Central Queensland Coal Project

Chapter 5 – Land

Environmental Impact Statement

CDM Smith

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Central Queensland Coal Project

Chapter 5 – Land

24 October 2017

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This chapter outlines the environmental values (EVs) of the Central Queensland Coal (herein referred to as the Project), haul road corridor and train loadout facility (TLF) in the context of topography, geology, mineral reserves, soil types, land use suitability and visual amenity. The potential impacts of the proposed mining activities on the existing EVs of the area are identified, as are the measures proposed to mitigate any potential impacts.

This chapter should also be read in conjunction with a number of other EIS chapters which provide further technical details of impacts on land EVs and the management of those impacts, including: Chapter 7 – Waste Management, Chapter 8 – Waste Rock and Rejects, and Chapter 11 – Rehabilitation and Decommissioning.

A Terms of Reference (ToR) cross-reference table is provided in Table 5-41 in Section 5.10.

5.1 Project Overview

The Project is located 130 km northwest of Rockhampton in the Styx Coal Basin in Central Queensland. The Project will be located within Mining Lease (ML) 80187 and ML 700022, which are adjacent to Mineral Development Licence (MDL) 468 and Exploration Permit for Coal (EPC) 1029, both of which are held by the Proponent.

The Project will involve mining a maximum combined tonnage of up to 10 million tonnes per annum (Mtpa) of semi-soft coking coal (SSCC) and high grade thermal coal (HGTC). Development of the Project is expected to commence in 2018 and extend for approximately 20 years until the current reserve is depleted.

The Project consists of three open cut operations that will be mined using a truck and shovel methodology. The run-of-mine (ROM) coal will ramp up to approximately 2 Mtpa during Stage 1 (Year 1-4), where coal will be crushed, screened and washed to SSCC grade with an estimate 80% yield. Stage 2 of the Project (Year 4-20) will include further processing of up to an additional 4 Mtpa ROM coal within another coal handling and preparation plant (CHPP) to SSCC and up to 4 Mtpa of HGTC with an estimated 95% yield. At full production two CHPPs, one servicing Open Cut 1 and the other servicing Open Cut 2 and 4, will be in operation.

A new train loadout facility (TLF) will be developed to connect into the existing Queensland Rail North Coast Rail Line. This connection will allow the product coal to be transported to the established coal loading infrastructure at the Dalrymple Bay Coal Terminal (DBCT).

The Project is located within the Livingstone Shire Council (LSC) Local Government Area (LGA). The Project is generally located on the “Mamelon” property, described as real property Lot 11 on MC23, Lot 10 on MC493 and Lot 9 on MC496. The TLF is located on the “Strathmuir” property, described as real property Lot 9 on MC230. A small section of the haul road to the TLF is located on the “Brussels” property described as real property Lot 85 on SP164785.

5.2 Relevant Legislation, Guidelines and Criteria

5.2.1 Environmental Protection Act 1994

The *Environmental Protection Act 1994* (EP Act) is the primary legislation for environmental management and protection in Queensland. It plays an important role in the protection and management of Queensland's environment, particularly in relation to the regulating activities which have potential to release contaminants into the environment (defined as Environmentally Relevant Activities (ERAs)).

The EP Act also governs the management, investigations and remediation of any contaminated land. If land becomes contaminated there is a duty to notify the Department of Environment and Heritage Protection (EHP).

5.2.2 Biosecurity Act 2014

The *Biosecurity Act 2014* (Biosecurity Act) has replaced the many separate pieces of legislation that were used to manage biosecurity, including the superseded *Land Protection (Pest and Stock Route Management) Act 2002*. The Biosecurity Act deals with pests (such as wild dogs and weeds), diseases (such as foot-and-mouth disease) and contaminants (such as lead on grazing land).

Under the Act, individuals and organisations whose activities pose potential risks to biosecurity will have greater legal responsibility for managing them. This obligation means Central Queensland Coal will have an obligation to undertake all reasonable steps to ensure no spread of pest, disease or contaminant. There are seven categories of restricted matter listed under the Act. Each category places restrictions on the biosecurity matter or requires actions to be taken to minimise the spread and adverse impact of the matter.

5.2.3 Stock Route Management Act 2002

The purpose of the *Stock Route Management Act 2002* is to provide management for the stock route network. The *Stock Route Management Act 2002* establishes principles for managing the stock route network and activities. The stock route network provides unique interconnectedness and geographical extent to allow for the movement of wildlife.

There are no stock routes near the Project area.

5.2.4 Regional Planning Interests Act 2014

The *Regional Planning Interests Act 2014* (RPI Act) replaced the *Strategic Cropping Land Act 2011* on the 13 June 2014. The RPI Act seeks to manage the impacts from resource activities, and other regulated activities through protecting:

- Living areas in regional communities;
- High-quality agricultural areas from dislocations;
- Strategic cropping land (SCL); and
- Regionally important EVs.

Under the RPI Act, an approval is required when a resource activity or regulated activity is proposed in an area of regional interest. Areas of regional interest are identified as:

- Priority living areas (PLAs);
- Priority agricultural areas (PAAs);
- Strategic cropping areas (SCAs); and
- Strategic environmental areas (SEAs).

The Project activities are not located within any mapped Area of Regional Interest; however, a small portion of SCA is mapped in the north-eastern portion of the Mine Lease (ML).

5.2.5 Guideline Mining – Model Mining Conditions

The purpose of the Model Mining Conditions is to provide a set of model conditions to form general environmental protection commitments for the mining activities and the Environmental Authority (EA) conditions pursuant to the EP Act. The guideline states that the '*model conditions should be applied to all new mining project applications lodged after the guideline is approved*', therefore the Project is subject to the criteria outlined in this guideline. Schedule H of the Model Mining Conditions prescribes conditions for land and rehabilitation management.

5.3 Environmental Objectives and Performance Outcomes

5.3.1 Environmental Objectives

The environmental objective relevant to land is provided in the EP Regulation. In accordance with the EP Regulation, the Project's objectives for land are to operate in a way that protects the EVs of land including soils, subsoils, landforms and associated flora and fauna.

5.3.2 Performance Outcomes

The land performance criteria are:

- There is no actual or potential disturbance or adverse effect to the EVs of land as part of carrying out the activity; and
- All of the following:
  - Activities that disturb land, soils, landforms and the land use, flora and fauna associated with the land will be managed in a way that prevents or minimises adverse effects on the EVs of land;
  - Areas disturbed will be rehabilitated or restored to achieve sites that are:
    - Safe to humans and wildlife;
    - Non-polluting;
    - Stable; and
    - Able to sustain an appropriate land use after rehabilitation or restoration.

- The activity will be managed to prevent or minimise adverse effects on the EVs of land due to unplanned releases or discharges, including spills and leaks of contaminants; and
- The application of water or waste to the land is sustainable and is managed to prevent or minimise adverse effects on the composition or structure of soils and subsoils.

5.4 Assessment Method

To adequately assess the potential impacts that the Project may have on soils and the current land use within the Project area, the following detailed assessments have been undertaken:

- Desktop assessment, including review of publicly available literature, maps and resources relevant to the geology, soils and landforms in the Project area; and
- Field surveys and laboratory analyses undertaken focusing on characterisation of soils for land use suitability, agricultural value and potential rehabilitation (as required) as part of the Environmental Impact Statement (EIS) process to improve understanding of soils within the Project area. A detailed field soil survey of the Central Queensland mine area was conducted over a four-day period in April 2017.

5.4.1 Topography

The topography and landscape was reviewed with reference to:

- LiDAR data captured for EPC 1029;
- Commonwealth Scientific and Industrial Research Organisation (CSIRO) Australian Soil Resource Information System (ASRIS) datasets and information obtained from the Department of Natural Resources and Mines (DNRM) - formerly the Department of Employment, Economic Development and Innovation (DEEDI);
- Resource and tenure maps and records from EHP;
- Local government mapping; and
- Cadastral data.

Specific topographic maps used for the assessment include:

- EHP 10 m contour data; and
- Queensland Globe (DNRM 2017a) feature of Google Earth.

Landforms were mapped using landscape units that provide a basis for the description of the physical environment. The information reflects the distribution of geological structures, landforms and associated soil types. Landscape units are a combination of several map units including:

- Broad landform (topography, slope and relief), geology and lithology;
- Dominant soil orders;
- Local climate, drainage networks and related soil profile classes;
- Regolith materials; and
- Similar geomorphological systems.

5.4.2 Geology

Various publicly available data sources were consulted to determine the geomorphology and geology underlying the Project are:

- Surface geological mapping from the Geological Survey of Queensland (1:250,000 Series) (Geoscience Australia 2008);
- Queensland Globe (DNRM 2017a) feature of Google Earth;
- Mines Online Maps (DNRM 2017b); and
- Geological information provided by Central Queensland Coal. This information was focused primarily on the economic geology for the area.

Published DNRM landform data was also consulted as part of the desktop assessment.

Existing mapping of the Project area indicates a number of geological units exist throughout Central Queensland mine, the haul road corridor and the TLF.

5.4.3 Soils

5.4.3.1 Desktop Assessment

A preliminary desktop soils and landform assessment was undertaken to inform the fieldwork component of the assessment. All information pertaining to topography and landform was derived from relevant publicly available soils and geology databases and available mapping. Existing published soils and landform information for the region was derived from the following sources:

- ASRIS 2011: This is a National soils mapping dataset made available by CSIRO which provides a general description of soils classified in accordance to the Australian Soil Classification (Isbell 2002);
- 'Atlas of Australian Soils' by CSIRO (Isbell et al. 1967): This provides general background information on landscape features and general soil families and soil types expected to occur in the region;
- Queensland Globe's ASS distribution map (scale 1:100,000): This mapping provides an indication of the likelihood of Acid Sulphate Soils (ASS) or potential ASS (PASS) being present across the Project site; and
- Review of site-specific soil sample records in the locality to further define local soil physical attributes and confirm application of land resource area descriptions.

5.4.3.2 Field Assessment

Field assessment methodologies were designed, developed and undertaken in accordance with the following:

- Technical Guidelines for Environmental Management of Exploration and Mining in Queensland ((DME 1995) (including the collection of soil samples in line with the Land Suitability Assessment Techniques (LSAT Guidelines) within DME 1995);
- The Australian Soil Classification (Isbell 2002);

- SPP – state interest guideline - Agriculture;
- Planning Guideline: The Identification of Good Quality Agricultural Land. Department of Primary Industries (DPI) and Department of Housing and Local Government Planning (DHLGP), (DPI/DHLGP 1993);
- Guidelines for Surveying Soil and Land Resources (McKenzie et al. 2008);
- Australian Soil and Land Survey Field Handbook (NCST 2009); and
- Australian Soil and Land Survey Handbook – Guidelines for Conducting Surveys (Gunn et al. 1988).

Density and Scale of the Soil and Landscape Surveys

For the purposes of producing an EIS, the most suitable soil mapping scale for strategic planning of the Central Queensland mine was identified as 1:50,000 based on the *Guidelines for Surveying Soil and Land Resources* (McKenzie et al. 2008). The guidelines nominate a medium intensity or semi-detailed investigation with a minimum soil sampling density of one sample per 100 hectares (ha). Of this, a minimum of 12 percent (%) of samples should be detailed soil profiles and descriptions and a maximum of 88% of sample sites should consist of a visual assessment of the soil and landscape characteristics in the immediate vicinity (herein termed 'observations').

The soil survey included 11 soil auger sites (where detailed soil profile descriptions were made and samples were taken), 16 observation locations, and laboratory analysis. The soil sampling density was equivalent to one profile or observation being taken every 43 ha compared to a total disturbance area of 1,160 ha. This density of sampling meets the requirements outlined in the nominated guidelines described above. The sampling locations of boreholes constructed for detailed analysis and those sites nominated as observations across the Project area are shown in Figure 5-1. The sampling density used in the investigation was determined based on existing and publicly available soil unit mapping. The sampling locations of boreholes constructed for detailed analysis and those sites nominated as observations in the haul road corridor and TLF are shown in Figure 5-1.

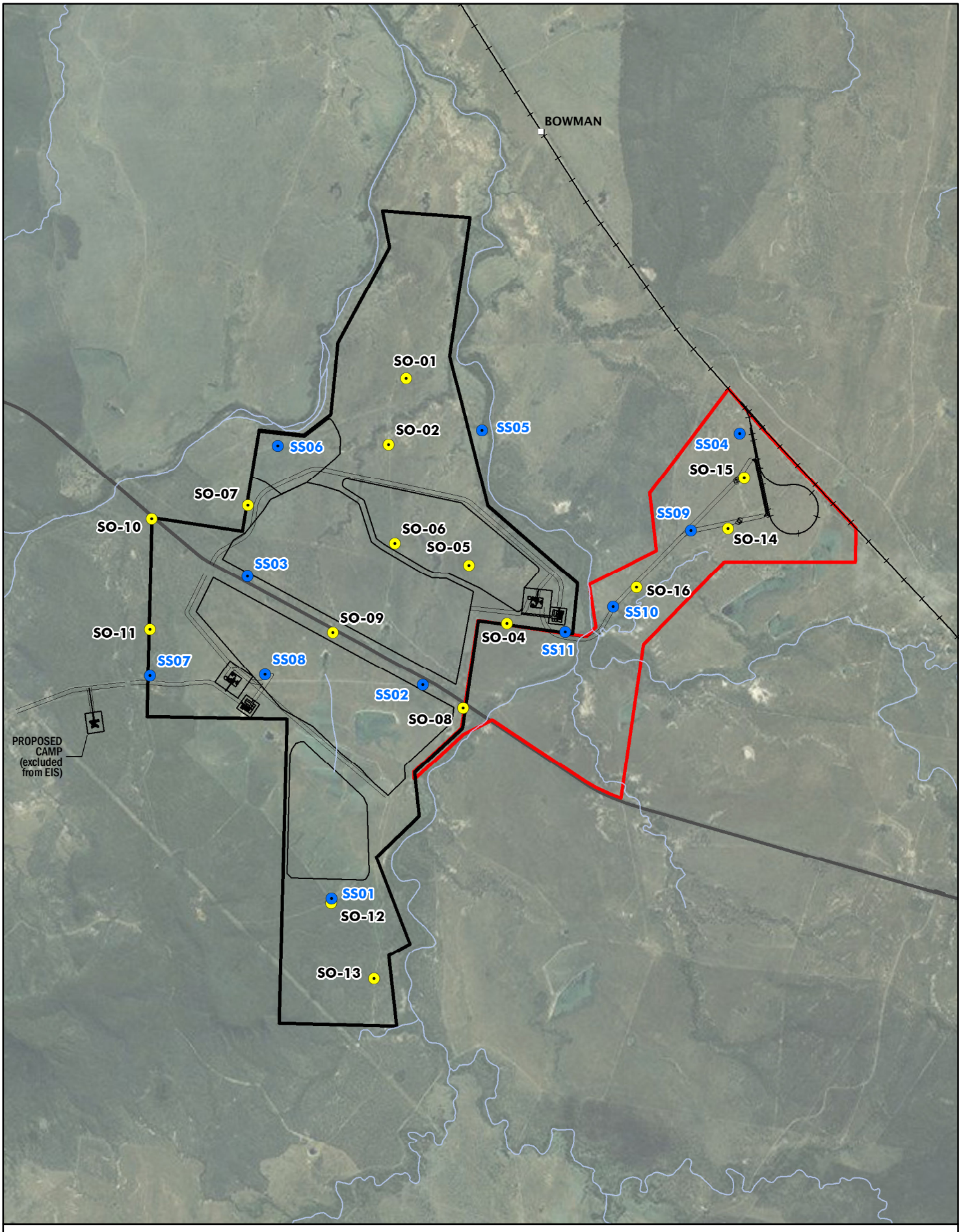


Figure 5-1
Project soil sample locations

Detailed Sites

Detailed soil profile descriptions were made at 11 sites in the Project area (shown as the subsoil sample locations in Figure 5-1). The detailed sites were augered to a depth of 1.5 m or until refusal was reached. Soil sampling of profiles was conducted as per the Guidelines for Surveying Soil and Land Resources (Gunn et al. 1988).

All soil samples were issued for laboratory analysis. These were selected for analysis based on the 'representativeness' of the sample to the surrounding soils area and the soil unit map being proposed. Sample results are presented in Section 5.5.4.3.

Several samples were taken from down the soil profile to allow for suitable information to be gathered from the A horizons 'topsoils' and B horizons 'subsoils'. Texture was assessed in-field where changes in the profile were evident.

Information recorded at each detailed sample location included the following:

- Location (GDA94);
- Major vegetation types and land use of immediate surrounding area;
- Landform type, position on the site and slope gradient;
- Published geology and land resource management unit for the location;
- Surface condition (including any presence of cracks, surface crusts, rock stones and cobbles, erosion status and micro relief);
- Types and vertical extent of soil horizons;
- Colour of the soil matched to the Munsell Soil Colour Charts (Munsell) and mottling of each horizon (Munsell 2000);
- Field texture (based on the behaviour of a moist bolus);
- Field pH (CSIRO pH Kit);
- Structure (presence and abundance of segregations, coarse fragments, structure, consistency, pedality and moisture content), noting that some disturbance of structure occurs during auguring;
- Boundary, including depth of horizons and the nature of the boundary (clear, distinct or diffuse between layers); and
- Photographs of the soil profile (from auger samples) and the surrounding landscape.

Observation Sites

In addition to the full soil profile samples, 16 observations were conducted in the Central Queensland Project area. The observations consisted of a visual assessment of soil conditions and the surrounding environment considering the general terrain of the area, and landform and vegetative characteristics across the site.

Information collected at each observation site included:

- General landform, vegetation, land use and slope;
- Actual geology or land resource area reference as described by relevant published data;
- Visible and inferred soil types present; and
- Any management issues of significance (including potential dispersive, acid sulfate, or highly erodible soils).

Observations were used to support the soils information gathered during the detailed site investigation and laboratory analysis and provided information on landform mapping boundaries.

5.4.3.3 Laboratory Analysis

Those samples collected from detailed sites that were considered most representative of the mapped soil units were submitted to a National Association of Testing Authorities (NATA) accredited laboratory for soil testing, providing information that directly informed the overall soils characterisation and determination of agricultural suitability of the soils. Laboratory analysis was also used in determining soil suitability for future rehabilitation based on physical and chemical parameters and potential future amelioration techniques. The parameters analysed for the surface (A horizon) and subsoil (B horizon) is presented in Table 5-1. Full laboratory results are presented in Appendix A3 – Soil Survey Results.

Table 5-1 Surface (A horizon) and subsoil (B horizon) parameters analysed

Parameters	Surface (A horizon) Parameters	Subsoil (B horizon) Parameters
pH	✓	✓
Moisture	✓	×
Chloride	✓	✓
Electrical conductivity	✓	✓
Organic matter (including % organic carbon)	✓	×
Total nitrogen and total kieldahl nitrogen	✓	×
Bicarbonate extractable phosphorus	✓	×
Particle size distribution by hydrometer	✓	✓
Dispersibility	✓	✓
Trace metals – copper, iron, manganese and zinc	✓	×
Extractable boron	✓	×
Full cation suite (Na, K, Ca, Mg, Fe, Al, Cl, S, CEC, SAR, ESP and exchangeable Ca:Mg)	✓	✓

5.4.4 Agricultural Land Suitability

5.4.4.1 Land Use Suitability

Classifying land suitability in Queensland is based on classifications provided in the LSAT Guidelines within the Technical Guidelines for Environmental Management of Exploration and Mining in Queensland (DME 1995). The class ratings and definitions, as described in Table 5-2, will be applied to mapped soil units to inform rehabilitation programmes for post-mining land use.

Table 5-2 Land suitability classes

Land suitability classes	Definition
Class 1	Suitable land with negligible limitations that is highly productive and requires only simple management to maintain economic production.
Class 2	Suitable land with minor limitations which either reduce production or require more than the simple management practices of Class 1 to maintain economic production.
Class 3	Suitable land with moderate limitations which either further lower production or require more than those management practices of Class 2 to maintain economic production.
Class 4	Currently unsuitable land with severe limitations which make it doubtful whether benefits of the activity will outweigh the inputs/costs required to achieve and maintain production in the long term under current environmental and economic conditions. A change in future conditions may induce a change to Class 3.
Class 5	Unsuitable land with extreme limitations that preclude its use.

Adopted from the LSAT Guidelines (DME 1995).

The LSAT Guidelines provide general criteria and threshold values for assessment of a range of soil limitations to rain fed cropping and beef cattle grazing land use. A combination of field and laboratory data has been used to assess whether any limitations exist across the Project site and, if so, the severity of those, as well as determining the land suitability class of each soil unit against the LSAT Guidelines.

Grazing suitability classifications evaluate the potential for grazing across the site and consider limiting factors including plant available water capacity, nutrient deficiency, soil physical factors, salinity, rockiness, micro relief, susceptibility to water erosion, topography and flooding.

5.4.4.2 Good Quality Agricultural Land

Good quality agricultural land (GQAL) is assessed using the Agricultural Land Classes (ALC) nominated in the Planning Guideline: The Identification of Good Quality Agricultural Land (1993). The relationship between GQAL and ALCs is shown in Table 5-3.

Table 5-3 Relationship between GQAL and ALCs

Agricultural land class	Land suitability (cropping)	Land suitability (grazing)	Description
A	1-3	1-3	**Crop land** – Land that is suitable for current and potential crops with limitations that range from none to moderate levels.
B	4	1-3	**Limited crop land** – Land that is marginal for current and potential crops due to severe limitations and suitable pastures. Engineering and/or agronomic improvements may be required before the land is considered suitable for cropping.
C	Sub categories are as follows:		**Pasture land** – Land that is suitable only for improved or native pastures due to limitations which preclude continuous cultivation for crop production; but some areas may tolerate a short period of ground disturbance for pasture establishment.
C1	5	1-2	**Land suitable for improved pastures**. In some circumstances may be considered as good quality agricultural land.
C2	5	3	**Land suitable for native pastures**.
C3	5	4	**Land suitable for limited grazing of native pastures**.
D	5	5	**Non-agricultural land** – Land not suitable for agricultural uses due to extreme limitations. This may be land which is unsuitable because of very steep slopes, shallow soils, rock outcrops or poor drainage.

5.4.5 Contaminated Land

A site history of the Project area was compiled and used to identify past and present potentially contaminating activities. This was undertaken in accordance with the Guidelines for contaminated land professionals (EHP 2012) and included:

- A review of the EHP Contaminated Land Register (CLR) and Environmental Management Register (EMR); and
- A review of historic aerial photography to identify any potentially contaminating land uses.

5.4.6 Infrastructure

Existing infrastructure associated with the agricultural land use was identified through desktop research and various field surveys. The Central Queensland Coal mine area is located entirely within a single property boundary (Mamelon). A road reserve corridor (Mt Bison Road) crosses Mamelon on the western side of the Bruce Highway and will require realignment as the reserve will be impacted by Open Cut 1. The land within the TLF and most of the haul road is within Strathmuir property, whilst a small section of the haul road crosses the Brussels property. Both properties are owned by private landholders.

The land within the Project disturbance areas does not support any homesteads, gas or water pipelines, or communications. The existing Powerlink 275 kilovolt Stanwell to Nebo transmission alignment is located in the south of the ML80187; however, the easement is situated well outside the proposed disturbance areas. Several stockyards are located within the disturbance area and will no longer be in use during mining operations.

The existing infrastructure that may be affected by the Project are:

Central Queensland Mine Area

- Unformed farm access tracks;
- Two windmills and dams;
- Two vacant homesteads and farming infrastructure; and
- Fence lines around paddocks.

Haul Road Corridor and Train Loadout Facility

- Fence lines around paddocks.

5.4.7 Environmentally Sensitive Areas

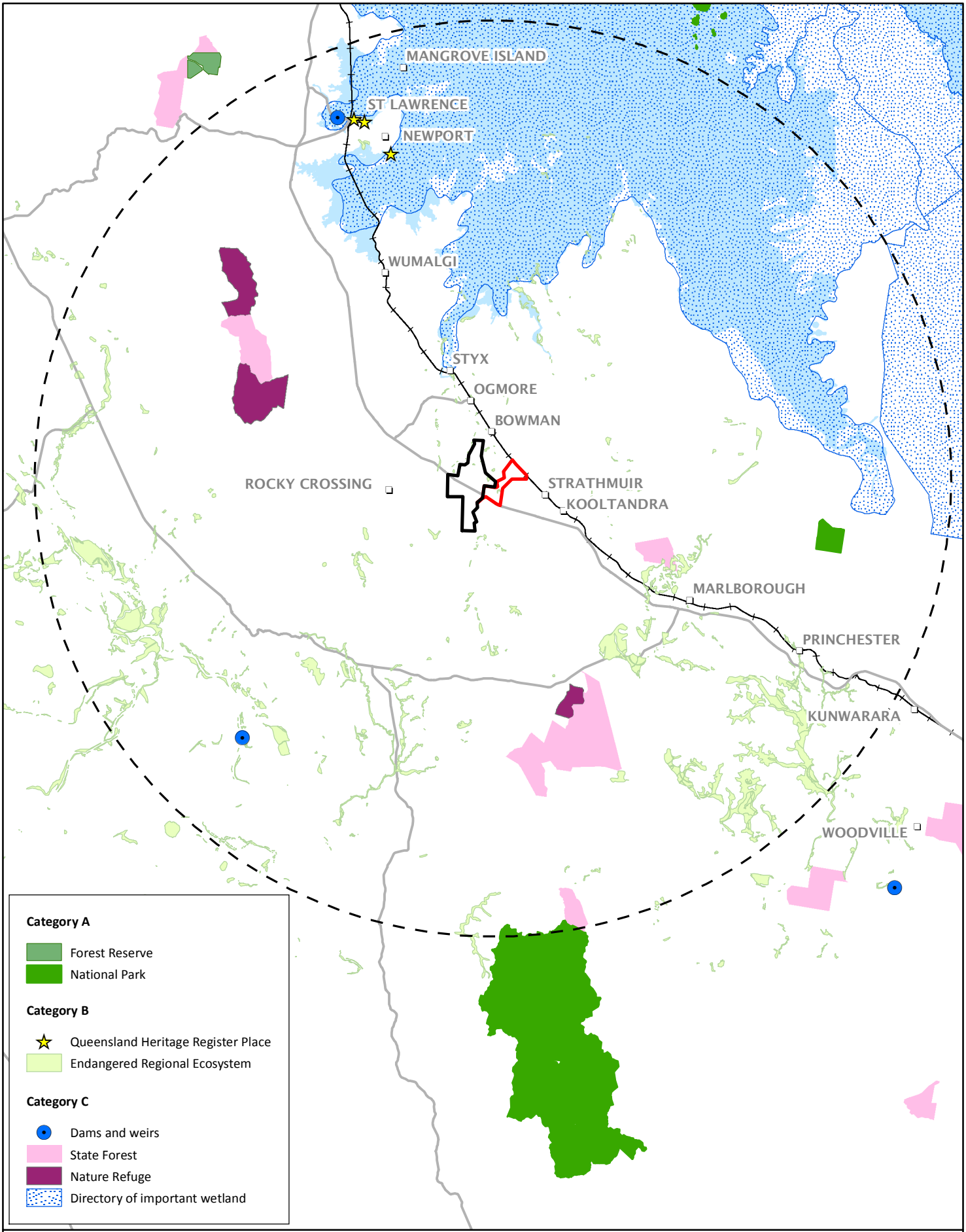
Environmentally sensitive area (ESA) mapping identified a Category B ESA within the ML (Figure 5-2). This Category B ESA is associated with remnant vegetation listed as Endangered under the *Vegetation Management Act 1999*. Several Category A, B and C ESAs are located within the wider locality (within 50 km of the Project area), including various protected areas and nature refuges (Table 5-4).

Tooloombah Creek Conservation Park (Category A) is located less than 1 km west of the ML boundary. The Great Barrier Reef World Heritage Area and Marine Park boundaries and Broad Sound Fish Habitat Area overlap (all Category B) and are located 8 km north of the Project. Waters associated with the Styx River are also designated as a 'coastal management district' which is also a Category C ESA.

Further details and locations of ESAs are presented in Chapter 14 – Terrestrial Ecology.

Table 5-4 Environmental sensitive areas within 50 km of the Project area

Environmentally Sensitive Area	Category	Approximate distance to Project area (km)
		Mine area
Tooloombah Creek Conservation Park	Category A	0.8
Great Barrier Reef World Heritage Area	Category B	8.0
Bukkulla Conservation Park	Category A	16.9
Marlborough State Forest	Category C	16.5
Eugene State Forest	Category C	19.0
Mt Buffalo State Forest	Category C	25.0
Develin Nature Refuge	Category C	19.0
Burwood Nature Refuge	Category C	19.3
Great Barrier Reef Marine Park – general use area	Category B	8.0
Fish Habitat Area – Broad Sound	Category B	8.0
Endangered remnant vegetation	Category B	Within entire 25 km radius
Marine Plants	Category B	7.5 (north – associated with Styx River estuarine plain)
Coastal Management District	Category C	2.0 (north – associated with Styx River)



N

0 5 10 km

Scale @ A4 1:540,000
Date: 17/07/17
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Legend

- ML 80187
- ML 700022
- Project Area 50 km buffer
- North Coast Rail Line
- Main road
- Estuary

Figure 5-2
Location of Environmentally Sensitive Areas within 50 km of the Project area

DATA SOURCE
QLD Spatial Catalogue (QSpatial), 2017

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5.4.8 Landscape Character and Visual Amenity

5.4.8.1 Visual Impact Assessment Method

The purpose of undertaking a Visual Impact Assessment (VIA) is to examine the extent of visual change to the landscape because of the Project and assess how the change will impact on the area's scenic amenity.

Specifically, the study:

- Assesses the existing landscape character of the Project area providing comment on the changes already made to the natural landscape since European settlement;
- Describes existing landscape features, panoramas and views that have or are expected to have value to the community;
- Identifies the potential sensitive receptors within the immediate landscape where visual amenity may be impacted; and
- Determines the significance of potential impacts from sensitive receptors. Consideration includes:
  - Value of existing vegetation as a visual screen;
  - Identification of the ability of the landscape to absorb change without significant detriment to the existing visual quality and landscape character; and
  - Ability to mitigate impacts through design considerations.

GIS modelling was utilised to determine potential visibility of the mining operation from a variety of sensitive receptors. This GIS information has been combined with available field data to quantify the landscape change.

The study area for the EIS was defined by the visual catchment of the Project, or the area from which the Project could reasonably be seen. The visual catchment was determined through the review of aerial photographs, topographic maps and landform.

The VIA assessment relied on the following data sources:

- Aerial photography;
- 1 Second SRTM v1.0 Digital Elevation Models (Geoscience Australia 2011);
- Derived hill shade from 1 Second SRTM v1.0 Digital Elevation Models;
- Homestead locations (DNRM 2015a); and
- Queensland Globe (DNRM 2015a) feature of Google Earth.

5.4.8.2 Desktop Assessment

When undertaking a VIA it is generally recognised that there is a limit to the human field of vision. The key factors in determining visual impact are based on:

- The human perception of views and parameters of vision;
- The natural topography and topographical change; and
- The natural vegetation that has the potential to screen views.

Scientific studies undertaken by Costella (1995) and Ball et al. (2005) identify the relationship between the potential landscape change and the proportion of area the development occupies (i.e. how much can be seen) within the horizontal and vertical line of sight.

The duration in which people view the landscape is a crucial factor in analysing the sensitivity to change. Variations in the landscape are more noticeable from lookouts and permanent viewing points compared to a view while travelling along a road. As such, the relative duration spent at each viewing location has a significant influence on the sensitivity of change to the landscape.

5.4.8.3 Landscape Character

The landscape character assessment included mapping and describing broad landscape character types and any discrete landscape character areas within each character type. The potential impact on landscape character is measured by the responses felt by sensitive receptors towards the combined effects of the new development. Determining the landscape character areas includes consideration of:

- Landform;
- Vegetation;
- Intensity; and
- Character of land.

5.4.8.4 Identification of Sensitive Receptors

Potential sensitive visual receptors were identified with the aid of mapping data sources (including GIS) and the soil surveys. They are nominated at locations where the Project may be visible to residents, or areas where visitors spend extended amounts of time. Sensitive receptors include homesteads as well as areas from which transient views are possible, such as roads, service stations and rail lines.

5.4.8.5 Calculation of Zone of Theoretical Visibility

A zone of theoretical visibility (ZTV) is the theoretic assessment of visibility to or from a designated point in the landscape. It uses elevation data to calculate the extent of visibility from that point to anywhere in the study area. The mapping does not consider buildings or vegetation screening and hence reflects a 'bare-earth landscape', which represents the "worst case scenario". The ZTV generated for this assessment is based on 1s Shuttle Radar Topography Mission (SRTM) v1.0 Digital Elevation Model (DEM) (Geoscience Australia 2011) and an observer eye height of 1.8 m. A ZTV was generated for each of the relevant homesteads identified for the preliminary investigation area.

5.4.8.6 Visual Sensitivity

Visual sensitivity refers to receptors and their sensitivity to their visual environment. Visual impacts relate to the change that arise in composition of available views as a result of changes to the existing landscape, people's responses to these changes, and the overall impacts with respect to visual amenity.

For this assessment, key visual receptors include any nearby residents, users of transport routes (road and rail) as well as users of public recreation whom all have differing sensitivities to their visual environment. Generally, sensitivity is derived from a combination of factors including:

- The receptors interest in the visual environment i.e. high, medium or low interest in their everyday visual environment, and the duration of the effect;
- The receptors duration of viewing opportunity, i.e. prolonged, regular viewing opportunities;
- Number of viewers and their distance / angle of view from the source of the effect, extent of screening/filtering of the view, where relevant;
- Magnitude of change in the view (i.e. loss / addition of features that change the view's composition) and integration of changes within the existing view (form, mass, height, colour and texture); and
- Effectiveness of proposed mitigation.

For the purposes of this assessment, the terminology set out in Table 5-5 has been used to describe visual sensitivity.

Table 5-5 Visual sensitivity definitions

Sensitivity	Definition
High	Occupiers of residential properties with long viewing periods, within proximity to the proposed development. Communities that place value upon the landscape and enjoyment of views of the landscape setting.
Medium	Outdoor workers who may also have intermittent views of the Project area. Viewers at outdoor recreation areas located within proximity but where viewing periods are limited. Occupiers of residential properties with long viewing periods, at a distance from or screened/filtered views of the Project area.
Low	Road users in motor vehicles, trains or on transport routes that are passing though or adjacent to the study area and have short term / transient views.
Neutral	Viewers from locations where there is screening by vegetation or structures where only occasional views are available and viewing times are short.
Nil	No view of the Project area is possible.

5.4.8.7 Limitations

Key viewing locations were selected as the most sensitive viewing locations or where the Project is likely to be viewed by the greatest number of people via a desktop assessment. Despite this limitation, the most important sensitive receptors, in terms of number of people being affected, have been captured as part of this assessment.

5.5 Description of Environmental Values

5.5.1 Topography

Elevations across the Styx catchment range from 0 to 540 m above sea level. The area predominantly comprises flat or undulating lands, draining via several smaller creeks and tributaries to the Styx River and estuary, and into the Coral Sea (see Figure 5-3). The land within the Project area can be described as gently undulating (see Plate 5-1 to Plate 5-8).

A LiDAR survey was conducted of the EPC 1029 area. Based on this data, elevations within the ML area vary between 4.5 and 155 m AHD, with the Project area located between 11.4 and 43.8 m AHD.

Based on the Capricornia Coastal Lands program (DPI, 1995), the ML area contains the following geomorphological land units:

- Broad, level to gently undulating alluvial plains and fans on alluvium, including some areas of gilgai microrelief (melonhole);
- Level to gently undulating plains and rises on sedimentary rocks and unconsolidated sediments, including some minor to severe melonhole;
- Undulating rises and low hills on deeply weathered sedimentary and metamorphic rocks;
- Narrow floodplains along the Styx River;
- Dissected low plateaus on gently dipping sedimentary rocks; and
- Rolling low hills and rises on hard sedimentary rocks.

Plate 5-1: Terrain at the south of Open Cut 1 - waste dump (SS01 location)

Plate 5-2: Terrain looking south across Open Cut 1 (SS02 location)

Plate 5-3: Terrain looking east across Open Cut 2 (SS03 location)

Plate 5-4: Terrain at the TLF (SS04 location)

Plate 5-5: Terrain next to Deep Creek looking south towards Open Cut 2 (SS05 location)

Plate 5-6: Terrain looking south over Open Cut 4 (SS06 location)

Plate 5-7: Terrain looking east towards Open Cut 1 (SS07 location)

Plate 5-8: Terrain looking east towards Open Cut 1 (SS08 location)

5.5.2 Land Use

The current land use of the Project area is cleared livestock breeding and fattening on improved pasture with limited areas of native remnant vegetation. Investigations of land use following industry classification methods have been undertaken to define the current land use. This information has in turn allowed for the determination of the final land use, post-mining activities, to allow the development of potential rehabilitation strategies to minimise potential environmental impacts.

Central Queensland Coal intends to manage its operations and conduct decommissioning and rehabilitation activities to ensure that the land disturbed is returned to land suitable for grazing or revegetated to meet conservation objectives where appropriate.

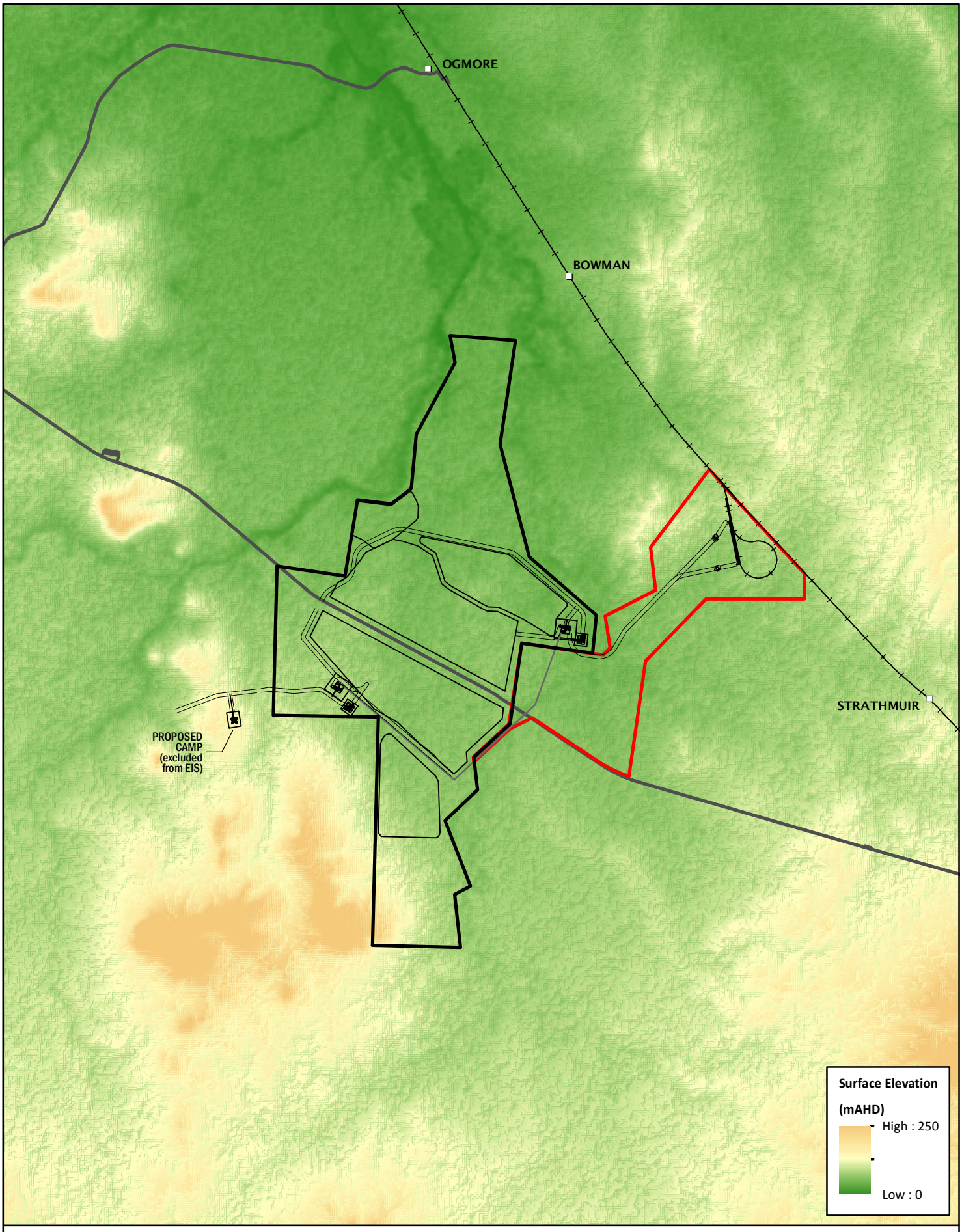


Figure 5-3
Site topography

N

0 1 2 km

Legend

- ML 80187
- ML 700022
- Proposed mine infrastructure
- North Coast Rail Line
- Main road
- Watercourse

Scale @ A4 1:80,000
Date: 24/07/17
Drawn: Gayle B.

DATA SOURCE
QLD Spatial Catalogue (QSpatial), 2017
1 Second SRTM v1.0 DEM
Geoscience Australia, 2011

CDM Smith

BRUGGEMANNGD B:\BES150160 Styx Coal\GIS\DATA\MXD\FINAL\03 EIS Preparation\BES150160.03-033 R2 topography.mxd 7/24/2017

5.5.3 Geology

5.5.3.1 Regional Geology

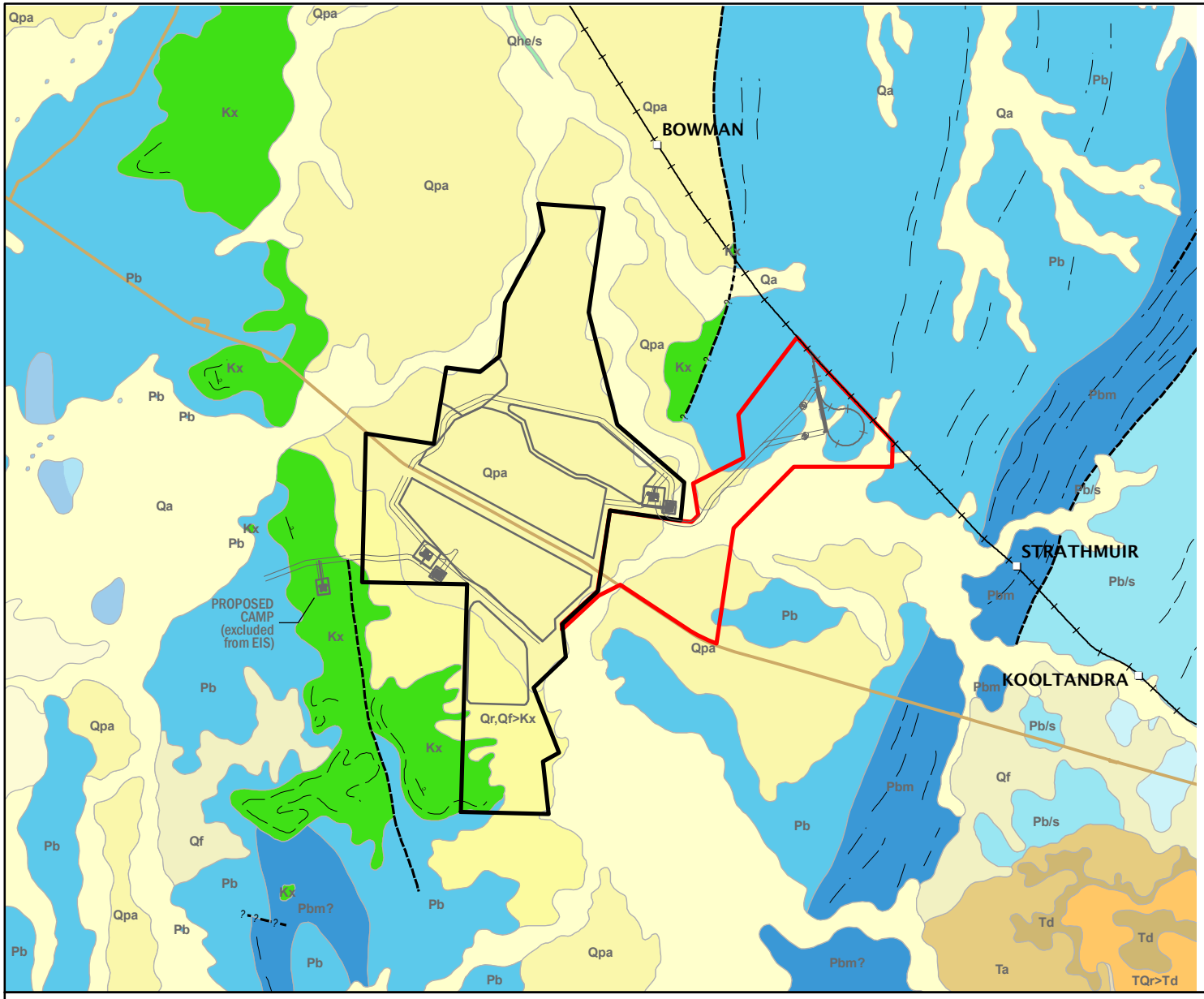
The Styx Coal reserves lie in the Styx Basin, a small, Early Cretaceous, intracratonic sag basin that covers an area of approximately 300 km^2 onshore and 500 km^2 offshore. The known coal bearing strata of the basin are referred to as the Styx Coal Measures and consist of quartzose, calcareous, lithic and pebbly sandstones, pebbly conglomerate, siltstone, carbonaceous shale and coal. The environment of deposition was freshwater, deltaic to paludal with occasional marine incursions (Taubert 2002). The regional geology of the Styx Basin is shown at Figure 5.4 and described in Table 5-6.

Table 5-6 Geological units underlying the Styx Basin

Period	Group	Sub-group/formation	Dominant lithology
Quaternary	Surficial	Quaternary Alluvial	Alluvium, coastal swamp deposits
Cainozoic	Surficial	Undifferentiated sediment	Sand, soil, alluvium, lateritic gravel
Lower Cretaceous	-	Styx Coal Measures	Quartz sandstone, conglomerate, siltstone, carbonaceous shale, coal
Upper Permian	Back Creek Group	Boomer Formation	Volcanolithic sandstone, claystone, siltstone, pebble conglomerate
Permian	Back Creek Group	Back Creek Group	Undifferentiated: fossiliferous volcanolithic sandstone, siltstone, limestone

The Styx Coal Measures are preserved as basin infill in a half graben geometry which has an overall plunge to the north. Earlier attempts to understand coal-seam geometry are thought to have been incorrect, in assuming that the deposit was basically flat lying rather than incorporating the north and east dipping components.

The Styx Basin is relatively undeveloped, except for two small scale, government owned mines that were in operation from 1919 to 1963. The Ogmore and Bowman collieries, located close to the north and northeast of ML80187 respectively, produced small qualities of low quality coal, for use in steam trains and other boiler requirements (see Chapter 18 - Cultural Heritage).



FAULTS
- Fault Approximate
- Fault Concealed
- Fault Inferred
- Trend Line
- Trend Line Showing Dip 5 to 15 Degrees

QUATERNARY
- Qa-QLD (Qa)
- Qf-QLD (Qf)
- Qr-QLD,Qf-QLD>Styx Coal Measures (Qr,Qf>Kx)

PLEISTOCENE
- Qpa-QLD (Qpa)

HOLOCENE
- Qhe/s-YARROL/SCAG (Qhe/s)

LATE TERTIARY-QUATERNARY
- TQr-QLD>Td-QLD (TQr>Td)
- TQr-QLD (TQr)

TERTIARY
- Ta-YARROL/SCAG (Ta)
- Td-QLD (Td)

EARLY CRETACEOUS
- Styx Coal Measures (Kx)

LATE PERMIAN
- Back Creek Group-Pb (Pb)
- Back Creek Group/s (Pb/s)
- Back Creek Group/s? (Pb/s?)
- Boomer Formation (Pbm)
- Boomer Formation? (Pbm?)

N

0 1 2 km

Legend
- ML 80187
- ML 700022
- Proposed mine infrastructure
- North Coast Rail Line
- Main road

Scale @ A4 1:100,000
Date: 12/07/17
Drawn: Gayle B.

Figure 5-4
Regional geology

DATA SOURCE
QLD Spatial Catalogue (QSpatial), 2016

CDM Smith

5.5.3.2 Geology of the Project Area

The stratigraphy of the Project area is shown at Figure 5-5. The coal seams are relatively shallow, and the average cumulative thickness of the full sequence of coal (Grey to V_L2 seams) is approximately 6 m, contained within a sequence of approximately 120 m of coal bearing strata.

The coal seams dip generally to the east in the area west of the Bruce Highway, with the Violet seam, the lowest coal seam in the sequence subcropping in the western part of ML80187. The deposit structure is currently interpreted to be a syncline structure, the axis of which runs northwest / southeast through the mine area. This structural interpretation follows the deposit structure originally described by Morten (1955).

Currently no faults have been interpreted, and the apparent undulation seen in the floor contours of the coal seams is interpreted to be small scale folding associated with the syncline in the area.

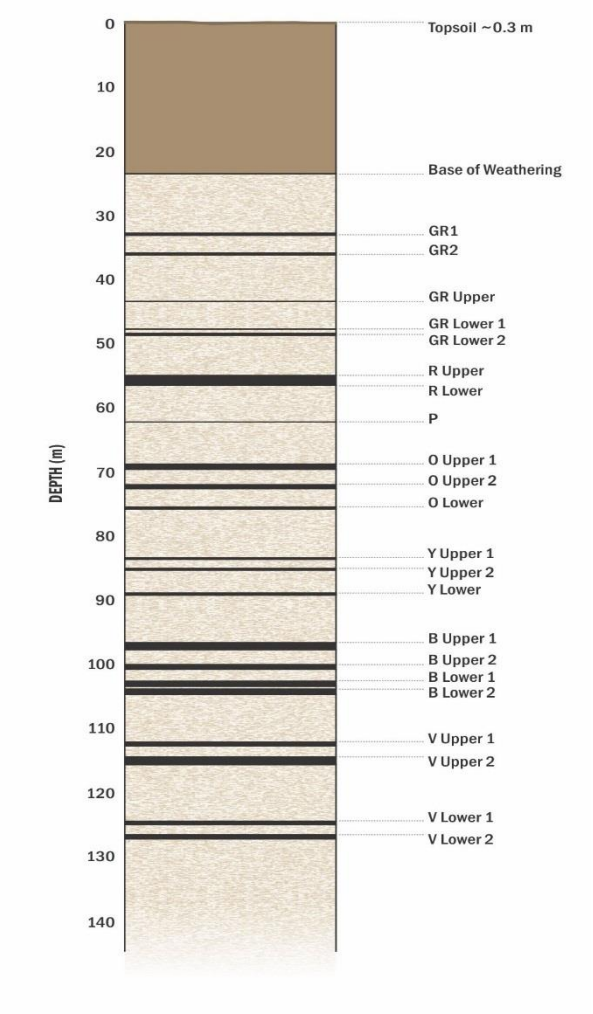


Figure 5-5 Schematic stratigraphic section

The economic Cretaceous coal measures targeted for mining are the Styx Coal Measures, contained within the Styx Basin. The Styx basin is located on the central Queensland coast, north of Marlborough. It is a Lower Cretaceous sedimentary basin which unconformably overlies Permian sedimentary rocks of the Back Creek Group that have been compressed into a broad regional syncline, the Strathmuir Syncline. The basin extends beneath the sea bed into the Broad Sound near the Port of St Lawrence. Its portion on land is approximately 20 km wide (east-west) and 70 km long (north-south).

The majority of the Styx Coal Measures are concealed beneath Tertiary sediment. Queensland Geological Survey mapping shows the eastern margin of the Styx Basin extends to the eastern edge of the terrestrial Cainozoic sediments that conceal it. The Styx Coal Measures outcrop in the western margin of the Styx Basin as low forested hills. These outcrops form a series of detached hills, orientated north-south, that continue for about 60 kilometres northward to the coastline near the Port of St Lawrence. The outcrops generally form small hills and hillocks, but at their greatest height, are 100 metres above the low-lying sediment flats to the east. The hills are probably the coal-barren basal section of the Styx Coal Measures sequence, which consists of thick beds of quartz-dominant sandstones.

The strata of the Styx Basin dip gently to the east, at around 3 degrees. Tertiary-aged, lateritised sedimentary rocks outcrop to the east of the southern part of the basin. Styx Basin sediments lap onto Permian strata in the west, but appear to be faulted against them in the east. The southern part of the basin is bounded to the east by a post-depositional high-angle reverse fault. Adjacent to this fault, the Cretaceous sediments are folded and faulted.

The Styx Basin sediments were laid down on a coastal plain which developed on the Palaeozoic Strathmuir Syncline during the Early Cretaceous. The Styx Basin probably developed by subsidence of the Strathmuir Synclinorium, an older feature containing Permian Bowen Basin strata. A schematic geological section (east-west) across the Styx Basin is shown in Figure 5-6.

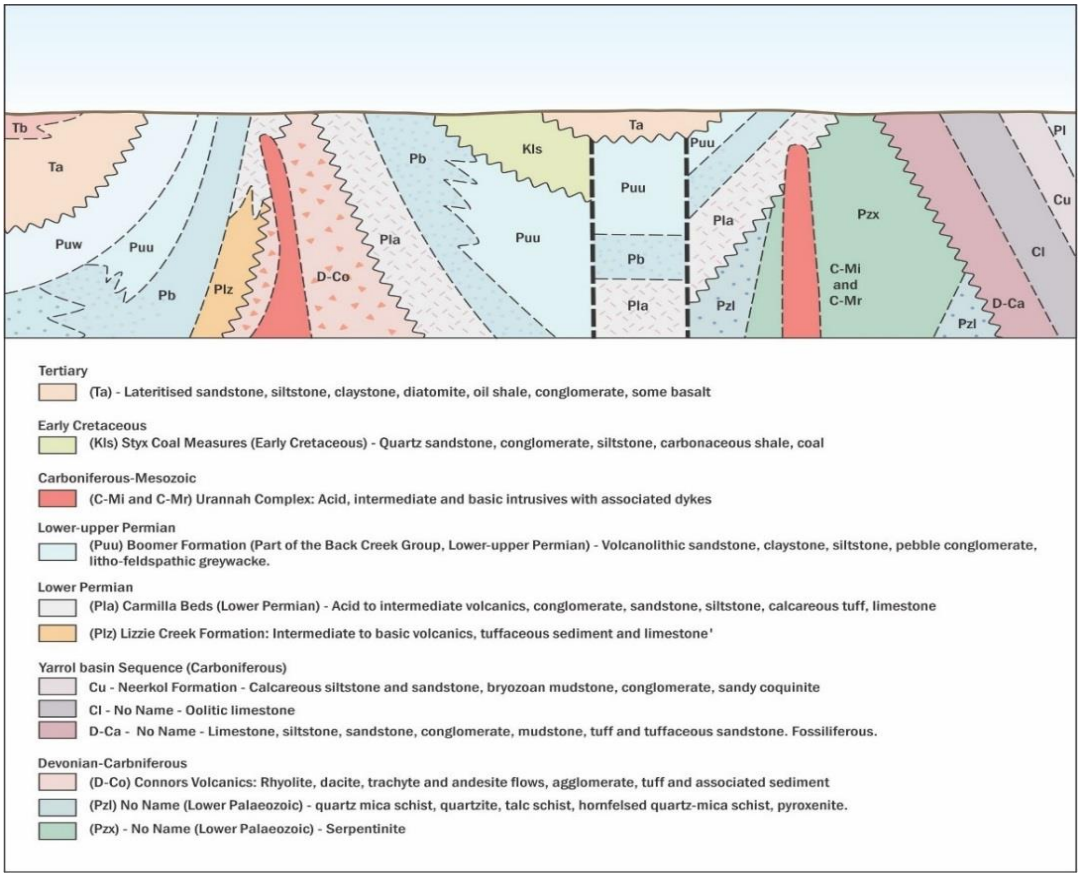


Figure 5-6 Schematic west to east geological cross section (from Australia 1:250 000 Geological Series)

Cretaceous Coal Seam Characteristics – Styx Coal Measures

The coal seams that comprise the Styx Coal Measures are generally thin, commonly less than two metres in thickness. Seam splitting is common and seam thicknesses vary considerably. All seams are potentially economically exploitable, despite their relatively small thicknesses. Coal quality throughout the deposit is fairly consistent, and all seams demonstrate coking properties.

The seams were divided into seam groups and named using a colour scheme. From the base of the Measures to the top, they are tagged as: Violet, Blue, Yellow, Orange, Pink, Red, Green and Grey.

The coal plies may coalesce to form substantially thick seams in parts of the deposit (e.g. Violet and Blue) but in other seams (Orange, Green, Grey) coalescence is not evident in the ML 80187 area. It is common for the coal plies to lense out over moderate distances. The Orange, Green and Grey Seams are characteristically coal ply groups that may coalesce elsewhere in the Styx Basin, but do not coalesce within the proposed mining area. The Red, Yellow and Pink Seams split into two plies in isolated areas. The Red Seam is the most consistent in thickness and quality throughout the ML 80187 area, and occurs in the middle of the coal-bearing part of the stratigraphic sequence. The Red Seam commonly exceeds two metres in thickness.

All plies and coalesced seams demonstrate coal quality and seam thickness characteristics that are attractive mining targets. Coal quality analysis and reconciliation with geophysical data show that the majority of ROM coal will require wash-plant treatment to remove partings. Sulphur content is low, even in the raw sample analysis. Pyrite has not been noted in any geological logging or results of quality analysis. Float-sink, drop-shatter, sizing and associated analyses indicate wash-plant yields are likely to be around 80% of ROM coal. Basic seam thickness information is provided in Table 5-7.

Table 5-7 Cretaceous coal measures coal seam characteristics

Seam	Ply	Seam thickness (m)		
		Min	Max	Average
Grey	GR1	0.11	1.09	0.42
	GR2	0.10	0.77	0.37
Green	GR Upper	0.10	0.85	0.34
	GR Lower1	0.10	0.79	0.37
	GR Lower2	0.10	0.29	0.19
Red	R Upper	0.10	2.24	0.81
	R Lower	0.10	1.32	0.71
Pink	P	0.10	0.25	0.16
Orange	O Upper1	0.10	0.60	0.33
	O Upper2	0.10	0.39	0.26
	O Lower	0.10	0.71	0.36
Yellow	Y Upper1	0.10	2.74	0.64
	Y Upper2	0.10	1.03	0.30
	Y Lower	0.10	0.78	0.37
Blue	B Upper1	0.10	1.76	0.56
	B Upper2	0.10	1.71	0.71
	B Lower1	0.10	2.23	0.53
	B Lower2	0.11	0.88	0.37
Violet	VI Upper1	0.10	1.35	0.36
	VI Upper2	0.10	0.30	0.18
	VI Lower1	0.10	1.19	0.43
	VI Lower2	0.10	0.74	0.34
	VI Lower2	0.10	0.71	0.39

5.5.3.3 Fossils

A review of the Queensland Museum palaeontology database (May 2017) records indicate no significant fossils have previously been identified within the Central Queensland mine area and are considered unlikely to occur. If fossils with the potential to be of paleontological significance are discovered, the immediate site of the fossil find will be isolated and the Queensland Museum will be notified. This requirement will be included in the Environmental Management (EM) Plan.

5.5.4 Soils

5.5.4.1 Desktop Assessment

An assessment of publicly available soil and landform mapping data provided an initial indication of relevant soil types across and surrounding the Project area. Results from the desktop assessment as they relate to soils and landforms are described below.

Mapped landscape units identified four broad scale units that occur within the Project area – CC32, Mw26, Ub89 and Vd3 (Figure 5-8). The landscape unit descriptions provided by ASRIS are summarised below:

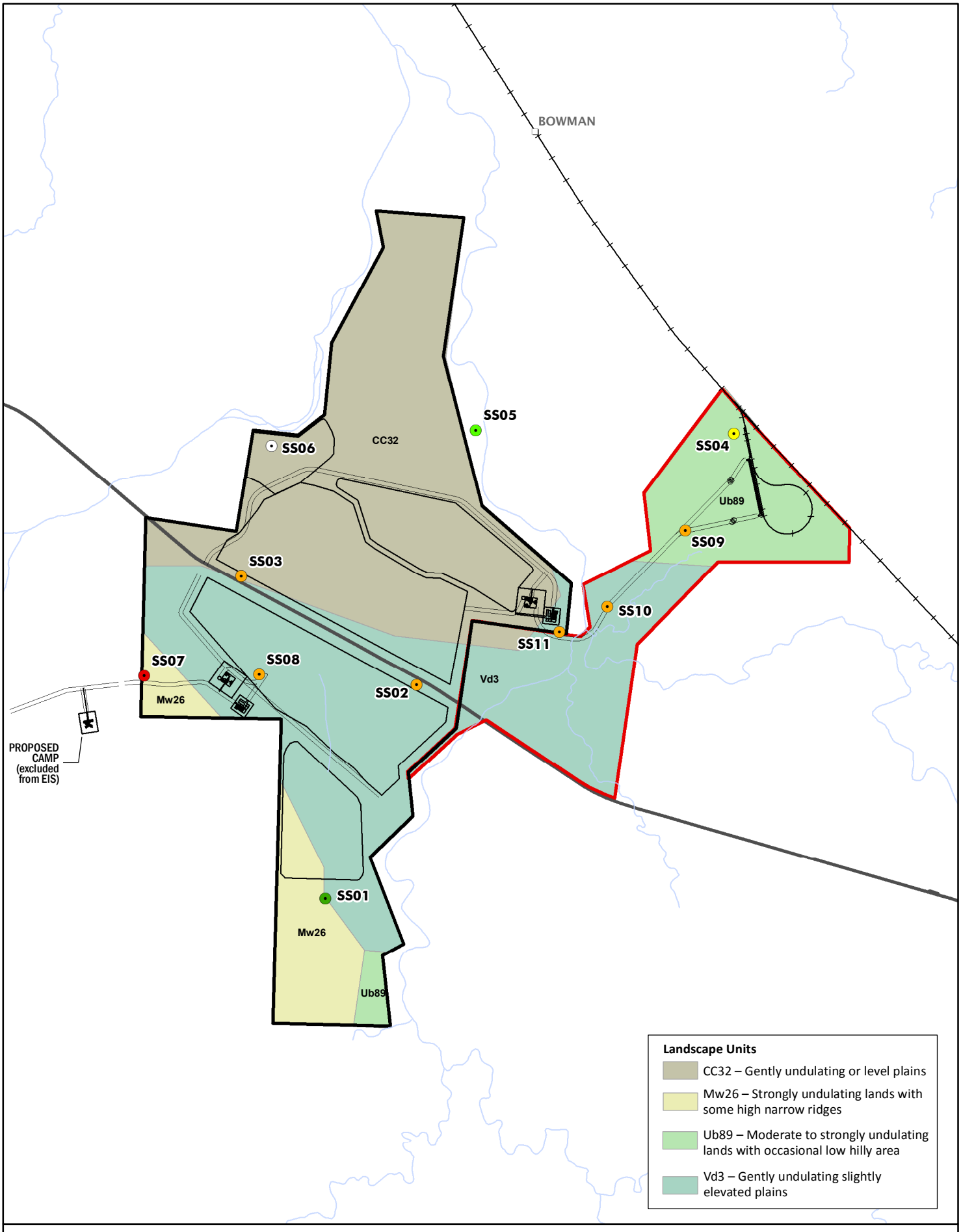
CC32: Gently undulating or level plains - This landform comprises gently undulating or level plains, often with slight to moderate gilgai microrelief and is characterised by deep grey clays with lesser deep brown clays. Closely associated are extensive areas of loamy duplex soils and friable brown clays.

Mw26: Strongly undulating lands with some high narrow ridges - This landform comprises strongly undulating lands with some high narrow ridges, low dissected mesas and steep-scarped low cuestas and is characterised by deep sandy red earths that are occasionally gravelly. On higher more dissected landscape sites are shallow stony loams, and lower flatter slopes mostly have deep sandy-surface duplex soils.

Ub89: Moderate to strongly undulating lands with occasional low hilly areas - This landform comprises moderate to strongly undulating lands with occasional low hilly areas and is characterised by shallow loamy duplex soils. A prominent stony layer is often present at the base of the A horizons. Higher ridges and low hilly areas have very shallow stony similar duplex soils.

Vd3: Gently undulating slightly elevated plains - This landform comprises gently undulating slightly elevated plains with a slight gilgai microrelief and is characterised by soils with deep loamy A horizons. Duplex soils occur on level sites, in most puffs (the small mounds in gilgai settings), and in all depressions. In the latter, A horizons are deep. Grey clays occur occasionally on some better-defined puffs.

Queensland soil maps indicate sodosols, vertosols and kandosols are the predominant soil orders within the Project area (Figure 5-7). ASRIS indicated the same dominant soil orders across the mine, haul road corridor and TLF. The vertosols correspond to the flatter landscape (CC32) in the north of the Project site. The sodosols are the most widespread soil order in the Project surrounds and correspond to the more elevated plains (Vd3) which run east-west through the central axis of the Project site. The Kandosols correspond to the undulating land (Mw26) to the south west of the Project site.



N

0 0.5 1 km

Scale @ A4 1:60,000
Date: 24/07/17
Drawn: Gayle B.

Legend

Soil Sampling Classification

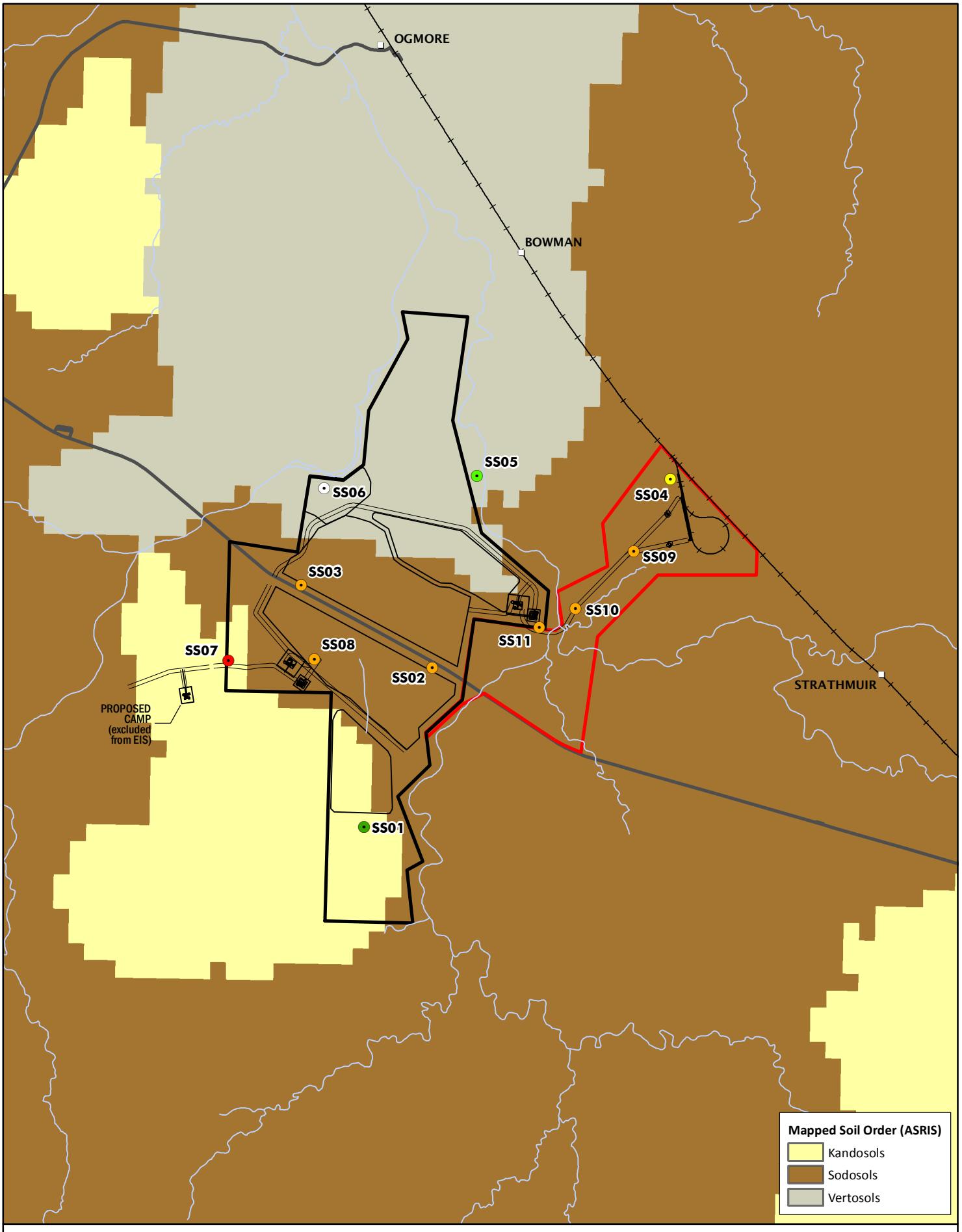
- Rudosol
- Sodosol
- Brown Sodic Kandosol
- Dermosol
- Vertosol
- Red Kandosol

- ML 80187
- ML 700022
- Proposed mine infrastructure
- North Coast Rail Line
- Main road
- Watercourse

Figure 5-7
Project mapped landscape units

DATA SOURCE
QLD Spatial Catalogue (QSpatial), 2017
Australian Soil Resource Information System (ASRIS), 2014

CDM Smith



Legend

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- Proposed mine infrastructure
- North Coast Rail Line
- Main road
- Watercourse

N

0 1 2 km

Scale @ A4 1:80,000
Date: 24/07/17
Drawn: Gayle B.

Figure 5-8
Queensland government mapped soil units

DATA SOURCE
QLD Spatial Catalogue (QSpatial), 2017
Mapped Soil Order, Australian Soil Resource Information System (ASRIS), 2014

CDM Smith

BRUGGEMANNGD B:\BES150160 Styx Coal\GIS\DATA\MXD\FINAL\03 EIS Preparation\BES150160.03-018 R2 dominant soils.mxd 7/24/2017

5.5.4.2 Field Assessment

During the field assessment eight full soil samples were collected (SS01 – SS08) and 13 soil observations undertaken (SO-01 to SO-13). The description of each of the full soils samples are provided at Table 5-8 to Table 5-18.

There was reasonable alignment between the soil orders mapped by desktop analyses and the soil classifications made by field investigations. The exceptions were: SS01 (mapped as a Kandosol but classed as a Rudosol due to negligible pedological organisation but sharing many of the characteristics of a Kandosol); SS04 (mapped as a Sodosol but as classed as a Kandosol due to a lack of a strong texture-contrast between A and B horizons despite being sodic); and SS05 (mapped as a Vertosol but classed as a Dermosol due to soil texture not being sufficiently heavy to meet the criteria for Vertosols).

The two sites classed as Kandosols (SS04 and SS07) are distinctly different soils despite being grouped within the same soil order. This is reflected in their classification with SS04 being classed as a brown sodic Kandosol and SS07 being classed as a Red Kandosol.

Table 5-8 SS01 description

Site ID: SS01	**Date 6/05/17**	
Location: Lot 11 on MC23	**Easting: 772837**	**Northing: 7483395**
Geology: Qr-QLD, Qf-QLD>Styx Coal Measures (Qr,Qf>Kx)	Mapped Soil Type: Kandosol	
Micro-relief: Nil	Field Based Soil Type: Rudosol	
Landuse: Grazing (not cleared)	Land Disturbance: High area is full of weeds with minimal native vegetation	
Landscape Unit: Mw26 – Strongly undulating lands with some high narrow ridges	Landform Element: Upper slope	
Landform Pattern: Plain	Vegetation: Low and scattered regrowth of Narrow-leaf Ironbark (*E. crebra*) and *Melaleuca* species	
Slope: Very gently inclined (1%)	Drainage: Imperfectly drained	
Surface Condition: Soft	Erosion Potential: Low	

Figure 1: SS01 Landscape

Figure 2: SS01 Soil Profile, Depth to 1.2 m

Horizon	**Depth (m)**	**Description**
A	0 – 1.2	Dark brown (10 YR 3/3); fine sandy (single grain)
Terminate		

Laboratory Results

Analysis	**Depth Tested (m)**					
	0.0 – 0.1	**0.1 – 0.2**	**0.2 – 0.3**	**0.5 – 0.6**	**0.8 – 0.9**	**1.1 – 1.2**
pH Value (pH unit)	5.3	5.4	5.5	5.5	5.6	5.6
Electrical Conductivity (us/cm)	20	10	7	7	16	34
Moisture Content (%)	9.6	7.9	8.8	9.6	12.2	10.3

Colour (Munsell)	Very Dark Gray	----	----	Light Brownish Gray	----	Light Brownish Gray
Texture	Loamy Sand	----	----	Sand	----	Loamy Sand
Emerson Class Number	3	----	----	8	----	3
Soil Particle Density (Clay / Silt / Sand) (g/cm^3)	2.37	2.5	2.4	2.58	2.5	2.4
Exchange Acidity (meq/100g)	0.6	0.6	0.3	0.5	0.4	0.3
Exchangeable Aluminium (meq/100g)	0.4	0.3	0.2	0.3	0.2	0.2
Exchangeable Calcium (meq/100g)	0.8	0.7	0.3	0.1	<0.1	<0.1
Exchangeable Magnesium (meq/100g)	0.5	0.5	0.4	0.3	1.1	1.3
Exchangeable Potassium (meq/100g)	0.4	0.2	0.2	0.2	0.2	<0.1
Exchangeable Sodium (meq/100g)	<0.1	<0.1	<0.1	<0.1	<0.1	0.4
Cation Exchange Capacity (meq/100g)	2.3	2	1.2	1.1	1.7	2
Exchangeable Sodium Percent (%)	2.2	1.5	1.9	1.8	6.6	21.1
Calcium / Magnesium Ratio	1.6	1.4	0.8	0.3	<0.1	<0.1
Magnesium / Potassium Ratio	1.3	1.8	2.5	2.1	7.2	----
Sulfur (%)	<0.01	----	----	----	----	----
Chloride (mg/kg)	<10	----	----	<10	----	40
Boron (mg/kg)	0.3	----	----	----	----	----
Copper (mg/kg)	<1.00	----	----	----	----	----
Iron (mg/kg)	197	----	----	----	----	----
Manganese (mg/kg)	5.64	----	----	----	----	----
Zinc (mg/kg)	<1.00	----	----	----	----	----
Nitrite + Nitrate as N (mg/kg)	1.8	----	----	----	----	----
Total Kjeldahl Nitrogen as N (mg/kg)	730	----	----	----	----	----
Total Nitrogen as N (mg/kg)	730	----	----	----	----	----
Bicarbonate Ext. P (mg/kg)	<5	----	----	----	----	----
Organic Matter (%)	2	----	----	----	----	----
Particle size distribution						
Clay (<2 µm) (%)	11	11	8	11	14	18
Silt (2-20 µm) (%)	8	5	9	3	3	4
Fine Sand (0.02-0.2 mm) (%)	12	10	10	10	10	9
Coarse Sand (0.2-2.0 mm) (%)	19	21	19	16	14	17
Gravel (>2mm) (%)	50	53	54	60	59	52

Table 5-9 SS02 description

Site ID: SS02	**Date 6/05/2017**	
Location: Lot 1 on MC813349	**Easting: 773943**	**Northing: 7485595**
Geology: Qpa-QLD (Qpa)	Mapped Soil Type: Sodosol	
Micro-relief: Nil	Field Based Soil Type: Sodosol	
Landuse: Grazing	Land Disturbance: Minor	
Landscape Unit: Vd3 - Gently undulating slightly elevated plains	Landform Element: Upper slope	
Landform Pattern: Plain	Vegetation: Cleared area with scattered immature trees including Beefwood (*Grevillea striata*), Brigalow (*Acacia harpophylla*) and Poplar Box (*E. populnea*). Beside fence line of larger trees – Poplar Box	
Slope: Level (0.6 %)	Drainage: Imperfectly drained	
Surface Condition: Firm	Erosion Potential: Low	

Figure 1: SS02 Landscape

Figure 2: SS02 Soil Profile, Depth to 1.2 m

Horizon	**Depth (m)**	**Description**
A1	0.0 – 0.15	Dull yellow orange (10 YR 7/2), loamy sand, diffuse (>100 m)
A2	0.15 – 0.35	Greyish yellow brown (10 YR 6/2), clayey sand, gradual 50 – 100 mm)
A3	0.35 – 0.45	Dull yellow orange (10 (YR 6/3), clayey sand, clear (20 – 50 mm)
B1	0.45 – 0.84	Yellowish brown (10 YR5/6), clayey sand, gradual 50 – 100 mm)
B2	0.84 – 1.2	Brown (10 YR 4/6), clayey sand
Terminate		

Laboratory Results

Analysis	**Depth Tested (m)**					
	0.0 – 0.1	**0.1 – 0.2**	**0.2 – 0.3**	**0.5 – 0.6**	**0.8 – 0.9**	**1.1 – 1.2**
pH Value (pH unit)	6.2	6	6.1	7.6	8	8
Electrical Conductivity (us/cm)	10	38	192	581	554	517
Moisture Content (%)	3.3	8.2	9.6	13.6	10	10
Colour (Munsell)	Brown	----	----	Pale Brown	----	Brown
Texture	Loamy Sand	----	----	Clay Loam	----	Clay Loam
Emerson Class Number	3	----	----	2	----	2
Soil Particle Density (Clay / Silt / Sand) (g/cm^3)	2.36	2.56	2.5	2.48	2.33	2.35
Exchange Acidity (meq/100g)	----	----	----	----	----	----
Exchangeable Aluminium (meq/100g)	----	----	----	----	----	----
Exchangeable Calcium (meq/100g)	2.4	4.1	5.1	2.1	2.1	1.8

Exchangeable Magnesium (meq/100g)	1.9	5.7	7.9	4	3.6	3.1
Exchangeable Potassium (meq/100g)	0.2	0.2	0.3	<0.2	<0.2	<0.2
Exchangeable Sodium (meq/100g)	0.2	1.1	2	1.3	1.5	1.3
Cation Exchange Capacity (meq/100g)	4.7	11.4	15.5	7.4	7.2	6.1
Exchangeable Sodium Percent (%)	3.9	9.6	13.1	17	20.9	21.3
Calcium / Magnesium Ratio	1.3	0.7	0.6	0.5	0.6	0.6
Magnesium / Potassium Ratio	10.6	21.9	28.3	----	----	----
Sulfur (%)	<0.01	----	----	----	----	----
Chloride (mg/kg)	<10	----	----	990	----	820
Boron (mg/kg)	0.2	----	----	----	----	----
Copper (mg/kg)	<1.00	----	----	----	----	----
Iron (mg/kg)	62.5	----	----	----	----	----
Manganese (mg/kg)	62.7	----	----	----	----	----
Zinc (mg/kg)	<1.00	----	----	----	----	----
Nitrite + Nitrate as N (mg/kg)	<0.1	----	----	----	----	----
Total Kjeldahl Nitrogen as N (mg/kg)	550	----	----	----	----	----
Total Nitrogen as N (mg/kg)	550	----	----	----	----	----
Bicarbonate Ext. P (mg/kg)	<5	----	----	----	----	----
Organic Matter (%)	1.3	----	----	----	----	----
Particle size distribution						
Clay (<2 µm) (%)	18	22	51	42	35	36
Silt (2-20 µm) (%)	42	60	32	33	31	29
Fine Sand (0.02-0.2 mm) (%)	24	13	15	23	29	30
Coarse Sand (0.2-2.0 mm) (%)	2	<1	1	<1	4	4
Gravel (>2mm) (%)	14	4	1	1	1	1

Table 5-10 SS03 description

Site ID: SS03	**Date 5/05/2017**	
Location: Lot 10 on MC493	**Easting: 771804**	**Northing: 7487330**
Geology: Qpa-QLD (Qpa)	Mapped Soil Type: Sodosol	
Micro-relief: Nil	Field Based Soil Type: Sodosol	
Landuse: Grazing	Land Disturbance: Minor	
Landscape Unit: Vd3 - Gently undulating slightly elevated plains	Landform Element: Upper slope	
Landform Pattern: Plain	Vegetation: RE 11.4.2 - Poplar Box and Narrow-leaf Ironbark dominated woodland with sparse understorey	
Slope: Level (0.6 %)	Drainage: Poorly drained	
Surface Condition: Firm	Erosion Potential: Moderate	

Figure 1: SS03 Landscape

Figure 2: SS03 Soil Profile, Depth to 1.2 m

Horizon	**Depth (m)**	**Description**
A1	0.0 – 0.23	Bright Brown (10 YR 6/6), loamy sand, diffuse (>100 mm)
A2	0.23 – 0.33	Dull yellowish brown (10 YR 5/4), clayey sand, diffuse (>100 mm)
A3	0.33 – 0.5	Yellowish brown (10 YR 5/6), light clay, clear (20 – 50 mm)
B	0.5 – 1.2	Brown (10 YR 4/6), light medium clay
Terminate		

Laboratory Results

Analysis	**Depth Tested (m)**					
	0.0 – 0.1	**0.1 – 0.2**	**0.2 – 0.3**	**0.5 – 0.6**	**0.8 – 0.9**	**1.1 – 1.2**
pH Value (pH unit)	6.3	6.5	7	8.3	9.1	9.1
Electrical Conductivity (us/cm)	7	13	51	215	492	412
Moisture Content (%)	2.8	3.2	6.4	8.4	8.4	7.5
Colour (Munsell)	Brown	----	----	Yellowish Brown	----	Yellowish Brown
Texture	Clay Loam	----	----	Clay Loam	----	Clay Loam
Emerson Class Number	3	----	----	1	----	1
Soil Particle Density (Clay / Silt / Sand) (g/cm^3)	2.38	2.37	2.32	2.32	2.46	2.43
Exchange Acidity (meq/100g)	----	----	----	----	----	----
Exchangeable Aluminium (meq/100g)	----	----	----	----	----	----
Exchangeable Calcium (meq/100g)	1.6	1.3	1.8	0.8	0.7	0.8
Exchangeable Magnesium (meq/100g)	2.5	2.6	4.6	3.3	3.2	3.5

Exchangeable Potassium (meq/100g)	<0.1	<0.1	<0.1	<0.2	<0.2	<0.2
Exchangeable Sodium (meq/100g)	0.3	0.6	1.4	1.7	2.1	2.6
Cation Exchange Capacity (meq/100g)	4.8	4.6	7.9	5.8	6	6.9
Exchangeable Sodium Percent (%)	7	12.4	18.1	29	35.2	37.7
Calcium / Magnesium Ratio	0.6	0.5	0.4	0.2	0.2	0.2
Magnesium / Potassium Ratio	----	----	----	----	----	----
Sulfur (%)	<0.01	----	----	----	----	----
Chloride (mg/kg)	<10	----	----	190	----	430
Boron (mg/kg)	0.3	----	----	----	----	----
Copper (mg/kg)	<1.00	----	----	----	----	----
Iron (mg/kg)	40.5	----	----	----	----	----
Manganese (mg/kg)	36.9	----	----	----	----	----
Zinc (mg/kg)	<1.00	----	----	----	----	----
Nitrite + Nitrate as N (mg/kg)	<0.1	----	----	----	----	----
Total Kjeldahl Nitrogen as N (mg/kg)	440	----	----	----	----	----
Total Nitrogen as N (mg/kg)	440	----	----	----	----	----
Bicarbonate Ext. P (mg/kg)	<5	----	----	----	----	----
Organic Matter (%)	1.1	----	----	----	----	----
Particle size distribution						
Clay (<2 µm) (%)	23	26	45	38	34	32
Silt (2-20 µm) (%)	15	17	14	17	14	16
Fine Sand (0.02-0.2 mm) (%)	20	19	12	20	23	24
Coarse Sand (0.2-2.0 mm) (%)	12	11	8	8	11	11
Gravel (>2mm) (%)	30	27	21	17	18	17

Table 5-11 SS04 description

Site ID: SS04	**Date 5/05/2017**	
Location: Lot 9 on MC230	**Easting: 777863**	**Northing: 7489007**
Geology: Back Creek Group-Pb (Pb)	Mapped Soil Type: Sodosol	
Micro-relief: Nil	Field Based Soil Type: Kandosol (Brown sodic Kandosol)	
Landuse: Grazing	Land Disturbance: Minor	
Landscape Unit: Ub89 – Moderate to strongly undulating lands with occasional low hilly areas	Landform Element: Upper slope	
Landform Pattern: Rises	Vegetation: Cleared pasture	
Slope: Gently inclined (6 %)	Drainage: Very poorly drained	
Surface Condition: Surface crust	Erosion Potential: Moderate	
Figure 1: SS04 Landscape	**Figure 2: SS04 Soil Profile, Depth to 0.5 m**	
		

Horizon	**Depth (m)**	**Description**
A1	0.0 – 0.23	(10 YR 6/2), clayey sand, diffuse (>100 mm)
A2	0.23 – 0.45	Dull yellowish brown (10 YR 5/3), loamy sand, clear (20 – 50 mm)
B	0.45 – 0.5	(10 YR 5/4), loamy sand, abrupt (5 – 20 mm)
Terminate		Ceased hole – hit rock

Laboratory Results

Analysis	**Depth Tested (m)**					
	0.0 – 0.1	**0.1 – 0.2**	**0.2 – 0.3**	**0.45 – 0.5**		
pH Value (pH unit)	7	7.6	8.2	9.5		
Electrical Conductivity (us/cm)	45	71	160	339		
Moisture Content (%)	7.3	8.3	9	7.5		
Colour (Munsell)	Dark Greyish Brown	----	----	Brown		
Texture	Clay Loam	----	----	Sandy Clay Loam		
Emerson Class Number	2	----	----	2		
Soil Particle Density (Clay / Silt / Sand) (g/cm3)	2.45	2.47	2.37	2.47		
Exchange Acidity (meq/100g)	----	----	----	----		
Exchangeable Aluminium (meq/100g)	----	----	----	----		
Exchangeable Calcium (meq/100g)	2.8	1.1	0.9	1.2		
Exchangeable Magnesium (meq/100g)	7.4	3.7	3	3.1		
Exchangeable Potassium (meq/100g)	0.3	<0.2	<0.2	<0.2		

Exchangeable Sodium (meq/100g)	1.8	1	0.9	1.1		
Cation Exchange Capacity (meq/100g)	12.5	5.7	4.8	5.4		
Exchangeable Sodium Percent (%)	15	17.2	19.3	19.7		
Calcium / Magnesium Ratio	0.4	0.3	0.3	0.4		
Magnesium / Potassium Ratio	22.4	----	----	----		
Sulfur (%)	<0.01	----	----	----		
Chloride (mg/kg)	30	----	----	130		
Boron (mg/kg)	0.5	----	----	----		
Copper (mg/kg)	<1.00	----	----	----		
Iron (mg/kg)	64.6	----	----	----		
Manganese (mg/kg)	2.03	----	----	----		
Zinc (mg/kg)	<1.00	----	----	----		
Nitrite + Nitrate as N (mg/kg)	0.2	----	----	----		
Total Kjeldahl Nitrogen as N (mg/kg)	1000	----	----	----		
Total Nitrogen as N (mg/kg)	1000	----	----	----		
Bicarbonate Ext. P (mg/kg)	<5	----	----	----		
Organic Matter (%)	1.6	----	----	----		
Particle size distribution						
Clay (<2 µm) (%)	35	40	32	19		
Silt (2-20 µm) (%)	14	13	13	13		
Fine Sand (0.02-0.2 mm) (%)	12	12	14	13		
Coarse Sand (0.2-2.0 mm) (%)	10	13	11	18		
Gravel (>2mm) (%)	29	22	30	37		

Table 5-12 SS05 description

Site ID: SS05	**Date 5/05/2017**	
Location: Lot 10 on MC493	**Easting: 774667**	**Northing: 7489109**
Geology: Qa-QLD (Qa)	Mapped Soil Type: Vertosol	
Micro-relief: Nil	Field Based Soil Type: Dermosol	
Landuse: Grazing	Land Disturbance: Minor	
Landscape Unit: CC32 – Gently undulating or level plain	Landform Element: Upper slope	
Landform Pattern: Plain	Vegetation: Cleared area beside RE 11.3.4 – mixed eucalypt open forest on alluvial soils. Weedy understorey dominated by Lantana (*Lantana camara*)	
Slope: Gently inclined (6 %)	Drainage: Imperfectly drained	
Surface Condition: Loose	Erosion Potential: Moderate	

Figure 1: SS05 Landscape

Figure 2: SS05 Soil Profile, Depth to 1.2 m

Horizon	**Depth (m)**	**Description**
A1	0.0 – 0.2	Greyish yellow brown (10 YR 6/2), sandy loam, diffuse (>100 mm)
A2	0.2 – 0.35	Dull yellowish brown (10 YR 5/3), sandy loam, abrupt (5-25 mm)
B	0.35 – 1.2	Brown (10 YR 3/4), sandy loam
Terminate		

Laboratory Results

Analysis	**Depth Tested (m)**					
	0.0 – 0.1	**0.1 – 0.2**	**0.2 – 0.3**	**0.5 – 0.6**	**0.8 – 0.9**	**1.1 – 1.2**
pH Value (pH unit)	6.8	6.7	6.6	6.6	6.7	6.7
Electrical Conductivity (us/cm)	16	12	9	6	6	5
Moisture Content (%)	6.2	6.2	7.2	10.9	12.4	11.7
Colour (Munsell)	Very Dark Greyish Brown	----	----	Brown	----	Yellowish Brown
Texture	Loam	----	----	Loam	----	Loamy Sand
Emerson Class Number	3	----	----	3	----	3
Soil Particle Density (Clay / Silt / Sand) (g/cm^3)	2.33	2.55	2.49	2.65	2.26	2.45
Exchange Acidity (meq/100g)	----	----	----	----	----	----
Exchangeable Aluminium (meq/100g)	----	----	----	----	----	----
Exchangeable Calcium (meq/100g)	1.6	5.8	5.1	6.2	5	3.7
Exchangeable Magnesium (meq/100g)	2.5	2	1.8	2.3	2.6	2.4

Site ID: SS05			Date 5/05/2017			
Exchangeable Potassium (meq/100g)	<0.1	0.9	0.6	0.4	0.2	0.2
Exchangeable Sodium (meq/100g)	0.3	<0.1	<0.1	<0.1	<0.1	0.1
Cation Exchange Capacity (meq/100g)	4.8	8.7	7.6	9	7.9	6.4
Exchangeable Sodium Percent (%)	7	0.6	0.6	0.6	0.8	2
Calcium / Magnesium Ratio	0.6	2.9	2.8	2.7	1.9	1.5
Magnesium / Potassium Ratio	----	2.3	2.8	5.4	10.9	12.9
Sulfur (%)	<0.01	----	----	----	----	----
Chloride (mg/kg)	<10	----	----	<10	----	<10
Boron (mg/kg)	0.3	----	----	----	----	----
Copper (mg/kg)	<1.00	----	----	----	----	----
Iron (mg/kg)	75.5	----	----	----	----	----
Manganese (mg/kg)	19.1	----	----	----	----	----
Zinc (mg/kg)	1.19	----	----	----	----	----
Nitrite + Nitrate as N (mg/kg)	0.2	----	----	----	----	----
Total Kjeldahl Nitrogen as N (mg/kg)	990	----	----	----	----	----
Total Nitrogen as N (mg/kg)	990	----	----	----	----	----
Bicarbonate Ext. P (mg/kg)	28	----	----	----	----	----
Organic Matter (%)	2.4	----	----	----	----	----
Particle size distribution						
Clay (<2 µm) (%)	20	23	20	22	20	21
Silt (2-20 µm) (%)	16	13	11	15	10	11
Fine Sand (0.02-0.2 mm) (%)	22	18	24	23	23	20
Coarse Sand (0.2-2.0 mm) (%)	28	30	30	30	33	34
Gravel (>2mm) (%)	14	16	15	10	14	13

Table 5-13 SS06 description

Site ID: SS06	**Date 5/05/2017**	
Location: Lot 10 on MC493	**Easting: 772179**	**Northing: 7488909**
Geology: Qpa-QLD (Qpa)	Mapped Soil Type: Vertosol	
Micro-relief: Melonhole gilgai in proximity	Field Based Soil Type: Vertosol	
Landuse: Grazing	Land Disturbance: Minimal	
Landscape Unit: CC32 – Gently undulating or level plain	Landform Element: Upper slope	
Landform Pattern: Plateau	Vegetation: Cleared pasture	
Slope: Very gently inclined (1 %)	Drainage: Imperfectly drained	
Surface Condition: Cracking	Erosion Potential: Moderate	

Figure 1: SS06 Landscape

Figure 2: SS06 Soil Profile, Depth to 1.2 m

Horizon	**Depth (m)**	**Description**
A1	0.0 – 0.18	Dull yellow orange (10 YR 6/3), loamy sand, gradual (50 – 100 mm)
A2	0.18 – 0.34	Dull yellowish brown (10 YR 5/4), loamy sand, clear (20 – 50 mm)
B	0.34 – 1.2	Dull yellowish brown (10 YR 4/3), clay loam
Terminate		

Laboratory Results

Analysis	**Depth Tested (m)**					
	0.0 – 0.1	**0.1 – 0.2**	**0.2 – 0.3**	**0.5 – 0.6**	**0.8 – 0.9**	**1.1 – 1.2**
pH Value (pH unit)	7.5	7.9	9	9.3	9.1	9.2
Electrical Conductivity (us/cm)	26	64	189	396	1160	1190
Moisture Content (%)	9.2	9	11.2	12.3	14.8	11.5
Colour (Munsell)	Dark Greyish Brown	----	----	Dark Greyish Brown	----	Brown
Texture	Sandy Clay	----	----	Sandy Clay	----	Sandy Clay
Emerson Class Number	3	----	----	1	----	2
Soil Particle Density (Clay / Silt / Sand) (g/cm^3)	2.33	2.55	2.49	2.65	2.26	2.45
Exchange Acidity (meq/100g)	----	----	----	----	----	----
Exchangeable Aluminium (meq/100g)	----	----	----	----	----	----
Exchangeable Calcium (meq/100g)	2.9	2.9	4.9	5.5	2.8	3.5
Exchangeable Magnesium (meq/100g)	2	2	3.9	6.8	4.3	5.4
Exchangeable Potassium (meq/100g)	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Exchangeable Sodium (meq/100g)	0.2	0.2	0.9	4.3	3.4	4
Cation Exchange Capacity (meq/100g)	5.3	5.3	9.9	16.7	10.6	12.8

Site ID: SS06			Date 5/05/2017			
Exchangeable Sodium Percent (%)	4.2	4.7	9.3	26	32.4	30.8
Calcium / Magnesium Ratio	1.4	1.4	1.2	0.8	0.7	0.6
Magnesium / Potassium Ratio	----	----	----	----	----	----
Sulfur (%)	<0.01	----	----	----	----	----
Chloride (mg/kg)	<10	----	----	<10	----	<10
Boron (mg/kg)	1.2	----	----	----	----	----
Copper (mg/kg)	2.65	----	----	----	----	----
Iron (mg/kg)	112	----	----	----	----	----
Manganese (mg/kg)	23.5	----	----	----	----	----
Zinc (mg/kg)	<1.00	----	----	----	----	----
Nitrite + Nitrate as N (mg/kg)	0.6	----	----	----	----	----
Total Kjeldahl Nitrogen as N (mg/kg)	1590	----	----	----	----	----
Total Nitrogen as N (mg/kg)	1590	----	----	----	----	----
Bicarbonate Ext. P (mg/kg)	47	----	----	----	----	----
Organic Matter (%)	2.3	----	----	----	----	----
Particle size distribution						
Clay (<2 µm) (%)	34	38	44	40	48	49
Silt (2-20 µm) (%)	30	30	29	26	26	26
Fine Sand (0.02-0.2 mm) (%)	24	22	18	18	15	13
Coarse Sand (0.2-2.0 mm) (%)	5	4	3	3	4	3
Gravel (>2mm) (%)	7	6	6	13	7	9

Table 5-14 SS07 description

Site ID: SS07	**Date 6/05/2017**	
Location: Lot 1 on MC813349	**Easting: 770623**	**Northing: 7486115**
Geology: Qr-QLD, Qf-QLD>Styx Coal Measures (Qr, Qf>Kx)	Mapped Soil Type: Kandosol	
Micro-relief: Nil	Field Based Soil Type: Red Kandosol	
Landuse: Grazing	Land Disturbance: Minimal	
Landscape Unit: Mw26 – Strongly undulating lands with some high narrow ridges	Landform Element: Upper slope	
Landform Pattern: Lower slope	Vegetation: Edge of disturbed regrowth habitat located within RE 11.5.8a – Mixed eucalypt woodland including Poplar Gum (*E. platyphylla*) Ghost Gum (*E. dallachiana*) and Pink Bloodwood (*Corymbia intermedia*). Mid-dense lower tree and shrub layer	
Slope: Very gently inclined (1 %)	Drainage: Imperfectly drained	
Surface Condition: Loose	Erosion Potential: Moderate	

Figure 1: SS07 Landscape

Figure 2: SS07 Soil Profile, Depth to 1.2 m

Horizon	**Depth (m)**	**Description**
A1	0 – 0.1	(2 YR 6/5), fine sandy, diffuse (>100 mm)
A2	0.1 – 0.2	(2 YR 5/6), loamy sand, diffuse (>100 mm)
B	0.2 – 1.2	(2 YR 4/6), loamy sand
Terminate		

Laboratory Results

Analysis	**Depth Tested**					
	0.0 – 0.1	**0.1 – 0.2**	**0.2 – 0.3**	**0.5 – 0.6**	**0.8 – 0.9**	**1.1 – 1.2**
pH Value (pH unit)	5.6	5.7	5.6	5.6	5.6	6.6
Electrical Conductivity (us/cm)	7	9	9	9	8	7
Moisture Content (%)	6	6.9	10	10.5	9.6	9.1
Colour (Munsell)	Dark Red	----	----	Dark Red	----	Dark Red
Texture	Silty Clay Loam	----	----	Silty Clay Loam	----	Clay Loam
Emerson Class Number	4	----	----	4	----	4
Soil Particle Density (Clay / Silt / Sand) (g/cm^3)	2.51	2.42	2.53	2.66	2.63	2.6
Exchange Acidity (meq/100g)	0.2	0.2	0.2	0.2	<0.1	----
Exchangeable Aluminium (meq/100g)	0.2	0.2	0.1	<0.1	<0.1	----
Exchangeable Calcium (meq/100g)	0.6	0.6	0.5	<0.1	<0.1	<0.1

Exchangeable Magnesium (meq/100g)	1.8	2.1	2.5	2.7	2.6	2.4
Exchangeable Potassium (meq/100g)	0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Exchangeable Sodium (meq/100g)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Cation Exchange Capacity (meq/100g)	2.7	2.9	3.2	2.9	2.6	2.6
Exchangeable Sodium Percent (%)	2	2.3	2.8	3.3	3.6	2.8
Calcium / Magnesium Ratio	0.3	0.3	0.2	<0.1	<0.1	<0.1
Magnesium / Potassium Ratio	17.9	----	----	----	----	----
Sulfur (%)	<0.01	----	----	----	----	----
Chloride (mg/kg)	<10	----	----	<10	----	<10
Boron (mg/kg)	0.2	----	----	----	----	----
Copper (mg/kg)	<1.00	----	----	----	----	----
Iron (mg/kg)	15.9	----	----	----	----	----
Manganese (mg/kg)	1.36	----	----	----	----	----
Zinc (mg/kg)	<1.00	----	----	----	----	----
Nitrite + Nitrate as N (mg/kg)	----	----	----	----	----	----
Total Kjeldahl Nitrogen as N (mg/kg)	----	----	----	----	----	----
Total Nitrogen as N (mg/kg)	----	----	----	----	----	----
Bicarbonate Ext. P (mg/kg)	<5	----	----	----	----	----
Organic Matter (%)	0.8	----	----	----	----	----
Particle size distribution						
Clay (<2 µm) (%)	35	42	50	44	37	38
Silt (2-20 µm) (%)	5	5	3	4	4	6
Fine Sand (0.02-0.2 mm) (%)	10	9	7	12	13	10
Coarse Sand (0.2-2.0 mm) (%)	14	12	13	12	14	14
Gravel (>2mm) (%)	36	32	27	29	32	32

Table 5-15 SS08 description

Site ID: SS08	**Date 6/05/2017**	
Location: Lot 1 on MC813349	**Easting: 772020**	**Northing: 7486135**
Geology: Qpa-QLD (Qpa)	Mapped Soil Type: Sodosol	
Micro-relief: Nil	Field Based Soil Type: Sodosol	
Landuse: Grazing	Land Disturbance: Minimal	
Landscape Unit: Vd3 – Gently undulating slightly elevated plains	Landform Element: Upper slope	
Landform Pattern: Plain	Vegetation: Cleared pasture	
Slope: very gently inclined (1 %)	Drainage: Imperfectly drained	
Surface Condition: Firm	Erosion Potential: Low	
Figure 1: SS08 Landscape 	**Figure 2: SS08 Soil Profile, Depth to 1.2 m** 	

Horizon	**Depth (m)**	**Description**
A1	0.0 – 0.13	(10 YR 6/2), loamy sand, gradual (50 – 100 mm)
A2	0.13 – 0.2	(10 YR 6/6), clayey sand, gradual (50 – 100 mm)
B	0.2 – 1.2	(10 YR 5/2), light clay
Terminate		

Laboratory Results

Analysis	**Depth Tested**					
	0.0 – 0.1	**0.1 – 0.2**	**0.2 – 0.3**	**0.5 – 0.6**	**0.8 – 0.9**	**1.1 – 1.2**
pH Value (pH unit)	6.3	7.2	7.3	7.4	8.4	8.5
Electrical Conductivity (us/cm)	15	16	26	85	592	636
Moisture Content (%)	3.8	5.7	8.9	5.8	8.6	10
Colour (Munsell)	Brown	----	----	Yellowish Brown	----	Dark Yellowish Brown
Texture	Clay Loam	----	----	Sandy Clay Loam	----	Sandy Clay
Emerson Class Number	3	----	----	1	----	1
Soil Particle Density (Clay / Silt / Sand) (g/cm^3)	2.44	2.48	2.54	2.55	2.43	2.5
Exchange Acidity (meq/100g)	----	----	----	----	----	----
Exchangeable Aluminium (meq/100g)	----	----	----	----	----	----
Exchangeable Calcium (meq/100g)	5	4.3	4.4	0.4	0.7	1
Exchangeable Magnesium (meq/100g)	3.9	5	6.2	1.5	3.7	4.9

Exchangeable Potassium (meq/100g)	0.1	0.1	0.1	<0.2	<0.2	<0.2
Exchangeable Sodium (meq/100g)	0.3	0.7	1	0.6	1.8	2.5
Cation Exchange Capacity (meq/100g)	9.3	10.2	11.7	2.5	6.2	8.5
Exchangeable Sodium Percent (%)	3.3	7.2	8.8	24	29.2	29.9
Calcium / Magnesium Ratio	1.3	0.9	0.7	0.3	<0.2	0.2
Magnesium / Potassium Ratio	34.9	46.7	50.1	----	----	----
Sulfur (%)	<0.01	----	----	----	----	----
Chloride (mg/kg)	<10	----	----	<10	----	<10
Boron (mg/kg)	0.3	----	----	----	----	----
Copper (mg/kg)	<1.00	----	----	----	----	----
Iron (mg/kg)	69.5	----	----	----	----	----
Manganese (mg/kg)	62.8	----	----	----	----	----
Zinc (mg/kg)	<1.00	----	----	----	----	----
Nitrite + Nitrate as N (mg/kg)	<0.1	----	----	----	----	----
Total Kjeldahl Nitrogen as N (mg/kg)	910	----	----	----	----	----
Total Nitrogen as N (mg/kg)	910	----	----	----	----	----
Bicarbonate Ext. P (mg/kg)	<5	----	----	----	----	----
Organic Matter (%)	1.9	----	----	----	----	----
Particle size distribution						
Clay (<2 µm) (%)	21	47	49	35	38	38
Silt (2-20 µm) (%)	17	14	10	15	15	16
Fine Sand (0.02-0.2 mm) (%)	18	12	14	15	12	20
Coarse Sand (0.2-2.0 mm) (%)	11	8	7	11	10	11
Gravel (>2mm) (%)	33	19	20	24	25	15

Table 5-16 SS09 description

Site ID: SS09	**Date 14/06/2017**	
Location: Lot 9 on MC230	**Easting: 775681**	**Northing: 7486642**
Geology: Qa-QLD	Mapped Soil Type: Sodosol	
Micro-relief: Nil	Field Based Soil Type: Sodosol	
Landuse: Grazing	Land Disturbance: Minor	
Landscape Unit: Ub89 – Moderate to strongly undulating lands with occasional low hilly areas	Landform Element: Upper slope	
Landform Pattern: Low hills	Vegetation: Cleared pasture	
Slope: very gently inclined (1 %)	Drainage: Imperfectly drained	
Surface Condition: Firm	Erosion Potential: Low	

Figure 1: SS09 Landscape

Figure 2: SS09 Soil Profile, Depth to 0.8 m

Horizon	**Depth (m)**	**Description**
A1	0.0 – 0.15	(10 YR 6/2), clayey sand, gradual (50 – 100 mm)
A2	0.15 – 0.2	(10 YR 5/3), silty clay loam, gradual (50 – 100 mm)
B	0.2 – 0.8	(10 YR 5/4), silty clay loam
Terminate		

Laboratory Results

Analysis	**Depth Tested**			
	0.0 – 0.1	**0.1 – 0.2**	**0.2 – 0.3**	**0.5 – 0.6**
pH Value (pH unit)	6.4	7.3	8	8.9
Electrical Conductivity (us/cm)	48	365	588	750
Moisture Content (%)	5.3	----	----	9.3
Colour (Munsell)	Brown	----	----	Brown
Texture	Sandy Clay	----	----	Sandy Clay
Emerson Class Number	1	----	----	2
Soil Particle Density (Clay / Silt / Sand) (g/cm^3)	2.73	2.67	2.75	2.72
Exchange Acidity (meq/100g)	----	----	----	----
Exchangeable Aluminium (meq/100g)	----	----	----	----
Exchangeable Calcium (meq/100g)	----	0.7	0.8	0.8
Exchangeable Magnesium (meq/100g)	----	3.4	4.6	3.8
Exchangeable Potassium (meq/100g)	----	<0.2	<0.2	<0.2
Exchangeable Sodium (meq/100g)	----	1.3	2	2.1

Cation Exchange Capacity (meq/100g)	----	5.3	7.5	6.7
Exchangeable Sodium Percent (%)	----	24	27.4	32
Calcium / Magnesium Ratio	----	0.2	<0.2	<0.2
Magnesium / Potassium Ratio	16.1	----	----	----
Sulfur (%)	<0.01	----	----	----
Chloride (mg/kg)	40	----	----	1190
Boron (mg/kg)	<0.2	----	----	----
Copper (mg/kg)	13	----	----	----
Iron (mg/kg)	76300	----	----	----
Manganese (mg/kg)	178	----	----	----
Zinc (mg/kg)	20	----	----	----
Nitrite + Nitrate as N (mg/kg)	0.2	----	----	----
Total Kjeldahl Nitrogen as N (mg/kg)	470	----	----	----
Total Nitrogen as N (mg/kg)	470	----	----	----
Bicarbonate Ext. P (mg/kg)	<5	----	----	----
Organic Matter (%)	1.4	----	----	----
Particle size distribution				
Clay (<2 µm) (%)	26	47	45	41
Silt (2-20 µm) (%)	11	12	13	12
Fine Sand (0.02-0.2 mm) (%)	33	23	21	20
Coarse Sand (0.2-2.0 mm) (%)	16	11	10	18
Gravel (>2mm) (%)	14	7	11	9

Table 5-17 SS10 description

Site ID: SS10	**Date 14/06/2017**	
Location: Lot 9 on MC230	**Easting: 776267**	**Northing: 7486953**
Geology: Qpa-QLD (Qpa)	Mapped Soil Type: Sodosol	
Micro-relief: Nil	Field Based Soil Type: Sodosol	
Landuse: Grazing	Land Disturbance: Minimal	
Landscape Unit: Vd3 – Gently undulating slightly elevated plains	Landform Element: Upper slope	
Landform Pattern: Low hills	Vegetation: Cleared pasture	
Slope: very gently inclined (1 %)	Drainage: Imperfectly drained	
Surface Condition: Firm	Erosion Potential: Moderate	

Figure 1: SS10 Landscape

Figure 2: SS10 Soil Profile, Depth to 0.8 m

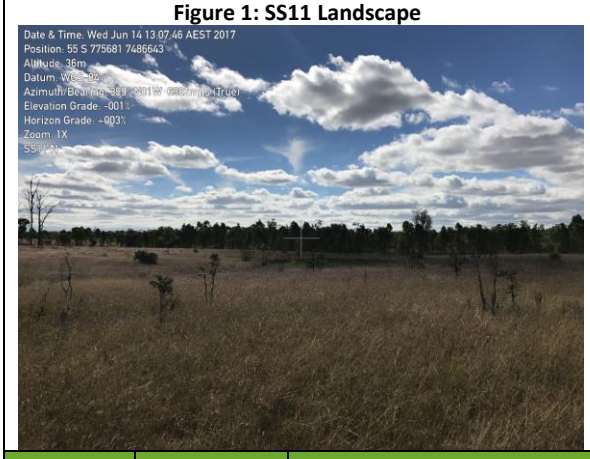
Horizon	**Depth (m)**	**Description**
A1	0.0 – 0.2	(10 YR 6/2), clayey sand, gradual (50 – 100 mm)
A2	0.2 – 0.35	(10 YR 5/3), loamy sand, gradual (50 – 100 mm)
B	0.35 – 0.8	(10 YR 5/4), loamy sand
Terminate		

Laboratory Results

Analysis	**Depth Tested**				
	0.0 – 0.1	**0.1 – 0.2**	**0.2 – 0.3**	**0.5 – 0.6**	**0.8 – 0.9**
pH Value (pH unit)	6.6	7.4	7.7	8.7	9.4
Electrical Conductivity (us/cm)	49	220	310	680	792
Moisture Content (%)	5.3	----	----	9	----
Colour (Munsell)	Brown	----	----	Brown	----
Texture	Loam	----	----	Clay Loam	----
Emerson Class Number	2	----	----	1	----
Soil Particle Density (Clay / Silt / Sand) (g/cm^3)	----	----	----	----	----
Exchange Acidity (meq/100g)	----	----	----	----	----
Exchangeable Aluminium (meq/100g)	----	----	----	----	----
Exchangeable Calcium (meq/100g)	----	0.3	0.9	0.6	1.5
Exchangeable Magnesium (meq/100g)	----	1	3.1	3.1	3.8
Exchangeable Potassium (meq/100g)	----	<0.2	<0.2	<0.2	<0.2
Exchangeable Sodium (meq/100g)	----	0.6	1.8	2.3	2.6

Cation Exchange Capacity (meq/100g)	----	2	5.8	6.1	7.9
Exchangeable Sodium Percent (%)	----	31.3	31.4	38.3	33.2
Calcium / Magnesium Ratio	----	0.3	0.3	0.2	0.4
Magnesium / Potassium Ratio	----	----	----	----	----
Sulfur (%)	<0.01	----	----	----	----
Chloride (mg/kg)	50	----	----	920	----
Boron (mg/kg)	<0.2	----	----	----	----
Copper (mg/kg)	<5	----	----	----	----
Iron (mg/kg)	5480	----	----	----	----
Manganese (mg/kg)	35	----	----	----	----
Zinc (mg/kg)	<5	----	----	----	----
Nitrite + Nitrate as N (mg/kg)	<0.1	----	----	----	----
Total Kjeldahl Nitrogen as N (mg/kg)	450	----	----	----	----
Total Nitrogen as N (mg/kg)	450	----	----	----	----
Bicarbonate Ext. P (mg/kg)	<5	----	----	----	----
Organic Matter (%)	1	----	----	----	----
Particle size distribution					
Clay (<2 µm) (%)	----	----	----	----	----
Silt (2-20 µm) (%)	----	----	----	----	----
Fine Sand (0.02-0.2 mm) (%)	----	----	----	----	----
Coarse Sand (0.2-2.0 mm) (%)	----	----	----	----	----
Gravel (>2mm) (%)	----	----	----	----	----

Table 5-18 SS11 description

Site ID: SS11	**Date 14/06/2017**	
Location: Lot 10 on MC493	**Easting: 775681**	**Northing: 7486643**
Geology: Qa-QLD	Mapped Soil Type: Sodosol	
Micro-relief: Nil	Field Based Soil Type: Sodosol	
Landuse: Grazing	Land Disturbance: Minimal	
Landscape Unit: Vd3 – Gently undulating slightly elevated plains	Landform Element: Upper slope	
Landform Pattern: Low hills	Vegetation: Cleared pasture	
Slope: very gently inclined (1 %)	Drainage: Imperfectly drained	
Surface Condition: Firm	Erosion Potential: Moderate	
Figure 1: SS11 Landscape	**Figure 2: SS11 Soil Profile, Depth to 0.9 m**	
		

Horizon	**Depth (m)**	**Description**
A1	0.0 – 0.2	(10 YR 6/2), sandy loam, gradual (50 – 100 mm)
A2	0.2 – 0.3	(10 YR 7/2), sandy loam, gradual (50 – 100 mm)
B	0.3 – 0.9	(10 YR 4/6), sandy clay
Terminate		

Laboratory Results

Analysis	**Depth Tested**				
	0.0 – 0.1	**0.1 – 0.2**	**0.2 – 0.3**	**0.5 – 0.6**	**0.8 – 0.9**
pH Value (pH unit)	6.1	6.3	6.6	8	8.6
Electrical Conductivity (us/cm)	5	8	42	521	873
Moisture Content (%)	6.7	----	----	9.3	----
Colour (Munsell)	Brown	----	----	Brown	----
Texture	Sandy Loam	----	----	Clay Loam	----
Emerson Class Number	3	----	----	1	----
Soil Particle Density (Clay / Silt / Sand) (g/cm^3)	2.61	2.64	2.63	2.68	2.69
Exchange Acidity (meq/100g)	----	----	----	----	----
Exchangeable Aluminium (meq/100g)	----	----	----	----	----
Exchangeable Calcium (meq/100g)	1.4	1.1	0.8	----	----
Exchangeable Magnesium (meq/100g)	1.5	1.6	1.7	----	----
Exchangeable Potassium (meq/100g)	0.2	<0.1	<0.1	----	----
Exchangeable Sodium (meq/100g)	<0.1	0.2	0.6	----	----

Cation Exchange Capacity (meq/100g)	3.3	3	3.3	----	----
Exchangeable Sodium Percent (%)	3	7.4	19.9	----	----
Calcium / Magnesium Ratio	0.9	0.7	0.5	----	----
Magnesium / Potassium Ratio	8	----	----	----	----
Sulfur (%)	<0.01	----	----	----	----
Chloride (mg/kg)	<10	----	----	810	----
Boron (mg/kg)	<0.2	----	----	----	----
Copper (mg/kg)	5	----	----	----	----
Iron (mg/kg)	14900	----	----	----	----
Manganese (mg/kg)	409	----	----	----	----
Zinc (mg/kg)	12	----	----	----	----
Nitrite + Nitrate as N (mg/kg)	0.2	----	----	----	----
Total Kjeldahl Nitrogen as N (mg/kg)	560	----	----	----	----
Total Nitrogen as N (mg/kg)	560	----	----	----	----
Bicarbonate Ext. P (mg/kg)	5	----	----	----	----
Organic Matter (%)	0.9	----	----	----	----
Particle size distribution					
Clay (<2 µm) (%)	16	16	20	33	29
Silt (2-20 µm) (%)	17	18	18	21	19
Fine Sand (0.02-0.2 mm) (%)	61	57	59	43	48
Coarse Sand (0.2-2.0 mm) (%)	6	9	3	2	4
Gravel (>2mm) (%)	<1	<1	<1	1	<1

Soil Order

A summary of the five soil orders observed across the Project site, are identified in Table 5-19. The characteristics for each of the soil orders identified within the Project area are described in Table 5-20.

Table 5-19 Soil order summary

Soil Order	Description
Dermosol	Soils which have B2 horizons with structure more developed than weak throughout the major part of the horizon, and do not have clear or abrupt textural B horizons.
Sodosol	Soils which have a clear and strong texture contrast from the A horizon and a sodic B horizon (exchangeable sodium percentage >6%).
Kandosol	Soils which lack strong texture contrast, have massive or only weakly structured B horizons and are not calcareous throughout.
Rudosol	Soil with negligible (rudimentary) pedologic organisation apart from minimal development of an Al horizon or the presence of less than 10% of B horizon material (including pedogenic carbonate) in fissures in the parent rock or saprolite. The soils are apedal or only weakly structured in the A1 horizon and show no pedological colour changes apart from the darkening of an A1 horizon. There is little or no texture or colour change with depth unless stratified or buried soils are present.
Vertosol	Clayey soils (having a field texture of 35% clay or greater throughout the profile) with vertic (shrink-swell) properties.

Table 5-20 Characteristics of soil families identified within the Project area

Soil family	Water availability	Drainage	Aeration	Physical root limitation	Erosion hazard	Nutrient availability	Potential toxicities	Workability
Dermosol	Moderate to high.	Tend to be well drained.	Usually well aerated.	Generally, few restrictions.	Depends on vegetation cover, slope and rainfall.	Moderate to high fertility.	Uncommon.	Generally good.
Sodosol	Limited plant water availability.	Most are poorly drained. Generally low permeability.	Depends on site drainage, often poorly aerated.	Clay sodic B horizon generally will restrict root growth.	Depends on vegetation cover, slope and rainfall. Severe on slopes in high intensity rainfall areas.	Mostly deficient in nitrogen and phosphorus.	Secondary salinity may be a problem.	Surface soil subject to crusting and hard setting.
Kandosol	Moderate to high, less in shallower soils.	Most are well drained. Generally high permeability.	Usually well aerated.	Generally, few restrictions.	Depends on vegetation cover, slope and rainfall. Severe on slopes in high intensity rainfall areas.	Mostly deficient in nitrogen and phosphorus.	Uncommon. Potentially aluminium induced by strong acidity.	Generally good. Surface soil subject to crusting and hard setting.
Rudosol	Low to moderate.	Depends on texture.	Depends on texture.	Not typically restrictive for root growth.	Depends on vegetation cover, slope and rainfall.	Typically, low.	Uncommon.	Dependent on parent material.
Vertosol	Moderate to high.	Poor.	Depends on site drainage.	Cracks provide opportunities for root growth.	Depends on vegetation cover, slope and rainfall.	Moderate to high.	Uncommon.	Difficult due to heavy textures.

5.5.4.3 Summary of Key Soil Properties

The following summary of key soils properties is based on in-field assessment and receipt of laboratory data. Further details of the laboratory analysis for each of the samples is included at Appendix A3 – Soil Survey Results.

Soil Depth

Soil depth generally extended beyond the sampling limit (1.2 m) but would be expected to be variable across the Project area with shallower soils occurring in undulating terrain to the south and deeper soils being present in the flatter terrain to the north. Topsoil thickness is indicated by field classifications of A horizons, which varied by soil type as follows:

- Brown sodic Kandosol, 0.45 m (SS04);
- Dermosol, 0.35 m (SS05);
- Red Kandosol (SS07);
- Rudosol, 1.2 m (SS01);
- Sodosol, 0.2–0.45 m (SS02, SS03, SS08, SS09, SS10, SS11); and
- Vertosol, 0.35 m (SS06).

The median topsoil thickness is 0.35 m.

Emerson Aggregate Test

The Emerson aggregate test measures the dispersion potential of soils and has a direct effect on the erosion susceptibility of a soil, as outlined further below. The Emerson classes as per AS1289.3.8.1 – 2006 are described in Table 5-21.

Table 5-21 Emerson class descriptions

Emerson Class	Definition
Class 1	Air-dried crumbs of soil show a strong dispersing reaction, i.e. a colloidal cloud covers nearly the whole of the bottom of the beaker, usually in a very thin layer. The reaction should be evident within 10 min. In extreme cases, all the water in the beaker becomes cloudy, leaving only a coarse residue in a cloud of clay.
Class 2	Air-dried crumbs of soil show a moderate to slight reaction. A moderate reaction consists of an easily recognizable cloud of colloids in suspension, usually spreading in thin streaks on the bottom of the beaker. A slight reaction consists of the bare hint of cloud in water at the surface of the crumbs.
Class 3	The soil remoulded at the plastic limit disperses in water.
Class 4	The remoulded soil does not disperse in water. Calcium carbonate (calcite) or calcium sulfate (gypsum) is present.
Class 5	The remoulded soil does not disperse in water and the 1:5 soil / water suspension remains dispersed after five min.
Class 6	The remoulded soil does not disperse in water and the 1:5 soil / water suspension begins to flocculate within five min.
Class 7	The air-dried crumbs of soil remain coherent (do not disperse) in water and swell.
Class 8	The air-dried crumbs of soil remain coherent (do not disperse) in water and do not swell.

All but one of the soil samples were rated as between Class 1 and Class 4 based on the Emerson aggregate test undertaken at the laboratory. A single result was rated as Class 8 (SS01 at 0.5 – 0.6 tested depth) and is considered an anomaly as the laboratory advised that this sample was pure sand, with no reaction, no dispersion and no ribboning.

Of the samples analysed 14 were rated as Class 1 or Class 2. These sample locations indicate soils that have greater dispersive potential and, when disturbed, are prone to erosion and soil structural decline. Of the remaining samples, 10 were rated as Class 3 and three were rated as Class 4. These samples are considered to only have moderate dispersive tendencies, can be remoulded and will not readily disperse in water.

Sodicity

Exchangeable Sodium Percentage (ESP) measures the sodicity of a soil which, along with the Emerson aggregate test, is directly related to a soils structural stability and erosion potential. The sodicity ratings for soils, following Northcote and Skene (1972), are shown in Table 5-22.

Table 5-22 Soil sodicity / ESP ratings

Sodicity Rating	ESPs proposed for Australian soils (%)
Non-sodic	0 – 6
Sodic	6 – 15
Strongly sodic	> 15

A combination of non-sodic, sodic and strongly sodic soils was identified from the soil samples (see Table 5-23). These results indicate that there are some areas of increased potential for soil structural decline.

Table 5-23 Soil sodicity / ESP results

Sample	Depth	ESP Result (%)	Sodicity Rating
SS01	0.0 – 0.1	2.2	Non-sodic
	0.1 – 0.2	1.5	Non-sodic
	0.2 – 0.3	1.9	Non-sodic
	0.5 – 0.6	1.8	Non-sodic
	0.8 – 0.9	6.6	Sodic
	1.1 – 1.2	21.1	Strongly sodic
SS02	0.0 – 0.1	3.9	Non-sodic
	0.1 – 0.2	9.6	Sodic
	0.2 – 0.3	13.1	Sodic
	0.5 – 0.6	17	Strongly sodic
	0.8 – 0.9	20.9	Strongly sodic
	1.1 – 1.2	21.3	Strongly sodic
SS03	0.0 – 0.1	7.0	Sodic
	0.1 – 0.2	12.4	Sodic
	0.2 – 0.3	18.1	Strongly sodic
	0.5 – 0.6	29	Strongly sodic
	0.8 – 0.9	35.2	Strongly sodic
	1.1 – 1.2	37.7	Strongly sodic
SS04	0.0 – 0.1	15	Sodic / Strongly sodic
	0.1 – 0.2	17.2	Strongly sodic
	0.2 – 0.3	19.3	Strongly sodic
	0.45 – 0.5	19.7	Strongly sodic
SS05	0.0 – 0.1	7	Sodic
	0.1 – 0.2	0.6	Non-sodic

Sample	Depth	ESP Result (%)	Sodicity Rating
	0.2 – 0.3	0.6	Non-sodic
	0.5 – 0.6	0.6	Non-sodic
	0.8 – 0.9	0.8	Non-sodic
	1.1 – 1.2	2	Non-sodic
SS06	0.0 – 0.1	4.2	Non-sodic
	0.1 – 0.2	4.7	Non-sodic
	0.2 – 0.3	9.3	Sodic
	0.5 – 0.6	26	Strongly sodic
	0.8 – 0.9	32.4	Strongly sodic
	1.1 – 1.2	30.8	Strongly sodic
SS07	0.0 – 0.1	2	Non-sodic
	0.1 – 0.2	2.3	Non-sodic
	0.2 – 0.3	2.8	Non-sodic
	0.5 – 0.6	3.3	Non-sodic
	0.8 – 0.9	3.6	Non-sodic
	1.1 – 1.2	2.8	Non-sodic
SS08	0.0 – 0.1	3.3	Non-sodic
	0.1 – 0.2	7.2	Sodic
	0.2 – 0.3	8.8	Strongly sodic
	0.5 – 0.6	24	Strongly sodic
	0.8 – 0.9	29.2	Strongly sodic
	1.1 – 1.2	29.9	Strongly sodic
SS09	0.0 – 0.1	-	-
	0.1 – 0.2	24	Strongly sodic
	0.2 – 0.3	27.4	Strongly sodic
	0.5 – 0.6	32	Strongly sodic
SS10	0.0 – 0.1	-	-
	0.1 – 0.2	31.3	Strongly sodic
	0.2 – 0.3	31.4	Strongly sodic
	0.5 – 0.6	38.3	Strongly sodic
	0.8 – 0.9	33.2	Strongly sodic
SS11	0.0 – 0.1	3	Non-sodic
	0.1 – 0.2	7.4	Sodic
	0.2 – 0.3	19.4	Strongly sodic
	0.5 – 0.6	-	-
	0.8 – 0.9	-	-

The ESP data has been summarised by soil type and soil horizon in Figure 5-9, with the sodicity evident in the Sodosols, Vertosols and the brown sodic Kandosol.

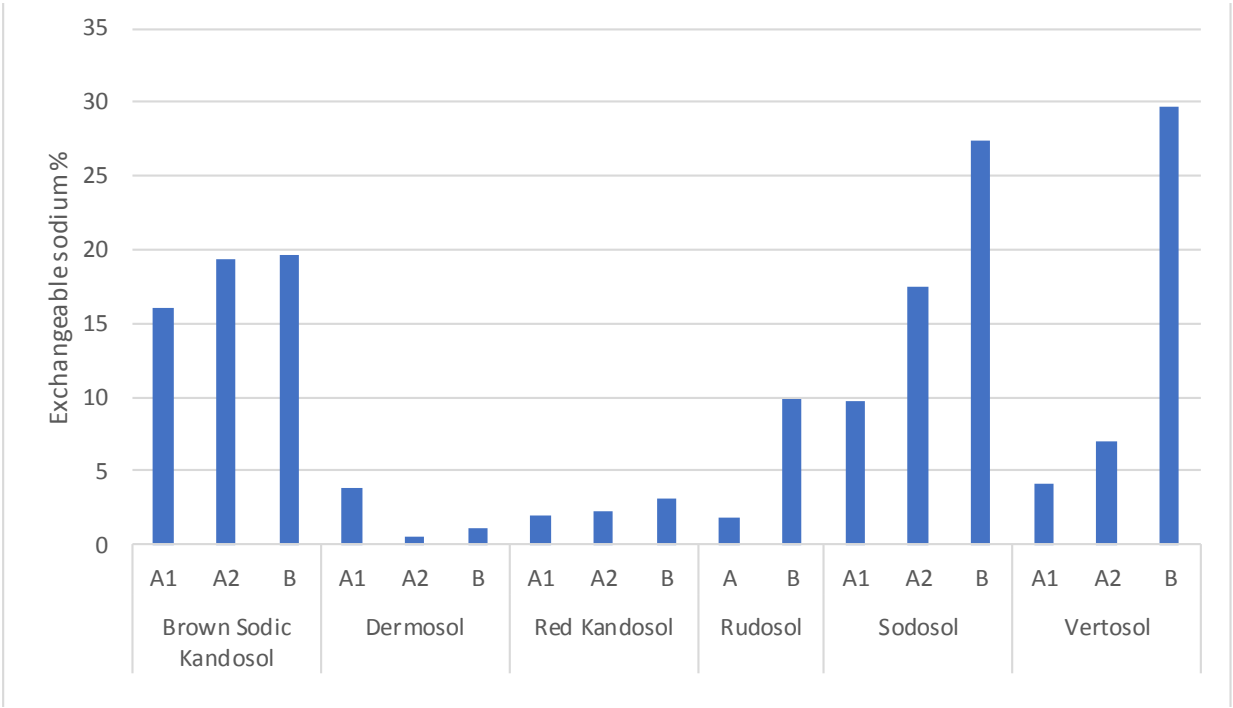


Figure 5-9 Average Exchangeable Sodium Percentage (ESP) by soil type and soil horizon

Soil Erosion Susceptibility

The susceptibility of an area of land to water erosion is a function of the soil type, soil cover, topography and slope, rainfall intensity and land use. An erosion and sediment control plan (ESCP), prepared by a Certified Professional in Erosion and Sediment Control (CPESC), will be developed for the construction and operation phases of the Project. The plan will consider and address the variables in a seasonal context to measure (using the Revised Universal Soil Loss Equation) and manage the risk of soil erosion from all activities associated with the mine, haul road and TLF. Soil conservation and site rehabilitation shall also be integrated into the detailed ESCP.

The sites erosion hazard and erosion risk is considered important in determining the appropriate erosion and sediment controls (ESC) to be implemented as part of the Project's construction and operation phases. Soil erosion hazard can be described as the susceptibility of a parcel of land to the prevailing agents of erosion and soil erosion risk is the likelihood of environmental harm occurring due to disturbance activities of the Project.

An assessment of soil erosion susceptibility is provided in Table 5-24, which lists influencing factors for each soil type.

Table 5-24 Soil erosion susceptibility

Soil Order	Sodicity	Emerson Class	Texture	Landform	Vegetation cover	Erosion susceptibility
Dermosol	Non-sodic	Class 3	Loam	Undulating plain	Cleared with mixed eucalypt open forest	Low susceptibility due to low relief and non-dispersive soils
Sodosol	Sodic	Class 3 – Class 1	Clay loam – sandy clay	Gently undulating plains	Cleared	Highly susceptible when disturbed
Kandosol	Non-sodic	Class 4	Clay loam	Undulating rises	Variable but mostly cleared	Moderate-High on slopes in high intensity rainfall areas.
Rudosol	Non-sodic	Class 3	Loamy sand	Gently undulating plain	Grazed but not cleared	Low susceptibility due to sandy texture and flat terrain

Soil Order	Sodicity	Emerson Class	Texture	Landform	Vegetation cover	Erosion susceptibility
Vertosol	Sodic	Class 1 and Class 4	Sandy clay	Level to gently undulating plain	Cleared	High for disturbed soil and stockpiles, but erosion hazard limited by flat terrain

As the mine is in a sub-tropical climate, soil erosion management shall be undertaken in a two-season approach - wet season (December to March) and dry season (April to November). The erosion hazard based on average monthly rainfall depth (recorded for nearby Marlborough) referenced from the International Erosion Control Association (IECA) – Best Practice Erosion and Sediment Control Guidelines (2008) is described in Table 5-25.

Table 5-25 Erosion hazard based on average monthly rainfall depth (Marlborough)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
High	High	High	Moderate	Low	Moderate	Low	V Low	V Low	Low	Moderate	High

Source: IECA 2008 Table 4.4.5

The region's seasonality also makes it prone to wind erosion, particularly during the dry season. Wind erosion is a key contributor to dust-generation which has the potential to impact residents surrounding the site, vegetation communities and the operation of the mine itself if located downwind. The site shall employ various erosion control techniques which, if designed, installed and maintained correctly, will reduce the wind erosion hazard to very low in both the dry and wet seasons.

Electrical Conductivity

Electrical conductivity (EC) relates to the degree of salinity in the soil. The higher the EC value, the more soluble salt is in the soil. High soil salinity can be a limitation for vegetation growth, particularly for salt-sensitive species. The soil salinity rating by clay content following Rayment and Lyons (2011) is described in Table 5-26.

Table 5-26 Soil salinity ratings

Soil Salinity Rating	$EC_{1:5}$ (dSm^{-1})			
	10 – 20% Clay	20 – 40% Clay	40 – 60% Clay	60 – 80% Clay
Very Low	< 0.07	< 0.09	< 0.12	< 0.15
Low	0.07 - 0.15	0.09 - 0.19	0.12 - 0.24	0.15 - 0.3
Medium	0.15 - 0.34	0.19 - 0.45	0.24 - 0.56	0.3 - 0.7
High	0.34 - 0.63	0.45 - 0.76	0.56 -0.96	0.7 - 1.18
Very High	0.63 - 0.93	0.76 - 1.21	0.96 - 1.53	1.18 - 1.87
Extreme	> 0.93	> 1.21	>1.53	> 1.87

The soil salinity results and ratings from samples collected across the Project area are shown in Table 5-27. Samples were generally rated Very Low to Medium across the Project area, indicating soil salinity is generally not a limitation for vegetation growth. The exceptions were samples taken from SS02, SS03, SS06, SS08 and SS11 at depths below 0.5 metres below ground level (mbgl), which rated between High to Very High soil salinity, indicating a build-up of salts in some subsoils. The site SS09, located nearby to the TLF, was the only location presenting high salinity ratings between 0.0 – 0.5 mbgl.

Table 5-27 Soil salinity results and ratings

Sample	Depth	Clay (%)	$EC_{1:5}$ (dSm^{-1})	Soil Salinity Rating
SS01	0.0 – 0.1	11	0.02	Very Low
	0.1 – 0.2	11	0.01	Very Low
	0.2 – 0.3	8	0.007	Very Low
	0.5 – 0.6	11	0.007	Very Low
	0.8 – 0.9	14	0.016	Very Low
	1.1 – 1.2	18	0.034	Very Low
SS02	0.0 – 0.1	18	0.01	Very Low
	0.1 – 0.2	22	0.038	Very Low
	0.2 – 0.3	51	0.192	Low
	0.5 – 0.6	42	0.581	High
	0.8 – 0.9	35	0.554	High
	1.1 – 1.2	36	0.517	High
SS03	0.0 – 0.1	23	0.007	Very Low
	0.1 – 0.2	26	0.013	Low
	0.2 – 0.3	45	0.051	Medium
	0.5 – 0.6	38	0.215	Medium
	0.8 – 0.9	34	0.492	High
	1.1 – 1.2	32	0.412	Medium
SS04	0.0 – 0.1	35	0.045	Very Low
	0.1 – 0.2	40	0.071	Very Low
	0.2 – 0.3	32	0.160	Low
	0.45 – 0.5	19	0.339	Medium
SS05	0.0 – 0.1	20	0.016	Very Low
	0.1 – 0.2	23	0.012	Very Low
	0.2 – 0.3	20	0.009	Very Low
	0.5 – 0.6	22	0.006	Very Low
	0.8 – 0.9	20	0.006	Very Low
	1.1 – 1.2	21	0.005	Very Low
SS06	0.0 – 0.1	34	0.026	Very Low
	0.1 – 0.2	38	0.064	Very Low
	0.2 – 0.3	44	0.189	Low
	0.5 – 0.6	40	0.396	Medium
	0.8 – 0.9	48	1.160	Very High
	1.1 – 1.2	49	1.190	Very High
SS07	0.0 – 0.1	35	0.007	Very Low
	0.1 – 0.2	42	0.009	Very Low
	0.2 – 0.3	50	0.009	Very Low
	0.5 – 0.6	44	0.009	Very Low
	0.8 – 0.9	37	0.008	Very Low
	1.1 – 1.2	38	0.007	Very Low
SS08	0.0 – 0.1	21	0.015	Very Low
	0.1 – 0.2	47	0.016	Very Low
	0.2 – 0.3	49	0.026	Very Low
	0.5 – 0.6	35	0.085	Very Low
	0.8 – 0.9	38	0.592	High
	1.1 – 1.2	38	0.636	High
SS09	0.0 – 0.1	26	0.048	High
	0.1 – 0.2	47	0.365	Medium
	0.2 – 0.3	45	0.588	High
	0.5 – 0.6	41	0.750	High
SS10	0.0 – 0.1	~10-20#	0.049	Very Low
	0.1 – 0.2	~10-20#	0.220	Medium

Sample	Depth	Clay (%)	$EC_{1:5}$ (dSm^{-1})	Soil Salinity Rating
	0.2 – 0.3	~10-20#	0.310	Medium
	0.5 – 0.6	~20-40#	0.680	High
	0.8 – 0.9	~20-40#	0.792	Very High
SS11	0.0 – 0.1	16	0.005	Very Low
	0.1 – 0.2	16	0.008	Very Low
	0.2 – 0.3	20	0.042	Very Low
	0.5 – 0.6	33	0.521	High
	0.8 – 0.9	29	0.873	Very High

#Estimated range based on field texture

Soil EC measurements from 1 to 5 soil water dilutions ($EC_{1:5}$) are influenced by soil texture. Salts are more readily dissolved from light-textured (sandy) soils and less readily dissolved from heavy-textured (clayey) soils due to clay adsorption processes. To correct for this, EC1:5 can be converted to an estimated ECe (soil EC from a saturated paste extract) using the conversion factors provided by Shaw (1994). This data is summarised by soil type and horizon in Figure 5-10 and shows most soils are non-saline (ECe < 1.5 dS/m); the exceptions being the subsoils of the brown sodic Kandosols, the Sodosols and the Vertosols.

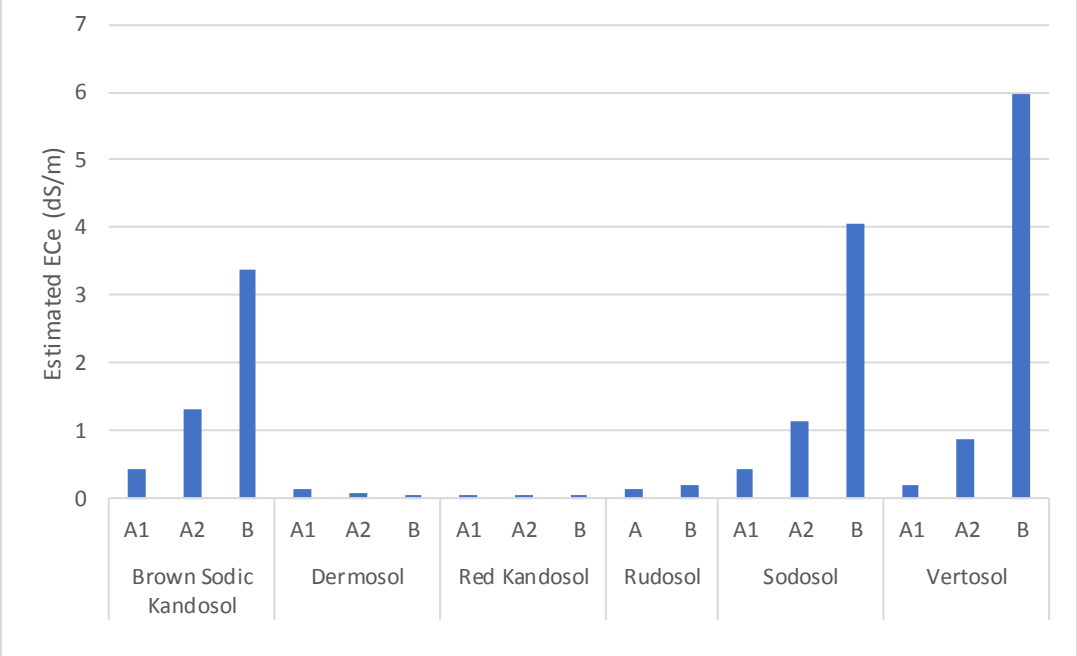


Figure 5-10 Soil salinity (estimated ECe) summarised by soil type and horizon

Soil pH Characteristics

Soil pH has a strong influence on the solubility and form of chemical compounds, the availability of ions in the soil solution as well as microbial activity. The optimum pH range for plant growth varies between species with a pH of 5.5–7.0 considered ideal for many native plants and pH 6.0–7.0 best for pasture grass. Plants are fairly tolerant of pH range and it is only if pH is less than 4.5 or greater than 9.0 that pH is likely to have direct effects on plant growth (DME 1995). At a pH outside the optimum range, indirect effects (due to the change in the availability of plant nutrients) can occur. The general interpretation of pH following Hazelton and Murphy (2007) is shown in Table 5-28.

Table 5-28 Soil pH_{H2O} ratings

pH	Rating
>9.0	Very Strongly Alkaline
9.0 – 8.5	Strongly Alkaline
8.4 – 7.9	Moderately Alkaline
7.8 – 7.4	Mildly Alkaline
7.3 – 6.6	Neutral
6.5 – 6.1	Slightly Acid
6.0 – 5.6	Moderately Acid
5.5 – 5.1	Strongly Acid
5.0 – 4.5	Very Strongly Acid

Soil pH measured from samples collected across the site ranged from Strongly Acidic at SS01 located south of Open Cut 1 to Very Strongly Alkaline at SS03 and SS04. Soil pH results are shown at Table 5-29 and these are summarised by soil type and horizon in Figure 5-11. The results suggest a correlation between soil pH and soil salinity, with the more alkaline conditions corresponding to more saline (and sodic) conditions.

Table 5-29 Soil pH characteristics

Sample	Depth	pH	Rating
SS01	0.0 – 0.1	5.3	Strongly Acid
	0.1 – 0.2	5.4	Strongly Acid
	0.2 – 0.3	5.5	Strongly Acid
	0.5 – 0.6	5.5	Strongly Acid
	0.8 – 0.9	5.6	Moderately Acid
	1.1 – 1.2	5.6	Moderately Acid
SS02	0.0 – 0.1	6.2	Slightly Acid
	0.1 – 0.2	6.0	Moderately Acid
	0.2 – 0.3	6.1	Slightly Acid
	0.5 – 0.6	7.6	Mildly Alkaline
	0.8 – 0.9	8.0	Moderately Alkaline
	1.1 – 1.2	8.0	Moderately Alkaline
SS03	0.0 – 0.1	6.3	Slightly Acid
	0.1 – 0.2	6.5	Slightly Acid
	0.2 – 0.3	7.0	Neutral
	0.5 – 0.6	8.3	Moderately Alkaline
	0.8 – 0.9	9.1	Very Strongly Alkaline
	1.1 – 1.2	9.1	Very Strongly Alkaline
SS04	0.0 – 0.1	7.0	Neutral
	0.1 – 0.2	7.6	Mildly Alkaline
	0.2 – 0.3	8.2	Moderately Alkaline
	0.45 – 0.5	9.5	Very Strongly Alkaline
SS05	0.0 – 0.1	6.8	Neutral
	0.1 – 0.2	6.7	Neutral
	0.2 – 0.3	6.6	Neutral
	0.5 – 0.6	6.6	Neutral
	0.8 – 0.9	6.7	Neutral
	1.1 – 1.2	6.7	Neutral
SS06	0.0 – 0.1	7.5	Mildly Alkaline
	0.1 – 0.2	7.9	Moderately Alkaline
	0.2 – 0.3	9.0	Strongly Alkaline
	0.5 – 0.6	9.3	Very Strongly Alkaline

Sample	Depth	pH	Rating
	0.8 – 0.9	9.1	Very Strongly Alkaline
	1.1 – 1.2	9.2	Very Strongly Alkaline
SS07	0.0 – 0.1	5.6	Moderately Acid
	0.1 – 0.2	5.7	Moderately Acid
	0.2 – 0.3	5.6	Moderately Acid
	0.5 – 0.6	5.6	Moderately Acid
	0.8 – 0.9	5.6	Moderately Acid
	1.1 – 1.2	6.6	Neutral
SS08	0.0 – 0.1	6.3	Slightly Acid
	0.1 – 0.2	7.2	Neutral
	0.2 – 0.3	7.3	Neutral
	0.5 – 0.6	7.4	Mildly Alkaline
	0.8 – 0.9	8.4	Moderately Alkaline
	1.1 – 1.2	8.5	Strongly Alkaline
SS09	0.0 – 0.1	6.4	Slightly Acid
	0.1 – 0.2	7.3	Neutral
	0.2 – 0.3	8.0	Moderately Alkaline
	0.5 – 0.6	8.9	Strongly Alkaline
SS10	0.0 – 0.1	6.6	Neutral
	0.1 – 0.2	7.4	Mildly Alkaline
	0.2 – 0.3	7.7	Mildly Alkaline
	0.5 – 0.6	8.7	Strongly Alkaline
	0.8 – 0.9	9.4	Strongly Alkaline
SS11	0.0 – 0.1	6.1	Slightly Acid
	0.1 – 0.2	6.3	Slightly Acid
	0.2 – 0.3	6.6	Neutral
	0.5 – 0.6	8.0	Moderately Alkaline
	0.8 – 0.9	8.6	Strongly Alkaline

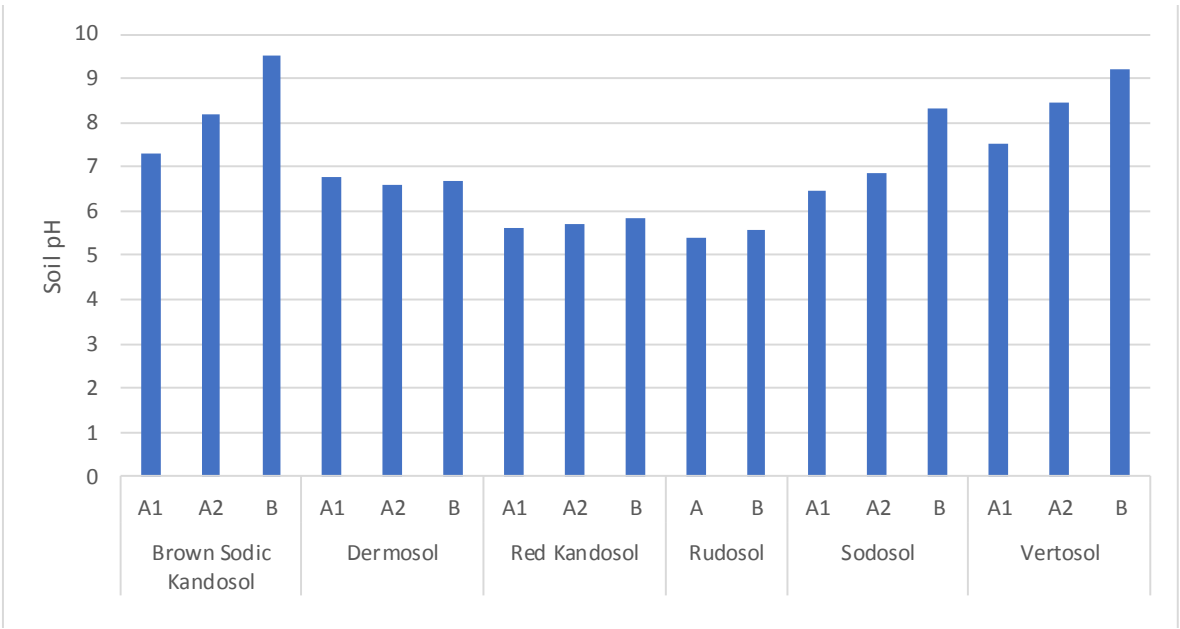


Figure 5-11 Soil pH_{H2O} averaged by soil type and horizon

Cation Exchange Capacity and Exchangeable Cations

Cation Exchange Capacity (CEC) is a measure of a soil's capacity to retain and release elements (e.g. nutrients) and is closely related to soil texture. A low CEC indicates a low potential for a soil to store and release nutrients. Guidelines for exchangeable cation test results specific to Queensland do not exist; however, the NSW Government Department of Environment, Climate Change and Water (NSW DECCW) provides guideline values for the interpretation of laboratory cation analysis (NSW DECCW, 2008). The NSW DECCW ranking for laboratory exchangeable cation test results are summarised at Table 5-30.

Table 5-30 Cation exchange capacity and exchangeable cations interpretation criteria

Analyte	Unit	Very Low	Low	Moderate	High	Very High
CEC	meq/100g	<6	6-12	12-25	25-40	>40
Exchangeable Calcium	meq/100g	<2	2-5	5-10	10-20	>20
Exchangeable Magnesium	meq/100g	<0.3	0.3-1.0	1-3	3-8	>8
Exchangeable Potassium	meq/100g	<0.2	0.2-0.3	0.3-0.7	0.7-2.0	>2.0
Exchangeable Sodium	meq/100g	<0.1	0.1-0.3	0.3-0.7	0.7-2.0	>2.0

The CEC and exchangeable cation results and ratings when compared to Table 5-30 are described in Table 5-31. The CEC data is summarised by soil type and horizon in Figure 5-12.

Table 5-31 Cation exchange capacity and exchangeable cations interpretation criteria

Sample	Depth	CEC		Exchangeable Calcium		Exchangeable Magnesium		Exchangeable Potassium		Exchangeable Sodium	
		Result	Rating	Result	Rating	Result	Rating	Result	Rating	Result	Rating
SSO1	0.0 – 0.1	2.3	VL	0.8	VL	0.5	L	0.4	M	<0.1	VL
	0.1 – 0.2	2.0	VL	0.7	VL	0.5	L	0.2	L	<0.1	VL
	0.2 – 0.3	1.2	VL	0.3	VL	0.4	L	0.2	L	<0.1	VL
	0.5 – 0.6	1.1	VL	0.1	VL	0.3	L	0.2	L	<0.1	VL
	0.8 – 0.9	1.7	VL	<0.1	VL	1.1	M	0.2	L	<0.1	VL
	1.1 – 1.2	2.0	VL	<0.1	VL	1.3	M	<0.1	VL	0.4	M
SS02	0.0 – 0.1	4.7	VL	2.4	L	1.9	M	0.2	L	0.2	L
	0.1 – 0.2	11.4	L	4.1	L	5.7	H	0.2	L	1.1	H
	0.2 – 0.3	15.5	M	5.1	M	7.9	H	0.3	L	2.0	H
	0.5 – 0.6	7.4	L	2.1	L	4.0	H	<0.2	VL	1.3	H
	0.8 – 0.9	7.2	L	2.1	L	3.6	H	<0.2	VL	1.5	H
	1.1 – 1.2	6.1	L	1.8	VL	3.1	H	<0.2	VL	1.3	H
SS03	0.0 – 0.1	4.8	VL	1.6	VL	2.5	M	<0.1	VL	0.3	L
	0.1 – 0.2	4.6	VL	1.3	VL	2.6	M	<0.1	VL	0.6	M
	0.2 – 0.3	7.9	L	1.8	VL	4.6	H	<0.1	VL	1.4	H
	0.5 – 0.6	5.8	VL	0.8	VL	3.3	H	<0.2	VL	1.7	H
	0.8 – 0.9	6.0	L	0.7	VL	3.2	H	<0.2	VL	2.1	VH
	1.1 – 1.2	6.9	L	0.8	VL	3.5	H	<0.2	VL	2.6	VH
SS04	0.0 – 0.1	12.5	M	2.8	L	7.4	H	0.3	L	1.8	H
	0.1 – 0.2	5.7	VL	1.1	VL	3.7	H	<0.2	VL	1	H
	0.2 – 0.3	4.8	VL	0.9	VL	3	H	<0.2	VL	0.9	H
	0.45 – 0.5	5.4	VL	1.2	VL	3.1	H	<0.2	VL	1.1	H
SS05	0.0 – 0.1	4.8	VL	1.6	VL	2.5	M	<0.1	VL	0.3	L
	0.1 – 0.2	8.7	L	5.8	M	2.0	M	0.9	H	<0.1	VL
	0.2 – 0.3	7.6	L	5.1	M	1.8	M	0.6	M	<0.1	VL
	0.5 – 0.6	9.0	L	6.2	M	2.3	M	0.4	M	<0.1	VL
	0.8 – 0.9	7.9	L	5.0	M	2.6	M	0.2	L	<0.1	VL
	1.1 – 1.2	6.4	L	3.7	L	2.4	M	0.2	L	0.1	L
SS06	0.0 – 0.1	5.3	VL	2.9	L	2.0	M	<0.2	VL	0.2	L

Sample	Depth	CEC		Exchangeable Calcium		Exchangeable Magnesium		Exchangeable Potassium		Exchangeable Sodium	
		Result	Rating	Result	Rating	Result	Rating	Result	Rating	Result	Rating
	0.1 – 0.2	5.3	VL	2.9	L	2.0	M	<0.2	VL	0.2	L
	0.2 – 0.3	9.9	L	4.9	L	3.9	H	<0.2	VL	0.9	H
	0.5 – 0.6	16.7	M	5.5	M	6.8	H	<0.2	VL	4.3	VH
	0.8 – 0.9	10.6	L	2.8	L	4.3	H	<0.2	VL	3.4	VH
	1.1 – 1.2	12.8	M	3.5	L	5.4	H	<0.2	VL	4.0	VH
SS07	0.0 – 0.1	2.7	VL	0.6	VL	1.8	M	0.1	VL	<0.1	VL
	0.1 – 0.2	2.9	VL	0.6	VL	2.1	M	<0.1	VL	<0.1	VL
	0.2 – 0.3	3.2	VL	0.5	VL	2.5	M	<0.1	VL	<0.1	VL
	0.5 – 0.6	2.9	VL	<0.1	VL	2.7	M	<0.1	VL	<0.1	VL
	0.8 – 0.9	2.6	VL	<0.1	VL	2.6	M	<0.1	VL	<0.1	VL
	1.1 – 1.2	2.6	VL	<0.1	VL	2.4	M	<0.1	VL	<0.1	VL
SS08	0.0 – 0.1	9.3	L	5.0	L	3.9	H	0.1	VL	0.3	M
	0.1 – 0.2	10.2	L	4.3	L	5.0	H	0.1	VL	0.7	M
	0.2 – 0.3	11.7	L	4.4	L	6.2	H	0.1	VL	1.0	H
	0.5 – 0.6	2.5	VL	0.4	VL	1.5	M	<0.2	VL	0.6	M
	0.8 – 0.9	6.2	L	0.7	VL	3.7	H	<0.2	VL	1.8	H
	1.1 – 1.2	8.5	L	1.0	VL	4.9	H	<0.2	VL	2.5	VH
SS09	0.0 – 0.1	-	-	-	-	-	-	-	-	-	-
	0.1 – 0.2	5.3	VL	0.7	VL	3.4	M	<0.2	VL	1.3	
	0.2 – 0.3	7.5	L	0.8	VL	4.6	H	<0.2	VL	2	
	0.5 – 0.6	6.7	L	0.8	VL	3.8	H	<0.2	VL	2.1	VH
SS10	0.0 – 0.1	-	-	-	-	-	-	-	-	-	-
	0.1 – 0.2	2.0	VL	0.3	VL	1.0	M	<0.2	VL	0.6	M
	0.2 – 0.3	5.8	VL	0.9	VL	3.1	H	<0.2	VL	1.8	H
	0.5 – 0.6	6.1	L	0.6	VL	3.1	H	<0.2	VL	2.3	VH
	0.8 – 0.9	7.9	L	1.5		3.8	H	<0.2	VL	2.6	VH
SS11	0.0 – 0.1	3.3	VL	1.4	VL	1.5	M	0.2	L	<0.1	VL
	0.1 – 0.2	3.0	VL	1.1	VL	1.6	M	<0.1	VL	0.2	L
	0.2 – 0.3	3.3	VL	0.8	VL	1.7	M	<0.1	VL	0.6	M
	0.5 – 0.6	-	-	-	-	-	-	-	-	-	-
	0.8 – 0.9	-	-	-	-	-	-	-	-	-	-

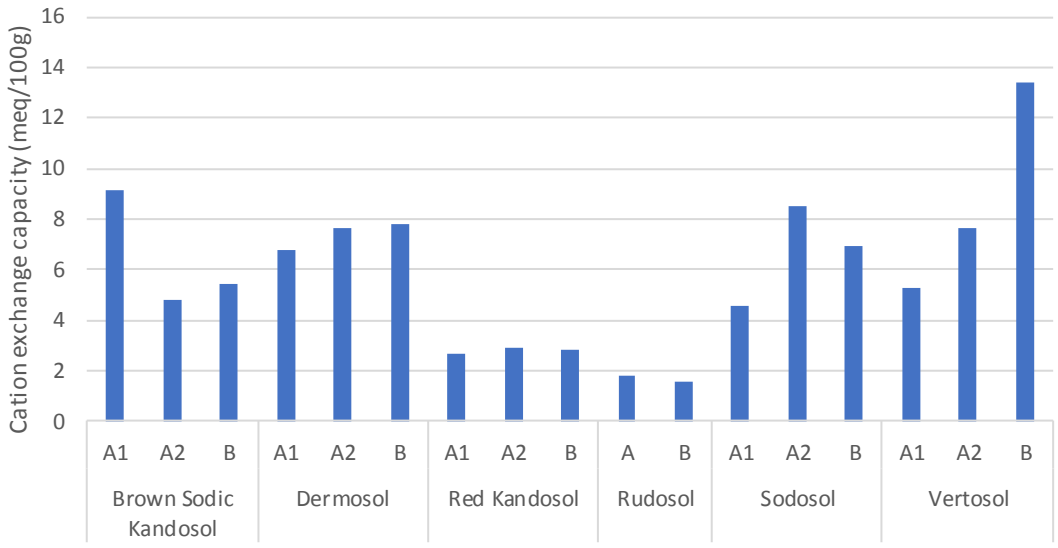


Figure 5-12 Average cation exchange capacities by soil type and horizon

The majority of soil samples across the Project area contain CEC levels that are considered to be Very Low (<6) to Low (<12), and particularly so in the sandy textured red Kandosol and Rudosol soils. The exception was moderate CEC levels being present in the B horizon of the Vertosols.

In terms of major cation concentrations, the following results were obtained:

- Exchangeable Calcium results were generally Very Low (<2) to Low (2–5) except for SS05 which was mostly rated as Moderate (5-10);
- Exchangeable Magnesium results were generally Moderate (1-3) to High (3-8) except for SS01 which was rated as Low (<0.3);
- Exchangeable Potassium rating levels were generally Very Low (<0.2) to Low (0.2-0.3), except for SS01 which had a single Moderate Rating (0.3-0.7) at a depth of between 0.0 and 0.1 and SS05 which ranged between Very Low (<0.2) to High (0.7-2.0); and
- Exchangeable Sodium levels varied across the site ranging between Very Low to Very High.

Phosphorus (P)

Phosphorus (P) deficiency is one of the most widespread nutrient deficiencies in Australian soils. Phosphorus forms part of the proteins in plant cells, so it is important in growing tissue where cells are actively dividing (such as the development of seedling roots, flowering and the formation of seed). Phosphorus-deficient plants appear as stunted, dark green plants with short, erect leaves and stout stems which often develop orange, red or purplish discolouration.

The interpretation of phosphorus test results is provided in terms of the soils plant response to phosphorus fertiliser application and is dependent on local conditions.

The guidelines summarised below provide a rating of a soil's likely response to the addition of phosphorus and provide an indication of phosphorus levels in soil corresponding to the response rating. The Department of Agriculture and Fisheries (DAF 2010) provides recommended phosphorus levels for the Western Darling Downs and Central Queensland regions which are applicable to the Project area.

Recommended available P levels for the Central Queensland regions are nominated in Table 5-32 (DAF, 2010).

Table 5-32 Value response ratings for soil bicarb P (mg/kg - Qld Western Downs)

Rating P	Response Most Likely, Marginal P	Response Likely Adequate P	Response Possible Good P	Response Unlikely
Total P	0.0-10	11-15	16-20	>20

The results and ratings of reactive P laboratory tests are shown in Table 5-33.

Table 5-33 Soil bicarb P response ratings and results (mg/kg – Central Queensland)

Sample	Depth	Reactive Phosphorus as P (mg/kg)	Rating
SS01	0.0 – 0.01	<5	Response Most Likely, Marginal P
SS02	0.0 – 0.01	<5	Response Most Likely, Marginal P
SS03	0.0 – 0.01	<5	Response Most Likely, Marginal P
SS04	0.0 – 0.01	<5	Response Most Likely, Marginal P
SS05	0.0 – 0.01	28	Response Unlikely
SS06	0.0 – 0.01	47	Response Unlikely
SS07	0.0 – 0.01	<5	Response Most Likely, Marginal P
SS08	0.0 – 0.01	<5	Response Most Likely, Marginal P
SS09	0.0 – 0.01	<5	Response Most Likely, Marginal P
SS10	0.0 – 0.01	<5	Response Most Likely, Marginal P
SS11	0.0 – 0.01	5	Response Most Likely, Marginal P

Soils analysed from the Project area exhibited reactive P levels less than 10 mg/kg which is consistent with the typical response of most Australian soils, except for SS05 and SS06 were rated as soils that were unlikely to have a response to the addition of phosphorus.

Nitrogen (N)

Nitrogen (N) occurs as several mineralised forms, some of which (nitrate and ammonia) are available to plants. Total nitrogen measures the mineralised forms and the majority contained in organic matter which is not immediately available to plants as a measure of the potential nitrogen source. Total Kjeldahl nitrogen (TKN); however, is the sum of free-ammonia and organic nitrogen that is readily available to plants, and this is the value that needs to be considered in the planning phase of the Project. The guidelines summarised below in Table 5-34 provide a rating of a soils available nitrogen source (Rayment and Lyon, 2011).

Table 5-34 Ratings by weight for TKN

Rating	Very Low	Low	Medium	High	Very High
TKN % by weight	<0.05	0.05-0.15	0.15-0.25	0.25-0.5	>0.5

The results and ratings of TKN laboratory tests are presented in Table 5-35.

Table 5-35 Ratings of TKN % by weight and results

Sample	Depth	TKN (%)	Rating
SS01	0.0 – 0.01	0.073	Low
SS02	0.0 – 0.01	0.055	Low
SS03	0.0 – 0.01	0.044	Very Low
SS04	0.0 – 0.01	0.100	Low
SS05	0.0 – 0.01	0.099	Low
SS06	0.0 – 0.01	0.159	Medium
SS07	0.0 – 0.01	---	
SS08	0.0 – 0.01	0.091	Low
SS09	0.0 – 0.01	0.047	Very Low
SS10	0.0 – 0.01	0.045	Very Low
SS11	0.0 – 0.01	0.056	Low

TKN ratings within samples analysed across the Project area rated as either Very Low (<0.05%) to Low (0.05-0.15%), except for SS05 which rated as Medium (0.15-0.25%).

Total Organic Carbon

Total organic carbon (TOC) is a vital component of soils, as it not only represents the carbon content of soils, but can indicate the nutrient holding capacity and fertility of a soil. The TOC ratings used in assessing soils, following Rayment and Lyons (2011) are shown in Table 5-36.

Table 5-36 Organic carbon ratings

Organic Carbon (%)	Rating
<0.5	Very Low
0.5 – 1.5	Low
> 1.5 – 2.5	Medium
> 2.5 – 5.0	High
> 5.0	Very High

The results and ratings of the TOC laboratory tests for each of the deep boreholes are shown in Table 5-37.

Table 5-37 Organic carbon results and ratings

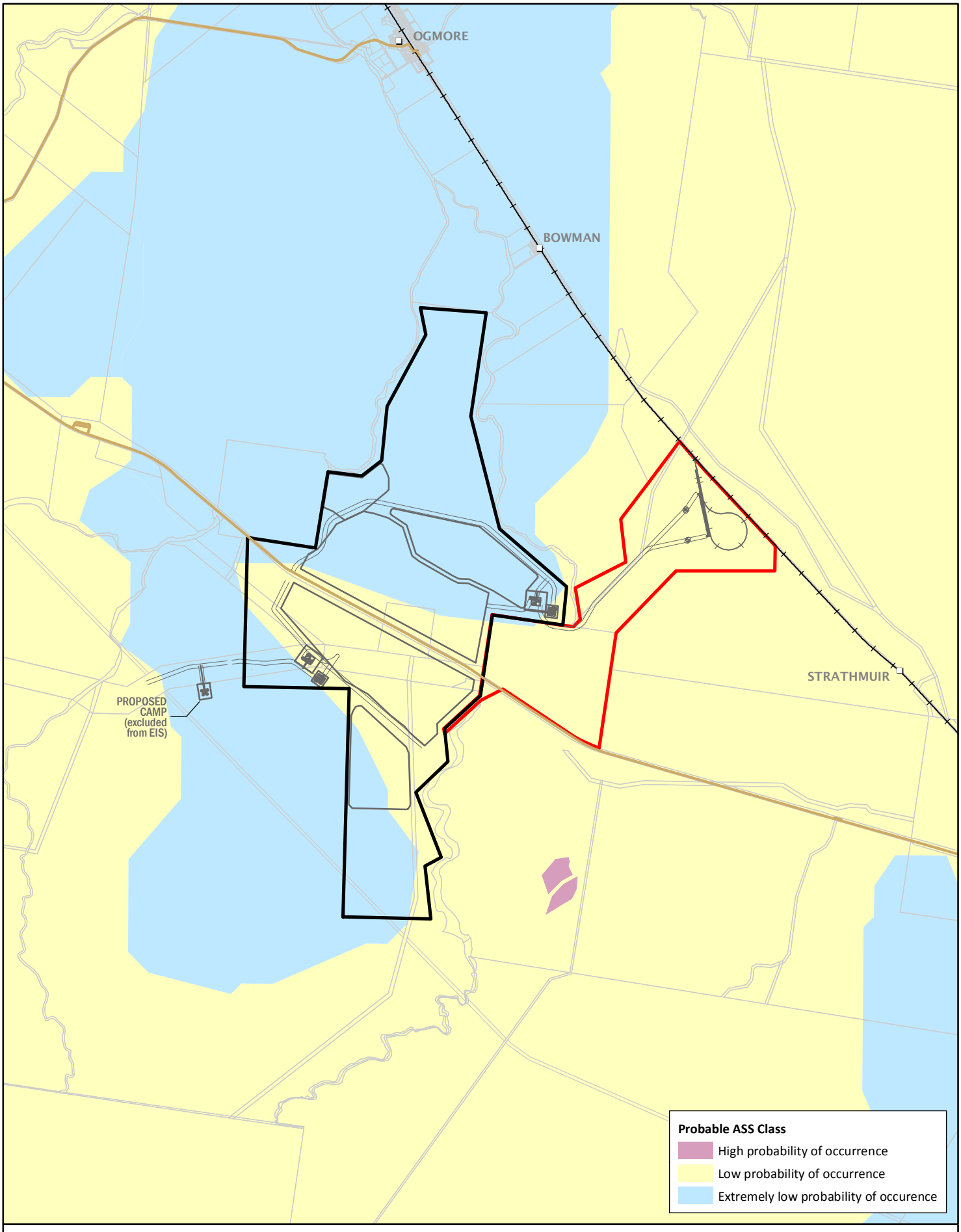
Sample	Depth	Organic Carbon Result (%)	Rating
SS01	0.0 – 0.01	2	Medium
SS02	0.0 – 0.01	1.3	Low
SS03	0.0 – 0.01	1.1	Low
SS04	0.0 – 0.01	1.6	Medium
SS05	0.0 – 0.01	2.4	Medium
SS06	0.0 – 0.01	2.3	Medium
SS07	0.0 – 0.01	0.8	Low
SS08	0.0 – 0.01	1.9	Medium
SS09	0.0 – 0.01	1.4	Low
SS10	0.0 – 0.01	1.0	Low
SS11	0.0 – 0.01	0.9	Low

Samples across the Project site recorded TOC ratings of Low (<0.5%) to Medium (>1.5 – 2%).

Acid Sulfate Soils

Acid sulfate soils (ASS) are generally associated with low energy coastal environments. ASS can; however, form inland when there are sources of sulfide and soils are saturated for long periods of time in favourable conditions.

The CSIRO National ASS mapping illustrates that the bulk of EPC 1029 is described as having a low to extremely low probability of containing ASS. The National ASS mapping (Fitzpatrick et al. 2011) in relation to the proposed mine, and the location of the 10m AHD contour is shown at Figure 5-13. As can be seen, the site straddles the low to extremely low ASS categories, and is located beyond the 20m contour meaning the State Planning Policy 2/02 - Planning and Managing Development Involving Acid Sulfate Soils is not triggered. Given the low to extremely low risk of encountering ASS, specific ASS sampling has not been undertaken.



N

0 1 2 km

Scale @ A4 1:80,000
Date: 10/08/17
Drawn: Gayle B.

Legend

- ML 80187
- ML 700022
- Proposed mine infrastructure
- North Coast Rail Line
- Main road
- Cadastral boundary

Figure 5-13
Probability of acid sulfate soil occurrence

DATA SOURCE
QLD Spatial Catalogue (QSpatial), 2017

CDM Smith

5.5.5 Agricultural Land Suitability

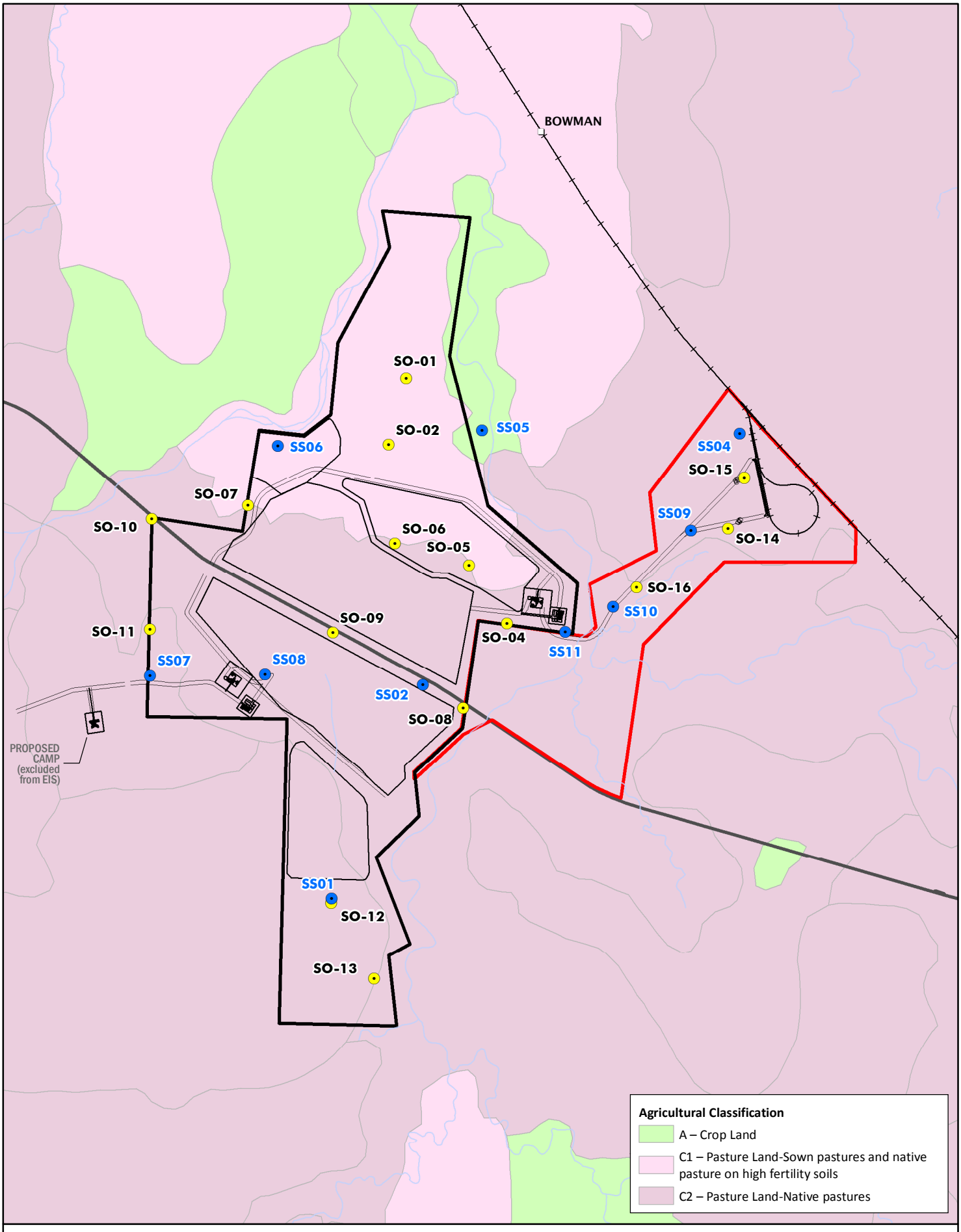
5.5.5.1 Past and Existing Land Uses

Cattle grazing is the principal agricultural industry in the Project area. The current mapped agricultural land uses are shown at Figure 5-14. Important agricultural areas identified in the Queensland Agricultural Land Audit (DAF 2016) relevant to the Project are shown at Figure 5-15. It shows some areas with high potential for pasture production and an area in the centre of the mine suitable for intensive livestock production.

Based on historical studies carried out as part of the EIS (see Chapter 18 - Cultural Heritage) the first pastoral runs within the Project area were issued licenses in the early 1860s. Since then cattle grazing has continued across the broader Project area. This was confirmed through a review of information pertaining to land use derived from review of previous land use assessments, aerial photo interpretation and informal discussions with the existing landholders.

Cattle grazing, for both fattening and breeding of stock, has relied on stock dams, fencing and associated access tracks constructed within the Project area.

The Central Queensland mine is suitable for beef cattle grazing on pastures. Whilst some areas are theoretically suitable for future cropping there is no intention to undertake cropping activities within the Mamelon property or the areas associated with the Central Queensland mine on the Brussels property and Strathmuir property.



N

0 0.5 1 km

Scale @ A4 1:60,000
Date: 10/08/17
Drawn: Gayle B.

Legend

Soil Sample Location

- Observation Soil
- Subsoil Sample
- ML 80187
- ML 700022
- Proposed mine infrastructure
- North Coast Rail Line
- Main road
- Watercourse

Figure 5-14
Current regional agricultural land use

DATA SOURCE
QLD Spatial Catalogue (QSpatial), 2017
QLD Natural Resources & Mines, 2017

CDM Smith

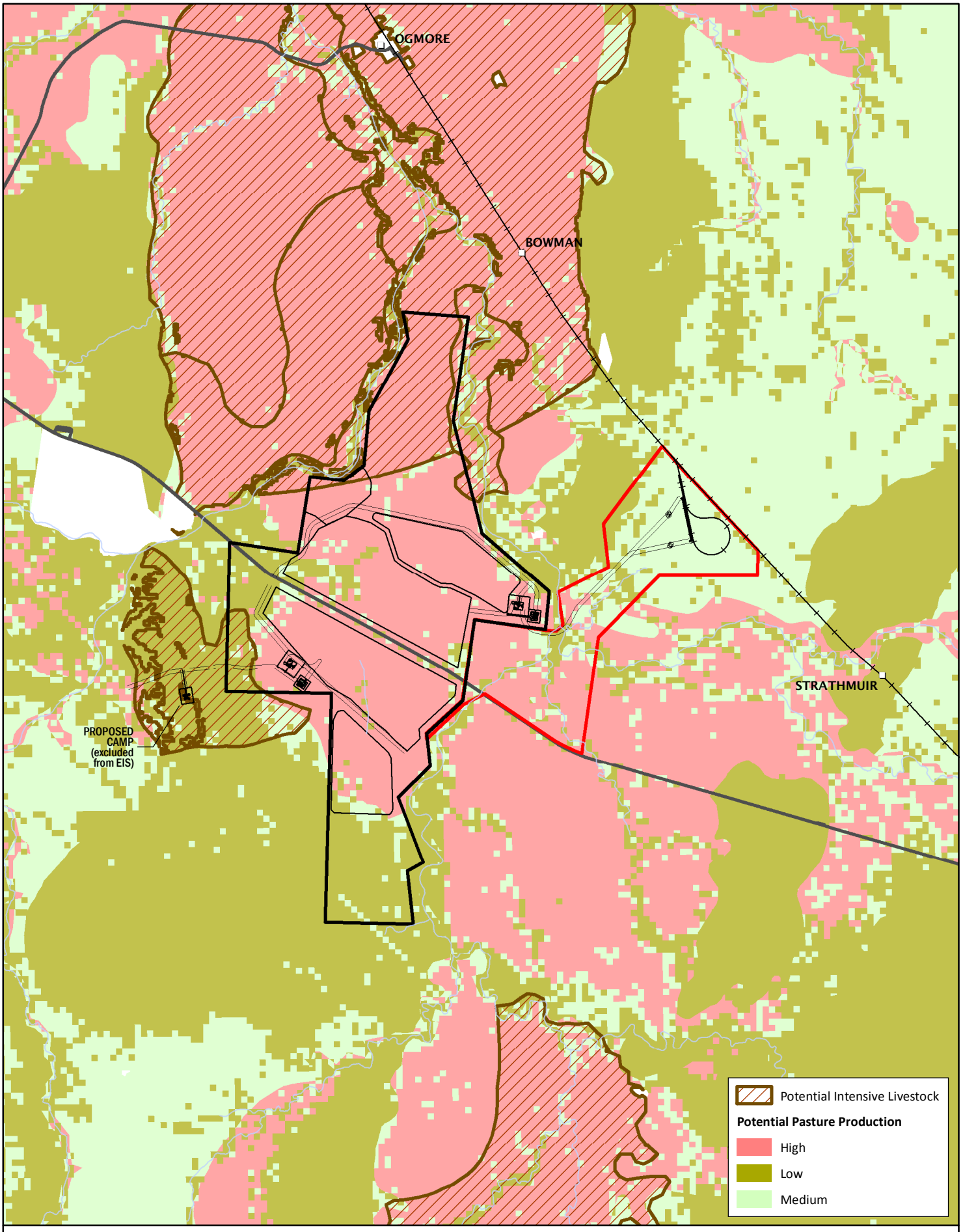


Figure 5-15
Mapped important agricultural areas

N

0 1 2 km

Legend

- ML 80187
- ML 700022
- Proposed mine infrastructure
- North Coast Rail Line
- Main road
- Watercourse

Scale @ A4 1:80,000
Date: 10/08/17
Drawn: Gayle B.

DATA SOURCE
QLD Spatial Catalogue (QSpatial), 2017

CDM Smith

5.5.5.2 Good Quality Agricultural Land

Classifying land suitability in Queensland is based on classifications provided in the LSAT Guidelines within the Technical Guidelines for Environmental Management of Exploration and Mining in Queensland (DME 1995) and is outlined in Table 5-2.

The Queensland Government's SPPs on GQAL (now superseded), SPP 1/92 Development and Conservation of Agricultural Land, and accompanying Planning Guideline: The Identification of Good Quality Agricultural Land (DPI/DHLGP 1993) are also taken into consideration when assessing GQAL. The policy calls for areas designated as GQAL to not be diminished unless there is a greater benefit to the community.

Mapped GQAL within the area of the Project is shown on Figure 5-16. Given grazing activities are the dominant agricultural land use in the areas, the mine activities and associated infrastructure has been positioned to avoid disturbance to mapped GQAL.

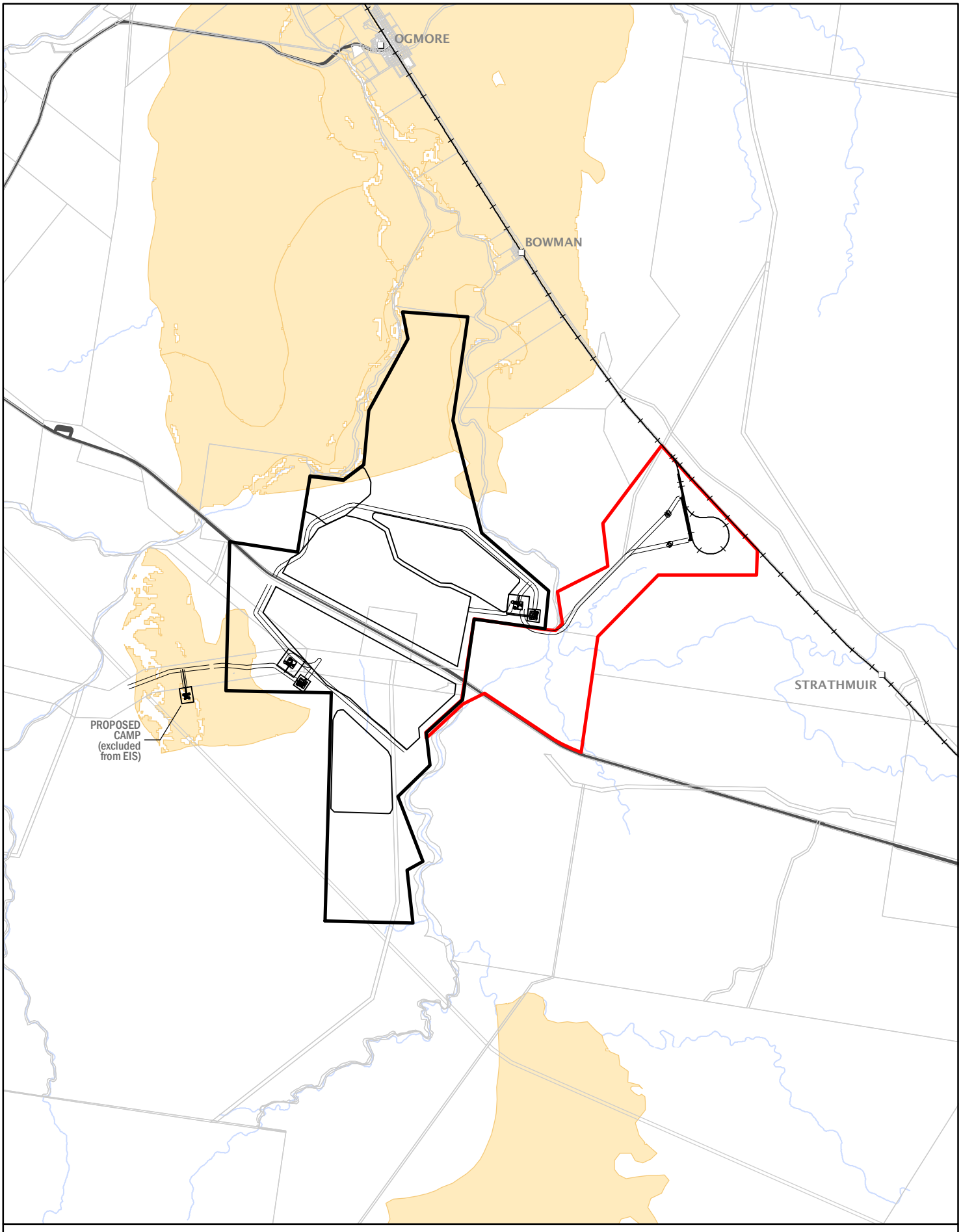


Figure 5-16
GQAL impacted by the Project

N

0 1 2 km

Scale @ A4 1:80,000
Date: 10/08/17
Drawn: Gayle B.

Legend

- Good Quality Agricultural Land
- ML 80187
- ML 700022
- Proposed mine infrastructure
- North Coast Rail Line
- Main road
- Cadastral boundary
- Watercourse

DATA SOURCE
QLD Spatial Catalogue (QSpatial), 2017

CDM Smith

BRUGGEMANNGD B:\BES150160 Styx Coal\GIS\DATA\MXD\FINAL\03 EIS Preparation\BES150160.03-031 R1 GQAL impact.mxd 8/10/2017

5.5.5.3 Strategic Cropping Land

The occurrence of mapped Strategic Cropping Area (SCA) near the Project is shown at Figure 5-17. The SCA is identified by the DNRM Strategic Cropping Land Trigger Map as Strategic Cropping Land (SCL). SCL is land that is, or likely to be, highly suitable for cropping because of a combination of the land's soil, climate and landscape features. The SCA is an Area of Regional Interest under the RPI Act. The purpose of the RPI Act is to manage resource developments in areas of Queensland that contribute to the State's economic, social and environmental prosperity at a regional scale. No other Areas of Regional Interest are present within or adjacent to the Project footprint.

SCA have been divided into five zones to assist in determining whether land mapped as SCL on the SCL Trigger Map meets the SCL criteria as identified in Schedule 3 of the RPI Act. These zones lie within a broad band that adjoins the eastern coastline of Queensland, running from the New South Wales border to Mossman. Due to the diversity of agricultural and horticultural crops able to be grown across Queensland, the zones have been delineated to collectively accommodate this diversity. Of the zones of SCA, the Project site is situated in the Coastal Queensland Cropping Zone.

The RPI Act will apply to the Project for areas within the SCA. Section 19 of the RPI Act restricts the carrying out of a resource activity in the SCA unless the activity is permitted through a Regional Interests Development Approval. A resource activity is an activity authorised by a ML granted under the *Mineral Resources Act 1989* (Qld) (MR Act). This authorisation will therefore apply to the Project if SCL is present. Notwithstanding, resource activities within the SCA are exempt from requiring an approval under the RPI Act when there is land owner agreement and the activity is not likely to result in a regional impact.

No areas of SCL are anticipated to be disturbed by the Project.

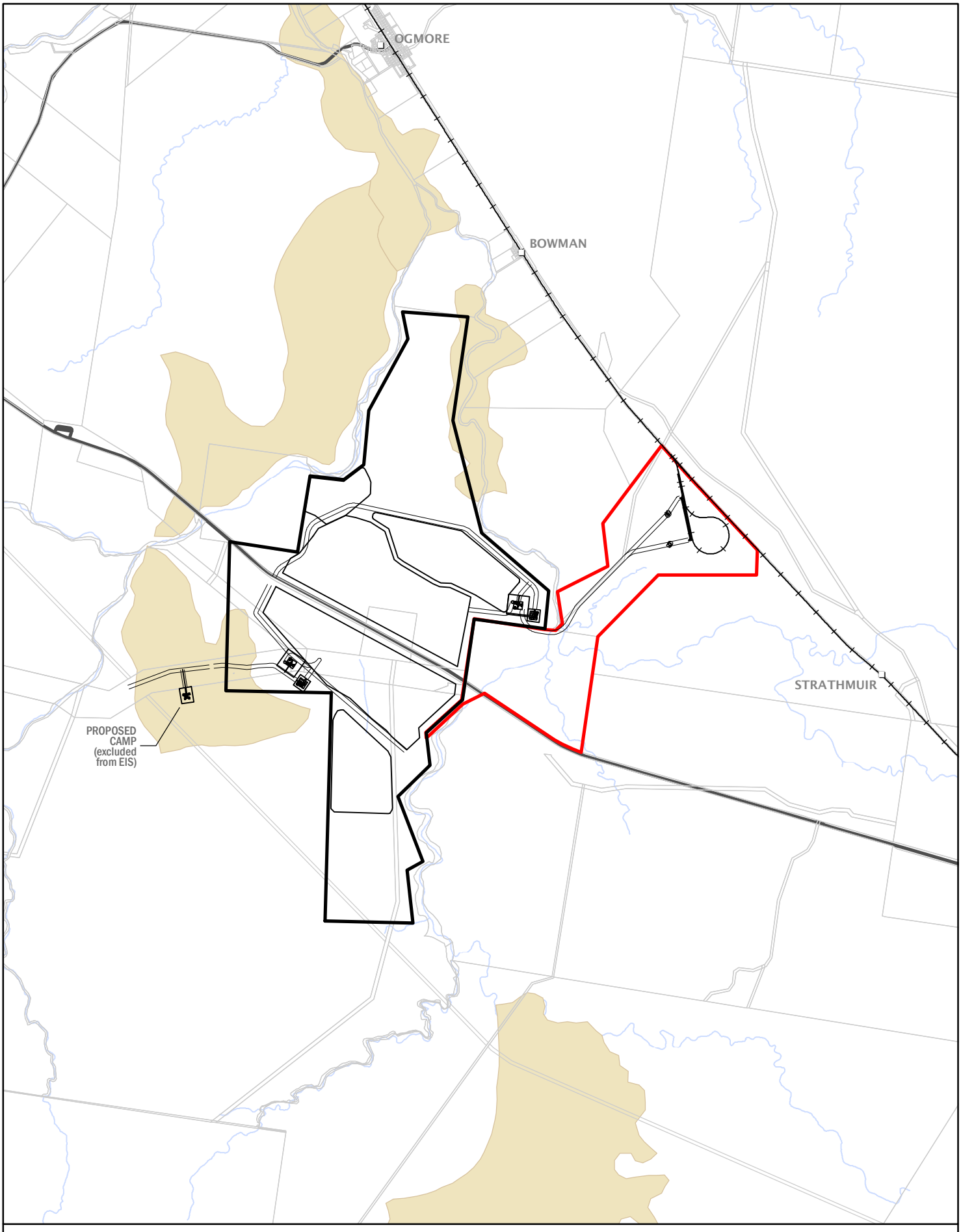


Figure 5-17
Strategic Cropping Land

N

0 1 2 km

Scale @ A4 1:80,000
Date: 10/08/17
Drawn: Gayle B.

Legend

- Strategic Cropping Land
- ML 80187
- ML 700022
- Proposed mine infrastructure
- North Coast Rail Line
- Main road
- Cadastral boundary
- Watercourse

DATA SOURCE
QLD Spatial Catalogue (QSpatial), 2017

CDM Smith

BRUGGEMANNGD B:\BES150160 Styx Coal\GIS\DATA\MXD\FINAL\03 EIS Preparation\BES150160.03-029 R1 strategic cropping land.mxd 8/10/2017

5.5.6 Contaminated Land

As part of the desktop assessment, a search of the EHP EMR and CLR database was undertaken to determine whether a notifiable activity had been undertaken within the Project area. The EMR provides information on historic and current land uses, including whether the land has been, or is currently used for a notifiable activity, or has been contaminated by hazardous material.

The CLR includes land that has been proven (through investigation) to be contaminated, and is causing or has the potential to cause serious environmental harm. Therefore, land will only be recorded on the CLR when an investigation shows it is contaminated and action must be undertaken to remediate or manage the land.

There are no land parcels within the Project area that are listed on the EMR or CLR.

5.5.7 Landscape Character and Visual Amenity

5.5.7.1 Landscape Character

The Project area and surrounding terrain is classified as predominately flat or undulating. The topography typically ranges from 4.5 to 155 m AHD within the ML with the mine area located between 11.4 to 43.8 m AHD.

The land surrounding the Project area is predominately used for cattle grazing. The closest protected area is the Tooloombah Creek Conservation Park which is located approximately 1 km to the east. The areas of known or potential nature conservation values which are of State or regional interest and are within 30 km of the Project include Bukkulla Conservation Park, Marlborough State Forest, Mount Buffalo State Forest and Eugene State Forest.

The Project area consists of several wetlands of varying size. Most of these have been artificially created ('turkey nest' dams and dammed creek lines). A single High Ecological Value, considered as a 'Wetland Protection Area' is in the western portion of the ML. A wetland listed in the Directory of Important Wetlands, Broad Sound, is located 8 km directly north, or 9.7 km downstream of the Project area. The lower Styx River forms part of the catchment of the wetland.

The Project is largely located within the Marlborough Plains subregion, one of the 13 subregions of the Brigalow Belt North bioregion. The southern portion of the ML occurs in the adjacent Nebo-Connors Ranges subregion. Large sections of the Brigalow Belt North bioregion have been cleared of remnant native vegetation for grazing, agriculture and mining. Remaining vegetation is generally confined to rockier hilly areas, linear strips of roadside vegetation, riparian vegetation and relatively small isolated remnants. Thus, clearing over the past 150 years has resulted in a highly-fragmented landscape with remnant vegetation patches separated by large expanses of cleared land.

Creeks and Drainage Lines

The mine area and TLF is situated within the lower catchments of Tooloombah Creek and Deep Creek, which are sub-catchments within the Styx River catchment. Both creeks feed directly into the Styx River (2 km north of the Project area) which discharges into the Broad Sound area approximately 8 km north of the Project. The haul road to the TLF crosses Deep Creek. Tooloombah Creek and Deep Creek are non-perennial or ephemeral, and only flow during and immediately following rainfall events.

There are two water features that surround the Project area which are defined as watercourses by DNRM, in accordance with the definition of a watercourse provided in the Water Act. These two watercourses are situated outside the ML and include:

- Tooloombah Creek; and
- Deep Creek.

Both Tooloombah Creek and Deep Creek are located outside the Project area, however several of their tributary drainage features reside within the Project area. These drainage features are minor in nature, are ranked as either first or second order drainage features, and are classified as non-perennial. This implies that the drainage features do not continually contain water and the stream flow is seasonal in nature and directly following rainfall events. The Project surface infrastructure is predominantly located within the Deep Creek catchment, except for the pit dewater dam which is located within the Tooloombah Creek catchment. Clean water diversions of existing drainage lines are proposed to prevent contamination through contact with stockpiling, processing and mine pit areas. The diversions do; however, direct water to the same watercourse in which they would otherwise discharge to, albeit further downstream than the diversion discharge location. The proposed diversions are discussed in detail in Chapter 9 – Surface Water.

Surface water features within the Project area include:

- Minor un-named drainage lines feeding into Tooloombah Creek:
  - Two 1st order drainage lines
  - One 2nd order drainage line
- Minor un-named drainage lines feeding into Deep Creek:
  - Nine 1st order drainage lines
  - One 2nd order drainage line

Vegetation

The Project is largely located within the Marlborough Plains subregion, one of the 13 subregions of the Brigalow Belt North bioregion. The southern portion of the ML occurs in the adjacent Nebo-Connors Ranges subregion. The Project area is located close to the boundary of the Brigalow Belt South bioregion located to the south. Vegetation within the Marlborough Plains subregion is dominated by alluvial plains and colluvial slopes, usually supporting woodlands characterised by Poplar Gum (*Eucalyptus platyphylla*), Ghost Gum (*Corymbia dallachiana*), Forest Red Gum (*E. tereticornis*) and paperbarks (*Melaleuca* spp.) with low rises supporting Narrow-Leaved Ironbark (*E. crebra*).

Large sections of the Brigalow Belt North bioregion have been cleared of remnant native vegetation for grazing, agriculture and mining. Remaining vegetation is generally confined to rockier hilly areas, linear strips of roadside vegetation, riparian vegetation and relatively small isolated remnants. Thus, clearing over the past 150 years has resulted in a highly-fragmented landscape with remnant vegetation patches separated by large expanses of cleared land.

Areas to the north and east of the Project area have been substantially impacted by vegetation clearing associated with cattle grazing activity. Connectivity between remaining tracts of vegetation is tenuously maintained by thin strips of riparian vegetation along creek lines such as Tooloombah Creek and Deep Creek which border the Project. Nevertheless, woodland and open forest habitat

remaining in the south and east of the site remains contiguous with an extensive tract of remnant vegetation, which includes Tooloombah Creek Conservation Park. To the west of the Project remains extensive tracts of remnant forest associated with the nearby Broad Sound Range.

Vegetation within the Project area and immediate surrounds comprises:

- Heavily disturbed habitats that have previously undergone significant clearing for cattle production. Where this habitat occurs north of the Bruce Highway it is often dominated by patches of regrowth Brigalow;
- Substantial areas of less disturbed eucalypt woodland; and
- Smaller pockets of relatively closed canopy (open forest) vegetation generally with a dense weedy shrub layer. These are largely associated with the creek systems adjacent to the Project (ML) boundary.

Night Lighting

The rural location of the Project means that there is no existing night-time illumination of the land within the proposed development area. The largest source of night-time lighting emissions nearby is expected to be from vehicle movements on the Bruce Highway. It is not anticipated that light spill from the nearby towns of Marlborough and Ogmore would result in levels of glow in the night sky.

5.5.7.2 Visual Amenity Assessment

The VIA process utilised a combination of GIS topographical analysis and field surveys to determine the potential impact of the Project's components on various sensitive receptors (see Figure 5-18), including the towns of Ogmore and Marlborough, local roads and other sensitive receptors nominated below. An assessment of the sensitive receptors can be found in Table 5-38.

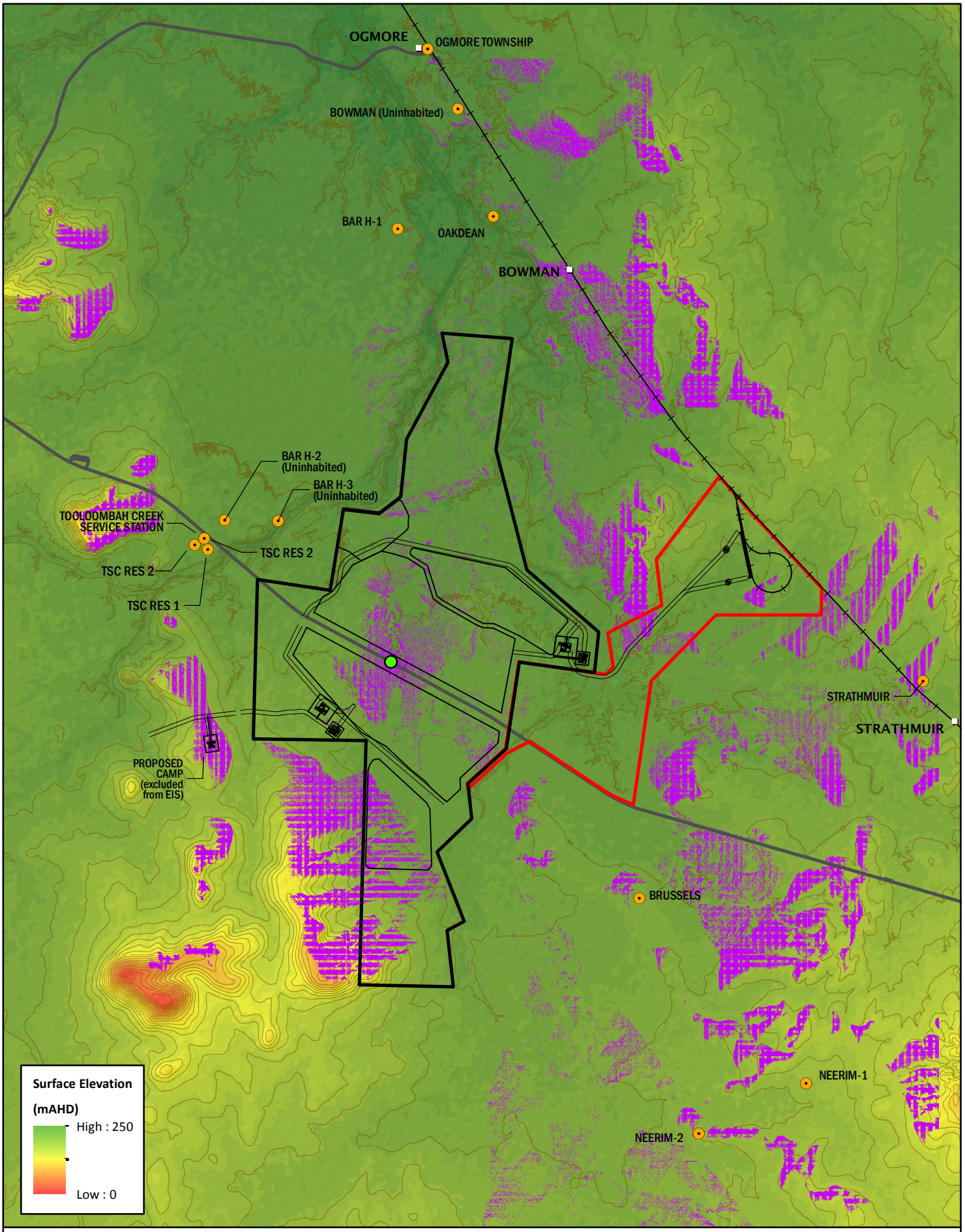


Figure 5-18
Viewshed modelling

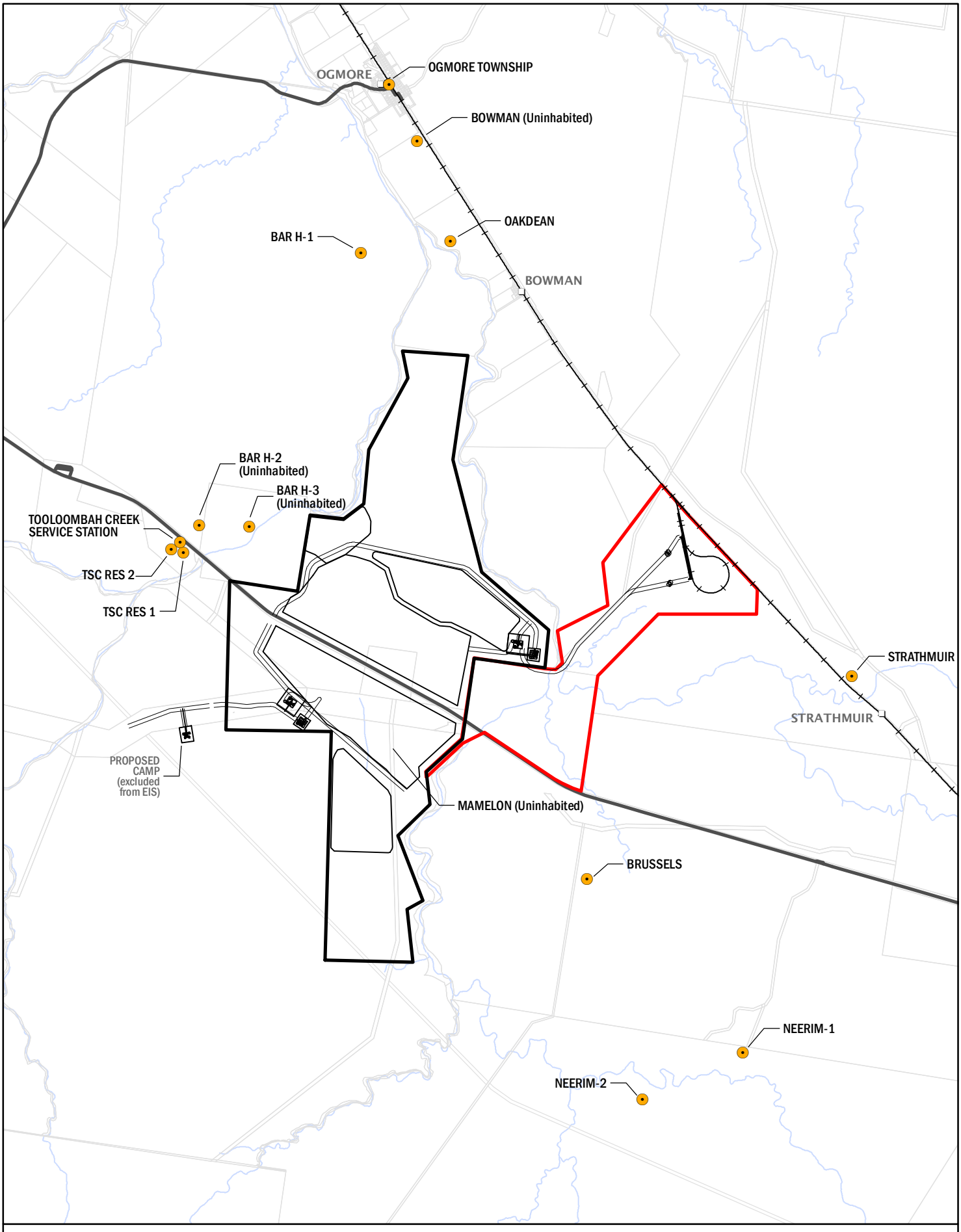


Figure 5-19
Sensitive receptors

N

0 1 2 km

Scale @ A4 1:80,000
Date: 10/08/17
Drawn: Gayle B.

Legend

- Sensitive receptor
- ML 80187
- ML 700022
- Proposed mine infrastructure
- North Coast Rail Line
- Main road
- Cadastral boundary
- Watercourse

DATA SOURCE
QLD Spatial Catalogue (QSpatial), 2017

CDM Smith

Ogmore Township

The Project is located approximately 9 km southwest of the Ogmore township. As discussed in Section 5.4.8, a theoretical assessment of visibility was undertaken from the Project mine area using a ZTV assessment at 5 m above ground level (ZTV is the theoretic assessment of visibility to or from a designated point in the landscape). There are a number of topographical rises and vegetation between the town and the Project. The rises coupled with the vegetation between the points of interest means that the Project will not be visible from the Ogmore township. It is highly unlikely that the night lighting from the Project would be visible at Ogmore because of the lighting from traffic on the Bruce Highway and the township is already lit by some street lighting and this existing artificial lighting would restrict views of the wider night sky.

Homesteads

Six inhabited homesteads and the Ogmore township were identified as sensitive receptors within the study area (see Table 5-38). In addition, there are three uninhabited homesteads. The impact to homesteads were branded into two categories using the ZTV assessment. Homesteads and their view potential were rated:

- Potentially impacted: where Project components are located in ZTV. These areas require further assessment considering additional landscape buffers such as vegetation and other features; and
- Not impacted: where Project components are not located in ZTV. Site surveys were used where possible to determine whether the Project would be viewable from several sensitive receptor locations.

Other

Three uninhabited structures have been identified within the study area. These properties are used for cattle grazing and breeding and thus these structures are likely to be working sheds or family houses that are not yet inhabited. These uninhabited structures have been assessed as homesteads given the duration of stay at these locations and the frequency of use is unknown and some of these locations have the potential to be inhabited at a later stage.

The Tooloombah Creek Service Station (Mobil) is located on the Bruce Highway approximately 1 km west from the Project. The next closest petrol station is located in Marlborough, approximately 50 km to the south of the Tooloombah Creek Service Station. Given the extensive distance between petrol stations along this stretch of the Bruce Highway the Tooloombah Creek Service Station is likely to be frequently visited by motorists. As such, the Tooloombah Creek Service Station is considered a sensitive receptor for this visual assessment. The Tooloombah Creek Service Station is near the Project; however, the ZTV assessment identified that any infrastructure at a height of 5 m at the designated point within the Project area will not be visible from the Tooloombah Creek Service Station.

An assessment of the sensitive receptors can be found in Table 5-38. It should be noted that the assessment used the ZTV findings, along with mathematics to further define the actual visual impact to the sensitive receptors. The human eye cannot see past 5 km into the horizon (at sea level) given the curve of the Earth's surface; however, if an object is at a greater height than sea level the distance the human eye can see is increased (Wolchover 2012). The mathematics behind this uses Pythagoras theorem to calculate the distance the human eye can see from a defined height (5 m for infrastructure) taking into account the earth's radius. As such, at a height of 5 m the infrastructure

can be seen from up to 8 km away. There are many factors that can affect this result and this is discussed in Table 5-38.

The mining operations will be visible to vehicles travelling in both directions along the Bruce Highway without any mitigation. Earthen mounds will be constructed from waste material derived from the overburden and established as screens between the Bruce Highway and the mining pits. The screens will be over-planted initially with a cover crop to control erosion and planted out with endemic native species as part of the progressive rehabilitation program. Native vegetation will be retained, to the extent practicable, between the Bruce Highway and the screens to further soften the visual influence of the screens to people travelling on the Bruce Highway.

Table 5-38 Visual receptor analysis

Receptor name	ZTV Classification	Topography and existing natural elements	Visual impact
Ogmore Township	Not impacted Sensitive receptor is not located within ZTV from the Project area.	Natural topographic rises and distances to the designated point at which the ZTV was measured makes the Project un-viewable from the Ogmore Township.	Nil
Oakdean	Potentially impacted Sensitive receptor is located within ZTV and is within 8 km from the Project area.	The Oakdean homestead is located approximately 5.5 km north of the Project area. The homestead and Project is separated by riparian vegetation associated with the Styx River as such the impact is expected to minimal as this vegetation will potentially screen the visibility of the Project. Lighting from the Project is likely to be visible given the proximity of the homestead to the Project.	Medium
Bowman (uninhabited)	Potentially impacted Sensitive receptor is located within ZTV and is within 8 km from the Project area.	The Bowman receptor is located approximately 7.5 km north of the Project area. The homestead and Project is separated by riparian vegetation associated with the Styx River as such the impact is expected to minimal as this vegetation will potentially screen the visibility of the Project. Lighting from the Project is unlikely to be visible given the proximity of the homestead to the Project.	Low
Strathmuir	Not impacted Sensitive receptor is not located within ZTV from the Project area.	Natural topographic rises and distances to the designated point at which the ZTV was measured makes the Project un-viewable from the Strathmuir homestead.	Nil
Brussels	Potentially impacted Sensitive receptor is located within ZTV and is within 8 km from the Project area.	The Brussels homestead is located approximately 3.2 km southeast of the Project area. The homestead and Project is separated by riparian vegetation associated with the Deep Creek as such the impact is expected to minimal as this vegetation will potentially screen the visibility of the Project. Lighting from the Project is likely to be visible given the proximity of the homestead to the Project.	Medium

Receptor name	ZTV Classification	Topography and existing natural elements	Visual impact
Neerim-1	Not impacted Sensitive receptor is not located within ZTV from the Project area.	Natural topographic rises and distances to the designated point at which the ZTV was measured makes the Project un-viewable from the Neerim-1 homestead.	Nil
Neerim-2	Potentially impacted Sensitive receptor is located within ZTV and is within 8 km from the Project area.	The Neerim-2 homestead is located approximately 7.7 km south of the Project area. The homestead and Project is separated by riparian vegetation associated with an unnamed creek as such the impact is expected to minimal as this vegetation will potentially screen the visibility of the Project. Lighting from the Project is unlikely to be visible given the proximity of the homestead to the Project.	Low
Tooloombah Creek Service Station	Not impacted Sensitive receptor is not located within ZTV from the Project area.	Natural topographic rises and distances to the designated point at which the ZTV was measured makes the Project un-viewable from the Tooloombah Creek Service Station.	Nil
Bar H-1	Not impacted Sensitive receptor is not located within ZTV from the Project area.	Natural topographic rises and distances to the designated point at which the ZTV was measured makes the Project un-viewable from the Bar H-1 homestead.	Nil
Bar H-2 (uninhabited)	Not impacted Sensitive receptor is not located within ZTV from the Project area.	Natural topographic rises and distances to the designated point at which the ZTV was measured makes the Project un-viewable from the Bar H-2 infrastructure.	Nil
Bar H-3 (uninhabited)	Not impacted Sensitive receptor is not located within ZTV from the Project area.	Natural topographic rises and distances to the designated point at which the ZTV was measured makes the Project un-viewable from the Bar H-3 infrastructure.	Nil

5.6 Potential Impacts and Mitigation Measures

The assessment above has identified the following EVs which could be impacted by the Project: the disturbance and loss of relatively good quality soils, existing land uses, and the existing landscape character and visual amenity of the area. The risk of disturbing existing contaminated land is negligible given no records of contaminated land exist. Similarly, no potential for ASS has been found.

This section describes the key components of the Project which could affect EVs associated with land. Management measures have been determined in response to these potential impacts and best reflect the requirements for land management throughout the construction, operation and rehabilitation phases of the Project.

The information contained in this Section has been provided at a level of detail suitable for strategic planning. However, to make decisions about specific construction activities at the detailed planning phase a higher intensity soil survey will need to be undertaken within the disturbance areas and will be used to inform the Project-specific Rehabilitation Management Plan and Erosion and Sediment Control Plan (ESCP).

5.6.1 Mine Area

The key infrastructure features associated with the Central Queensland mine area that will result in soil disturbance and will subsequently require management measures are outlined below. The type of impact has also been identified against the nominated infrastructure. Identified impacts to soil also include the contamination of soil. Construction of the Project infrastructure will have an overall effect on agricultural land uses. The mine area will disturb 1,128 ha of land, which is defined as follows:

- Open Cuts 1, 2 and 4 (land disturbance, soil quality, soil erosion);
- Two CHPPs and product coal stockpiles (land disturbance, soil quality, soil erosion);
- Two ROM coal stockpile area and ROM dump station (local waterways, land disturbance, soil quality, soil erosion);
- ROM coal haul roads and waste rock haul roads (local waterways, land disturbance, soil quality, soil erosion);
- Product coal and conveyor (local waterways, land disturbance, soil quality, soil erosion);
- Sewage and waste management facilities including package sewage treatment plant (soil quality);
- Water supply pipeline and management facilities, including raw water supply, storage and a water treatment plant to treat water to potable quality (topography, land disturbance, soil quality, soil erosion);
- Mine affected water dams, sediment affected water dams and clean water dams (topography, local waterways);
- Light and heavy vehicle internal roads (land disturbance, soil erosion);
- Night lighting of the MIA; and
- Buildings associated with the construction and operation of the Central Queensland mine (land disturbance, soil quality, soil erosion).

5.6.2 Train Loadout Facility

The key infrastructure features within the haul road corridor and TLF which will require soil disturbance and subsequent management measures are prescribed below. The haul road corridor will disturb 9 ha and the TLF 23 ha of land, which are defined as follows:

- 4.5 km haul road from the product stockpiles to the TLF (topography, local waterways, land disturbance, soil erosion);
- Access roads (topography, local waterways, land disturbance, soil erosion);
- Cross-drainage structures (topography, local waterways, land disturbance, soil quality, soil erosion);
- Sub-surface power, water and telecommunications services (topography, local waterways, land disturbance, soil quality, soil erosion);
- Construction of dams and sumps to collect surface runoff (topography, local waterways, land disturbance, soil quality, soil erosion);
- Preparation of area for product coal stockpile;
- Rail loop connecting to the North Coast Rail line (topography, local waterways, land disturbance, soil quality, soil erosion);
- Night lighting of the TLF;
- Hardstand area to receive product coal haul trucks from the haul road (land disturbance, soil erosion); and
- Area for administration buildings, workshop, fuel storage and light vehicle parking (local waterways, land disturbance, soil, soil erosion).

5.7 Qualitative Risk Assessment

Potential impacts on the land resulting from a combination of construction of the proposed infrastructure and ongoing mining activities within the Project area have been assessed utilising the risk assessment framework outlined in Chapter 1 - Introduction. The risk impact assessment at Table 5-39 is a qualitative risk assessment that outlines the potential impacts, the initial risk, mitigation measures and the residual risk following the implementation of the mitigation measures. Soil management strategies in the form of mitigation measures are also identified.

For the purposes of this risk assessment, levels are defined as follows:

- Extreme – Extensive long-term harm with widespread impacts that are irreversible in 5 to 10 years. Significant non-compliances with the EA and/or other approval conditions that result in significant degradation to EVs;
- High – Major long-term and widespread harm that are reversible in <5 years. Non-compliances with the EA and / or other approval conditions that result in major degradation to EVs;
- Medium – Moderate environmental harm that is contained onsite or minor widespread harm that are reversible in <1 years. Non-compliances with the EA and/or other approval conditions that result in minimal degradation to EVs; and
- Low – Minor unplanned onsite harm that does not extend off-site. No non-compliances with the EA and/or other approval conditions.

Table 5-39 Qualitative risk assessment

Issue and associated Project phase	Potential impacts	Potential risk	Mitigation measures	Residual risk
Soil and Land Disturbance (Construction Operation and Decommissioning)	The Project will disturb 1,160 ha of land. The clearing of vegetation and other earthmoving activities associated with construction of the Central Queensland mine and mine facilities can initiate soil erosion if not done in a controlled manner, releasing sediments into nearby water systems and decreasing the overall value of the land. Minimising disturbance will be vital in minimising associated impacts to land and soils. The impacts resulting from each of individual disturbance activities will vary, however they are not anticipated irreversible.	High	To protect the surrounding environment, works should be undertaken in a manner such that the impact to soils, landforms and any receiving waters is minimal. This will be achieved by the scheduling of construction activities and the dedication of specific work areas. The following mitigation measures are proposed: ▪ No Go Zones shall be established prior to clearing/grubbing activities and maintained throughout the life of the Project. This will be achieved by installing physical demarcation along work area perimeters to visibly delineate the maximum allowable area of disturbance; ▪ All vehicle movements will be restricted to stabilised access locations. Stabilised access points and nominated construction and haul roads will prevent excessive ground disturbance from the movement of vehicles and machinery across the Project site; ▪ The scheduling of works will also assist in minimising ground disturbance by ensuring that activities are organised sequentially with areas of disturbance reflecting construction activities taking place at that time; ▪ No surfaces will be left open if they are not being worked on and all areas will have topsoil pulled back over and be suitably compacted once construction work in the area has finished. Grassed areas cleared for construction of any mine-related infrastructure will be re-contoured and landscaped once construction is complete to minimise erosion impacts; ▪ Where significant excavation is required, excavated material will be deposited upslope of the work and diversion measures to control soil and water flows will be installed (including banks and berms). Any diversion measures will discharge to a stabilised control or sedimentation trap;	Low

Issue and associated Project phase	Potential impacts	Potential risk	Mitigation measures	Residual risk
			▪ Excavations shall be kept open for the shortest period possible and this will be achieved by incorporating a more detailed construction schedule into the Project planning phase; ▪ Preserving as much of the vegetated areas and areas with stable grass cover will greatly reduce the soil disturbance and subsequent erosion hazard, as well as provide a natural sediment filter; and ▪ Sediment fences or other appropriate ESC should be installed downslope of any disturbed lands. The implementation of effective ESC measures (described in detail below) will assist in achieving further protection of the surrounding environment.	
Soil and Land Contamination (Construction, Operation and Decommissioning)	The key potential soil impacts that will affect the Project site are physical soil disturbance, contamination of soils and degradation of soils. The physical degradation of soil may occur because of the use of heavy machinery, leading to severely limited revegetation potential, decreased water infiltration and, in some instances, increased erosion. Soil quality can also be affected by poor topsoil stripping and handing and by contamination. Contamination can affect future soil use and land suitability. If not managed correctly, contamination of soils may occur because of activities related to things such as the CHPP, ROM dump station, mine affected water dams and the sewage and waste management facilities on the Project site. Storage of hazardous and other chemicals also presents a risk to soils as spills can result in significant contamination. ASS or PASS do not occur within the Project area. As such there is no risk of ASS-related contamination.	Medium	The main objectives of the soil management measures nominated herein are to, near as practical, return the land to pre-existing environmental conditions by: ▪ Provision of appropriate spill control materials including booms and absorbent materials at refuelling facilities at all times to contain spills; ▪ Ensure all refuelling facilities and the storage and handling of oil and chemicals comply with relevant Australian Standards. Management and mitigation measures for wastewater are discussed in Chapter 7 - Waste Management; ▪ Ensure all staff are made aware of the potential for groundwater quality to be impacted and the requirement to report any spills; ▪ Establish procedures to ensure safe and effective fuel, oil and chemical storage and handling. This includes storing these materials within roofed, bunded areas to contain spills and prevent uncontrolled discharge to the environment; ▪ Appropriate waste rock and rejects management and disposal (see Chapter 8 – Waste Rock and Rejects, which addresses mineral waste management); ▪ As much as possible, avoiding impact to any areas of soil with sodic properties;	Low

Issue and associated Project phase	Potential impacts	Potential risk	Mitigation measures	Residual risk
			▪ Maintaining topsoil quantity and quality; ▪ Restoring land use and capability; ▪ Returning the land to a stable landform (i.e. no major erosion) with no greater soil management inputs than those required for the current land use of livestock grazing; and ▪ Minimising dust generation.	
Erosion and Soil Stability (Construction Operation and Decommissioning)	Sodosols within the central section of the transport corridor have physical and chemical properties that make them relatively more susceptible to erosion (highly sodic). Across the Project site there are some areas with subsoils (B horizons) displaying strongly sodic or dispersive properties. These soil properties will further increase the likelihood of erosion occurring if not properly managed. The risk of erosion on land within the transport corridor is most likely to occur following site clearance and prior to construction of the road. Mining activities increase the potential risk of erosion when soils are being disturbed, particularly when soils are subject to flooding and wind, are sodic in nature, or are on steep slopes. Within the Project area erosion is most likely to occur in areas because of excavation activities, including: ▪ Cut and cover; ▪ Topsoil stripping and stockpiling of materials; and ▪ Construction of infrastructure areas including roads, machinery pads and dams.	High	An ESCP will be developed by a CPESC in accordance with relevant legislation and guidelines. This will relate to the whole Project and identify the risk of erosion and sedimentation within each area of the Project based on the soil type present. It is expected that greater ESC management will be required in areas of the transport corridor which have been identified as of higher erosion risk. The ESCP will include: ▪ Size and location of all ESCs; ▪ Design of ESCs to be able to cope with the required rainstorm event for the area; ▪ Areas requiring soil stabiliser; ▪ The period of maximum disturbance for each area (with critical works being scheduled for the dry season as much as practical); and ▪ Boundaries of areas to be cleared and clear delineation on Project drawings. Any sediment collection structures will be inspected at intervals prescribed in the ESCP and after each significant rainfall event. Soil stabiliser will be applied across the site in locations deemed necessary in the ESCP. The ESCP will specify the required application rate and frequency and this will be adhered to throughout the construction phase until soils are stabilised with permanent controls or are revegetated. Temporary and permanent stormwater and drainage controls will be designed to be able to withstand the required stormwater capacity for a given average recurrence interval storm event. All temporary controls must be in place and working prior to ground disturbance and construction activities commencing.	Low

Issue and associated Project phase	Potential impacts	Potential risk	Mitigation measures	Residual risk
			Dust suppression methods (application of water) for stockpiles, roads and other exposed surfaces will be implemented during the construction and operational phases. All direct runoff from contaminated surfaces (stockpiles) will be re-directed into environmental dams to avoid contamination to surrounding areas. A detailed ESCP will prepared by a Certified Professional in Erosion and Sediment Control (CPESC). This will consider these variables in a seasonal context to measure (using the Revised Universal Soil Loss Equation) and manage the risk of soil erosion across the Project site. Soil conservation and site rehabilitation will also be integrated into the detailed ESCP.	
Visual Amenity (Construction Operation and Decommissioning)	The VIA assessment undertaken included 11 of the homesteads near the Project that had the potential to be impacted by changes in the visual landscape because of the Project. Of the 11 homesteads that the study comprised, none are at risk of visual impacts. Three homesteads (Oakdean, Brussels and Neerim-2) will have a low visibility of the Project. This is minimal since natural rises between the homesteads and the Project, and the existing vegetation, will provide a natural screen. In addition, an analysis has been undertaken to assess the impact the Project is likely to have on people travelling along the Bruce Highway and local road network surrounding the Project. The topography and existing vegetation in the area in unlikely to provide a natural screen, and as such mining operations will be visible from the road.	Low	No mitigation for visual amenity required.	Low
Night Lighting	Lighting impacts are expected to be high for the Brussels and Oakdean given their proximity to the Project. Lighting impacts are not expected at any other sensitive receptors.	High	Lighting to be used at the two MIAs will be designed to minimise upwards light spill. This will include the use of towers designed to a minimum height, positioning of towers to adequately illuminate working areas and directional shields attached to lamps to minimise horizontal and upwards spill.	Low

5.8 Conclusion

The Project will occupy land that is presently used for cattle grazing. There are no occupied homesteads within the proposed mining lease boundaries but there are a number of farm dams and bores used for stock watering, access tracks and fences along paddock boundaries. No other infrastructure such as water, power, telecommunications or gas pipelines are present.

The only designated ESA that will be directly affected are areas of endangered remnant vegetation. There are no National Parks, nature refuges or declared catchments within the Project area, or registered areas of existing contaminated land.

Soils within the Project area have a low erosion potential although some soils within parts of the transport corridor and TLF have a higher erosion risk. Soil types include clay soils with a relatively high fertility.

In terms of agriculture, the soils provide moderate quality grazing pastures with some areas of good quality grazing land over vertosols in the north of the Project area. No areas of mapped SCL will be disturbed by the Project.

Physical impacts to the land will include land clearing and topsoil removal for the open-cut pits, mine waste rock dumps, water storage dams, and other surface infrastructure including the haul road and TLF.

Measures to minimise these impacts include:

- Provision of alternative stock watering supplies until dams and bores are reinstated;
- Remediation of paddock fencing;
- Sensitive clearance, handling and storage of topsoils;
- Establishing appropriate soil erosion and sediment controls;
- Ripping of soils and access tracks cracked by subsidence; and
- Progressive rehabilitation of disturbed land to allow today's land uses to continue after the completion of mining.

5.9 Commitments

Central Queensland Coal's commitments, in relation to the land are provided in Table 5-40.

Table 5-40 Commitments – land

Commitments
Soils and landforms
Design and implement a Project Erosion and Sediment Control Plan to be certified by a suitably qualified person, prior to construction.
Schedule construction activities and dedicate specific work areas to minimise the impact to soils, landforms and any receiving waters.
Establish No Go Zones, prior to clearing / grubbing activities, and maintain throughout the life of the Project. This will be achieved by installing physical demarcation along work area perimeters to visibly delineate the maximum allowable area of disturbance.
Restrict vehicle movements to stabilised access locations. Stabilised access points and nominated construction and haul roads will prevent excessive ground disturbance from the movement of vehicles and machinery across the Project site.
No surfaces will be left open if they are not being worked on and all areas will have topsoil pulled back over and be suitably compacted once construction work in the area has finished. Grassed areas cleared for construction of any mine-related infrastructure will be re-contoured and landscaped once construction is complete to minimise erosion impacts.
Where significant excavation is required, excavated material will be deposited up-slope of the work and diversion measures to control soil and water flows will be installed (including banks and berms). Any diversion measures will discharge to a stabilised control or sedimentation trap.
Excavations shall be kept open for the shortest period of time possible and this will be achieved by incorporating a more detailed construction schedule into the Project planning phase.
Topsoil management
Topsoil and subsoil stripping during construction to be carried out using small digger and dump truck, under an approved Permit to Work and supervision of Environmental staff.
Prior to stripping, all vegetation will be cleared progressively to the minimum extent required for the impending future works.
Supervisors and earthmoving plant operators will be trained to visually identify the topsoil layers to ensure that stripping operations are conducted in accordance with stripping plans and in-situ soil conditions.
Care will be taken to ensure soil moisture conditions are appropriate for stripping and stockpiling, for example the moisture content of the topsoil material is not too dry or too wet.
All soils to be appropriately stockpiled away from mining operations for future rehabilitation use.
Soil that has been stockpiled until it is reused will be protected from excessive disturbance or traffic, and stockpiled and kept away from drainage lines.
Drainage will be constructed to manage or divert surface water flows around soil stockpiles and maintained to ensure proper functioning.
Weed and pests will be monitored and controlled as required on soil stockpiles.
Contamination
Provision of appropriate spill control materials including booms and absorbent materials at refuelling facilities to contain spills.
Ensure all refuelling facilities and the storage and handling of oil and chemicals to comply with relevant Australian Standards.
Ensure all staff to be made aware of the potential for groundwater quality to be impacted and the requirement to report any spills.
Establish procedures to ensure safe and effective fuel, oil and chemical storage and handling. This includes storing these materials within roofed, bunded areas to contain spills and prevent uncontrolled discharge to the environment.
Returning the land to a stable landform (i.e. minimal subsidence and no major erosion) with no greater soil management inputs than those required for the current land use of livestock grazing.
Night lighting
Lighting to be used at the Mine Infrastructure Area will be designed to minimise upwards light spill.
Towers designed to a minimum height, positioning of towers to adequately illuminate working areas and directional shields attached to lamps to minimise horizontal and upwards spill.

5.10 ToR Cross-reference Table

Table 5-41 ToR cross reference

Terms of Reference	Section of the EIS
8.2 Land	
Conduct the impact assessment in accordance with the EHP's *EIS information guideline—Land*, and, if any quarry material is needed for construction of project works including related infrastructure, use EHP's *EIS information guideline—Quarry material*.	Chapter 3 – Project Description
Describe potential impacts of the proposed land uses taking into consideration the proposed measures that would be used to avoid or minimise impacts. The impact prediction must address the following matters: • Any changes to the landscape and its associated visual amenity in and around the project area.	Sections 5.4.8, 5.5.7 and 5.7
• Any existing or proposed mining tenement under the *Mineral Resources Act 1989*, petroleum authority under the *Petroleum and Gas (Production and Safety) Act 2004*, petroleum tenure under the *Petroleum Act 1923*, geothermal tenure under the *Geothermal Energy Act 2010* and greenhouse gas tenure under the *Greenhouse Gas Storage Act 2009* overlying or adjacent to the project site.	Chapter 3 – Project Description
• Temporary and permanent changes to land uses of the project site and adjacent areas, considering actual and potential agricultural uses, regional plans and local government planning schemes, and any key resource areas that were identified as containing important extractive resources of state or regional significance which the state considers worthy of protection.	Sections 5.2 and 5.5
• Identify any existing or proposed incompatible land uses within and adjacent to the site, including the impacts on economic resources and the future availability and viability of the resource including extraction, processing and transport location to markets.	Section 5.5.5
• Identify any infrastructure proposed to be located within, or which may have impacts on, the Stock Route Network[1],[2] and the *Stock Route Management Act 2002*.	Section 5.2.3
• Propose suitable measures to avoid or minimise impacts related to land use.	Sections 5.5.2 and 5.7
Assess the project against the requirements of the *Regional Planning Interests Act 2014*[3], including any relevant Regional Plan. Further advice is provided in the '*DILGP Companion guide – A guide for state agencies and proponents on the requirements of the Regional Planning Interests Act 2014 in the planning and development process'* (Department of Infrastructure, Local Government and Planning, July 2016[4]) and the *DAFF Environmental Impact Assessment Companion Guide*' (Department of Agriculture, Fisheries and Forestry, August 2014[5]).	Chapter 1 - Introduction
Describe how the project will avoid or minimise impacts on any land identified as Strategic Cropping Land on the Trigger Map for Strategic Cropping Land[6].	Section 5.5.5.3
Show how the land form during and after disturbance will be stable over time and will meet any requirements of project or property plans under the *Soil Conservation Act 1986*.	Chapter 11 – Rehabilitation and Decommissioning

[1] https://www.qld.gov.au/environment/land/stock-routes/about/

[2] https://www.dnrm.qld.gov.au/__data/assets/pdf_file/0010/99622/stock-route-management-strategy.pdf

[3] http://www.dilgp.qld.gov.au/planning/regional-planning/regional-planning-interests-act.html

[4] http://www.dilgp.qld.gov.au/planning/regional-planning/rpi-act-forms-guidelines-and-fact-sheets.html

[5] https://publications.qld.gov.au/dataset/daff-environmental-impact-assessment-companion-guide/resource/7b1825c4-5e42-4cf8-aa2d-7fa55c2f5e4c

[6] https://www.dnrm.qld.gov.au/land/accessing-using-land/strategic-cropping-land

Terms of Reference	Section of the EIS
Detail any known or potential sources of contaminated land that could be impacted by the project. Describe how any proposed land use may result in land becoming contaminated.	Section 5.5.6, 5.6 and 5.7
Identify existing or potential native title rights and interests possibly impacted by the project and the potential for managing those impacts by an Indigenous Land Use Agreement or other measure in accordance with the *Native Title (Queensland) Act 1993* and consistent with the Queensland Government *Native Title Work Procedures*[7].	Chapters 3 – Project Description and 18 – Cultural Heritage

[7] https://www.dnrm.qld.gov.au/land/indigenous-land/queensland-government-native-title-work-procedures