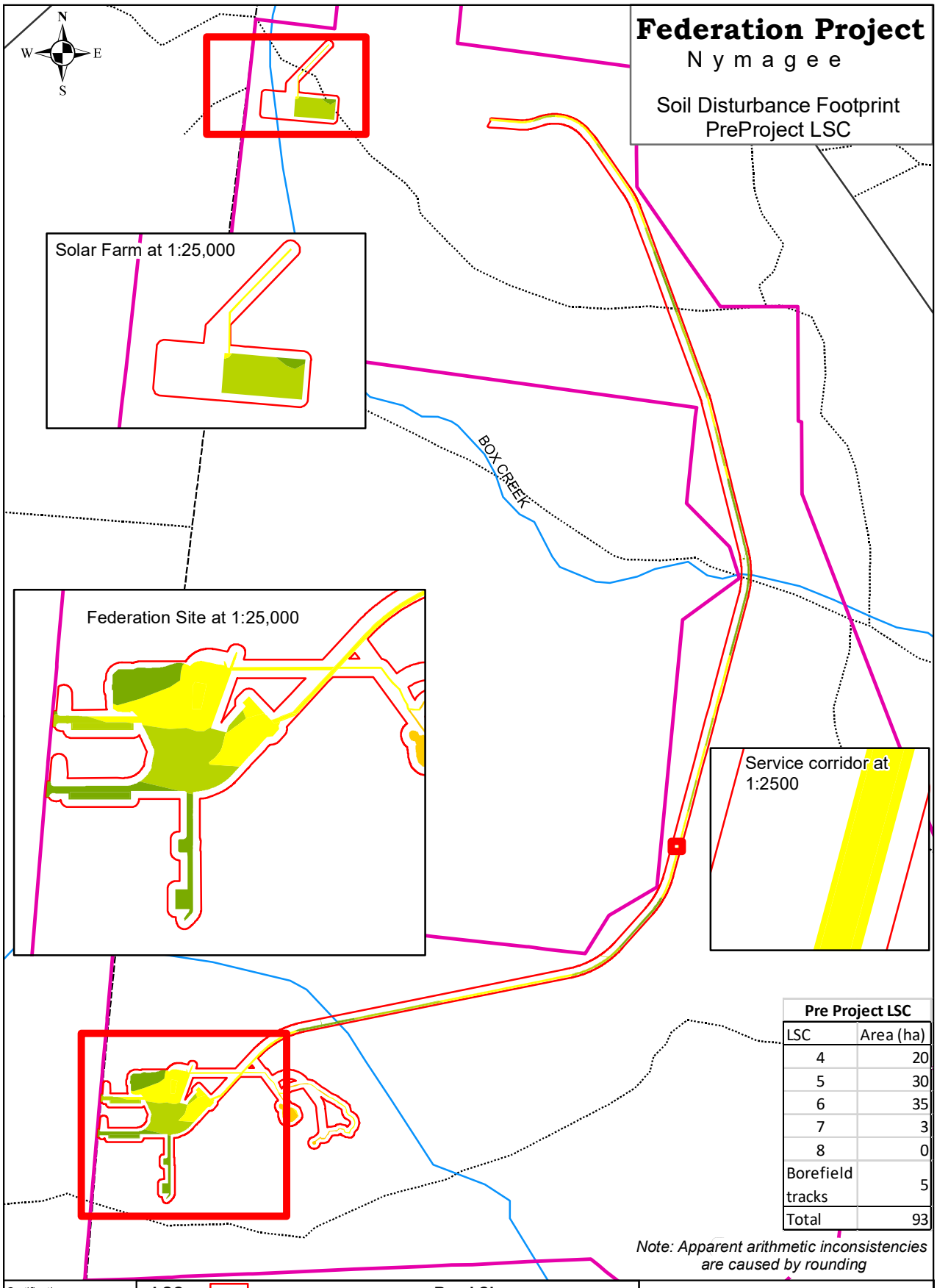
Soil disturbance in the EIS Disturbance Area will occur in two phases, there will be initial disturbance covering 32 ha for the Exploration Decline Program. Additional land will be disturbed if the Project proceeds, otherwise the area disturbed by the Exploration Decline Program will be rehabilitated as described in SSM (2021).

8.1. PROJECT SOIL DISTURBANCE FOOTPRINT

The combined footprint of the Project and the Exploration Decline Program is 93 ha.

Within this area, the approved Exploration Decline Program covers 36 ha and consists of:

- The footprint of a surface infrastructure area to support the Federation Decline Program (32 ha).
- A 3 m wide water pipeline corridor from the Federation Site to the Hera Mine (4 ha). This area was not assessed by SSM (2021).


Federation Project
Nymagee
Soil Disturbance Footprint
PreProject LSC
N
W
E
S
Solar Farm at 1:25,000
BOX CREEK
Federation Site at 1:25,000
Service corridor at 1:2500
Pre Project LSC
LSC | Area (ha)
4 | 20
5 | 30
6 | 35
7 | 3
8 | 0
Borefield tracks | 5
Total | 93
Note: Apparent arithmetic inconsistencies are caused by rounding
Certification
LSC
4
5
6
7
Soil Study Area
Federation Hera Project Area
Road Class
Secondary Road
Minor Road
Track
Scale: 1:50,000 on A4
0 0.25 0.5 1 1.5 Km
Draft/Uncontrolled Document Unless Signed & Dated
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Roads: NSW Minerals
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Datum: WGS 84
Projection: UTM
SSM
Sustainable Soil Management

Figure 8.1

The Project would disturb an additional 57 ha in the Soil Study Area (Figure 8.1) consisting of:

- Increased area of redesigned Federation Site (10 ha).
- Widening of the corridor connecting the Federation Site and Hera Mine Site by 15 m (22 ha).
- A 5 m wide expansion of the Services Corridor connecting the Federation Site with the Hera Mine to accommodate potential tailings and return water pipelines (7 ha).
- Gravel pit and access road (3 ha).
- Access track to communications tower (2 ha).
- Solar farm and associated powerline (9 ha).

The final disturbance zone is a proposed borefield, which covers 5 ha and comprises 14 km of 3 m wide bore pipeline access tracks with pipes laid on surface (Figure 2.1), and 15 of 20 m square bore pads. Borefield disturbance was mostly outside the Soil Study Area and would generally follow existing farm tracks and fence lines. This was excluded from assessment of the impact of the Project on LSC as little change in LSC would be expected in this area.

8.1.1. Pre-Project LSC in EIS Disturbance Footprint

The Project Soil Disturbance Footprint (total 53 ha) contains 13 ha of LSC class 4 land, 18 ha of LSC class 5, 19 ha of LSC class 6 and 3 ha pf LSC class 7 (Figure 8.1).

The EIS Disturbance Footprint contains 20 ha of LSC class 4 land, 30 ha of LSC class 5, 35 ha of LSC class 6 and 3 ha of LSC class 7 (Figure 8.1).

8.2. POTENTIAL PROJECT IMPACTS ON SOIL

The goal of the soil management practices would be to minimize soil degradation in the forms of:

- **Soil compaction** associated with heavy vehicle and machinery use during soil stripping, stockpiling and respreading operations.
- **Loss of soil resource** when areas of soil, that have not been stripped, are disturbed during construction of infrastructure or buried beneath stockpiles.
- **Soil sheet erosion** when the stable topsoil is disturbed and when surface drainage is modified by reshaping the land.
- **Soil gully erosion** in drains constructed to divert surface water around the proposed mining operations.
- **Soil contamination** from hydrocarbon spills.

The planned soil disturbance in the Project Soil Disturbance Footprint avoids disturbance associated with tailings management. The tailings would either be placed into the approved tailings storage facility at Hera Mine or used to backfill underground stopes. Soil will be stripped in areas proposed for waste rock storage during mining operations, and will subsequently be used in

rehabilitation of those areas. The majority of infrastructure at the Federation Site, including diversion drains and water storage dams is in the footprint of the Exploration Decline Program. While this land is part of the Soil Study Area, it is not included in this disturbance assessment, as Exploration Decline Program has been approved by the State Resources Regulator.

The planned disturbance and rehabilitation in the Project Soil Disturbance Footprint is described in Table 8.1. Disturbance inherited from the Federation Exploration Decline Program is outlined in Table 8.2. Some infrastructure, such as tracks, solar farm, linear infrastructure may remain for the benefit of a future landholder. If this were to be the case the proposed rehabilitation activities in described in Table 8.1 would not occur.

To assist with land management / grazing practices, fencing arrangements at the Federation Site and solar farm would be agreed with the landholder.

Some disturbance areas would not require topsoil be stripped, due to the nature of the disturbance. These areas will be: the solar farm, pipelines and powerlines. In these areas, natural regrowth (including weeds) will be controlled prior to rehabilitation.

Roads and tracks would be constructed to a standard that is appropriate for the weight and frequency of traffic.

During the post mining closure and rehabilitation period, stripped and stockpiled soil will be used in rehabilitation.

Revegetation would be recruitment of naturally occurring native and naturalised species. . This is considered appropriate as the disturbed areas are relatively small and surrounded by native and naturalised vegetation. In addition, where possible some of the Project Soil Disturbance Footprint would be revegetated during operations. If occasional use of areas such as tracks is required during the Project the height of vegetation would be lowered to a few tens of centimetres by slashing.

Weed management would be required in disturbed areas as the ecological niche of many weeds is to populate bare land.

Table 8.1. Footprint soil management summary in Project Soil Disturbance Footprint.

Zone	Planned Disturbance	Planned Rehabilitation
Federation Site		
Whole Site	Clear and grub trees, strip topsoil and stockpile. Control regrowth.	Landform as required, replace stockpiled topsoil, allow regrowth of vegetation
Heavy vehicle access road, Site roads	Strip topsoil and stockpile. Import subgrade and road surface and compact. (including from other existing and proposed Project disturbance areas)	Rip road to create porosity, replace topsoil, allow regrowth of vegetation.
Topsoil stockpiles	Place topsoil stockpiles.	Remove stockpile, loosen surface that remains, allow regrowth of vegetation.
Infrastructure hardstand areas	Strip topsoil and stockpile, level site. Construct hard stand areas.	Remove infrastructure, demolish hardstand areas, loosen subgrade, replace topsoil, allow regrowth of vegetation.
Services Corridor		
Whole corridor	Strip and stockpile topsoil from track, clear and grub trees, control regrowth.	Loosen track surface, replace stockpiled topsoil allow regrowth.
Pipelines	On surface, minimal disturbance to soils	None. Remove and dispose of pipeline, allow regrowth.
HV powerline	Holes drilled for power poles and poles installed.	Remove poles, backfill holes, allow regrowth.
Track	Strip and stockpile topsoil. Level surface, provide drains to manage runoff. Import road surface and form track.	Loosen track surface replace stockpiled topsoil allow regrowth.
Access to gravel pit and communications tower		
Gravel pit access road	Strip and stockpile topsoil. Level surface, provide drains to manage runoff. Import road surface and form road.	Loosen track surface replace stockpiled topsoil allow regrowth.
Gravel pit	Excavate gravel	Minimal
Communications tower access	Strip and stockpile topsoil. Level surface, provide drains to manage runoff. Import road surface and form track.	Loosen track surface replace stockpiled topsoil allow regrowth.
Solar farm and powerline		
Whole site	Clear and grub trees.	None.
Solar farm	manage regrowth and weeds	Remove infrastructure, allow regrowth
Solar panels	Piles driven into soil.	Piles extracted from soil, allow regrowth.

Table 8.1. Footprint soil management summary in Project Soil Disturbance Footprint.

Internal power distribution	Power cable buried in trenches.	Cables removed (copper is valuable), surface levelled, allow regrowth.
Power line	Holes drilled for power poles and poles installed.	Remove poles, backfill holes, allow regrowth.
Bore water pipeline and bore pads		
Pipeline paths	Use existing tracks and fence lines where possible to minimise disturbance. Elsewhere tracks on surface with limited vehicle use.	Add drains to manage runoff where needed, loosen surface of tracks remove pipelines, allow regrowth
Bore pad	Clear and grub footprint, then allow regrowth.	Decommission bore, allow regrowth.

Table 8.2. Soil management processes during the Federation Exploration Decline Program (From SSM, 2021).

Infrastructure type	Disturbance and Rehabilitation
Decline and Box Cut	Topsoil will be stripped and stockpiled. Box cut constructed and waste rock stored for the life of the Program, before being placed back in the void and the existing land shape reformed. Subgrade loosened and topsoil replaced.
Ventilation Rises and Escapeway	The 3 shafts with combined area of 30 m^2 will be capped with concrete.
Material storage areas	Topsoil will be stripped and stockpiled. Level area will be constructed by cutting high areas and filling low areas. Existing land shape reformed at end of the Program as any rock not used to backfill box cut will be transported to Hera. Subgrade loosened and topsoil replaced.
Topsoil stockpiles	Topsoil will be stockpiled, then removed and respread.
Water Storages	Topsoil will be stripped and stockpiled. Storages constructed using cut and fill and lined as required. At the end of the Program, the existing land shape would be reformed. Subgrade loosened and topsoil replaced.
Hardstand areas	Topsoil will be stripped and stockpiled. Large level areas will be constructed by cutting high areas and filling low areas and placing gravel. At the end of the Program, gravel would be removed and existing land shape reformed. Subgrade loosened and topsoil replaced.
Roads	Topsoil pushed to one side and stockpiled adjacent to the road. Engineered roads will be constructed by smoothing the land surface, compacting the subgrade, then placing gravel. An area of 1.5 ha of roads will be retained at end of the Program for the benefit of the landholder. The remainder will have the gravel removed and existing land shape reformed. Subgrade loosened and topsoil replaced.
Vegetation	Clear trees during Program establishment. Maintain as grassland during Program.

8.3. SUMMARY OF SOIL MANAGEMENT DURING THE PROJECT

The first step in the soil management strategy adopted in the Project would be to strip suitable soil from the whole of the EIS Disturbance Area. In the 3 m wide track of the services corridor, this will consist of moving the topsoil off the track to a windrow beside the track. In the Federation Site, the topsoil will be stripped from 39 ha of the Disturbance Area depicted in the inset of Figure 8.2. This is the whole of the Federation Site less the topsoil stockpiles as described in Tables 8.1 and 8.2.

The depth of soil suitable for use as topsoil in Table 7.1 was combined with the area of each Soil Mapping Unit in the Federation Site to give an estimate of the volume of soil suitable for stripping in the Federation Site in Table 8.3.

Table 8.3. Soil stripping depths and volumes.

Soil Mapping Unit	Area in Federation Site to be disturbed (ha)	Maximum Stripping Depth (cm)	Volume available (m^3)
		Topsoil	Topsoil
Dermosol	10	75	72,000
NonCalcic Dermosol	13	60	75,000
Rudosol	12	15	18,000
Acidic Rudosol	5	30	14,000
Total			179,000

Rehabilitation would be managed as general classes: remaining void, waste rock emplacement, other disturbance areas and decommissioned roads.

8.4. LSC IN PROJECT SOIL DISTURBANCE FOOTRPINT DURING THE PROJECT

The LSC class allocated to land during the Project varied with the planned land use. It was assumed that the Federation Site would be fenced to exclude livestock, so this area was allocated LSC class 8 (Table 8.4). The service corridor between the Federation Site and Hera Mine was separated into a 3 m wide track that was allocated to LSC Class 8 and the remainder of the corridor that would be cleared and grubbed, but be vegetated during The Project, so was allocated the LSC class of neighbouring undisturbed land. Similarly, the footprints of the potential tailings and return water pipelines would have similar vegetation to that growing on the ground in the surrounding woodland, so was allocated the same LSC as before the Project.

Table 8.4. Change in LSC in Project Soil Disturbance Footprint Area during the Project

Zone	**During project LSC**
Federation Site	8
Topsoil stockpiles	7
Services Corridor: Track Pipeline and powerline corridor	 8 Pre-project LSC
Gravel quarry and access road	8
Communications tower access track	8
Solar farm	Largest value of 5 or pre-project LSC
Solar farm powerline corridor	Pre-project LSC
Borefield access track	Pre-project LSC

Access tracks to the gravel quarry and communications tower as well as the gravel quarry were allocated LSC class 8 (Table 8.4).as little vegetation would be expected to grow in these areas during the Project.

It is assumed that fencing and strategic grazing would be used to manage vegetation at the solar farm, so LSC class was constrained to LSC 5 (not suitable for cultivation).

The result of applying these rules was that 57% of the Project Soil Disturbance Footprint (during operations) was allocated to LSC class 8, 18% to LSC class 5, 17% to LSC class 5 and 7% to LSC class 4 (Figure 8.2).

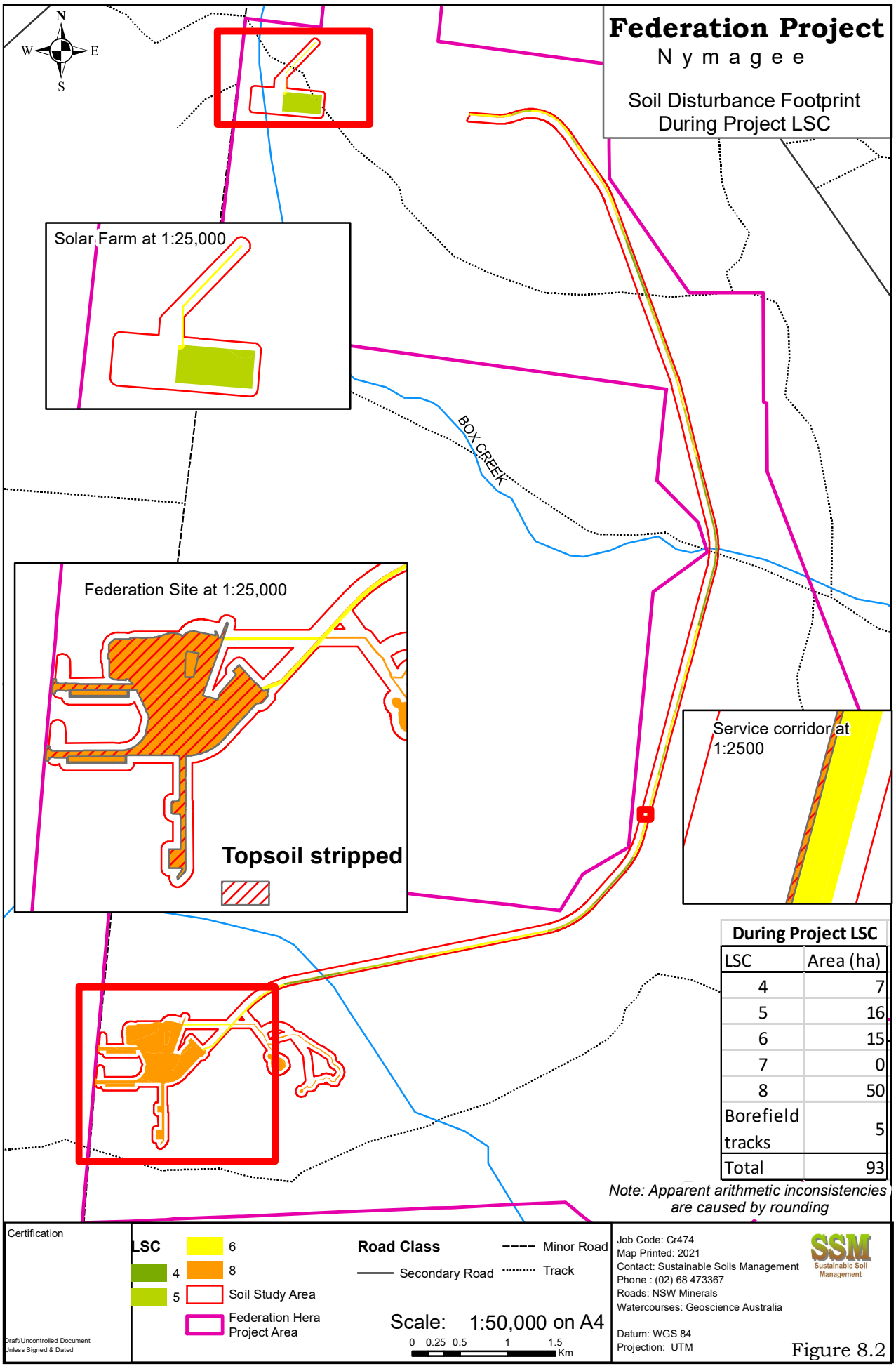
Federation Project
Nymagee
Soil Disturbance Footprint
During Project LSC
N
W
E
S
Solar Farm at 1:25,000
BOX CREEK
Federation Site at 1:25,000
Topsoil stripped
Service corridor at 1:2500
During Project LSC
LSC | Area (ha)
4 | 7
5 | 16
6 | 15
7 | 0
8 | 50
Borefield tracks | 5
Total | 93
Note: Apparent arithmetic inconsistencies are caused by rounding
Certification
Draft/Uncontrolled Document Unless Signed & Dated
LSC
4
5
6
8
Soil Study Area
Federation Hera Project Area
Road Class
Minor Road
Secondary Road
Track
Scale: 1:50,000 on A4
0 0.25 0.5 1 1.5 Km
Job Code: Cr474
Map Printed: 2021
Contact: Sustainable Soils Management
Phone : (02) 68 473367
Roads: NSW Minerals
Watercourses: Geoscience Australia
Datum: WGS 84
Projection: UTM
SSM
Sustainable Soil Management

Figure 8.2

8.5. POST PROJECT LAND AND SOIL CAPABILITY

The goal in the Project's rehabilitation plan is to return disturbed land to a condition that is stable, non-polluting, and supports the proposed post mining landuse, which is rangeland grazing. with mixed native vegetation Rehabilitation practices would essentially be to provide favourable soil conditions for plant growth and allow recruitment of naturalised plants. This assumes that some infrastructure is not retained for the benefit of future landholders (which is possible) and hence is not rehabilitated.

A secondary goal is to return the land to the same LSC class as existed before the Project. Soil requirements to achieve this are listed in Table 8.5.

Table 8.5. Soil requirements to achieve selected LSC class based on OEH (2012).

Hazard	**Region Specific Requirement**		
	LSC 4 (Dermosol)	**LSC 5 (NonCalcic Dermosol)**	**LSC 6 (Rudosol, Acidic Rudosol)**
Water erosion	Slope flatter than 5%	Slope flatter than 5%	Slope flatter than 33%
Wind Erosion	Any exposure with texture observed		
Soil Structure Decline	Hardsetting or more stable structure		
Acidification	pH_{CaCl2} > 4.0 with observed texture	Any	
Salinity	Any		
Shallow soil	Minimum soil depth of 50 cm	Minimum soil depth of 25 cm	
Mass movement	Mass movement not observed		

*OEH (2012) does not specify site properties, but relies on regional Hydrogeological Landscape Maps that were published in January 2021 and rate the Program site as low salinity hazard. In practise it would be reasonable that ECe for LSC 4 should be less than 4 dS/m and ECe for LSC 6 should be less than 8 dS/m.

The volume of soil required to achieve the aim of restoring land to the LSC class that existed before the Project is shown in Table 8.6. This indicates that there is sufficient soil available to provide the whole of the Project Soil Sisturbance Footprint. However, this will only be required in areas that are drastically disturbed, such as the box cut and possible waste rock emplacements. In other areas, loosening the subgrade and replacing 15 cm topsoil should be adequate.

Table 8.6. Post Project LSC class in the Project Soil Disturbance Footprint changes during the Project.

Soil Mapping Unit	Area in Federation Site to be disturbed (ha)	Depth required (cm)	Volume required (m^3)
		Soil	Soil
Dermosol	10	50	48,000
NonCalcic Dermosol	13	25	31,000
Rudosol	12	25	29,000
Acidic Rudosol	5	25	12,000
Total			120,000

Application of the practices outlined above should allow the land to be restored to the LSC that existed before the Project (Table 8.7).

Table 8.7. Post-Project LSC class in the Soil Disturbance Footprint.

Zone	Estimated post-mining LSC class
Federation Site	Pre-project LSC (Except 1.5 ha roads retained for landholder)
Topsoil stockpiles	Pre-project LSC
Services Corridor: Track Pipeline and powerline corridor	 Pre-project LSC Pre-project LSC
Gravel quarry Gravel quarry access road	8 Pre-project LSC
Communications tower access track	Pre-project LSC
Solar farm	Pre-project LSC
Solar farm powerline corridor	Pre-project LSC
Borefield access track	Pre-project LSC

Land in the Project Soil Disturbance Footprint can be returned to the same LSC class that existed before the Project with the exception of 1.5 ha of roads that will retained for use by the landholder (Table 8.2).and the gravel quarry area.

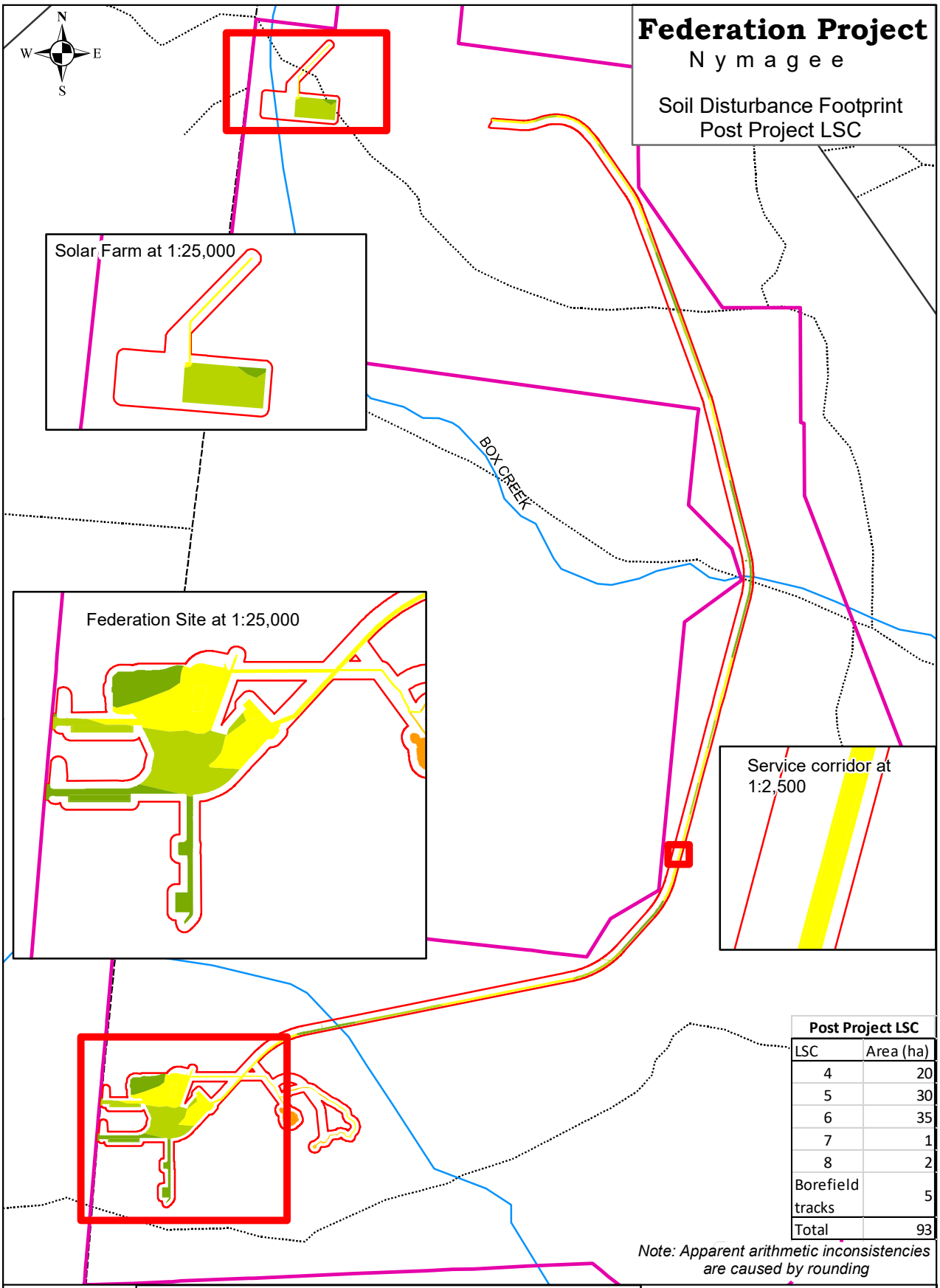
Federation Project
Nymagee
Soil Disturbance Footprint
Post Project LSC
N
W
E
S
Solar Farm at 1:25,000
BOX CREEK
Federation Site at 1:25,000
Service corridor at 1:2,500
Post Project LSC
LSC | Area (ha)
4 | 20
5 | 30
6 | 35
7 | 1
8 | 2
Borefield tracks | 5
Total | 93
Note: Apparent arithmetic inconsistencies are caused by rounding
Certification
LSC
4
5
6
7
8
Soil Study Area
Federation Hera Project Area
Road Class
Minor Road
Secondary Road
Track
Scale: 1:50,000 on A4
0 0.25 0.5 1 1.5 Km
Job Code: Cr474
Map Printed: 2021
Contact: Sustainable Soils Management
Phone : (02) 68 473367
Roads: NSW Minerals
Watercourses: Geoscience Australia
Datum: WGS 84
Projection: UTM
SSM Sustainable Soil Management
Draft/Uncontrolled Document Unless Signed & Dated

Figure 8.3

8.6. LAND AND SOIL CAPABILITY CHANGES

The main changes in LSC class associated with the Project are exclusion of agriculture from the Federation Site during the Project and lack of vegetation on roads. As such, this land has no agricultural value and was allocated to LSC class 8. However, disturbance to the soil would be managed (see Section 9) so that it is possible to restore the land to the LSC class that was present before the Project. This would result in a small movement of 2 ha from LSC 7 (very low capability land) to LSC 8 (extremely low capability land) between the pre-Project and post-Project states (Table 8.8).

Table 8.8. Change in areas of each Land and Soil Capability class in the Project Soil Disturbance Footprint over the life of the Project.

LSC Class	Capability	Pre-mining area (ha)	During Mining (ha)	Post-mining area (ha)	Change (ha) (Pre to Post mining)
Land with a wide range of uses (cropping, grazing, horticulture, nature conservation)					
1	Extremely high	0	0	0	0
2	Very high	0	0	0	0
3	High	0	0	0	0
Land with a variety of uses (cropping with restricted cultivation, pasture cropping, grazing, some horticulture, forestry, nature conservation)					
4	Moderate	20	7	20	0
5	Moderate-low	30	16	30	0
Land with a limited range of uses (grazing, forestry, and nature conservation					
6	Low	35	15	35	0
Land generally unable to support agriculture (selective forestry and nature conservation)					
7	Very low	3	0	1	-2
8	Extremely low	0	50	2	+2

** Note: Apparent arithmetic inconsistencies are caused by rounding*

9. MANAGEMENT OF DISTURBED SOIL

The goal of returning land in the Project Soil Disturbance Footprint to a pre-mining LSC class can be achieved if care is taken to avoid soil contamination and maintain soil productivity in stockpiled topsoils. The near neutral soil pH in the top 30 cm combined with reasonable cation ratios and generally low chemical fertility as described in Section 4.2 indicated that disturbed soil should not be sensitive to the conditions of placement (i.e., stockpiles). However, all soil in the Soil Study Area, whether disturbed or not is erodible (Section 7), so care would be required to minimise concentration of water flows that lead to water erosion. This may seem incongruous in the relatively arid climate at Nymagee. But this climate means that the soil is often very dry and susceptible to erosion when rain falls.

Recommended practices for the soil that would be stockpiled and respread are outlined below.

9.1. SOIL MANAGEMENT PRACTISES

9.1.1. Prevent Soil Contamination

Hydrocarbon management practises would be implemented to prevent hydrocarbon spills during construction and operations, and spill containment materials would be available to clean up spills if they occur.

Construction material brought on to the site would need to be clean and contaminant and weed free.

9.1.2. Soil Stripping

The following soil stripping and handling techniques should be implemented where practicable to minimise soil deterioration:

- The area to be stripped would be clearly defined on the ground. The target depths of soil to be stripped at each location would be clearly communicated to machinery operators and supervisors.
- A combination of suitable equipment would be used for stripping and placing soil in stockpiles. Machinery circuits would be located to minimise compaction of both undisturbed and stockpiled soil.
- The soil material should be maintained in a slightly moist condition during stripping. Material should not be stripped in either an excessively dry or wet condition.
- All machinery brought onto the site for soil stripping should comply with weed management and biosecurity protocols established for the site.
- Trees present should be cleared and grubbed prior to soil stripping.
- Handling and rehandling topsoil would be minimised as far as possible.

9.1.3. Soil Stockpiling

The stripped soils resource should be stored in a way that minimises compaction of the whole stockpile, and maximises biological activity. The

following techniques should be implemented where practicable to achieve these goals:

- All soil stockpiles would have batter slope of 1V:4H to limit erosion potential.
- Soil stockpiles would be designed and constructed to a depth not greater than 3 m in order to minimise the development of anaerobic conditions and to minimise the deterioration of biota and seed banks.
- The surface of soil stockpiles would be left in a rough condition to promote water infiltration rather than runoff. If required, sediment controls would be implemented downslope of stockpiles to capture eroded sediment.
- Overland flow onto and across stockpile sites would be kept to a practical minimum, and not allowed to concentrate to the extent that it causes visible erosion. This would be achieved by placing stockpiles on locally high areas.
- Stockpiles would be seeded with appropriate grasses and forbs to stabilise the surface, limit dust generation, minimise erosion and provide competition for weeds.
- After the stockpiles are established, machinery and vehicles would be excluded from general access. Stockpile locations would be marked on site maps to identify them so that they are protected from disturbance.
- Stockpiles would be surveyed and data recorded about the volumes and soil types present.
- Stockpiles would be monitored for the establishment of weeds and control programmes implemented as required.
- Soil transported by dump trucks may be placed directly into storage. Soil transported by bottom dumping scrapers is best pushed to form stockpiles by other equipment (e.g., bulldozer or excavator) to avoid tracking by the scraper over previously laid soil.

9.1.4. Soil Respreading

The aim of respreading is to construct a layered material with properties that can perform similar functions to the undisturbed soil. The recommended process for spreading of topsoil is as follows:

- A soil balance plan showing the depths and volumes of soil to be spread would be prepared before the soil is spread. The plan would take account of the erodibility of the stockpiled soil, with more erodible soil being placed on flatter areas to minimise the potential for erosion.
- Stockpiled soil would be tested to determine the required ameliorants.
- The land surface would be reshaped to appropriate landforms, then the resulting surface ripped.
- Ameliorants would be mixed with the soil as it is being spread if required.
- Soil should be moist to just moist, not wet or dry when being respread.
- Traffic patterns should minimise compaction of topsoiled areas.

- Soil would be lightly scarified to encourage rainfall infiltration.
- Pasture or appropriate vegetation types would be seeded as soon as possible after soil is respread.
- Erosion and sediment controls would be implemented where necessary prior to vegetation establishment.

9.2. MONITORING AND REPORTING

The successful management of soil for use in rehabilitation in the Project Soil Disturbance Footprint would depend on the following key steps:

1. Stripping and stockpiling sufficient soil to provide soil for the area to be rehabilitated (Table 8.6).
2. Maintaining biological activity and adequate aeration in the stockpiled soil.
3. Preparation of the subgrade and construction of the rehabilitated soil profile.
4. Establishment of desired plants on the rehabilitated soil.

All these steps require some degree of monitoring. It is likely that steps 1 and 3 would require the most intensive monitoring, and annual monitoring of vegetation health, groundcover percentage, weed presence, gully erosion presence, soil subsidence and water pooling is recommended.

Monitoring of stripping and stockpiling should ensure that the design depth of topsoil is stripped and that the subsoil is soil, rather than weathered rock. The volumes of topsoil and subsoil should be checked to ensure that there is sufficient soil to enable the planned rehabilitation.

Maintenance of biological activity would require plants to be grown. The species and vigour of plants growing on the stockpiles should be monitored.

The soil stockpiles should be tested before the soil is spread to determine the ameliorants required to construct a fertile soil profile. It is likely that nutrients would be required in the topsoil, and some lime would be required in most soil that is spread.

Achieving the planned LSC class depends on accurate placement of the subsoil and topsoil. Achieving the desired soil thickness would in turn depend on accurate preparation of the subgrade. As such, an accurate survey of the thickness of the soil layer should be conducted.

10. POTENTIAL IMPACT OF PROJECT ON AGRICULTURAL PRODUCTIVITY

The main potential impact of the Project on agricultural productivity would be to remove an area from agricultural landuse for the duration of mining plus the time taken for the land to return to its current level of production. This was estimated based on the following assumptions:

- The area of 50 ha that would be removed from agricultural production as reported and reduced to LSC class 8 as reported in Figure 8.2
- Productivity of the land removed from agriculture would be equivalent to the average for rangeland grazing in the Cobar Local Government Area (LGA).
- Land would return to its current level of agricultural productivity after the site is rehabilitated.

This section presents a summary of agricultural productivity in the Cobar Shire to support assumptions about potential agricultural productivity . This level of productivity was combined with gross margins from NSW DPI to estimate the value of production that would be foregone when the land is used for a mine rather than for grazing.

10.1. AGRICULTURAL PRODUCTION IN COBAR SHIRE

10.1.1. Overview

The Cobar Shire covers 4,557,535 ha (45,558 km^2, Table 10.1), west of the centre of New South Wales. It is in the Cobar Peneplain Bioregion, which is a low undulating plain where surface elevation is controlled by underlying Palaeozoic (540 to 250 million years ago) rock. The dominant agricultural landuse is grazing (Table 10.1). ACLUMP (2016) report that 93% of the Cobar LGA is used for grazing (Figure 10.1), but ABS (2017) appears to indicate that 38% of this land returned an estimated value of agricultural operations (EVAO) less than $5,000 per holding so did not classify 1,700,579 used for agriculture as agricultural holdings (Table 10.1).

Table 10.1. Landuse in Cobar Local Government area.

Zone	Total Area (ha)	Data source	Area of agricultural holdings (ha)	Land used mainly for grazing (ha and %)
Cobar Shire	4,557,535	ABS (2017)*	2,649,421	2,467,066 (93%)
		ACLUMP (2016)	4,247,000	3,956,000 (93%)

**ABS (2017) reported statistics for holdings with a 2010-11 estimated value of agricultural operations greater than $5,000.*

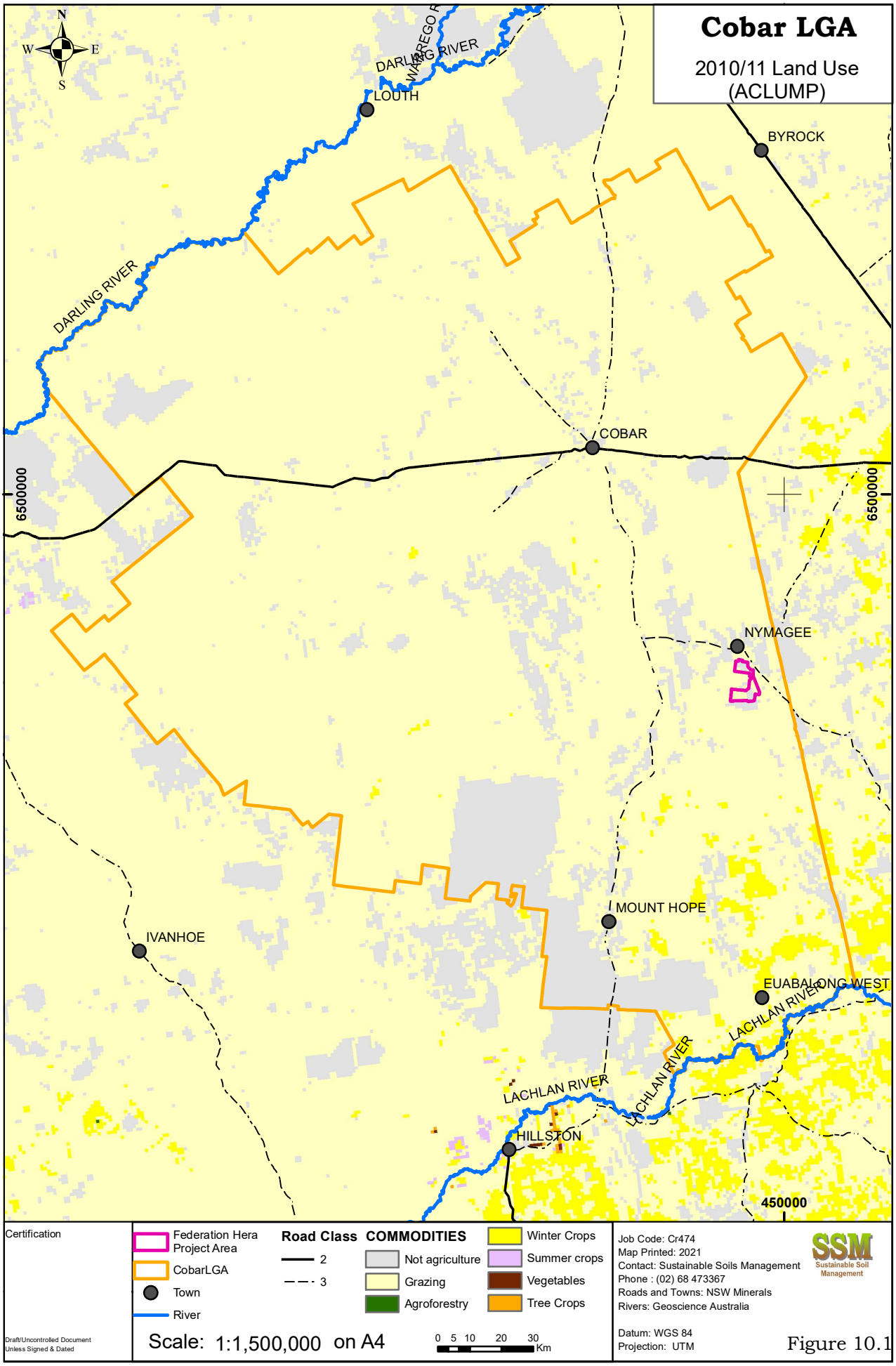
Cobar LGA
2010/11 Land Use
(ACLUMP)
N
W
E
S
WARREGO RIVER
DARLING RIVER
LOUTH
BYROCK
COBAR
6500000
6500000
NYMAGEE
MOUNT HOPE
IVANHOE
EUABALONG WEST
LACHLAN RIVER
LACHLAN RIVER
LACHLAN RIVER
HILLSTON
450000
Certification
Federation Hera Project Area
CobarLGA
Town
River
Road Class
2
3
COMMODITIES
Not agriculture
Grazing
Agroforestry
Winter Crops
Summer crops
Vegetables
Tree Crops
Scale: 1:1,500,000 on A4
0 5 10 20 30 Km
Draft/Uncontrolled Document Unless Signed & Dated
Job Code: Cr474
Map Printed: 2021
Contact: Sustainable Soils Management
Phone : (02) 68 473367
Roads and Towns: NSW Minerals
Rivers: Geoscience Australia
Datum: WGS 84
Projection: UTM
SSM
Sustainable Soil Management

Figure 10.1

A population of 4,412 lived in the Cobar LGA in 2020 (Table 10.2). Approximately 90% of these live in Cobar town, with the remainder living in towns of Nymagee, Euabalong, Murrin Bridge, smaller towns and on farms. Mining is the dominant employer in the Shire, while agriculture employs 12% of the Shire's labour force. The ratio between the area of agricultural holdings in Table 10.1 and the number employed in agriculture indicates that it takes between 11,000 and 17,000 ha in the Cobar LGA to support one full time labour unit.

Table 10.2. Employment in Cobar LGA (ABS, 2021).

Population Category	Number
Total persons	4,412
Total labour force	2,014
Total employed in agriculture	236 (12%)
Total employed in mining	645 (32%)
Total employed in manufacturing and construction	115 (6%)
Service and support	1,009 (51%)

10.1.2. Agriculture in the Cobar LGA.

Approximately 93% of the area of agricultural holdings in the Cobar LGA is used for grazing (Table 10.3). A much smaller 1.7% is used for cropping, and a further 7% of agricultural holdings was either set aside for conservation or not used for agriculture. There is a gap in the ABS data equivalent to 31% of the area of the Cobar LGA. Further analysis will focus on the area of agricultural holdings in Table 10.3.

Table 10.3. Landuse of holdings with estimated value of agricultural operations greater than $5,000. in the Cobar LGA.

Landuse Type	Area (ha)	Area (%)
Agricultural Holdings	2,649,421	58
Grazing	*2,467,066*	*93*
Cropping	*46,333*	*1.7*
Set aside for conservation	*59,738*	*4*
Land not used for agriculture	*76,682*	*2.9*
National Parks and Protected Areas	493,118	11
Unaccounted	1,414,996	31
Total – Cobar LGA	**4,557,535**	**100**

The most recent data in which production in the Cobar LGA was separated from the remainder of Far West and Orana (basically Wellington to Broken Hill and north to the Queensland border) is 2010/11. The gross value of grazing production in the Cobar LGA 2010-11 of $17.7 million (Table 10.4) is equivalent to a little over $7/ha. Grain growing in the Cobar Shire in the same year returned an average gross of $338/ha.

Table 10.4. Annual value of Agricultural production in Cobar LGA (ABS, 2012).

Product Type	Value ($ million)
Wool	6.7
Livestock sales	11.0
Grain and hay	15.7

Carrying capacity is a key driver of the expected returns from grazing enterprises. One method of comparing different animal enterprises is to use a standard animal. In New South Wales it is common to use Dry Sheep Equivalent (DSE), which is equivalent to a 50 kg wether.

Stocking rates in 2010/11 from ABS were combined with standard conversion rates from Millear *et al,* (2003) to estimate that the Cobar LGA carried 676,660 DSEs (Table 10.5). This is equivalent to 0.27 DSE/grazed ha.

Table 10.5. Stocking rate of Cobar LGA in 2010/11 (ABS, 2012).

Stock Class	Females mated	Other age and sex classes	Total number	Estimated Dry Sheep Equivalent*
Sheep	139,741	104,924	244,665	398,380
Cattle	12,155	9,634	21,789	248,548
Goats	-	-	29,732	29,732
Total				676,660

*Dry Sheep Equivalents estimated using ratios of 2.1 for 53 kg self replacement merino ewe, 14.9 for a 500 kg cow growing store weaners, 7 for other cattle and 1 for goats.

10.1.3. Estimate of Potential Agricultural Production in the Mine Site

A common sheep enterprise around the Project is to run a self-replacing flock of merino ewes. Self-replacing means that ewes are bred on-farm, rams are purchased from studs and lambs and ewes older than breeding age are sold. DPI (2020) estimates a gross margin of $120/ewe, and a DSE rating of 2.3 DSE/ewe to give a gross margin of $52/DSE.

The selected gross margin of $52/DSE combined with the average stocking rate of 0.27 DSE/ha in Section 10.1.2 gives an average annual Gross Margin of approximately $14/ha. This gross margin is double the average gross return in 2010-11 (ABS, 2012), and was applied to land with LSC from class 4 to 6 inclusive.

A uniform return to LSC class 4 to 6 was used because the sporadic and variable nature of rainfall means that pasture and shrub growth is likely to be too inconsistent to reliably allocate a different stocking rate to each LSC. However, land with LSC 7 was allocated zero stocking rate and gross margin.

10.2. PRE-MINING POTENTIAL AGRICULTURAL PRODUCTIVITY

The current carrying capacity of the 47 ha that was alienated from grazing during the life of the mine (Table 8.8) is estimated to be 4.2 merino ewes. This is equivalent to 12.4 DSE, which would be expected to return an annual gross margin of approximately $659 (calculated as 47 ha * 0.27 DSE/ha * $52/DSE).

10.3. POTENTIAL AGRICULTURAL PRODUCTIVITY DURING MINING

The planned mine life of 12 to 14 years (Section 1) means that it was prudent to assume that the areas assigned LSC 8 in Table 8.8 would not produce fodder for grazing livestock during this period. Consequently, this area was assessed to carry 0 head for the duration of the Project.

10.4. POTENTIAL AGRICULTURAL PRODUCTIVITY POST REHABILITATION

The primary aim of rehabilitation would be to create a stable, non-polluting landscape. An adjunct to this aim would be that the rehabilitated land should be able to support the existing stocking rate. This is because a relatively small mass of vegetation is harvested by grazing livestock.

The vegetation harvested by 0.27 DSE/ha of livestock is equivalent to around 100 kg/ha/year of dry matter. This dry matter was calculated on the assumption that 1 DSE is equivalent to approximately 1 kg dry matter per day. As such, the vegetation established during rehabilitation should be able to supply the feed required by grazing animals if it is dense enough to provide the function of protecting the soil surface from wind erosion.

As such, it is estimated that the carrying capacity of rehabilitated land would return to 0.27 DSE/ha stocking rate that is carried by land not disturbed by mining.

11. REFERENCES

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12. LIMITATIONS

The investigations described in this report identified actual conditions only at those locations where sampling occurred. This data has been interpreted and an opinion given regarding the overall physical and chemical conditions at the site.

Although the information in this report has been used to interpret conditions at the site, actual conditions may vary from those inferred, especially between sampling locations. Consequently, this report should be read with the understanding that it is a professional interpretation of conditions at the site based on a set of data. Although the data were considered representative of the site, they cannot fully define the conditions across the site.

APPENDIX I:

Logs of Soil Description.

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TEST HOLE OA001

Date Excavated: 22/10/20
Logged by: PJH Datum: WGS84
Easting: 434256 Northing: 6436888
Surface Elevation(m):
Equipment: Excavator

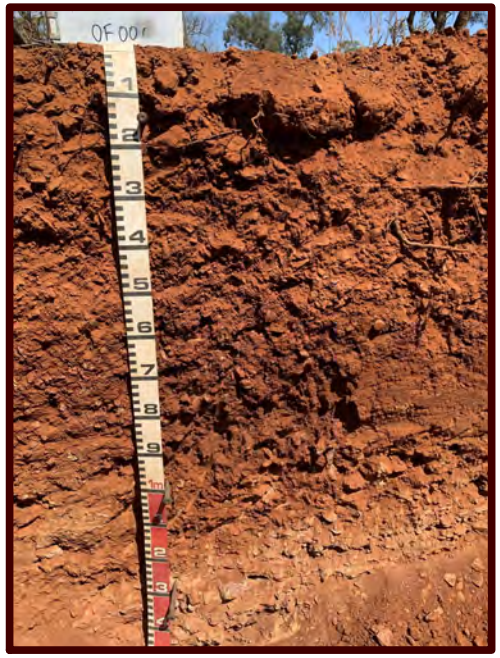
Australian Soil Class: Red-Orthic Tenosol
Annual Crop Rootzone (cm): 140
Plant Available Water (mm): 81
Drainage: Well drained
Estimated Permeability: < 5 mm/day

Geology: Sandstone
Landuse: Remnant
Surface condition: Hard-setting
Surface gravel: 20% fine gravel
Outcrop: None

Landscape Properties

Landscape position: Midslope
Microrelief: No microrelief
Erosion: Partly stabilised Sheet
Vegetation: Turpentine, Mallee

DEPTH (centimetres)	Horizon	PROFILE DESCRIPTION	Field pH	Effervescence	Proportion Coarse Fragments 0 0.5 1	Moisture	Field ECe (dS/m)	SAMPLE
	A	Red sandy clay loam with moderate grade of crumb structure and ped size of 0.5. Soil is not dispersive, completely slakes, has a moderate to good SOILpak score and has many roots present.	4	Nil		Dry		
	BC1	Red clay loam with moderate grade of angular blocky structure and ped size of 0.5. Soil is not dispersive, completely slakes, has a moderate to good SOILpak score and has an average number of roots present.	5.5	Nil		Dry		
50								
	BC2	Red clay loam with strong grade of angular blocky structure and ped size of 1.0. Soil is not dispersive, completely slakes, has a moderate SOILpak score and has an average number of roots present.	6	Nil		Dry		
100								
	C1	Red light clay with strong grade of angular blocky structure and ped size of 0.5. Soil is not dispersive, completely slakes, has a moderate SOILpak score and has few roots present.	7.5	Nil		Dry		
	C2	Red light clay with strong grade of angular blocky structure and ped size of 0.5. Soil is not dispersive, completely slakes, has a moderate SOILpak score and has few roots present.	7.5	Nil		Dry		
150		COMMENTS: Medium subrounded sandstone material gravel throughout. Bottom of hole at 150						



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5 Lawson St
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+61 2 68473367 Fax: +61 2 68473401

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TEST HOLE OA002

Date Excavated: 22/10/20
Logged by: PJH Datum: WGS84
Easting: 433854 Northing: 6436822
Surface Elevation(m):
Equipment: Excavator

Australian Soil Class: Red Dermosol
Annual Crop Rootzone (cm): 80
Plant Available Water (mm): 92
Drainage: Well drained
Estimated Permeability: < 5 mm/day

Geology: Siltstone
Landuse: Remnant
Surface condition: Hard-setting
Surface gravel: 5% fine gravel
Outcrop: None

DEPTH (centimetres)	Horizon	GRAPHIC LOG	PROFILE DESCRIPTION	Field pH	Effervescence	Proportion Coarse Fragments 0 0.5 1	Moisture	Field ECe (dS/m)	SAMPLE
	A		Red clay loam with strong grade of subangular blocky structure and ped size of 5 cm breaking to 0.5 cm. Soil is not dispersive, partially slakes, has a good SOILpak score and has many roots present.	4.5	Nil		Dry		
	B		Red light clay with strong grade of angular blocky structure and ped size of 5 cm breaking to 1 cm. Soil is not dispersive, completely slakes, has a moderate to good SOILpak score and has many roots present.	4.5	Nil		Dry		
50	C1		Red light medium clay with strong grade of polyhedral structure and ped size of 0.5. Soil is not dispersive, completely slakes, has a moderate SOILpak score and has few roots present.	5	Nil		Trace		
100	C2		Brown light clay with moderate grade of polyhedral structure and ped size of 0.5. Soil is not dispersive, completely slakes, has a moderate SOILpak score and has few roots present.	6	Nil		Trace		
150			COMMENTS: B horizon subplastic - CL to LC. Rock in C horizons is angular siltstone coarse gravel. Undisturbed. Bottom of hole at 150						

Landscape Properties

Landscape position: Midslope
Microrelief: No microrelief
Erosion: Stabilised
Vegetation: Callitris, turpentine, forbs, some wiregrass

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5 Lawson St
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+61 2 68473367 Fax: +61 2 68473401

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TEST HOLE OA003

Date Excavated: 22/10/20
Logged by: PJH Datum: WGS84
Easting: 433516 Northing: 6436977
Surface Elevation(m):
Equipment: Excavator

Australian Soil Class: Red-Orthic Tenosol
Annual Crop Rootzone (cm): 70
Plant Available Water (mm): 62
Drainage: Well drained
Estimated Permeability: < 5 mm/day

Geology: Sandstone
Landuse: Remnant
Surface condition: Hard-setting
Surface gravel: 10% quartz gravel
Outcrop: None

Landscape Properties

Landscape position: Lower slope
Microrelief: No microrelief
Erosion: Stabilised
Vegetation: Mallee, spase shrub, understones

DEPTH (centimetres)	Horizon	GRAPHIC LOG	PROFILE DESCRIPTION	Field pH	Effervescence	Proportion Coarse Fragments 0 0.5 1	Moisture	Field ECe (dS/m)	SAMPLE
	A		Red sandy clay loam with moderate grade of polyhedral structure and ped size of 5 cm breaking to 0.5 cm. Soil is not dispersive, doesn't slake, has a moderate to good SOILpak score and has many roots present.	5.5	Nil		Dry		
	Bt		Red clay loam with strong grade of polyhedral structure and ped size of 0.5. Soil is not dispersive, partially slakes, has a moderate to good SOILpak score and has an average number of roots present.	5.5	Nil		Dry		
50	B2		Red clay loam with strong grade of polyhedral structure and ped size of 0.5. Soil is not dispersive, completely slakes, has a moderate SOILpak score and has an average number of roots present.	5.5	Nil		Dry		
	C1		Red light clay with strong grade of polyhedral structure and ped size of 0.5. Soil is not dispersive, completely slakes, has a moderate SOILpak score and has few roots present.	7	Nil		Dry		
100	C2		Yellow sandy clay loam with single grained grade of structure. Soil is not dispersive, doesn't slake, has a poor to moderate SOILpak score and has few roots present.	8	Nil		Dry		
150			COMMENTS: Bedrock appears to be sandstone. Coarse fragments in C are angular sandstone cobbles. No forbs or grasses Bottom of hole at 150						

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Sustainable Soils Management
5 Lawson St
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+61 2 68473367 Fax: +61 2 68473401

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TEST HOLE OA004

Date Excavated: 22/10/20
Logged by: PJH Datum: WGS84
Easting: 433813 Northing: 6437194
Surface Elevation(m):
Equipment: Excavator

Australian Soil Class: Red Dermosol
Annual Crop Rootzone (cm): 70
Plant Available Water (mm): 100
Drainage: Moderately well drained
Estimated Permeability: 5 to 50 mm/day

Geology: Sandstone
Landuse: Remnant
Surface condition: Cryptogram crust
Surface gravel: None
Outcrop: None

Landscape Properties

Landscape position: Lower slope
Microrelief: No microrelief
Erosion: Stabilised
Vegetation: Bull mallee, turpentine, few callitris

DEPTH (centimetres)	Horizon	GRAPHIC LOG	PROFILE DESCRIPTION	Field pH	Effervescence	Proportion Coarse Fragments 0 0.5 1	Moisture	Field ECe (dS/m)	SAMPLE
	A		Red clay loam with moderate grade of subangular blocky structure and ped size of 3 cm breaking to 0.5 cm. Soil is not dispersive, completely slakes, has a good SOILpak score and has abundant roots present.	4.5	Nil		Dry		
50	B1		Red sandy clay loam with strong grade of angular blocky structure and ped size of 2 cm breaking to 0.5 cm. Soil is slightly dispersive, completely slakes, has a moderate to good SOILpak score and has an average number of roots present.	6	Nil		Dry		
	B2		Red silty clay loam with strong grade of angular blocky structure and ped size of 3 cm breaking to 0.5 cm. Soil is not dispersive, completely slakes, has a moderate to good SOILpak score and has an average number of roots present.	6.5	Nil		Dry		
100	B3		Red light clay with strong grade of angular blocky structure and ped size of 0.5. Soil is not dispersive, completely slakes, has a moderate SOILpak score and has few roots present.	7.5	Nil		Dry		
	R		Extremely weathered extremely low strength sandstone in the form of angular coarse gravel.						
150			COMMENTS: Deepest profile but topsoil is strongly hardsetting Bottom of hole at 150						

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Sustainable Soils Management
5 Lawson St
Warren, NSW, 2824
+61 2 68473367 Fax: +61 2 68473401

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TEST HOLE OA005

Date Excavated: 22/10/20
Logged by: PJH Datum: WGS84
Easting: 434062 Northing: 6437151
Surface Elevation(m):
Equipment: Excavator

Australian Soil Class: Red-Orthic Tenosol
Annual Crop Rootzone (cm): 45
Plant Available Water (mm): 42
Drainage: Imperfectly drained
Estimated Permeability: < 5 mm/day

Geology: Mudstone
Landuse: Remnant
Surface condition: Hard-setting
Surface gravel: 30% coarse angular gravel
Outcrop: None

Landscape Properties

Landscape position: Midslope
Microrelief: No microrelief
Erosion: Partly stabilised Sheet
Vegetation: Mallee, Forbs

DEPTH (centimetres)	Horizon	GRAPHIC LOG	PROFILE DESCRIPTION	Field pH	Effervescence	Proportion Coarse Fragments 0 0.5 1	Moisture	Field ECe (dS/m)	SAMPLE
	A		Red sandy clay loam with strong grade of subangular blocky structure and ped size of 3 cm breaking to 0.5 cm. Soil is not dispersive, doesn't slake, has a moderate to good SOILpak score and has many roots present.	5	Nil		Dry		
	Bt		Red light clay with strong grade of angular blocky structure and ped size of 3 cm breaking to 1 cm. Soil is moderately dispersive, completely slakes, has a moderate SOILpak score and has an average number of roots present.	5	Nil		Trace		
50	C		Grey light medium clay with strong grade of polyhedral structure and ped size of 0.5. Soil is slightly dispersive, completely slakes, has a moderate SOILpak score and has few roots present.	6	Nil		Trace		
100									
	R		Extremely weathered extremely low strength mudstone						
150			COMMENTS: Many shallow sumps with rock in spoil pile nearby. Bottom of hole at 115						

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5 Lawson St
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TEST HOLE OF101

Date Excavated: 15/6/21
Logged by: PJH Datum: WGS84
Easting: 437533 Northing: 6446672
Surface Elevation(m): 337.1
Equipment: Excavator

Australian Soil Class: Red-Orthic Tenosol
Annual Crop Rootzone (cm): 30
Plant Available Water (mm): 41
Drainage: Well drained
Estimated Permeability: 50 to 500 mm/day

Geology: Roset Sandstone
Landuse: Naturalised pasture
Surface condition: Soft Wet
Surface gravel: None
Outcrop: None

DEPTH (centimetres)	Horizon	GRAPHIC LOG	PROFILE DESCRIPTION	Field pH	Effervescence	Proportion Coarse Fragments 0 0.5 1	Moisture	Field ECe (dS/m)	SAMPLE
	A1		Black fine sandy clay loam with moderate grade of subangular blocky structure and ped size of 3 cm breaking to 1 cm. Soil is slightly dispersive, doesn't slake, has a moderate SOILpak score and has many roots present.	4.5	Nil		Moist		
	A3		Red fine sandy clay loam with moderate grade of subangular blocky structure and ped size of 5 cm breaking to 1 cm. Soil is not dispersive, completely slakes, has a moderate to good SOILpak score and has an average number of roots present.	4.5	Nil		Dry		
	BC		Red sandy clay loam with weak grade of subangular blocky structure and ped size of 0.1. Soil is not dispersive, completely slakes, has a moderate SOILpak score and has few roots present.	4.5	Nil		Dry		
50			COMMENTS: Cryptogram crust. Sandstone outcrop 30 m to west. Bottom of hole at 50						
100									

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+61 2 68473367 Fax: +61 2 68473401

Landscape Properties

Landscape position: Lower Slope
Microrelief: No microrelief
Erosion: Stabilised
Vegetation: White Cypress

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TEST HOLE OF102

Date Excavated: 15/6/21
Logged by: PJH Datum: WGS84
Easting: 438323 Northing: 6446301
Surface Elevation(m): 340.3
Equipment: Excavator

Australian Soil Class: Red-Orthic Tenosol
Annual Crop Rootzone (cm): 20
Plant Available Water (mm): 26
Drainage: Well drained
Estimated Permeability: 5 to 50 mm/day

Geology: Mudstone?
Landuse: Naturalised pasture
Surface condition: Firm Moist
Surface gravel: 10% medium to coarse gravel, angular siltstone
Outcrop: None

DEPTH (centimetres)	Horizon	PROFILE DESCRIPTION	Field pH	Effervescence	Proportion Coarse Fragments 0 0.5 1	Moisture	Field ECe (dS/m)	SAMPLE
	A11	Red silty clay loam with strong grade of subangular blocky structure and ped size of 2 cm breaking to 0.5 cm. Soil is slightly dispersive, doesn't slake, has a moderate to good SOILpak score and has abundant roots present.	4.5	Nil		Moist		
	A12	Red fine sandy clay loam with strong grade of subangular blocky structure and ped size of 3 cm breaking to 0.5 cm. Soil is not dispersive, completely slakes, has a moderate SOILpak score and has many roots present.	8	Nil		Moist		
	BC	Red fine sandy clay loam with weak grade of subangular blocky structure and ped size of 0.5. Soil is not dispersive, completely slakes, has a moderate SOILpak score and has few roots present.	5.5	Nil		Dry		
	C			Nil		Dry		
50								
		COMMENTS: Cryptogram crust. Coarse fragments in A11, A12 are medium gravel of angular siltstone. Bottom of hole at 80						
100								

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5 Lawson St
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+61 2 68473367 Fax: +61 2 68473401

Landscape Properties

Landscape position: Upper Slope
Microrelief: No microrelief
Erosion: Stabilised
Vegetation: White Cypress, buddah, corkscrew grass

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TEST HOLE OF103

Date Excavated: 15/6/21
Logged by: PJH Datum: WGS84
Easting: 438842 Northing: 6445231
Surface Elevation(m): 325.3
Equipment: Excavator

Australian Soil Class: Red Dermosol
Annual Crop Rootzone (cm): 60
Plant Available Water (mm): 89
Drainage: Moderately well drained
Estimated Permeability: 5 to 50 mm/day

Geology: Colluvium
Landuse: Naturalised pasture
Surface condition: Firm Moist
Surface gravel: None
Outcrop: None

DEPTH (centimetres)	Horizon	GRAPHIC LOG	PROFILE DESCRIPTION	Field pH	Effervescence	Proportion Coarse Fragments 0 0.5 1	Moisture	Field ECe (dS/m)	SAMPLE
	A11		Red clay loam with moderate grade of subangular blocky structure and ped size of 1 cm breaking to 0.5 cm. Soil is moderately dispersive, completely slakes, has a moderate SOILpak score and has many roots present.	5	Nil		Moist		
	B1		Red light clay with moderate grade of subangular blocky structure and ped size of 2 cm breaking to 0.5 cm. Soil is slightly dispersive, completely slakes, has a moderate SOILpak score and has many roots present.	5	Nil		Moist		
50	B2		Red light clay with moderate grade of subangular blocky structure and ped size of 5 cm breaking to 1 cm. Soil is not dispersive, partially slakes, has a moderate SOILpak score and has an average number of roots present.	5.5	Nil		Dry		
	B3		Red loamy sand with strong grade of subangular blocky structure and ped size of 5 cm breaking to 1 cm. Soil is not dispersive, partially slakes, has a moderate SOILpak score and has few roots present.	7	Nil		Dry		
100			COMMENTS: Cryptogram crust. Coarse fragments in B2 are fine gravel of subangular quartz. B2 a little subplastic (Clay loam to Light clay). Bottom of hole at 90						

Landscape Properties

Landscape position: Flat
Microrelief: No microrelief
Erosion: Stabilised
Vegetation: White Cypress, Box, Medic, Galvanized burr, Corkscrew grass, Windmill Grass

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5 Lawson St
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+61 2 68473367 Fax: +61 2 68473401

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TEST HOLE OF104

Date Excavated: 15/6/21
Logged by: PJH Datum: WGS84
Easting: 439324 Northing: 6443922
Surface Elevation(m): 342.5
Equipment: Excavator

Australian Soil Class: Red-Orthic Tenosol
Annual Crop Rootzone (cm): 50
Plant Available Water (mm): 50
Drainage: Poorly drained
Estimated Permeability: 5 to 50 mm/day

Geology: Mudstone?
Landuse: Naturalised pasture
Surface condition: Soft Wet
Surface gravel: None
Outcrop: None

DEPTH (centimetres)	Horizon	GRAPHIC LOG	PROFILE DESCRIPTION	Field pH	Effervescence	Proportion Coarse Fragments 0 0.5 1	Moisture	Field ECe (dS/m)	SAMPLE
	A1		Black sandy loam with weak grade of subangular blocky structure and ped size of 3 cm breaking to 1 cm. Soil is not dispersive, doesn't slake, has a poor to moderate SOILpak score and has abundant roots present.	5	Nil		Moist		
	A2e		Red sandy clay loam with weak grade of subangular blocky structure and ped size of 3 cm breaking to 1 cm. Soil is slightly dispersive, completely slakes, has a poor SOILpak score and has few roots present.	5.5	Nil		Dry		
50	BC		Brown light medium clay with moderate grade of subangular blocky structure and ped size of 0.5. Soil is not dispersive, completely slakes, has a moderate SOILpak score and has few roots present.	8.5	Nil		Dry		
			COMMENTS: Coarse fragments in A2 are ironstone. A2 Dry colour 5YR 7/4. C XW EL Sandstone. Soft wet, hardset dry. Bottom of hole at 60						
100									

Landscape Properties

Landscape position: Upper Slope
Microrelief: No microrelief
Erosion: Partly stabilised Sheet
Vegetation: Rosewood, Gum, Panicum, Galvanised Burr, Copper Burr, Curly Windmill Grass,

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5 Lawson St
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+61 2 68473367 Fax: +61 2 68473401

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TEST HOLE OF105

Date Excavated: 15/6/21
Logged by: PJH Datum: WGS84
Easting: 439542 Northing: 6442970
Surface Elevation(m): 329.8
Equipment: Excavator

Australian Soil Class: Red Dermosol
Annual Crop Rootzone (cm): 60
Plant Available Water (mm): 88
Drainage: Moderately well drained
Estimated Permeability: 5 to 50 mm/day

Geology: Mudstone?
Landuse: Naturalised pasture
Surface condition: Soft Wet
Surface gravel: None
Outcrop: None

DEPTH (centimetres)	Horizon	GRAPHIC LOG	PROFILE DESCRIPTION	Field pH	Effervescence	Proportion Coarse Fragments 0 0.5 1	Moisture	Field ECe (dS/m)	SAMPLE
	A		Red clay loam with moderate grade of subangular blocky structure and ped size of 5 cm breaking to 0.5 cm. Soil is slightly dispersive, partially slakes, has a moderate to good SOILpak score and has abundant roots present.	5	Nil		Moist		
	B1		Red light clay with moderate grade of subangular blocky structure and ped size of 3 cm breaking to 0.5 cm. Soil is not dispersive, completely slakes, has a moderate to good SOILpak score and has many roots present.	5	Nil		Moist		
50	B2		Red light clay with moderate grade of subangular blocky structure and ped size of 2 cm breaking to 0.5 cm. Soil is not dispersive, completely slakes, has a moderate SOILpak score and has few roots present.	5.5	Nil		Trace		
	BC		Red light medium clay with moderate grade of polyhedral structure and ped size of 3 cm breaking to 0.5 cm. Soil is not dispersive, completely slakes, has a moderate SOILpak score and has few roots present.	6	Nil		Trace		
100			COMMENTS: Cryptogram crust. C is Extremely weathered very low strength mudstone Bottom of hole at 90						

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Landscape Properties

Landscape position: Midslope
Microrelief: No microrelief
Erosion: Stabilised
Vegetation: White Cypress, Gum, Number 9 Wire Grass,

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TEST HOLE OF106

Date Excavated: 16/6/21
Logged by: PJH Datum: WGS84
Easting: 439609 Northing: 6441647
Surface Elevation(m): 320.1
Equipment: Excavator

Australian Soil Class: Red Dermosol
Annual Crop Rootzone (cm): 60
Plant Available Water (mm): 86
Drainage: Moderately well drained
Estimated Permeability: 5 to 50 mm/day

Geology: Colluvium
Landuse: Naturalised pasture
Surface condition: Soft Wet
Surface gravel: None
Outcrop: None

DEPTH (centimetres)	Horizon	GRAPHIC LOG	PROFILE DESCRIPTION	Field pH	Effervescence	Proportion Coarse Fragments 0 0.5 1	Moisture	Field ECe (dS/m)	SAMPLE
	A11		Red sandy clay loam with moderate grade of subangular blocky structure and ped size of 3 cm breaking to 0.5 cm. Soil is slightly dispersive, partially slakes, has a moderate SOILpak score and has many roots present.	5	Nil		Moist		
	A12		Red sandy clay loam with moderate grade of subangular blocky structure and ped size of 5 cm breaking to 1 cm. Soil is not dispersive, partially slakes, has a moderate SOILpak score and has an average number of roots present.	5	Nil		Moist		
50	A3		Red sandy clay loam with moderate grade of polyhedral structure and ped size of 5 cm breaking to 1 cm. Soil is not dispersive, completely slakes, has a moderate SOILpak score and has few roots present.	5	Nil		Dry		
	B2		Red sandy clay loam with moderate grade of polyhedral structure and ped size of 10 cm breaking to 1 cm. Soil is not dispersive, completely slakes, has a poor to moderate SOILpak score and has few roots present.	7.5	High		Dry		
100			COMMENTS: Cryptogram crust. Surface soil slumped. B2 very hard, refusal. Boundary to White Cypress ~ 100 m south. Pockets of Cypress. Patches of Kangaroo Grass nearby. Bottom of hole at 90						

Landscape Properties

Landscape position: Open depression
Microrelief: No microrelief
Erosion: Stabilised
Vegetation: Box, Curly Windmill Grass, Copper Burr, Panicum

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TEST HOLE OF107

Date Excavated: 16/6/21
Logged by: PJH Datum: WGS84
Easting: 439104 Northing: 6439782
Surface Elevation(m): 334.5
Equipment: Excavator

Australian Soil Class: Red Dermosol
Annual Crop Rootzone (cm): 50
Plant Available Water (mm): 58
Drainage: Moderately well drained
Estimated Permeability: 5 to 50 mm/day

Geology: Mudstone?
Landuse: Naturalised pasture
Surface condition: Soft Wet
Surface gravel: 5% angular quartz gravel
Outcrop: None

Landscape Properties

Landscape position: Midslope
Microrelief: No microrelief
Erosion: Stabilised
Vegetation: Mallee, Wilga, White Cypress

DEPTH (centimetres)	Horizon	GRAPHIC LOG	PROFILE DESCRIPTION	Field pH	Effervescence	Proportion Coarse Fragments 0 0.5 1	Moisture	Field ECe (dS/m)	SAMPLE
	A1		Red clay loam with strong grade of polyhedral structure and ped size of 3 cm breaking to 0.5 cm. Soil is slightly dispersive, partially slakes, has a moderate to good SOILpak score and has many roots present.	6	Nil		Moist		
	A3		Red sandy clay loam with moderate grade of subangular blocky structure and ped size of 3 cm breaking to 1 cm. Soil is moderately dispersive, completely slakes, has a moderate SOILpak score and has an average number of roots present.	7	Nil		Moist		
	BC		Red light clay with strong grade of polyhedral structure and ped size of 2 cm breaking to 0.5 cm. Soil is not dispersive, completely slakes, has a moderate SOILpak score and has few roots present.	7	Nil		Dry		
50	C		Red light clay with strong grade of polyhedral structure and ped size of 1 cm breaking to 0.5 cm. Soil is not dispersive, completely slakes, has a moderate SOILpak score and has few roots present.	8	Nil		Dry		
			COMMENTS: Cryptogram crust. Parent material and fragments yellow white, extremely weathered, very low strength, thinly laminated mudstone. Coarse fragments; A3 medium gravel, BC coarse gravel, CB cobbles. Bottom of hole at 90						
100									

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TEST HOLE OF108

Date Excavated: 16/6/21
Logged by: PJH Datum: WGS84
Easting: 438721 Northing: 6438781
Surface Elevation(m): 340.8
Equipment: Excavator

Australian Soil Class: Red Dermosol
Annual Crop Rootzone (cm): 50
Plant Available Water (mm): 53
Drainage: Moderately well drained
Estimated Permeability: 5 to 50 mm/day

Geology: Colluvium
Landuse: Naturalised pasture
Surface condition: Soft Wet
Surface gravel: None
Outcrop: None

DEPTH (centimetres)	Horizon	GRAPHIC LOG	PROFILE DESCRIPTION	Field pH	Effervescence	Proportion Coarse Fragments 0 0.5 1	Moisture	Field ECe (dS/m)	SAMPLE
	A11		Red sandy clay loam with moderate grade of subangular blocky structure and ped size of 5 cm breaking to 1 cm. Soil is not dispersive, doesn't slake, has a moderate to good SOILpak score and has abundant roots present.	4.5	Nil		Moist		
	A12		Red clay loam with moderate grade of subangular blocky structure and ped size of 3 cm breaking to 1 cm. Soil is not dispersive, completely slakes, has a moderate SOILpak score and has many roots present.	4.5	Nil		Moist		
	A2e		Red sandy loam with massive grade of structure and ped size of cm breaking to cm. Soil is moderately dispersive, partially slakes, has a terrible SOILpak score and has an average number of roots present.	4.5	Nil		Dry		
50	B		Red light clay with strong grade of polyhedral structure and ped size of 10 cm breaking to 1 cm. Soil is not dispersive, completely slakes, has a poor to moderate SOILpak score and has few roots present.	7	Nil		Trace		
100			COMMENTS: Coarse fragments in A are medium to coarse gravel of subrounded fine sandstone. A2 dry colour 2.5YR 6/4. Broad valley of colluvium from hill to SSW. Bottom of hole at 100						

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Landscape Properties

Landscape position: Ridge
Microrelief: No microrelief
Erosion: Stabilised
Vegetation: Gum, Wilga, Bogan Flea, Wiregrass, Number 9

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TEST HOLE OF109

Date Excavated: 16/6/21
Logged by: PJH Datum: WGS84
Easting: 437762 Northing: 6438165
Surface Elevation(m): 354.4
Equipment: Excavator

Australian Soil Class: Black-Orthic Tenosol
Annual Crop Rootzone (cm): 80
Plant Available Water (mm): 45
Drainage: Imperfectly drained
Estimated Permeability: 5 to 50 mm/day

Geology: Sandstone
Landuse: Naturalised pasture
Surface condition: Soft Wet
Surface gravel: 5% gravel to cobble quartz
Outcrop: 150 m east at crest

DEPTH (centimetres)	Horizon	GRAPHIC LOG	PROFILE DESCRIPTION	Field pH	Effervescence	Proportion Coarse Fragments 0 0.5 1	Moisture	Field ECe (dS/m)	SAMPLE
	A		Black sandy loam with weak grade of subangular blocky structure and ped size of 5 cm breaking to 1 cm. Soil is slightly dispersive, doesn't slake, has a poor to moderate SOILpak score and has abundant roots present.	4.5	Nil		Moist		
50	BC		Red sandy loam with moderate grade of subangular blocky structure and ped size of 3 cm breaking to 1 cm. Soil is not dispersive, partially slakes, has a poor to moderate SOILpak score and has many roots present.	4.5	Nil		Dry		
	C		Black sandy loam with weak grade of subangular blocky structure and ped size of 5 cm breaking to 2 cm. Soil is not dispersive, completely slakes, has a poor SOILpak score and has few roots present.	4.5	Nil		Dry		
	Rock								
100			COMMENTS: Coarse fragments are extremely weathered, very low strength yellow sandstone. C dry colour 7.5YR 5/3. Bottom of hole at 90						

Landscape Properties

Landscape position: Upper Slope
Microrelief: No microrelief
Erosion: Stabilised
Vegetation: Ironbark, Few White Cypress, A grass that looks like poa

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5 Lawson St
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+61 2 68473367 Fax: +61 2 68473401

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TEST HOLE OF110

Date Excavated: 16/6/21
Logged by: PJH Datum: WGS84
Easting: 437038 Northing: 6437997
Surface Elevation(m): 344.1
Equipment: Excavator

Australian Soil Class: Red-Orthic Tenosol
Annual Crop Rootzone (cm): 70
Plant Available Water (mm): 63
Drainage: Moderately well drained
Estimated Permeability: 5 to 50 mm/day

Geology: Sandstone?
Landuse: Naturalised pasture
Surface condition: Soft Wet
Surface gravel: 20% sandstone gravel
Outcrop: None

DEPTH (centimetres)	Horizon	GRAPHIC LOG	PROFILE DESCRIPTION	Field pH	Effervescence	Proportion Coarse Fragments 0 0.5 1	Moisture	Field ECe (dS/m)	SAMPLE
	A		Red light clay with moderate grade of subangular blocky structure and ped size of 2 cm breaking to 1 cm. Soil is slightly dispersive, partially slakes, has a moderate to good SOILpak score and has many roots present.	4.5	Nil				
	BC		Red light clay with strong grade of subangular blocky structure and ped size of 2 cm breaking to 1 cm. Soil is not dispersive, partially slakes, has a moderate SOILpak score and has an average number of roots present.	6	Nil				
50	C		Red light clay with strong grade of polyhedral structure and ped size of 2. Soil is not dispersive, completely slakes, has a moderate SOILpak score and has few roots present.	7	Nil				
			COMMENTS: Shallow soil. Coarse fragments yellow white, extremely weathered, very low strength mudstone						
100			Bottom of hole at 90						

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Landscape Properties

Landscape position: Upper Slope
Microrelief: No microrelief
Erosion: Active Sheet
Vegetation: Gum, Wilga, White Cypress

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TEST HOLE OF111

Date Excavated: 16/6/21
Logged by: PJH Datum: WGS84
Easting: 435442 Northing: 6437714
Surface Elevation(m): 323.1
Equipment: Excavator

Australian Soil Class: Red Dermosol
Annual Crop Rootzone (cm): 50
Plant Available Water (mm): 72
Drainage: Moderately well drained
Estimated Permeability: 5 to 50 mm/day

Geology: Colluvium
Landuse: Naturalised pasture
Surface condition: Soft Wet
Surface gravel: None
Outcrop: None

Landscape Properties

Landscape position: Flat
Microrelief: No microrelief
Erosion: Partly stabilised Sheet
Vegetation: White Cypress, Corkscrew grass

DEPTH (centimetres)	Horizon	GRAPHIC LOG	PROFILE DESCRIPTION	Field pH	Effervescence	Proportion Coarse Fragments 0 0.5 1	Moisture	Field ECe (dS/m)	SAMPLE
	A1		Red silty clay loam with moderate grade of subangular blocky structure and ped size of 5 cm breaking to 0.5 cm. Soil is slightly dispersive, partially slakes, has a moderate to good SOILpak score and has many roots present.	5	Nil		Moist		
	A1		Red silty clay loam with moderate grade of subangular blocky structure and ped size of 3 cm breaking to 1 cm. Soil is not dispersive, completely slakes, has a moderate SOILpak score and has an average number of roots present.	4.5	Nil		Trace		
50	B2		Red silty clay loam with moderate grade of subangular blocky structure and ped size of 5 cm breaking to 1 cm. Soil is not dispersive, completely slakes, has a moderate SOILpak score and has few roots present.	5	Nil		Dry		
	B3		Red clayey sand with moderate grade of polyhedral structure and ped size of 10 cm breaking to 1 cm. Soil is not dispersive, doesn't slake, has a poor to moderate SOILpak score and has few roots present.	8	High		Dry		
100			COMMENTS: Cryptogram crust. 30% of surface is Fine gravel. Moist only to 20 cm. Dead pine trees ring barked a century ago. Bottom of hole at 90						

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5 Lawson St
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TEST HOLE OF112

Date Excavated: 16/6/21
Logged by: PJH Datum: WGS84
Easting: 435789 Northing: 6436740
Surface Elevation(m): 340.8
Equipment: Excavator

Australian Soil Class: Red-Orthic Tenosol
Annual Crop Rootzone (cm): 35
Plant Available Water (mm): 50
Drainage: Imperfectly drained
Estimated Permeability: 5 to 50 mm/day

Geology: Sandstone?
Landuse: Naturalised pasture
Surface condition: Soft Wet
Surface gravel: 30% angular coarse gravel
Outcrop: None

DEPTH (centimetres)	Horizon	GRAPHIC LOG	PROFILE DESCRIPTION	Field pH	Effervescence	Proportion Coarse Fragments (0 0.5 1)	Moisture	Field ECe (dS/m)	SAMPLE
	A11		Red sandy clay loam with strong grade of subangular blocky structure and ped size of 3 cm breaking to 0.5 cm. Soil is not dispersive, partially slakes, has a moderate to good SOILpak score and has an average number of roots present.	4.5	Nil				
	A12		Red sandy clay loam with moderate grade of polyhedral structure and ped size of 5 cm breaking to 1 cm. Soil is not dispersive, partially slakes, has a moderate SOILpak score and has an average number of roots present.	4.5	Nil				
	B		Red sandy clay loam with weak grade of polyhedral structure and ped size of 3 cm breaking to 1 cm. Soil is slightly dispersive, completely slakes, has a moderate SOILpak score and has an average number of roots present.	4.5	Nil				
	C		Red sandy clay loam with weak grade of polyhedral structure and ped size of 0.5. Soil is slightly dispersive, completely slakes, has a moderate SOILpak score and has few roots present.	4.5	Nil				
50			COMMENTS: Cryptogram crust. Rock Extremely weathered very low strength mudstone. Bottom of hole at 50						
100									

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Landscape Properties

Landscape position: Midslope
Microrelief: No microrelief
Erosion: Stabilised
Vegetation: Thin leafed Mallee, Wilga, White Cypress, Corkscrew grass

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TEST HOLE OF113

Date Excavated: 17/6/21
Logged by: PJH Datum: WGS84
Easting: 434946 Northing: 6437131
Surface Elevation(m): 307.0
Equipment: Excavator

Australian Soil Class: Leptic Rudosol
Annual Crop Rootzone (cm): 50
Plant Available Water (mm): 34
Drainage: Well drained
Estimated Permeability: 5 to 50 mm/day

Geology: Mudstone?
Landuse: Naturalised pasture
Surface condition: Firm Moist
Surface gravel: 60% angular fine gravel
Outcrop: None

Landscape Properties

Landscape position: Midslope
Microrelief: No microrelief
Erosion: Active Sheet
Vegetation: Gum

DEPTH (centimetres)	Horizon	GRAPHIC LOG	PROFILE DESCRIPTION	Field pH	Effervescence	Proportion Coarse Fragments 0 0.5 1	Moisture	Field ECe (dS/m)	SAMPLE
	A		Red sandy clay loam with moderate grade of subangular blocky structure and ped size of 3 cm breaking to 1 cm. Soil is slightly dispersive, partially slakes, has a poor to moderate SOILpak score and has an average number of roots present.	5	Nil		Moist		
	BC		Red sandy clay loam with moderate grade of polyhedral structure and ped size of 0.5. Soil is not dispersive, partially slakes, has a poor to moderate SOILpak score and has few roots present.	6.5	Nil		Dry		
	C		Red sandy clay loam with weak grade of polyhedral structure and ped size of 0.5. Soil is not dispersive, partially slakes, has a poor to moderate SOILpak score and has few roots present.	7	Nil		Dry		
50			COMMENTS: Hectares of scalded land around this site. Bottom of hole at 50						
100									

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TEST HOLE OF114

Date Excavated: 17/6/21
Logged by: PJH Datum: WGS84
Easting: 434635 Northing: 6437205
Surface Elevation(m): 305.8
Equipment: Excavator

Australian Soil Class: Red-Orthic Tenosol
Annual Crop Rootzone (cm): 60
Plant Available Water (mm): 66
Drainage: Well drained
Estimated Permeability: 5 to 50 mm/day

Geology: Mudstone?
Landuse: Naturalised pasture
Surface condition: Soft Wet
Surface gravel: 10% angular medium gravel
Outcrop: None

DEPTH (centimetres)	Horizon	GRAPHIC LOG	PROFILE DESCRIPTION	Field pH	Effervescence	Proportion Coarse Fragments 0 0.5 1	Moisture	Field ECe (dS/m)	SAMPLE
	A		Red sandy clay loam with weak grade of subangular blocky structure and ped size of 1 cm breaking to 0.5 cm. Soil is not dispersive, partially slakes, has a good SOILpak score and has abundant roots present.	8	Nil		Moist		
	B		Red light clay with moderate grade of subangular blocky structure and ped size of 3 cm breaking to 1 cm. Soil is not dispersive, doesn't slake, has a moderate to good SOILpak score and has many roots present.	8	Nil		Dry		
50	BC		Red light clay with strong grade of angular blocky structure and ped size of 0.5. Soil is not dispersive, doesn't slake, has a poor SOILpak score and has few roots present.	8	Nil		Dry		
	C		Red light clay with strong grade of angular blocky structure and ped size of 0.5. Soil is not dispersive, completely slakes, has a poor SOILpak score and has few roots present.	8	Nil		Dry		
100			COMMENTS: Cryptogram crust. Topsoil appears to be water repellent. Coarse fragments angular gravel of mudstone or very fine sandstone. Bottom of hole at 90						

Landscape Properties

Landscape position: Midslope
Microrelief: No microrelief
Erosion: Stabilised
Vegetation: White Cypress, Mallee (or Gum), Kurrajong, Wilga

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TEST HOLE OF115

Date Excavated: 17/6/21
Logged by: PJH Datum: WGS84
Easting: 435417 Northing: 6436957
Surface Elevation(m): 304.6
Equipment: Excavator

Australian Soil Class: Leptic Rudosol
Annual Crop Rootzone (cm): _
Plant Available Water (mm): 0
Drainage: _____
Estimated Permeability: _____

Geology: Sandstone
Landuse: Naturalised pasture
Surface condition: Firm Moist
Surface gravel: 80% coarse gravel to cobbles
Outcrop: 20% sandstone

DEPTH (centimetres)	Horizon	GRAPHIC LOG	PROFILE DESCRIPTION	Field pH	Effervescence	Proportion Coarse Fragments 0 0.5 1	Moisture	Field ECe (dS/m)	SAMPLE
			COMMENTS: Observation site. Outcrop is vertically bedded finely laminated sandstone. There is a 1.5 m deep gully at 435357 E 6436993 N. There is rock outcrop at 435434 E 6436933 N. Bottom of hole at 0						
50									
100									

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Landscape Properties

Landscape position: Midslope
Microrelief: No microrelief
Erosion: Partly stabilised Sheet
Vegetation: White Cypress, some Mallee

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TEST HOLE OF116

Date Excavated: 17/6/21
Logged by: PJH Datum: WGS84
Easting: 433939 Northing: 6436318
Surface Elevation(m): 335.2
Equipment: Excavator

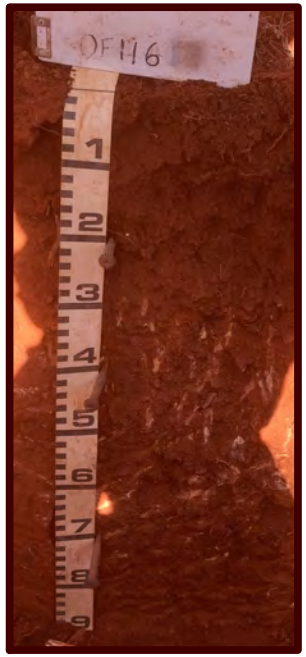
Australian Soil Class: Red Dermosol
Annual Crop Rootzone (cm): 50
Plant Available Water (mm): 49
Drainage: Moderately well drained
Estimated Permeability: 5 to 50 mm/day

Geology: Colluvium
Landuse: Naturalised pasture
Surface condition: Soft Wet
Surface gravel: 20% fine to coarse subangular gravel
Outcrop: None

DEPTH (centimetres)	Horizon	GRAPHIC LOG	PROFILE DESCRIPTION	Field pH	Effervescence	Proportion Coarse Fragments 0 0.5 1	Moisture	Field ECe (dS/m)	SAMPLE
	A		Red sandy clay loam with moderate grade of subangular blocky structure and ped size of 2 cm breaking to 0.5 cm. Soil is not dispersive, partially slakes, has a good SOILpak score and has many roots present.	5	Nil		Moist		
	2A		Red clay loam with moderate grade of subangular blocky structure and ped size of 1 cm breaking to 0.5 cm. Soil is not dispersive, completely slakes, has a moderate SOILpak score and has an average number of roots present.	5	Nil		Moist		
50	2B22		Red light clay with strong grade of polyhedral structure and ped size of 3 cm breaking to 1 cm. Soil is not dispersive, completely slakes, has a poor SOILpak score and has few roots present.	4.5	Nil		Dry		
	2B23		Red light clay with strong grade of polyhedral structure and ped size of 3 cm breaking to 1 cm. Soil is moderately dispersive, completely slakes, has a poor SOILpak score and has few roots present.	4.5	Nil		Dry		
100			COMMENTS: Coarse fragments are subangular medium to coarse gravel of quartz and sandstone. Buried profile appears to have been an eroded surface. Top soil could be parna. Bottom of hole at 90						

Landscape Properties

Landscape position: Flat
Microrelief: No microrelief
Erosion: Stabilised
Vegetation: Mallee/Spinifex, Some White Cypress, No other understorey



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TEST HOLE OF117

Date Excavated: 17/6/21
Logged by: PJH Datum: WGS84
Easting: 433391 Northing: 6436579
Surface Elevation(m): 326.2
Equipment: Excavator

Australian Soil Class: Red Dermosol
Annual Crop Rootzone (cm): 60
Plant Available Water (mm): 76
Drainage: Moderately well drained
Estimated Permeability: 5 to 50 mm/day

Geology: Colluvium
Landuse: Naturalised pasture
Surface condition: Firm Moist
Surface gravel: 20% rounded fine to coarse gravel
Outcrop: None

Landscape Properties

Landscape position: Flat
Microrelief: No microrelief
Erosion: Stabilised
Vegetation: Gum, Wattle

DEPTH (centimetres)	Horizon	GRAPHIC LOG	PROFILE DESCRIPTION	Field pH	Effervescence	Proportion Coarse Fragments 0 0.5 1	Moisture	Field ECe (dS/m)	SAMPLE
	A11		Red clay loam with strong grade of subangular blocky structure and ped size of 1 cm breaking to 0.5 cm. Soil is not dispersive, completely slakes, has a moderate to good SOILpak score and has abundant roots present.	4.5	Nil		Moist		
	A12		Red light clay with moderate grade of subangular blocky structure and ped size of 5 cm breaking to 1 cm. Soil is slightly dispersive, completely slakes, has a moderate SOILpak score and has many roots present.	4.5	Nil		Moist		
	2A		Red light clay with moderate grade of subangular blocky structure and ped size of 2 cm breaking to 0.5 cm. Soil is not dispersive, partially slakes, has a poor to moderate SOILpak score and has an average number of roots present.	5	Nil		Moist		
50									
	2B		Red light clay with strong grade of polyhedral structure and ped size of 3 cm breaking to 0.5 cm. Soil is not dispersive, partially slakes, has a moderate SOILpak score and has few roots present.	5.5	Nil		Dry		
			COMMENTS: A12 subplastic CL to LC. Coarse fragments in 2A and 2B subrounded fine to coarse gravel. Good soil structure. Firm moist, Cryptogram crust. Bottom of hole at 90						
100									

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5 Lawson St
Warren, NSW, 2824
+61 2 68473367 Fax: +61 2 68473401

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TEST HOLE OF118

Date Excavated: 17/6/21
Logged by: PJH Datum: WGS84
Easting: 435005 Northing: 6446915
Surface Elevation(m): 357.6
Equipment: Excavator

Australian Soil Class: Red Dermosol
Annual Crop Rootzone (cm): 70
Plant Available Water (mm): 103
Drainage: Moderately well drained
Estimated Permeability: 5 to 50 mm/day

Geology: Colluvium
Landuse: Naturalised pasture
Surface condition: Firm Moist
Surface gravel: None
Outcrop: None

Landscape Properties

Landscape position: Flat
Microrelief: No microrelief
Erosion: Stabilised
Vegetation: White Cypress, Bimble Box, Corkscrew Grass, Bogan Flea, Copper Burr

DEPTH (centimetres)	Horizon	GRAPHIC LOG	PROFILE DESCRIPTION	Field pH	Effervescence	Proportion Coarse Fragments 0 0.5 1	Moisture	Field ECe (dS/m)	SAMPLE
	A11		Red sandy clay loam with moderate grade of subangular blocky structure and ped size of 2 cm breaking to 0.5 cm. Soil is moderately dispersive, completely slakes, has a moderate SOILpak score and has abundant roots present.	4.5	Nil		Moist		
	A12		Red light clay with moderate grade of subangular blocky structure and ped size of 5 cm breaking to 1 cm. Soil is slightly dispersive, partially slakes, has a moderate SOILpak score and has many roots present.	4.5	Nil		Trace		
50	A2		Red light clay with weak grade of subangular blocky structure and ped size of 5 cm breaking to 1 cm. Soil is slightly dispersive, completely slakes, has a poor to moderate SOILpak score and has few roots present.	4.5	Nil		Dry		
	B2		Red light medium clay with strong grade of polyhedral structure and ped size of 10 cm breaking to 0.5 cm. Soil is slightly dispersive, completely slakes, has a moderate SOILpak score and has few roots present.	5	Nil		Dry		
	B23		Red light medium clay with strong grade of platy structure and ped size of 1. Soil is slightly dispersive, completely slakes, has a poor SOILpak score and has no roots present.	5.5	Nil		Dry		
100			COMMENTS: Cryptogram crust. A2 dry colour 2.5YR 5/6. Mangans in B23. This indicates site prone to flooding. Refusal at 80 cm. Bottom of hole at 90						

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5 Lawson St
Warren, NSW, 2824
+61 2 68473367 Fax: +61 2 68473401

Aurelia Metals Federation EIS
Cr474

TEST HOLE OF119

Date Excavated: 17/6/21
Logged by: PJH Datum: WGS84
Easting: 435166 Northing: 6446837
Surface Elevation(m): 316.1
Equipment: Excavator

Australian Soil Class: Red Dermosol
Annual Crop Rootzone (cm): 50
Plant Available Water (mm): 64
Drainage: Well drained
Estimated Permeability: 5 to 50 mm/day

Geology: Colluvium
Landuse: Naturalised pasture
Surface condition: Soft Wet
Surface gravel: 2% fine quartz gravel.
Outcrop: None

DEPTH (centimetres)	Horizon	GRAPHIC LOG	PROFILE DESCRIPTION	Field pH	Effervescence	Proportion Coarse Fragments 0 0.5 1	Moisture	Field ECe (dS/m)	SAMPLE
	A11		Red silty clay loam with moderate grade of subangular blocky structure and ped size of 5 cm breaking to 1 cm. Soil is slightly dispersive, partially slakes, has a moderate SOILpak score and has many roots present.	4.5	Nil		Moist		
	A12		Red silty clay loam with moderate grade of subangular blocky structure and ped size of 5 cm breaking to 1 cm. Soil is slightly dispersive, completely slakes, has a moderate SOILpak score and has many roots present.	4.5	Nil		Moist		
50	2A		Red sandy loam with weak grade of angular blocky structure and ped size of 10 cm breaking to 1 cm. Soil is not dispersive, completely slakes, has a poor to moderate SOILpak score and has few roots present.	5	Nil		Dry		
	2B		Red clayey sand with weak grade of angular blocky structure and ped size of 5 cm breaking to 1 cm. Soil is not dispersive, completely slakes, has a poor SOILpak score and has few roots present.	5.5	Nil		Dry		
100			COMMENTS: Cryptogram crust. Coarse fragments in 2A are fine subrounded gravel. This site dose not appear to get flooded, but drainage line at 435156 E 6446797 N (40 m south of pit). Refusal at 80 cm. Bottom of hole at 80						

Landscape Properties

Landscape position: Midslope
Microrelief: No microrelief
Erosion: Stabilised
Vegetation: White Cypress, Corkscrew Grass, Panicum

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TEST HOLE OF120

Date Excavated: 17/6/21
Logged by: PJH Datum: WGS84
Easting: 435301 Northing: 6446904
Surface Elevation(m): 309.8
Equipment: Excavator

Australian Soil Class: Red Dermosol
Annual Crop Rootzone (cm): 40
Plant Available Water (mm): 58
Drainage: Well drained
Estimated Permeability: 5 to 50 mm/day

Geology: Colluvium
Landuse: Naturalised pasture
Surface condition: Soft Wet
Surface gravel: None
Outcrop: None

DEPTH (centimetres)	Horizon	GRAPHIC LOG	PROFILE DESCRIPTION	Field pH	Effervescence	Proportion Coarse Fragments 0 0.5 1	Moisture	Field ECe (dS/m)	SAMPLE
	A11		Black sandy clay loam with strong grade of subangular blocky structure and ped size of 3 cm breaking to 0.5 cm. Soil is not dispersive, doesn't slake, has a moderate SOILpak score and has an average number of roots present.	4.5	Nil		Moist		
	A12		Red light clay with moderate grade of subangular blocky structure and ped size of 5 cm breaking to 1 cm. Soil is not dispersive, completely slakes, has a moderate SOILpak score and has few roots present.	4.5	Nil		Moist		
50	B1		Red light clay with moderate grade of polyhedral structure and ped size of 5 cm breaking to 1 cm. Soil is not dispersive, completely slakes, has a moderate SOILpak score and has few roots present.	5	Nil		Dry		
	B2		Red sandy clay with moderate grade of polyhedral structure and ped size of 10 cm breaking to 1 cm. Soil is not dispersive, completely slakes, has a poor to moderate SOILpak score and has few roots present.	5.5	Nil		Dry		
100			COMMENTS: Cryptogram Crust. a11 subplastic (SCL-LC). Coarse fragments in B2 fine to medium subangular quartz gravel. Bottom of hole at 80						

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Warren, NSW, 2824
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Landscape Properties

Landscape position: Upper Slope
Microrelief: No microrelief
Erosion: Stabilised
Vegetation: White Cypress, Bimble Box, Corkscrew Grass, Panicum

Aurelia Metals Federation EIS
Cr474

TEST HOLE OF121

Date Excavated: 18/6/21
Logged by: PJH Datum: WGS84
Easting: 435345 Northing: 6446802
Surface Elevation(m): 308.4
Equipment: Excavator

Australian Soil Class: Red Dermosol
Annual Crop Rootzone (cm): 60
Plant Available Water (mm): 85
Drainage: Moderately well drained
Estimated Permeability: 5 to 50 mm/day

Geology: Fine Sandstone
Landuse: Naturalised pasture
Surface condition: Soft Wet
Surface gravel: None
Outcrop: None

DEPTH (centimetres)	Horizon	GRAPHIC LOG	PROFILE DESCRIPTION	Field pH	Effervescence	Proportion Coarse Fragments 0 0.5 1	Moisture	Field ECe (dS/m)	SAMPLE
	A11		Red light clay with moderate grade of subangular blocky structure and ped size of 5 cm breaking to 1 cm. Soil is moderately dispersive, doesn't slake, has a moderate to good SOILpak score and has many roots present.	4.5	Nil		Moist		
	A12		Red light clay with moderate grade of subangular blocky structure and ped size of 10 cm breaking to 1 cm. Soil is moderately dispersive, partially slakes, has a moderate SOILpak score and has an average number of roots present.	4.5	Nil		Trace		
	B2		Red light clay with strong grade of polyhedral structure and ped size of 5 cm breaking to 1 cm. Soil is not dispersive, completely slakes, has a moderate SOILpak score and has few roots present.	4.5	Nil		Dry		
50	BC		Red light clay with strong grade of polyhedral structure and ped size of 5 cm breaking to 1 cm. Soil is not dispersive, completely slakes, has a moderate SOILpak score and has few roots present.	5	Nil		Dry		
100			COMMENTS: Cryptogram crust. Coarse fragments in BC are medium to coarse gravel of fine sandstone and quartz. Bottom of hole at 100						

Landscape Properties

Landscape position: Midslope
Microrelief: No microrelief
Erosion: Stabilised

Vegetation: White Cypress, Box with Mallee, Farm Crows Foot, Corkscrew, Panic

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5 Lawson St
Warren, NSW, 2824
+61 2 68473367 Fax: +61 2 68473401

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TEST HOLE OF122

Date Excavated: 18/6/21
Logged by: PJH Datum: WGS84
Easting: 435558 Northing: 6446897
Surface Elevation(m): 306.9
Equipment: Excavator

Australian Soil Class: Red Dermosol
Annual Crop Rootzone (cm): 70
Plant Available Water (mm): 104
Drainage: Well drained
Estimated Permeability: 5 to 50 mm/day

Geology: Colluvium
Landuse: Naturalised pasture
Surface condition: Soft Wet
Surface gravel: 5% fine gravel of angular quartz and fine sandstone
Outcrop: None

DEPTH (centimetres)	Horizon	GRAPHIC LOG	PROFILE DESCRIPTION	Field pH	Effervescence	Proportion Coarse Fragments 0 0.5 1	Moisture	Field ECe (dS/m)	SAMPLE
	A11		Red light clay with moderate grade of subangular blocky structure and ped size of 5 cm breaking to 1 cm. Soil is slightly dispersive, partially slakes, has a moderate to good SOILpak score and has abundant roots present.	5	Nil		Moist		
	A12		Red light clay with moderate grade of polyhedral structure and ped size of 5 cm breaking to 1 cm. Soil is moderately dispersive, completely slakes, has a moderate to good SOILpak score and has many roots present.	5	Nil		Moist		
	B22		Red light clay with moderate grade of polyhedral structure and ped size of 10 cm breaking to 1 cm. Soil is not dispersive, completely slakes, has a moderate SOILpak score and has an average number of roots present.	6.5	Nil		Trace		
50	B23		Black light clay with strong grade of angular blocky structure and ped size of 5 cm breaking to 1 cm. Soil is not dispersive, completely slakes, has a poor to moderate SOILpak score and has few roots present.	8	Nil		Dry		
			COMMENTS: Cryptogram crust. Box Trees 15to 20 m tall. Coarse fragments in B23 are coarse angular quartz gravel. Bottom of hole at 90						
100									

Landscape Properties

Landscape position: Upper Slope
Microrelief: No microrelief
Erosion: Stabilised
Vegetation: White Cypress, Bimble Box?

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5 Lawson St
Warren, NSW, 2824
+61 2 68473367 Fax: +61 2 68473401

APPENDIX II:

Results of Soil Tests from Nutrient Advantage Laboratories.

Table 1. Suitability for Wheat Production. Results of soil tests performed by Incitec/Pivot Laboratories on samples collected from Federation Project in June, 2021.

DRYLAND WHEAT RATING — Very Low | Low | Moderately low | OK | Moderately high | High

Pit	OA001	OA001	OA001	OA001	OA001	OA002	OA002	OA002	OA002	OA002	OA003	OA003	OA003	OA003	OA003
Depth (cm)	**0 to 5**	**5 to 15**	**15 to 30**	**30 to 60**	**60 to 100**	**0 to 5**	**5 to 15**	**15 to 30**	**30 to 60**	**60 to 100**	**0 to 5**	**5 to 15**	**15 to 30**	**30 to 60**	**60 to 80**
Colour	Red	Red				Red	Red				Red	Red			
Texture															
CEC (meq/100g)	7.0	7.7	7.8	9.5	21.2	9.8	7.8	6.6	6.0	13.3	12.0	9.2	8.0	17.1	21.2
pH water	6.2	5.3	5.4	6.3	7.6	7.3	7.0	6.7	6.8	7.1	6.8	6.4	6.8	7.0	7.2
pH $CaCl_2$	5.0	4.4	4.4	5.2	6.8	6.2	5.9	5.4	5.5	5.8	5.9	5.4	6.0	6.1	6.5
Organic C (%)	0.8	0.7				0.8	0.5				1.7	0.8			
Nitrate N (mg/kg)	1.3	13	10	4.9	1.9	0.7	0.9	0.7	0.5	0.5	4.6	4.6	16	11	20
Phosphorus Colwell (mg/kg)	9.0	5.0				5.0	5.0				5.0	5.0			
Phosphorus BSES (mg/kg)															
Phosphorus Buffer Index	110	80				62	54				62	58			
Sulphate S-KCl (mg/kg)	2.0	4.0				1.0	1.0				3.0	4.0			
Sulphate S-MCP (mg/kg)															
Potassium (meq/100 g)	0.9	0.7	0.6	0.4	0.7	0.9	0.8	0.6	0.5	0.4	1.1	0.8	0.6	0.8	0.9
Calcium (meq/100 g)	3.9	4.2	4.2	5.3	11	6.5	4.9	3.7	3.0	4.8	7.8	5.9	4.9	10	12
Magnesium (meq/100 g)	2.0	2.2	2.4	3.5	8.8	2.2	2.0	2.1	2.3	6.9	2.9	2.3	2.3	5.9	7.8
Aluminium (meq/100 g)	0.2	0.5	0.5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Sodium (meq/100 g)	0.0	0.1	0.1	0.2	0.6	0.0	0.1	0.0	0.1	1.1	0.1	0.1	0.1	0.2	0.4
Chloride (mg/kg)	10	10	10	13	10	10	10	10	10	21	10	10	12	16	59
Electrical Conductivity $_{(1:5)}$	0.0	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.1	0.1	0.1
Electrical Conductivity$_{se}$ (dS/m)	0.1	0.3				0.2	0.1				0.3	0.2			
Copper (mg/kg)	0.8	0.7				0.7	0.7				0.5	0.4			
Zinc (mg/kg)	0.7	0.1				0.5	0.2				0.2	0.1			
Manganese (mg/kg)	16	23				16	18				10	10			
Iron (mg/kg)	11	15				8	8				13	14			
Boron (mg/kg)	0.6	0.8				1.1	0.9				1.3	1.1			
Percentages of Exchangeable Cations															
ECaP (Calcium)	56.0%	54.9%	54.0%	55.6%	51.9%	66.7%	62.5%	56.5%	50.2%	36.2%	65.3%	64.3%	61.4%	58.6%	56.7%
EMgP (Magnesium)	28.7%	28.8%	30.8%	36.7%	41.5%	22.6%	25.5%	32.1%	38.5%	52.1%	24.3%	25.1%	28.8%	34.6%	36.9%
EKP (Potassium)	12.2%	9.2%	7.5%	4.5%	3.3%	9.3%	9.9%	9.3%	8.0%	2.6%	9.2%	9.0%	7.6%	4.9%	4.3%
ESP (Sodium)	0.3%	0.7%	1.3%	2.1%	2.8%	0.4%	0.8%	0.6%	1.7%	8.3%	0.4%	0.5%	0.9%	1.3%	1.7%
EAlP (Aluminium)	2.9%	6.5%	6.4%	1.0%	0.5%	1.0%	1.3%	1.5%	1.7%	0.8%	0.8%	1.1%	1.3%	0.6%	0.5%
Ca/Mg ratio	2.0	1.9	1.8	1.5	1.3	3.0	2.5	1.8	1.3	0.7	2.7	2.6	2.1	1.7	1.5
K/Mg ratio															
ESI	0.07	0.08	0.04	0.02	0.04	0.07	0.03	0.02	0.01	0.01	0.12	0.07	0.07	0.06	0.08

Table 1. Suitability for Wheat Production. Results of soil tests performed by Incitec/Pivot Laboratories on samples collected from Federation Project in June, 2021.

DRYLAND WHEAT RATING — Very Low | Low | Moderately low | OK | Moderately high | High

Pit	OA004	OA004	OA004	OA004	OA004	OA005	OA005	OA005	OA005	OF101	OF101	OF101
Depth (cm)	0 to 5	5 to 15	15 to 30	30 to 60	60 to 100	0 to 5	5 to 15	15 to 30	30 to 60	0 to 5	5 to 15	15 to 30
Colour	Red	Red				Red	Orange/Yellow			Brown	Brown	
Texture												
CEC (meq/100g)	7.9	8.8	8.7	8.8	15.6	9.2	7.2	6.8	13.6	8.0	5.9	5.7
pH water	6.4	6.8	7.0	7.6	8.4	6.7	6.6	6.4	6.7	6.7	5.7	5.7
pH $CaCl_2$	5.2	5.6	5.8	6.6	7.5	5.7	5.6	5.4	5.4	5.5	4.6	4.6
Organic C (%)	0.8	0.6				1.2	0.7			1.4	1.0	
Nitrate N (mg/kg)	1.0	0.8	1.0	1.0	1.0	7.7	4.6	9.0	4.5	2.5	1.2	1.1
Phosphorus Colwell (mg/kg)	6.0	5.0				5.0	5.0			5.0	5.0	
Phosphorus BSES (mg/kg)												
Phosphorus Buffer Index	59	52				56	48			48	44	
Sulphate S-KCl (mg/kg)	2.0	1.0				3.0	2.0			3.0	13	
Sulphate S-MCP (mg/kg)												
Potassium (meq/100 g)	1.3	1.5	1.1	0.9	1.0	0.9	0.6	0.6	0.5	0.5	0.3	0.3
Calcium (meq/100 g)	4.8	5.4	5.6	5.6	8.6	5.9	4.6	4.2	5.8	5.5	3.7	3.4
Magnesium (meq/100 g)	1.7	1.8	1.9	2.2	5.7	2.2	1.9	1.9	6.5	1.8	1.7	1.7
Aluminium (meq/100 g)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2
Sodium (meq/100 g)	0.0	0.0	0.0	0.1	0.2	0.0	0.0	0.0	0.7	0.1	0.1	0.1
Chloride (mg/kg)	10	10	10	10	10	10	10	10	12	10	10	10
Electrical Conductivity ($_{1:5}$)	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0
Electrical Conductivity$_{se}$ (dS/m)	0.1	0.1				0.2	0.2			0.2	0.3	
Copper (mg/kg)	0.9	0.8				0.7	0.5			0.6	0.6	
Zinc (mg/kg)	0.3	0.2				0.3	0.2			7.1	0.3	
Manganese (mg/kg)	19	17				16	6.4			14	21	
Iron (mg/kg)	12	9.1				16	20			19	29	
Boron (mg/kg)	0.8	0.8				1.2	0.8			0.8	0.8	
Percentages of Exchangeable												
ECaP (Calcium)	60.6%	61.2%	64.1%	63.3%	55.3%	64.5%	63.5%	61.6%	42.6%	69.2%	62.5%	59.5%
EMgP (Magnesium)	21.5%	20.4%	21.7%	24.9%	36.6%	24.0%	26.2%	27.9%	47.8%	22.6%	28.7%	29.8%
EKP (Potassium)	16.4%	17.0%	12.6%	10.1%	6.4%	10.1%	8.4%	8.7%	3.6%	6.0%	5.4%	5.8%
ESP (Sodium)	0.3%	0.3%	0.5%	0.6%	1.1%	0.3%	0.4%	0.4%	5.2%	0.9%	1.7%	1.4%
EAlP (Aluminium)	1.3%	1.1%	1.1%	1.1%	0.6%	1.1%	1.4%	1.5%	0.7%	1.3%	1.7%	3.5%
Ca/Mg ratio	2.8	3.0	2.9	2.5	1.5	2.7	2.4	2.2	0.9	3.1	2.2	2.0
K/Mg ratio												
ESI	0.08	0.06	0.04	0.05	0.05	0.12	0.07	0.09	0.01	0.02	0.02	0.02

Table 1. Suitability for Wheat Production. Results of soil tests performed by Incitec/Pivot Laboratories on samples collected from Federation Project in June, 2021.

DRYLAND WHEAT RATING — Very Low | Low | Moderately low | OK | Moderately high | High

Pit	OF103	OF103	OF103	OF103	OF103	OF104	OF104	OF104	OF106	OF106	OF106	OF106	OF106
Depth (cm)	0 to 5	5 to 15	15 to 30	30 to 60	60 to 90	0 to 5	5 to 15	15 to 30	0 to 5	5 to 15	15 to 30	30 to 60	60 to 90
Colour	Orange/Yellow	Orange/Yellow				Brown	Brown		Orange/Yellow	Orange/Yellow			
Texture													
CEC (meq/100g)	6.3	7.0	7.9	8.9	9.5	5.5	5.9	5.7	6.8	6.1	6.8	8.4	16.7
pH water	6.3	6.3	6.7	7.3	7.7	6.8	6.7	6.9	6.4	5.9	6.4	6.8	8.5
pH $CaCl_2$	5.1	5.1	5.6	6.3	6.6	5.5	5.4	5.7	5.1	4.6	5.1	6.0	7.9
Organic C (%)	1.0	0.4				0.8	0.7		0.9	0.5			
Nitrate N (mg/kg)	5.6	1.4	6.7	5.7	2.4	6.4	3.5	2.9	2.3	1.3	1.1	9.1	2.9
Phosphorus Colwell (mg/kg)	8.0	5.0				9.0	5.0		9.0	5.0			
Phosphorus BSES (mg/kg)													
Phosphorus Buffer Index	53	52				31	26		62	64			
Sulphate S-KCl (mg/kg)	1.0	5.0				2.0	3.0		2.0	4.0			
Sulphate S-MCP (mg/kg)													
Potassium (meq/100 g)	1.1	1.2	1.0	0.7	0.7	1.4	1.5	1.2	1.1	1.0	1.0	0.8	0.9
Calcium (meq/100 g)	4.0	4.5	5.2	5.8	6.0	2.5	2.7	2.7	4.1	3.6	4.2	5.5	13
Magnesium (meq/100 g)	1.1	1.2	1.6	2.2	2.6	1.5	1.6	1.6	1.5	1.3	1.5	1.9	2.6
Aluminium (meq/100 g)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1
Sodium (meq/100 g)	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.1
Chloride (mg/kg)	10	10	10	10	10	10	10	11	10	10	10	10	10
Electrical Conductivity ($_{1:5}$)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Electrical Conductivity$_{se}$ (dS/m)	0.2	0.2				0.3	0.2		0.1	0.1			
Copper (mg/kg)	1.2	1.0				0.6	0.7		0.9	0.9			
Zinc (mg/kg)	0.7	0.1				0.5	0.2		0.4	0.1			
Manganese (mg/kg)	22	16				13	12		26	39			
Iron (mg/kg)	21	12				38	40		18	18			
Boron (mg/kg)	0.7	0.7				1.2	1.6		0.7	0.8			
Percentages of Exchangeable													
ECaP (Calcium)	63.3%	64.1%	65.9%	65.4%	63.1%	45.3%	45.5%	47.8%	60.0%	58.8%	61.6%	65.9%	77.9%
EMgP (Magnesium)	17.4%	17.1%	20.3%	24.8%	27.3%	27.2%	26.9%	28.3%	22.0%	21.2%	22.0%	22.8%	15.6%
EKP (Potassium)	17.4%	17.1%	12.2%	8.0%	7.3%	25.4%	25.3%	21.2%	16.1%	16.3%	14.5%	9.5%	5.3%
ESP (Sodium)	0.3%	0.3%	0.4%	0.7%	1.3%	0.4%	0.7%	0.9%	0.4%	0.3%	0.4%	0.7%	0.6%
EAlP (Aluminium)	1.6%	1.4%	1.3%	1.1%	1.1%	1.8%	1.7%	1.8%	1.5%	3.3%	1.5%	1.2%	0.6%
Ca/Mg ratio	3.6	3.8	3.3	2.6	2.3	1.7	1.7	1.7	2.7	2.8	2.8	2.9	5.0
K/Mg ratio													
ESI	0.09	0.11	0.08	0.03	0.02	0.11	0.06	0.05	0.05	0.06	0.05	0.10	0.20

Table 1. Suitability for Wheat Production. Results of soil tests performed by Incitec/Pivot Laboratories on samples collected from Federation Project in June, 2021.

DRYLAND WHEAT RATING — Very Low | Low | Moderately low | OK | Moderately high | High

Pit	OF107	OF107	OF107	OF107	OF107	OF108	OF108	OF108	OF108	OF108	OF109	OF109	OF109	OF109	OF109
Depth (cm)	0 to 5	5 to 15	15 to 30	30 to 60	60 to 90	0 to 5	5 to 15	15 to 30	30 to 60	60 to 90	0 to 5	5 to 15	15 to 30	30 to 60	60 to 90
Colour	Orange/Yellow	Orange/Yellow				Orange/Yellow	Orange/Yellow				Brown	Brown			
Texture															
CEC (meq/100g)	10.0	10.5	8.0	16.8	15.8	6.3	5.3	4.9	5.2	22.6	3.8	8.0	4.8	3.5	4.2
pH water	7.6	7.5	7.2	7.2	7.2	6.2	6.1	5.5	5.7	8.2	5.2	4.9	5.0	5.0	5.3
pH $CaCl_2$	6.5	6.6	6.6	6.7	6.7	5.1	4.8	4.2	4.3	7.2	4.1	3.9	3.9	4.1	4.1
Organic C (%)	1.0	0.9				1.2	0.8				1.9	1.7			
Nitrate N (mg/kg)	3.4	4.5	26	72	56	1.9	1.3	0.5	0.5	0.5	2.2	2.1	4.4	8.4	4.1
Phosphorus Colwell (mg/kg)	7.0	5.0				6.0	5.0				5.0	5.0			
Phosphorus BSES (mg/kg)															
Phosphorus Buffer Index	62	51				36	50				66	120			
Sulphate S-KCl (mg/kg)	2.0	4.0				2.0	1.0				2.0	6.0			
Sulphate S-MCP (mg/kg)															
Potassium (meq/100 g)	1.7	1.5	0.8	0.9	0.7	0.9	0.8	0.6	0.5	1.1	0.7	2.7	0.6	0.4	0.4
Calcium (meq/100 g)	6.0	6.8	5.2	10	9.0	3.8	3.0	2.3	2.2	7.3	1.0	0.8	0.7	0.8	0.2
Magnesium (meq/100 g)	2.2	2.0	1.8	5.5	5.6	1.5	1.3	1.2	1.6	11	0.4	0.1	0.5	0.8	2.0
Aluminium (meq/100 g)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.8	0.8	0.1	1.7	2.8	3.0	1.5	1.5
Sodium (meq/100 g)	0.0	0.1	0.1	0.4	0.4	0.0	0.0	0.0	0.1	3.1	0.0	1.6	0.1	0.0	0.1
Chloride (mg/kg)	10	10	47	170	150	10	10	10	10	170	10	10	10	10	10
Electrical Conductivity ($_{1:5}$)	0.0	0.1	0.1	0.3	0.3	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0
Electrical Conductivity$_{se}$ (dS/m)	0.2	0.4				0.2	0.2				0.2	0.3			
Copper (mg/kg)	0.4	0.4				0.6	0.6				0.3	0.2			
Zinc (mg/kg)	0.2	0.2				0.6	0.2				0.3	0.1			
Manganese (mg/kg)	6.3	6.3				15	11				8.8	2.1			
Iron (mg/kg)	9.8	8.7				48	30				150	160			
Boron (mg/kg)	2.3	2.3				0.9	0.9				0.6	0.7			
Percentages of Exchangeable															
ECaP (Calcium)	59.9%	65.1%	64.8%	59.5%	57.0%	60.4%	57.0%	46.6%	42.6%	32.3%	26.3%	10.0%	14.6%	22.9%	4.8%
EMgP (Magnesium)	22.0%	19.1%	22.4%	32.7%	35.5%	23.8%	24.7%	24.3%	31.0%	48.7%	10.5%	1.3%	10.4%	22.9%	48.1%
EKP (Potassium)	17.0%	14.4%	10.3%	5.1%	4.4%	13.8%	16.0%	12.6%	9.7%	4.9%	17.9%	33.8%	11.6%	10.6%	9.4%
ESP (Sodium)	0.2%	0.5%	1.2%	2.1%	2.4%	0.3%	0.4%	0.4%	1.2%	13.7%	0.5%	20.0%	1.0%	0.9%	1.7%
EAlP (Aluminium)	1.0%	1.0%	1.2%	0.6%	0.6%	1.6%	1.9%	16.2%	15.5%	0.4%	44.7%	35.0%	62.4%	42.9%	36.1%
Ca/Mg ratio	2.7	3.4	2.9	1.8	1.6	2.5	2.3	1.9	1.4	0.7	2.5	8.0	1.4	1.0	0.1
K/Mg ratio															
ESI	0.20	0.13	0.11	0.14	0.11	0.09	0.05	0.05	0.02	0.02	0.04	0.00	0.04	0.05	0.02

Table 1. Suitability for Wheat Production. Results of soil tests performed by Incitec/Pivot Laboratories on samples collected from Federation Project in June, 2021.

DRYLAND WHEAT RATING — Very Low | Low | Moderately low | OK | Moderately high | High

Pit	OF110	OF110	OF110	OF110	OF110	OF111	OF111	OF111	OF111	OF111	OF112	OF112	OF112
Depth (cm)	0 to 5	5 to 15	15 to 30	30 to 60	60 to 90	0 to 5	5 to 15	15 to 30	30 to 60	60 to 90	0 to 5	5 to 15	15 to 30
Colour	Orange/Yellow	Orange/Yellow				Orange/Yellow	Orange/Yellow				Brown	Brown	
Texture													
CEC (meq/100g)	6.9	6.7	8.3	11.5	17.9	6.1	6.5	7.1	7.3	16.7	6.7	6.2	6.2
pH water	6.2	5.9	6.1	7.6	7.2	6.5	6.5	6.6	6.6	8.5	6.0	5.3	5.3
pH $CaCl_2$	4.9	4.6	4.7	6.7	6.1	5.2	5.4	5.6	5.7	7.9	4.8	4.3	4.4
Organic C (%)	0.7	0.6				0.5	0.4				2.3	1.1	
Nitrate N (mg/kg)	2.1	1.0	1.0	0.5	1.0	0.9	4.2	19	12	22	5.6	8.4	14
Phosphorus Colwell (mg/kg)	11	5.0				11	7.0				12	5.0	
Phosphorus BSES (mg/kg)													
Phosphorus Buffer Index	76	70				60	60				61	54	
Sulphate S-KCl (mg/kg)	1.0	1.0				2.0	5.0				5.0	10.0	
Sulphate S-MCP (mg/kg)													
Potassium (meq/100 g)	0.9	0.8	0.9	0.6	1.2	1.1	1.2	1.2	0.9	1.1	0.9	0.7	0.6
Calcium (meq/100 g)	3.7	3.8	5.0	5.9	11	3.8	4.3	4.8	4.9	13.0	3.8	2.6	2.5
Magnesium (meq/100 g)	2.1	1.8	2.2	4.6	5.4	1.1	0.9	1.0	1.4	2.4	1.9	2.3	2.5
Aluminium (meq/100 g)	0.2	0.3	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.6	0.5
Sodium (meq/100 g)	0.0	0.0	0.1	0.2	0.2	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.1
Chloride (mg/kg)	15	10	10	25	10	10	10	10	10	11	10	18	24
Electrical Conductivity ($_{1:5}$)	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.1	0.1	0.2	0.0	0.1	0.1
Electrical Conductivity$_{se}$ (dS/m)	0.1	0.1				0.1	0.2				0.2	0.4	
Copper (mg/kg)	0.7	0.7				0.8	0.8				1.0	1.1	
Zinc (mg/kg)	0.3	0.1				0.3	0.1				1.6	0.1	
Manganese (mg/kg)	8.1	9.7				12	13				20	7.9	
Iron (mg/kg)	15	15				11	8.5				49	75	
Boron (mg/kg)	0.9	1.1				0.8	0.9				1.1	0.9	
Percentages of Exchangeable													
ECaP (Calcium)	53.8%	56.4%	60.0%	51.5%	61.3%	62.1%	65.7%	67.4%	66.9%	77.8%	56.7%	41.8%	40.4%
EMgP (Magnesium)	30.5%	26.7%	26.4%	40.2%	30.1%	18.0%	13.8%	14.0%	19.1%	14.4%	28.4%	37.0%	40.4%
EKP (Potassium)	12.4%	12.2%	10.4%	5.3%	6.7%	18.0%	18.3%	16.9%	12.2%	6.6%	13.1%	10.8%	8.9%
ESP (Sodium)	0.4%	0.3%	0.8%	2.1%	1.3%	0.3%	0.6%	0.3%	0.4%	0.7%	0.3%	0.8%	2.3%
EAlP (Aluminium)	2.9%	4.5%	2.4%	0.9%	0.6%	1.6%	1.5%	1.4%	1.4%	0.6%	1.5%	9.6%	8.1%
Ca/Mg ratio	1.8	2.1	2.3	1.3	2.0	3.5	4.8	4.8	3.5	5.4	2.0	1.1	1.0
K/Mg ratio													
ESI	0.05	0.03	0.01	0.03	0.04	0.06	0.05	0.18	0.12	0.23	0.10	0.07	0.03

Table 1. Suitability for Wheat Production. Results of soil tests performed by Incitec/Pivot Laboratories on samples collected from Federation Project in June, 2021.

DRYLAND WHEAT RATING — Very Low | Low | Moderately low | OK | Moderately high | High

Pit	OF113	OF113	OF113	OF113	OF114	OF114	OF114	OF114	OF114	OF116	OF116	OF116	OF116	OF116
Depth (cm)	0 to 5	5 to 15	15 to 30	30 to 50	0 to 5	5 to 15	15 to 30	30 to 60	60 to 100	0 to 5	5 to 15	15 to 30	30 to 60	60 to 90
Colour	Brown	Brown			Brown	Orange/Yellow				Orange/Yellow	Orange/Yellow			
Texture														
CEC (meq/100g)	7.8	9.9	11.4	6.9	18.9	12.3	12.0	14.2	10.1	8.7	7.1	6.1	8.8	16.1
pH water	6.7	6.6	7.9	7.8	8.3	8.1	8.1	8.6	8.6	7.1	6.8	6.5	6.9	8.0
pH $CaCl_2$	5.4	5.8	7.3	7.1	7.6	7.3	7.3	7.9	7.8	5.9	5.6	5.4	5.6	6.7
Organic C (%)	0.6	0.6			2.2	0.6				0.9	0.5			
Nitrate N (mg/kg)	1.5	17	39	28	4.6	4.0	2.5	7.1	2.1	1.8	1.7	2.1	2.7	1.4
Phosphorus Colwell (mg/kg)	10	7.0			6.0	5.0				5.0	5.0			
Phosphorus BSES (mg/kg)														
Phosphorus Buffer Index	44	36			82	79				75	60			
Sulphate S-KCl (mg/kg)	2.0	7.0			2.0	2.0				2.0	2.0			
Sulphate S-MCP (mg/kg)														
Potassium (meq/100 g)	0.9	0.8	0.3	0.3	1.4	1.2	1.2	1.5	1.1	0.9	0.8	0.6	0.8	1.6
Calcium (meq/100 g)	5.4	7.2	8.6	4.7	15	8.6	8.4	9.6	6.3	5.3	4.3	3.7	5.0	8.6
Magnesium (meq/100 g)	1.4	1.7	2.1	1.6	2.4	2.4	2.2	2.9	2.5	2.3	1.9	1.6	2.7	5.0
Aluminium (meq/100 g)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Sodium (meq/100 g)	0.0	0.1	0.3	0.2	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.1	0.2	0.8
Chloride (mg/kg)	10	10	27	20	10	17	10	12	10	10	10	10	10	18
Electrical Conductivity ($_{1:5}$)	0.0	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.1
Electrical Conductivity$_{se}$ (dS/m)	0.1	0.4			0.6	0.5				0.2	0.1			
Copper (mg/kg)	0.9	0.9			0.5	0.5				0.5	0.5			
Zinc (mg/kg)	0.5	0.3			0.3	0.1				0.1	0.1			
Manganese (mg/kg)	7.2	6.6			4.4	5.4				15	16			
Iron (mg/kg)	13	14			10	5.2				13	13			
Boron (mg/kg)	0.5	1.0			1.8	1.1				0.9	0.9			
Percentages of Exchangeable														
ECaP (Calcium)	69.2%	72.5%	75.6%	68.3%	79.3%	69.8%	70.3%	67.8%	62.6%	61.3%	60.4%	61.1%	56.6%	53.5%
EMgP (Magnesium)	17.9%	17.1%	18.5%	23.3%	12.7%	19.5%	18.4%	20.5%	24.9%	26.6%	26.7%	26.4%	30.6%	31.1%
EKP (Potassium)	11.2%	8.1%	2.7%	4.1%	7.4%	9.7%	10.0%	10.6%	10.9%	10.8%	11.1%	10.1%	9.4%	10.0%
ESP (Sodium)	0.4%	1.3%	2.4%	2.9%	0.1%	0.2%	0.4%	0.4%	0.6%	0.2%	0.4%	0.8%	2.3%	4.7%
EAlP (Aluminium)	1.3%	1.0%	0.9%	1.5%	0.5%	0.8%	0.8%	0.7%	1.0%	1.2%	1.4%	1.7%	1.1%	0.6%
Ca/Mg ratio	3.9	4.2	4.1	2.9	6.3	3.6	3.8	3.3	2.5	2.3	2.3	2.3	1.9	1.7
K/Mg ratio						0.5	0.5	0.5	0.4	0.4	0.4	0.4		
ESI	0.05	0.05	0.06	0.03	0.95	0.49	0.14	0.37	0.13	0.13	0.05	0.04	0.01	0.01

Table 1. Suitability for Wheat Production. Results of soil tests performed by Incitec/Pivot Laboratories on samples collected from Federation Project in June, 2021.

DRYLAND WHEAT RATING Very Low | Low | Moderately low | OK | Moderately high | High

Pit	OF118	OF118	OF118	OF118	OF118	OF121	OF121	OF121	OF121	OF121	OF122	OF122	OF122	OF122	OF122
Depth (cm)	0 to 5	5 to 15	15 to 30	30 to 60	60 to 90	0 to 5	5 to 15	15 to 30	30 to 60	60 to 90	0 to 5	5 to 15	15 to 30	30 to 60	60 to 90
Colour	Orange/Yellow	Orange/Yellow				Orange/Yellow	Orange/Yellow				Orange/Yellow	Orange/Yellow			
Texture															
CEC (meq/100g)	6.9	5.8	6.0	4.9	12.1	8.0	6.4	6.1	8.5	10.6	7.5	6.8	9.4	9.6	11.6
pH water	6.2	5.7	5.3	5.7	6.5	6.1	5.3	5.4	5.8	6.8	6.6	5.9	6.9	7.4	7.7
pH $CaCl_2$	4.9	4.4	4.2	4.2	5.0	4.9	4.1	4.1	4.7	5.5	5.3	4.7	5.9	6.2	6.5
Organic C (%)	1.3	0.7				1.9	0.9				0.9	0.7			
Nitrate N (mg/kg)	4.9	1.5	12	10	3.8	2.3	1.0	0.8	0.9	0.9	2.2	0.8	1.1	0.9	0.8
Phosphorus Colwell (mg/kg)	9.0	6.0				7.0	5.0				5.0	5.0			
Phosphorus BSES (mg/kg)															
Phosphorus Buffer Index	82	91				81	74				64	61			
Sulphate S-KCl (mg/kg)	2.0	3.0				2.0	2.0				1.0	5.0			
Sulphate S-MCP (mg/kg)															
Potassium (meq/100 g)	1.5	1.1	0.9	0.6	0.9	0.9	0.8	0.7	0.7	0.8	1.0	1.0	0.9	0.8	1.0
Calcium (meq/100 g)	3.4	2.6	2.3	1.2	2.9	4.7	2.7	2.3	3.5	4.2	4.6	4.1	6.0	5.8	6.4
Magnesium (meq/100 g)	1.9	1.4	1.6	1.9	6.5	2.3	1.9	2.0	3.9	5.2	1.8	1.6	2.3	2.8	4.0
Aluminium (meq/100 g)	0.1	0.7	1.1	0.9	0.2	0.1	1.0	1.1	0.3	0.1	0.1	0.1	0.1	0.1	0.1
Sodium (meq/100 g)	0.0	0.0	0.1	0.3	1.6	0.0	0.0	0.0	0.1	0.3	0.0	0.1	0.1	0.1	0.2
Chloride (mg/kg)	10	10	10	10	37	10	10	10	10	10	10	10	10	10	10
Electrical Conductivity $(_{1:5})$	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Electrical Conductivity$_{se}$ (dS/m)	0.2	0.1				0.2	0.1				0.1	0.2			
Copper (mg/kg)	1.3	1.0				1.3	0.9				1.2	0.9			
Zinc (mg/kg)	1.0	0.2				0.8	0.2				0.6	0.1			
Manganese (mg/kg)	30	34				36	20				19	20			
Iron (mg/kg)	26	23				37	40				13	15			
Boron (mg/kg)	1.0	1.0				1.7	1.5				1.1	1.0			
Percentages of Exchangeable															
ECaP (Calcium)	49.1%	44.7%	38.5%	24.7%	24.0%	58.9%	42.0%	37.8%	41.1%	39.5%	61.2%	60.2%	64.0%	60.3%	55.0%
EMgP (Magnesium)	27.5%	24.1%	26.8%	39.1%	53.8%	28.8%	29.5%	32.8%	45.8%	48.9%	23.9%	23.5%	24.5%	29.1%	34.4%
EKP (Potassium)	21.7%	18.9%	15.4%	11.5%	7.4%	10.7%	12.6%	10.7%	8.0%	7.7%	13.3%	14.0%	9.9%	8.7%	8.2%
ESP (Sodium)	0.3%	0.3%	1.0%	6.2%	13.2%	0.4%	0.3%	0.7%	1.6%	2.9%	0.3%	0.9%	0.5%	0.8%	1.5%
EAlP (Aluminium)	1.4%	12.0%	18.4%	18.5%	1.7%	1.3%	15.6%	18.1%	3.5%	0.9%	1.3%	1.5%	1.1%	1.0%	0.9%
Ca/Mg ratio	1.8	1.9	1.4	0.6	0.4	2.0	1.4	1.2	0.9	0.8	2.6	2.6	2.6	2.1	1.6
K/Mg ratio															
ESI	0.10	0.06	0.04	0.00	0.01	0.08	0.06	0.03	0.02	0.01	0.08	0.03	0.06	0.02	0.01

APPENDIX III:

Coverage of Planning Secretary's Environmental Assessment Requirements.

Planning Secretary's Environmental Assessment Requirements

Section 4.12(8) of the *Environmental Planning and Assessment Act 1979*

Schedule 2 of the Environmental Planning and Assessment Regulation 2000

Application Number	SSD-24319456
Project Name	Federation Project involving: • underground mining of the Federation gold-lead-zinc-copper-silver mineral deposit; • extraction and processing of up to 6.95 million tonnes of ore over a period of up to 14 years; • establishment of ancillary surface infrastructure to support mining activities; • upgrades to the existing Hera Mine to facilitate mining and processing of ore from the Federation deposit; • establishment of a services corridor between the Federation site and Hera Mine; • ongoing operation of the Hera mine; and • surrender of the Hera Mine development consent (MP10_0191) for consolidation with the Federation Project.
Location	Burthong Road, Nymagee, within the Cobar Shire local government area
Applicant	Hera Resources Pty Limited
Date of Issue	17/08/2021
General requirements	The environmental impact statement (EIS) must be prepared in accordance with, and meet the minimum requirements of, clauses 6 and 7 of Schedule 2 of the *Environmental Planning and Assessment Regulation 2000 (the Regulation)*. In particular, the EIS must include, but not necessarily be limited to, the following: • a stand-alone executive summary; • a full description of the development, including: - regional geology including a supporting map, the resource to be extracted, demonstrating efficient resource recovery within environmental constraints; - details of the ore and waste rock, including mineralogy and deleterious elements and evidence of geological and grade (or quality) continuity of

mineralization in the deposit;

- the mine layout and scheduling;
- minerals processing and average and maximum annual production rates;
- details of construction, operation and decommissioning, including any
- proposed staging of the project or refurbishing of infrastructure over time;
- all components, infrastructure, materials, plant and equipment and activities (including any infrastructure that would be required for the development, but the subject of a separate approvals process);
- the likely interactions between the project and the existing Hera mine; and
- the likely interactions between the development and any other existing, approved or proposed developments in the vicinity of the site;

- site plans and maps at an adequate scale showing:
  - the location of project components;
  - existing infrastructure, land use, and environmental features in the vicinity of the project (including any other existing, approved or proposed infrastructure in the region); and
  - key environmental constraints that have been considered in the design of the project;
- a waste (overburden, tailings, etc.) management strategy;
- a water management strategy;
- a mine closure and rehabilitation strategy, including details of the progressive rehabilitation of the site;
- a general description of any infrastructure that would be required for, or linked to, the project that is the subject of a separate approval process;
- a strategic justification for the project;
- details of the approvals that must be obtained before the development may commence;
- the potential terms of any proposed voluntary planning agreement with the relevant local council;
- an assessment of the likely impacts of the development on the environment, focusing on the specific issues identified below, including:
  - a description of the existing environment likely to be affected by the development, using sufficient baseline data;

- an assessment of the likely impacts of all stages of the development, including any cumulative impacts, taking into consideration any relevant legislation, environmental planning instruments, guidelines, policies, plans and industry codes of practice;
- a description of the measures that would be implemented to avoid, mitigate and/or offset residual impacts of the development, including incident management procedures, and the likely effectiveness of these measures, and an assessment of:
  - whether these measures are consistent with industry best practice, and represent the full range of reasonable and feasible mitigation measures that could be implemented;
  - the likely effectiveness of these measures, including performance measures where relevant; and
  - whether contingency plans would be necessary to manage any residual risks; and
- a description of the measures that would be implemented to monitor and report on the environmental performance of the development if it is approved;

- a consolidated summary of the proposed environmental management and monitoring measures;
- consideration of the development against all relevant environmental planning instruments (including Part 3 of the *State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007*);
- an evaluation of the development as a whole, having regard to:
  - the requirements in Section 4.15 of the Environmental Planning and Assessment Act 1979, including ecologically sustainable development;
  - the suitability of the site with respect to potential land use conflicts with existing and future surrounding land uses and significant mineral resources;
  - the strategic need and justification for the development, having regard to the relevant NSW and national policies and guidelines;
  - feasible alternatives to the development (and its key components), including the consequences of not carrying out the project; and
  - the biophysical, economic and social costs and benefits of the development;
- a signed statement from the author of the EIS, certifying that the information contained within the document is neither false nor misleading.

The EIS must also be accompanied by a report from a qualified quantity

	surveyor providing: - a detailed calculation of the capital investment value (CIV) (as defined in clause 3 of the Regulation) of the proposal, including details of all assumptions and components from which the CIV calculation is derived. The report shall be prepared on company letterhead and indicate applicable GST component of the CIV; - an estimate of jobs that will be created during the construction and operational phases of the proposed development; and - certification that the information provided is accurate at the date of preparation.
Key issues	The EIS must address the following specific issues with the level of assessment of likely impacts proportionate to the significance of, or degree, of impact on, the issue, within the context of the project location and the surrounding environment and having regard to applicable NSW Government policies and guidelines. • **Land and Soils** – including an assessment of: - the likely impacts of the development on the soils and land capability of the site and surrounds, and a description of the mitigation and management measures to prevent, control or minimise impacts of the development; - whether the soils in the area of the project are potentially contaminated or are acid forming (i.e. acid sulphate soils) and if so, identification of best practice mitigation measures and strategies or remedial and/or disposal actions that will be required/undertaken if applicable in accordance with relevant guidance/standards; - the likely agricultural impacts of the development, including biosecurity risks; - the likely impact of the development on landforms (topography), including the long-term geotechnical stability of any new landforms on site; and - the compatibility of the development with other land uses in the vicinity of the development in accordance with the requirements of Clause 12 of *State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007*, paying particular attention to the agricultural land use in the region; • **Subsidence** – including an assessment of the likely subsidence effects, and the potential consequences of these effects and impacts on the natural and built environment, paying particular attention to features that are considered to have significant economic, social, cultural or environmental value, and taking into consideration: - recorded regional and historic subsidence levels, impacts and environmental consequences; - geotechnical assessment that supports mining methods and mine design; - the potential extent of fracturing of the strata above the underground mine; and - the implementation of a comprehensive subsidence monitoring program, if required, which is capable of detecting vertical, horizontal and far-field subsidence movements;

- **Water** – including:
  - an assessment of the likely impacts of the development on the quantity and quality of surface, and groundwater resources, having regard to the *NSW Aquifer Interference Policy*;
  - an assessment of the hydrological characteristics of the site and downstream;
  - an assessment of the likely impacts of the development on aquifers, watercourses, riparian land, water-related infrastructure and systems and other water users, including impacts to water supply from dams, and riparian and licensed water users;
  - a detailed site water balance, including a description of site water demands, water disposal methods (inclusive of volume and frequency of any water discharges), water supply and transfer infrastructure and water storage structures, and measures to minimise water use;
  - demonstration that water for the construction and operation of the development, for the life of the project, can be obtained from an appropriately authorised and reliable supply in accordance with the operating rules of any relevant *Water Sharing Plan* (WSP), and include an assessment of the current market depth where water entitlement is required to be purchased;
  - a description of the measures proposed, including monitoring activities and methodologies, to ensure the development can operate in accordance with the requirements of any relevant WSP or water source embargo;
  - a detailed description of the proposed water management system (including sewage), water monitoring program and other measures to mitigate surface and groundwater impacts;
  - an assessment of the potential flooding impacts of the project;
- **Noise, Vibration and Blasting** – including:
  - Identification of representative noise monitoring locations for determining compliance with applicable noise goals and where relevant noise goals would be set as representative limits.
  - an assessment of the likely construction and operational noise impacts of the development in accordance with the *Noise Policy for Industry NSW*, and the *Voluntary Land Acquisition and Mitigation Policy*;
  - if a claim is made for specific construction noise criteria for certain activities, then this claim must be justified and accompanied by an assessment of the likely construction noise impacts of these activities in accordance with the *Interim Construction Noise Guideline* ;
  - an assessment of the likely road noise impacts of the development in accordance with the *NSW Road Noise Policy*; and
  - an assessment of the likely blasting impacts of the development on people, animals, buildings and infrastructure, and significant natural features, having regard to the relevant ANZECC guidelines;
- **Air Quality** – including:
  - an assessment of the likely air quality impacts of the development, including cumulative impacts from nearby developments, in accordance with the *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (2016), and having regard to the NSW Government's *Voluntary Land Acquisition and Mitigation Policy*;
  - demonstrated ability to comply with the relevant regulatory framework, specifically the *Protection of the Environment Operations Act 1997* and

the *Protection of the Environment Operations (Clean Air) Regulation* 2010;
- identification of strategies to minimise point and/or fugitive and/or odour emissions/impacts (with proposed timing), including monitoring, in line with relevant guidance/standards
- an assessment of the likely greenhouse gas impacts of the development; and
- a description of the feasibility of measures that would be implemented to monitor and report on the emissions (including fugitive dust and greenhouse gases) of the development;

- **Biodiversity** – including:
  - an assessment of the biodiversity values and the likely biodiversity impacts of the development throughout its life, and impacts on biodiversity values in the region, in accordance with Section 7.9 of the *Biodiversity Conservation Act 2016* (NSW), the *Biodiversity Assessment Method* (BAM 2020) and documented in a Biodiversity Development Assessment Report (BDAR); and
  - the BDAR must document the application of the avoid, minimise and offset framework including assessing all direct, indirect and prescribed impacts in accordance with the BAM;
- **Heritage** – including:
  - an assessment of the likely Aboriginal and historic heritage (cultural and archaeological) impacts of the development, including adequate consultation with Aboriginal stakeholders having regard to the *Aboriginal Cultural Heritage Consultation Requirements for Proponents* (DECCW, 2010), and documented in an Aboriginal Cultural Heritage Assessment Report (ACHAR) including the significance of cultural heritage values for Aboriginal people who have a cultural association with the land;
  - include results of a surface survey (and test excavations, if required) undertaken by a qualified archaeologist to inform the need for targeted test excavation to better assess the integrity, extent, distribution, nature and overall significance of the archaeological record; and
  - demonstrate attempts to avoid impact upon cultural heritage values and identify any conservation outcomes, including mitigation measures and procedures for accidental finds at any stage of the project; and
  - an assessment of the impact on historic heritage, including heritage conservation areas and State and local heritage items within and near the site;
- **Traffic and Transport** – including an assessment of:
  - the likely traffic and transport impacts of the development on the capacity, condition, safety and efficiency of the road and rail network and any cumulative impacts of other developments in the locality, documented in an Transport Assessment prepared in accordance with relevant guidelines and including a description of:
    - the site access routes and site access points in accordance with the *Roads Act 1993*; and
    - of measures, including upgrade works, that would be implemented to mitigate and / or manage potential traffic impacts developed in consultation with the relevant road authority;
- **Hazards and Risks** – including:
  - preliminary risk screening in accordance with *State Environmental Planning Policy No. 33 – Hazardous and Offensive Development* and

the Department's Applying SEPP 33 with clear indication of class, quantity and location of all dangerous goods and hazardous materials associated with the development. If the preliminary risk screening indicate that the development is 'potentially hazardous', a Preliminary Hazard Analysis (PHA) must the prepared in accordance with the Department's *Hazardous Industry Planning Advisory Paper No. 6, 'Hazard Analysis'* and *Multi-Level Risk Assessment*;

- **Visual** – including an assessment of:
  - the likely visual and landscape impacts of the development on private land in the vicinity of the development, paying particular attention to any temporary and permanent modification of the landscape (e.g. overburden dumps, bunds, tailings facilities);
- **Waste Management** – including:
  - identification of all waste types that will be generated during construction and operation, their classification and the ways in which they can be legally handled, stored, transported, reused, recycled or disposed of, including sampling/monitoring, record keeping, waste tracking, contingency measures and any other verification practice, in accordance with relevant guidelines/standards;
  - assessment of how the project would comply with the EPA's *Sodium Cyanide Policy – Limits for gold mine tailings storage facilities* (EPA, 2012)
  - identify strategies for waste minimisation during construction and operation;
  - a tailings risk assessment based on the tailings composition and identification, quantification and classification of the potential waste streams likely to be generated during construction and operation, including and not limited to non-production wastes, reagent materials and cyanide compounds
  - description of onsite sewerage system construction/upgrade, implementation, performance and management measures including a supporting comment on how the system would service all sewage generated during the construction and operational periods; and
  - description of the measures to be implemented to store, manage, reuse, recycle and safely dispose of these materials including and not limited to operational water by-products, adequate spill detection and clean up systems, suitable locations for disposal or reuse of spoil generated during construction;
- **Closure, Rehabilitation and Final Landform** – including a Rehabilitation Strategy providing:
  - a detailed overview of the final land-use and final landform, rehabilitation objectives and closure criteria for the development, including the conceptual final landform design; and
  - identification and discussion of opportunities to improve rehabilitation and environmental outcomes for existing disturbed areas within the project site, and barriers or limitations to effective rehabilitation; and
- **Socio-Economic** – including an assessment of:
  - an assessment of the social impacts of the project, prepared in accordance with the Department's *Social Impact Assessment Guideline For State Significant Developments* (July 2021) (subject to transitional arrangements), including the likely impacts of the development on the local community, cumulative impacts (considering other mining

	developments in the locality), and consideration of construction and operational workforce accommodation;
	- an assessment of the likely economic impacts of the development, paying particular attention to:
	  o the significance of the resource;
	  o economic benefits of the project for the State and region;
	  o the demand for the provision of local infrastructure and services; and a Voluntary Planning Agreement in relation to the demand for the provision of local infrastructure and services.

Plans and Documents	The EIS must include all relevant plans, architectural drawings, diagrams and relevant documentation required under Schedule 1 of the Regulation. Provide these as part of the EIS rather than as separate documents. In addition, the EIS must include high quality files of maps and figures of the subject site and proposal.
Consultation	During the preparation of the EIS, you should consult with relevant local, State and Commonwealth Government authorities including infrastructure and service providers, the Hera Mine Community Consultative Committee, community groups, Registered Aboriginal Parties (RAPs), affected landowners, and holders of existing mining and exploration authorities. The EIS must describe the consultation process and the issues raised and identify where the design of the infrastructure has been amended in response to these issues. Where amendments have not been made to address an issue, a short explanation should be provided.
Expiry Date	If you do not lodge a Development Application and EIS for the development within 2 years of the issue date of these SEARs, your SEARs will expire. If an extension to these SEARs will be required, please consult with the Planning Secretary 3 months prior to the expiry date.
References	The assessment of the key issues listed above must take into account relevant guidelines, policies, and plans as identified. While not exhaustive, the following attachment contains a list of some of the guidelines, policies, and plans that may be relevant to the environmental assessment of this proposal.

Attachment 1

Environmental Planning Instruments, Policies, Guidelines & Plans

Please also refer to the Department's Policies and Guidelines including strategic plans and guidelines at:

https://www.planningportal.nsw.gov.au/major-projects/assessment/policies-and-guidelines

Land and Contamination	
	Australian Soil and Land Survey Handbook (CSIRO)
	Guidelines for Surveying Soil and Land Resources (CSIRO)
	Managing Urban Stormwater: Soils & Construction (Landcom)
	Guidelines for developments adjoining land and water managed by the Department of Environment, Climate Change and Water (DECCW, 2010)
	Contaminated Sites Sampling Design Guidelines 1995 (EPA)
	Soil and Landscape Issues in Environmental Impact Assessment (DPI)
	Australian and New Zealand Guidelines for the Assessment and Management of Contaminated Sites (ANZECC)
	National Environment Protection (Assessment of Site Contamination) Measure 1999 (with amendment April 2013)
	The land and soil capability assessment scheme: second approximation (OEH)
Water	
Water Sharing Plans	Relevant Water Sharing Plans
Groundwater	NSW State Groundwater Policy Framework Document and component policies (DPI)
	NSW State Groundwater Quality Protection Policy (DPI)
	NSW State Groundwater Quantity Management Policy (DPI)
	NSW Aquifer Interference Policy 2012 (DPI)
	Australian Groundwater Modelling Guidelines 2012 (Commonwealth)
	National Water Quality Management Strategy Guidelines for Groundwater Protection in Australia (ARMCANZ/ANZECC)
	Guidelines for the Assessment & Management of Groundwater Contamination

	(EPA)
Surface Water	NSW State Rivers and Estuary Policy (DPI Water)
	NSW Government Water Quality and River Flow Objectives at http://www.environment.nsw.gov.au/ieo/
	Using the ANZECC Guideline and Water Quality Objectives in NSW (DEC, 2006)
	National Water Quality Management Strategy: Australian Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ)
	National Water Quality Management Strategy: Australian Guidelines for Water Quality Monitoring and Reporting (ANZECC/ARMCANZ)
	National Water Quality Management Strategy: Guidelines for Sewerage Systems – Effluent Management (ARMCANZ/ANZECC)
	National Water Quality Management Strategy: Guidelines for Sewerage Systems – Use of Reclaimed Water (ARMCANZ/ANZECC)
	Approved Methods for the Sampling and Analysis of Water Pollutants in NSW (EPA)
	Managing Urban Stormwater: Soils & Construction (Landcom) and associated Volume 2E: Mines and Quarries (DECC)
	Managing Urban Stormwater: Treatment Techniques (EPA)
	Managing Urban Stormwater: Source Control (EPA)
	Technical Guidelines: Bunding & Spill Management (EPA)
	A Rehabilitation Manual for Australian Streams (LWRRDC and CRCCH)
	NSW Guidelines for Controlled Activities (NOW)
Flooding	Floodplain Development Manual (OEH)
	Floodplain Risk Management Guideline (OEH)
Biodiversity	
	Biodiversity Assessment Method (OEH)
	Threatened Species Assessment Survey and Guidelines (various - OEH)
	Biosecurity Act 2015
	Policy and Guidelines for Fish Habitat Conservation and Management (DPI)
	NSW State Groundwater Dependent Ecosystem Policy (DPI Water)
	Risk Assessment Guidelines for Groundwater Dependent Ecosystems (DPI Water)
	NSW Biodiversity Offsets Policy for Major Projects, Fact Sheet: Aquatic

	Biodiversity
Heritage	
	The Burra Charter (The Australia ICOMOS charter for places of cultural significance)
	Aboriginal Cultural Heritage Consultation Requirements for Proponents (DECCW)
	Code of Practice for Archaeological Investigations of Objects in NSW (DECCW)
	Guide to investigating, assessing and reporting on aboriginal cultural heritage in NSW (OEH)
	Due Diligence Code of Practice for the Protection of Aboriginal Objects in NSW (DECCW)
	Assessing Heritage Significance (NSW Heritage Office, 2001)
	Statements of Heritage Impact (Heritage Office and Department of Urban Affairs and Planning, 2002)
	NSW Heritage Manual (OEH)
Noise, Vibration and Blasting	
	Voluntary Land Acquisition and Mitigation Policy: For State Significant Mining, Petroleum and Extractive Industry Developments (DPE)
	NSW Noise Policy for Industry (EPA)
	Interim Construction Noise Guideline (EPA) or Construction Noise Guideline (EPA) – currently draft only – application subject to any transitional arrangements
	NSW Road Noise Policy (EPA)
	Environmental Noise Management – Assessing Vibration: a Technical Guideline (DEC)
	Technical Basis for Guidelines to Minimise Annoyance Due to Blasting Overpressure and Ground Vibration (ANZECC)
Air Quality	
	Voluntary Land Acquisition and Mitigation Policy: For State Significant Mining, Petroleum and Extractive Industry Developments (DPE)
	Approved Methods for the Modelling and Assessment of Air Pollutants in NSW (EPA, 2016)
	Approved Methods for the Sampling and Analysis of Air Pollutants in NSW (DEC)
	National Greenhouse Accounts Factors (Commonwealth)
Lighting and Visual	

	AS4282-1997 Control of the obtrusive effects of outdoor lighting
	Dark Sky Planning Guideline: Protecting the observing conditions at Siding Spring (DPE)
Transport	
	Guide to Traffic Generating Developments (RTA)
	Road Design Guide (RMS) & relevant Austroads Standards
	Austroads Guide to Traffic Management Part 12: Traffic Impacts of Development and RMS Supplements to Austroads
Hazards and Risks	
	Australian Dangerous Goods Code
	Australian Standard 4452 Storage and Handling of Toxic Substances
	Hazardous and Offensive Development Application Guidelines – Applying SEPP 33
	Hazardous Industry Planning Advisory Paper No. 6 – Guidelines for Hazard Analysis
	Multi-level Risk Assessment (DPI, 2011)
Socio-Economic	
	Social Impact Assessment Guideline: For State Significant Mining, Petroleum Production and Extractive Industry Development (DPE) or SIA new guidelines issued by the Department of Planning, Industry and Environment and applied subject to transitional arrangements.
Resource	
	Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves 2012 (JORC)
Waste	
	Waste Classification Guidelines (EPA)
	Protection of the Environment Operations (Waste) Regulation 2014
	Environmental Guidelines: Solid Waste Landfills (EPA)
	Tailings Management – Leading Practice Sustainable Development Program for the Mining Industry (Australian Government)
Rehabilitation	
	Mine Rehabilitation – Leading Practice Sustainable Development Program for the Mining Industry (Commonwealth)
	Mine Closure and Completion – Leading Practice Sustainable Development

	Program for the Mining Industry (Commonwealth)
	Strategic Framework for Mine Closure (ANZMEC-MCA)
	Mine Rehabilitation – Leading Practice Sustainable Development Program for the Mining Industry (Commonwealth)
	Integrated Mine Closure: Good Practice Guide (ICMM, 2019)
	Guidelines on Tailings Dams – Planning, Design, Construction, Operation and Closure – Revision 1 (ANCOLD, July 2019)
Environmental Planning Instruments	
	State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007
	State Environmental Planning Policy (State and Regional Development) 2011
	State Environmental Planning Policy (Infrastructure) 2007
	State Environmental Planning Policy (Rural Lands) 2008
	State Environmental Planning Policy No. 44 – Koala Habitat Protection
	State Environmental Planning Policy No. 55 – Remediation of Land
	State Environmental Planning Policy No 33 – Hazardous and Offensive Development
	Cobar Local Environmental Plan 2012