# APPENDIX G

Mine rehabilitation strategy

# Cobbora Holding Company Pty Limited

## *Mine Rehabilitation Strategy: Cobbora Coal Project*

**February 2013**

EMG05-012

GSS ENVIRONMENTAL
Environmental, Land and Project Management Consultants

**Prepared on behalf of EMGA Mitchell McLennan for Cobbora Holding Company Pty Limited**

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| | |
|---|---|
| AEMR | Annual Environmental Monitoring Report |
| ANZMEC | Australian and New Zealand Minerals and Energy Council |
| ASC | Australian Soil Classification |
| CHC | Cobbora Holding Company Pty Limited |
| CHPP | coal handling and preparation plant |
| DBH | depth, breadth and height |
| DGR | Director General's environmental assessment requirements |
| DTIRIS | Department of Trade & Investment, Regional Infrastructure and Services |
| DP&I | Department of Planning and Infrastructure |
| dS/m | deci-Siemen per metre |
| EC | electrical conductivity |
| EMM | EMGA Mitchell McLennan Pty Limited |
| EP&A Act | *Environmental Planning and Assessment Act 1979* (NSW) |
| ESP | exchange sodium percentage |
| GSSE | GSS Environmental |
| ha | hectares |
| kg/ha | kilogram per hectare |
| km | kilometre |
| $km^2$ | kilometre squared |
| m | metre |
| MCM | million cubic metres |
| mm | millimetre |
| MOP | Mining Operation Plan |
| Mtpa | million tonnes per annum |
| n.a. | not applicable |
| NSW | New South Wales |
| OEH | Office of Environment and Heritage |
| OOP | out-of-pit |
| pH | measure how acidic or basic a substance is. |

| | |
|---|---|
| Project, the | Cobbora Coal Project |
| ROM | run of mine |
| SEWPac | Department of Sustainability, Environment, Water, Population and Communities |
| t/ha/yr | tonnes per hectare per year |

# EXECUTIVE SUMMARY

GSS Environmental was commissioned by EMGA Mitchell McLennan Pty Limited on behalf of the proponent, Cobbora Holding Company Pty Limited, to prepare a mine rehabilitation strategy to accompany a major project application under Part 3A of the *Environmental Planning and Assessment Act 1979* (NSW) for the proposed Cobbora Coal Project (the Project).

This document, the *Mine Rehabilitation Strategy*:

- describes the existing environment;
- describes the post-mining landform and conceptual final landform design;
- provides the post-mining landform's Rural Land Capability classification, Agricultural Suitability classification and proposed land use;
- outlines short-term and long-term rehabilitation objectives;
- details actions to manage soil resources for conservation and use in the rehabilitation process;
- details the planned progressive revegetation of the site;
- provides the objectives and preliminary success criteria for mine closure;
- details the monitoring program requirements necessary to assess the performance of rehabilitation;
- outlines the principles of the final void management plan; and
- provides recommendation for regular review of the mine rehabilitation strategy.

The PAA is 27,386 ha and has a disturbance footprint that covers approximately 4,536 ha. The footprint was divided into five domains: (1) Mining Operations Domain, (2) Mine Infrastructure Domain, (3) Auxiliary Infrastructure Domain, (4) Road Network Domain, and (5) the Raw Water Dam Domain.

The PAA and disturbance footprint is covered by twenty-five different soil types. The majority of the soil types are Chromosols or Sodosols, there are also some Tenosols and Rudosols. The most common soil types across the PAA and disturbance footprint are Yellow Sodosols and Red Chromosols.

The dominant Rural Land Capability Class across the PAA is Class IV (35.3%). This land is mainly used for cattle and sheep grazing. The PAA also contains some Class III land (20.8%), Class V land (15.3%) and Class VI land (17.1%). The Class III land is used for the production of crops for feedstock (e.g. wheat and oats) as well as for the production of rotational crops such as canola and wheat. The Class V and Class VI land which is not timbered with native woodland is used for cattle grazing along with some merino wool and prime lamb production. The PAA also contains a small quantity of Class II land (2.1%), which is good quality cropping land.

The proposed disturbance footprint is primarily covered by Rural Land Capability Class IV (46.5%). The Project will also disturb some Class III land (9.7%). Non-impacted land on the PAA will be managed throughout the life of the mine by an on-going land management plan. This plan will ensure the best agricultural use of non-mine lands and provide opportunities for private farmers to use these through long-term leases. Post-mining there will be only minor changes to the Rural Land Capability within the PAA, including a small increase in Class IV (0.9%) and Class VIII (<1.0%) land, and small decreases in Class V (0.4%), VI (<1.0%) and VII (1.3%) land.

The Project's decommissioning strategy will return most land associated with the mine and auxiliary infrastructure components to their pre-mining state. The exception is the rail spur, which will have only its infrastructure elements removed; the embankments and cuttings will be left in place. The upgraded and realigned roads will remain in place as an active network, whilst the haul roads will be rehabilitated. The raw water dam will also left in place for re-use as a water resource in post-mining agricultural activities. The land within the Mining Operations Domain will be reshaped to form a gently inclined landform with some steeper perimeter slopes and will contain one void area. This reshaped landform will be capable of sustaining rural enterprises similar to the pre-mining landform and, in addition, the overall quantity of Class III land within the Mining Operations Domain will remain the same as the pre-mining landform. Sufficient topsoil resources are available from within the disturbance footprint to facilitate the successful achievement of the proposed post-mining land use.

A series of rehabilitation objectives and success criteria have been set for the PAA; these relate to its target post-mining land use classification. Recommendations on the management of final void areas, and final land use options, are addressed in this report. In year 15 (that is, five years prior to the mine's closure) a detailed closure plan will be prepared.

# 1.0 INTRODUCTION

EMGA Mitchell McLennan Pty Limited (EMM), on behalf of the proponent, Cobbora Holding Company Pty Limited (CHC), previously engaged GSS Environmental (GSSE) to undertake a mine rehabilitation strategy to support an Environmental Assessment (EA) to accompany a major Project Application under Part 3A of the *Environmental Planning and Assessment Act 1979* (NSW) (the EP&A Act) for the proposed Cobbora Coal Project (the Project).

The EA was prepared by EMM, with input from external specialists and placed on public exhibition for six weeks between 5 October 2012 and 16 November 2012. The EA was prepared in accordance with the requirements of the Department of Sustainability, Environment, Water, Population and Communities (SEWPaC), NSW Department of Planning and Infrastructure (DP&I) and other government agencies, as given in the Director-General's Requirements (DGRs) issued on 4 March 2010 and modified on 14 October 2011 and 23 December 2011.

In response, DP&I received 229 submissions on the Project. The range of issues raised in the submissions is summarised in Chapter 2 of the Preferred Project Report and Response to Submissions (PPR&RTS). The Project's mine rehabilitation strategy has been updated to as a response to some of these submissions. Specifically, these updates include:

- Provision of additional soil survey results conducted across the Mining Operations Domain;
- Updated topsoil balance; and
- Additional details on the soil replacement protocol for Rural Land Capability Class III re-instatement.

In addition, the mine plan has been adjusted as described in Chapter 3 of the PPR&RTS. Notwithstanding, the Project — particularly its layout and footprint — remains consistent with that described in the EA. However, given the mine plan adjustment and provision of additional soil survey results, the Mine Rehabilitation Strategy has been updated in its entirety.

## 1.1 Project Description Overview

The Project is a new open-cut coalmine that will be developed near Dunedoo in the central west of NSW. The Project Application Area (PAA) is approximately 274 square kilometres ($km^2$). The primary purpose of the Project is to provide coal to four major NSW power stations.

The mine will extract around 20 million tonnes per annum (Mtpa) of run-of-mine (ROM) coal. From this, a total of approximately 9.5 Mtpa of product coal will be produced for sale to Macquarie Generation, Origin Energy and Delta Electricity under long-term contracts. In addition, approximately 2.5 Mtpa will be produced for export or for sale on the spot domestic market.

The Project's key elements are:

- an open-cut mine;
- a coal handling and preparation plant (CHPP);
- a train loading facility and rail spur;
- a mine infrastructure area; and
- supporting infrastructure, which includes access roads, water supply and storage, and electricity supply.

It is envisaged that construction activities will commence in mid-2013 with coal supplied to customers from the second half of 2015. The mine life will be 21 years.

### 1.1.1 Open-cut Mine

Multiple open-cut mining pits will be developed within three mining areas:

- Mining Area A, north of the infrastructure area;
- Mining Area B, south of the infrastructure area; and
- Mining Area C, north-east of the infrastructure area.

There will be three out-of-pit waste rock emplacements:

- AC-OOP between mining areas A and C;
- B-OOP E adjacent to Mining Area B on the east side of Laheys Creek; and
- B-OOP W adjacent to Mining Area B on the west side of Laheys Creek.

A conventional load and haul operation is proposed using excavators, front-end loaders and trucks. Initially, trucks will haul waste rock to out-of-pit emplacements. Following this, the majority of the waste rock will be placed in the mined-out voids.

Trucks will haul excavated ROM coal to the CHPP where it will be tipped into hoppers above the primary crushers or onto secondary ROM stockpiles for later rehandling.

### 1.1.2 Coal Handling and Preparation Plant

The CHPP will treat up to 20 Mtpa of ROM coal to produce a product coal that meets the customers' coal sizing and quality requirements. Subject to the level of impurities (rejects) in the coal and washability characteristics, the ROM will be either crushed and bypassed or treated (washed) in the preparation plant. The rejects will typically include waste rock from above and below the coal seam as well as material dispersed within the coal.

The CHPP processes will be typical of those used in the majority of CHPPs in NSW, with product coal separated from rejects in a series of coal cleaning circuits. The CHPP area will also contain a truck dump station, crushing plants, coal stockpiles, and the infrastructure to move and stockpile the coal. Rejects from the CHPP will initially be discharged to out-of-pit tailings emplacements and then to in-pit emplacements.

### 1.1.3 Train Loading Facility and Rail Spur

Coal will be transported by rail to the Project's customers, Bayswater and Liddell power stations in the Upper Hunter Valley and Eraring and Vales Point power stations on Lake Macquarie on the NSW Central Coast.

Product coal will be loaded onto trains from an overhead train-loading bin located on a rail spur balloon loop. Approximately five trains will be loaded each day. The rail spur will be approximately 28 km long and will join the Dunedoo–Gulgong rail line near Tallawang. A locomotive provisioning facility and a siding for fuel delivery may be located adjacent to the balloon loop.

### 1.1.4 Mine Infrastructure Area

The Mine Infrastructure Area will be located adjacent to the mining areas. It will include workshops, hardstand and lay-down areas, bulk storage buildings, bulk fuel storage and a fuelling station, office buildings, an operations building and change-house, parking, an explosives magazine, and vehicle wash-down bays.

### 1.1.5 Supporting Infrastructure

#### *1.1.5.1 Access Roads*

The main access to the mine will be from the Golden Highway to the north of the mine, via a road diversion that will replace a section of Spring Ridge Road.

Internal roads will connect the access road to the workshop, administration buildings and to the mine infrastructure area. Internal roads will also connect the various areas of the Project.

#### *1.1.5.2 Water Supply*

The Project will require water primarily for the CHPP and for dust suppression. Water will be sourced by intercepting surface water and by pumping groundwater that enters the mine pits in accordance with the relevant permits and licences. Water will also be sourced from the Cudgegong River and pumped approximately 26 km to the primary raw water dam south-east of the mining area. Pre-existing high security water access licences have been purchased for the Project to allow up to 3.3 gigalitres (GL) of water to be extracted from the river.

#### *1.1.5.3 Electricity Supply*

The Project will require approximately 25 megavoltamperes (mva) of electrical power. The Project will be connected to the grid at a small switching yard adjacent to the Castlereagh Highway. A power line, generally running parallel to the rail spur, will deliver the electricity to a substation in the Mine Infrastructure Area.

An 11 kV power line will supply the Cudgegong River pump station from an existing grid approximately 2 km south of the pump station site.

## 1.2 Description of Rehabilitation Domains

The Project's disturbance footprint is approximately 4,536 ha. The PAA has been divided into six domains for the purposes of rehabilitation planning (**Figure 1.1**). This division is based on the level of disturbance and type if activity (**Table 1.1**).

**Table 1.1 – Project Application Area: Disturbance Overview**

| Domain | Disturbance Impact | Land Area | |
|---|---|---|---|
| | | ha | % |
| 1 | High | 4,123 | 15.1 |
| 2 | Medium | 132 | <1.0 |
| 3 | Low | 164 | <1.0 |
| 4 | Low | 100 | <1.0 |
| 5 | High | 17 | <1.0 |
| Sub total | | 4,536 | 16.6 |
| 6 | Nil | 22,850 | 83.4 |
| **Total** | | **27,386** | **100** |

An overview of each domain is provided below.

*Domain 1: Mining Operations Domain*

Domain 1 is the Mining Operations area (4,123 ha). It includes the open-cut Mining Areas A, B and C, and the out-of-pit waste rock emplacements AC-OOP, B-OOPE and B-OOPW. These Mining Areas and waste rock emplacements occur in three discrete disturbance areas:

- Northern Mining Operations area, which includes the open-cut Mining Areas A and C and out-of-pit waste rock emplacement AC-OOP;
- Southern Mining Operations area, which includes open-cut Mining Area B and out-of-pit waste rock emplacement area B-OOPW; and
- Eastern Operations Mining area, which includes out-of-pit waste rock emplacement area (B-OOPE).

*Domain 2: Mine Infrastructure Domain*

Domain 2 is the Mine Infrastructure area (132 ha). It includes the administration and workshop buildings, CHPP, coal stockpile area and locomotive provisioning infrastructure.

*Domain 3: Auxiliary Infrastructure Domain*

Domain 3 is the Auxiliary Infrastructure area (164 ha). It includes the water pipelines, rail lines and electricity infrastructure.

*Domain 4: Road Network Domain*

Domain 4 is the road network (100 ha). It includes the road upgrades and haul roads outside the mining area.

*Domain 5: Raw Water Dam Domain*

Domain 5 is the raw water storage dam (17 ha).

**Table 1.2: Disturbance Footprint by Domain**

| Domain | Disturbance Element | Disturbance Description | Size (ha) |
|---|---|---|---|
| Mining Operations Domain | | | |
| 1 | Mining areas | Open-cut mining areas and out-of-pit waste rock emplacement areas | 4,123 |
| Mine Infrastructure Domain | | | |
| 2 | Mine infrastructure areas | Infrastructure area west of Spring Ridge Road including the administration buildings and explosives magazine | 132 |
| | | Infrastructure area east of Spring Ridge Road including the CHPP, coal stockpile area, provisioning road, locomotive provisioning infrastructure and electricity substation | |
| Auxiliary Infrastructure Domain | | | |
| 3 | Water supply pipeline: raw water and supply pipeline | Pipeline construction corridors, including sections between the raw water dam and the CHPP | 164 |
| | Rail spur, rail siding and locomotive provisioning facility | Rail spur and siding: includes the switching station | |
| | Power easement | The power easement will be predominately within the rail spur footprint, with minor surface disturbance. Where this line deviates from the rail spur the footprint has a width of 40–60 m | |

| Domain | Disturbance Element | Disturbance Description | Size (ha) |
|---|---|---|---|
| Road Network Domain | | | |
| 4 | Roads | Realignment of Spring Ridge Road: west and north of the Northern Mining Operations area | 100 |
| | | Realignment of Dapper Road: | |
| | | Realignment of Brooklyn Road: | |
| | | Haul roads | |
| Raw Water Dam Domain | | | |
| 5 | Raw water dam | Dam located to the south-east of B-OOPE | 17 |
| **Total** | | | **4,536** |

## 1.3 Objectives of the Mine Rehabilitation Strategy

The *Strategic Framework for Mine Closure* (ANZMEC, 2000) rehabilitation contains a series of rehabilitation criteria. These criteria state that rehabilitation outcomes:

- should be consistent with the environmental assessment which formed the basis of approval;
- must be based on mine closure criteria and rehabilitation outcomes developed through stakeholder consultation;
- should integrate rehabilitated native vegetation with undisturbed native vegetation to provide for larger areas and wildlife corridors;
- should be suitable for an agreed subsequent land use that is, as far as possible, compatible with the surrounding land fabric and land use requirements;
- should address limitations on the use of rehabilitated land;
- be sustainable in terms of that land use;
- produce stable and permanent landforms, with soils, hydrology, and ecosystems with maintenance needs no greater than those of surrounding land (may include waste emplacements, voids, pits and water bodies providing that they are part of the accepted final outcome);
- securely and safely contain waste substances that have the potential to affect land use or result in pollution;
- do not present a hazard to persons, stock or native fauna;
- address threatened species issues;
- address heritage issues;
- be clean and tidy, and free of rubbish, metal and derelict equipment/structures, except for heritage and other agreed features; and
- be free from unacceptable air and water pollution, and other environmental effects outside the disturbed area.

The purpose of this *Mine Rehabilitation Strategy* is therefore to establish objectives for the rehabilitation of the disturbed land that will result from the construction and operation of the Cobbora Coal Mine. In order to meet these objectives, the *Mine Rehabilitation Strategy* provides:

- a summary of the PAA's existing biophysical environment;
- a rehabilitation strategy for the areas that are expected to be affected by surface disturbance;
- short-and long-term objectives for the rehabilitation of the site;
- a revegetation program based on current industry good practice and progressive learning as the site program is implemented;
- objectives and preliminary success criteria for mine closure; and
- a monitoring program to progressively assess performance of the rehabilitated areas.

## 1.4 Structure of the Mine Rehabilitation Strategy

This strategy comprises the following sections and information.

**Section 1.0: Introduction**

This section:

- provides a summary of the Project description;
- details the Project's disturbance footprint; and
- outlines the structure of the report.

**Section 2.0: Planning and Legislation**

This section:

- details the DGRs and other applicable standards; and
- outlines the relevance of key environmental assessment reports.

**Section 3.0: Existing Environment**

This section provides information on the PAA's:

- climate, topography and hydrology;
- soil landscapes and soil types; and
- vegetation and land use.

**Section 4.0: Post-mining Landform and Land Use**

This section:

- details the general decommissioning strategy for each rehabilitation domain;
- provides the conceptual final landform design;

- provides the post-mining landform's Rural Land Capability classification;
- provides the post-mining landform's Agricultural Suitability classification; and
- provides the proposed post-mining land use.

**Section 5.0: Rehabilitation Management Strategy**

This section:

- provides rehabilitation principles;
- provides short-term and long-term rehabilitation objectives;
- describes the planned progressive revegetation of areas across the mine site;
- describes suitability of soil resources;
- describes management actions for stripped topsoil resources;
- describes a revegetation program; and
- outlines the basic requirements necessary to control erosion.

**Section 6.0: Rehabilitation Monitoring and Performance**

This section:

- provides objectives and preliminary success criteria for mine closure; and
- details a monitoring program to assess the performance of the rehabilitated areas.

**Section 7.0 Final Void Management Plan**

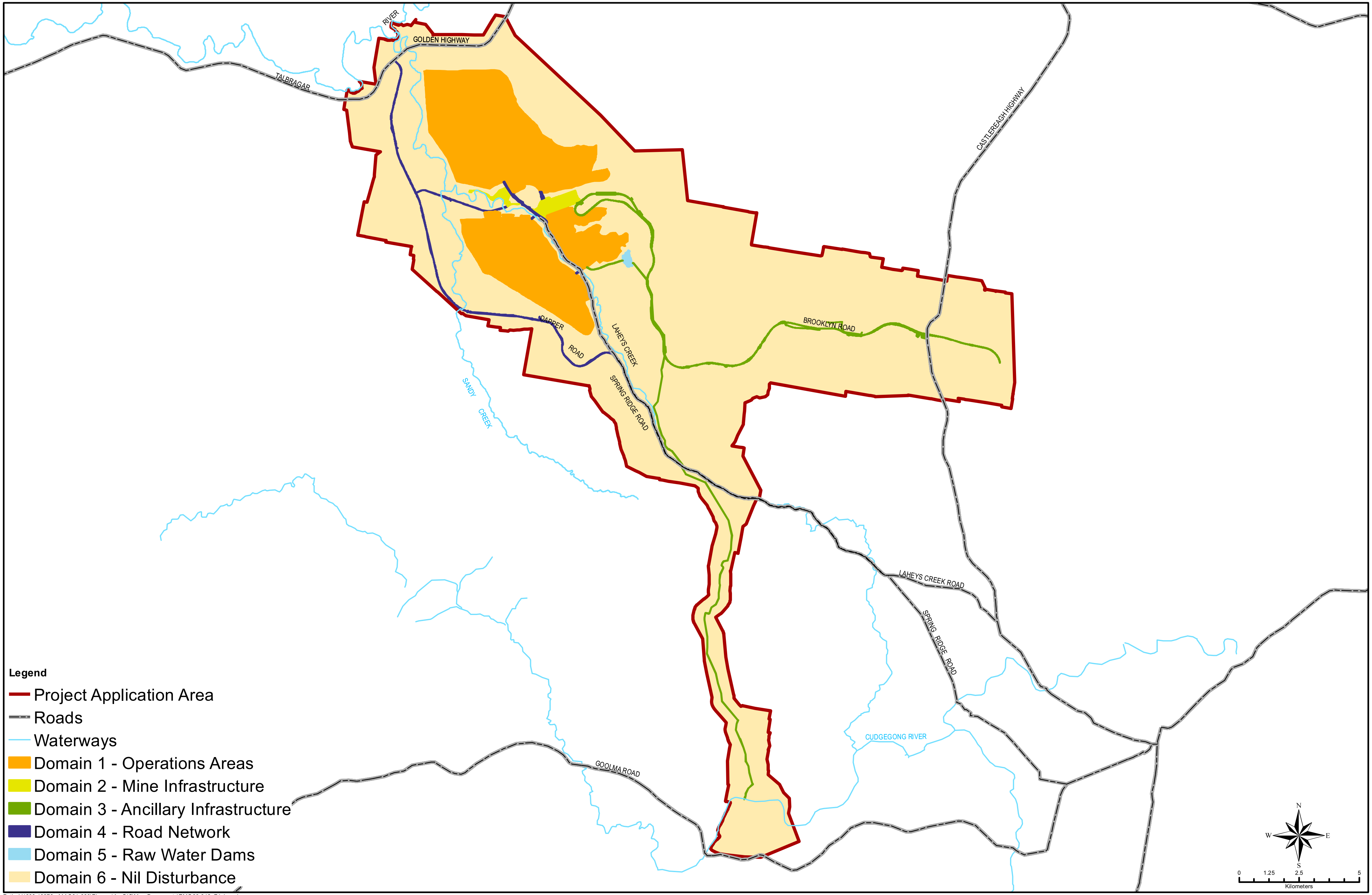
This section:

- describes the final void that will remain following cessation of mining;
- details the final slope stability and rehabilitation of the void; and
- recommends provisions for post-closure safety and final land use options for the void.

**Section 8.0: Review of Mine Rehabilitation Strategy**

This section:

- provides recommended frequencies for the review and update of this strategy throughout the life of the Project.

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Domain Plan

Cobbora Coal Project

**Figure 1.1**

# 2.0 PLANNING AND LEGISLATION

## 2.1 Director General's Environmental Assessment Requirements

The DGRs for the Project were issued on 4 March 2011, and revised DGRs were issued on 23 December 2011. This revision was provided in response to amendments to the proposed Project and government assessment requirements.

This *Mine Rehabilitation Strategy* has been prepared in accordance with the DGRs and consultation with NSW DP&I with regards to issues related to adequacy in November 2012. **Table 2.1** summarises the DGRs relevant to rehabilitation and indicates where specific issues have been addressed in this document.

**Table 2.1: Summary of Director General's Requirements**

| Specific Issue | | Where Addressed in Document |
|---|---|---|
| Provide a description of the proposed agricultural land and productivity, including: | | |
| – | a detailed assessment and mapping pre- and post-mining (including Rural Land Capability and Agricultural Suitability mapping) of soil characteristics, across all proposed areas of surface disturbance and an assessment of their value and limitations for rehabilitation; | Section 3 |
| – | a description of the agricultural resources (especially soils and water resources used or capable of being used for agriculture) and agricultural enterprises of the locality; | Section 3 |
| – | identification of any regionally or state-significant agricultural resources in the locality, with particular reference to higher productive alluvial soils and associated surface/groundwater systems that may be impacted directly or indirectly by the proposal; and | Section 3 |
| – | justification for any significant long-term changes to agricultural resources, particularly if highly productive agricultural resources (e.g. alluvial lands and associated groundwater resources) are proposed to be affected by the Project. | Section 4 |
| Provide a description of the proposed rehabilitation strategy for the Project, having regard for the key principles in the *Strategic Framework for Mine Closure* (ANZMEC, 2000), including: | | |
| – | nominated final land use, having regard for any relevant strategic land use planning or resources management plans or policies; | Section 4 |
| – | the potential for integrating this strategy with any other offset strategies in the region; and | Section 4 |
| – | rehabilitation objectives, methodology, monitoring programs, performance standards and proposed completion criteria. | Section 5 and 6 |

## 2.2 Policy and Guidelines

This report has generally been prepared in accordance with the requirements of the following relevant strategic land use planning and resource management plans and policies:

- The *Strategic Framework for Mine Closure* (ANZMEC, 2000).
- The draft *Strategic Regional Land Use Policy* (DP&I, 2011).
- For soil taxonomy, the *Australian Soil Classification* (ASC) (Isbell, 1996) system was used to classify the soil.

- For the Rural Land Capability classification assessment, *Systems Used to Classify Rural Lands in New South Wales* (Cunningham et al., 1988) was applied.

- For the Agricultural Suitability Classification assessment, *Agricultural Suitability Maps – uses and limitations* (NSW Agricultural & Fisheries, 1990) was applied.

- For the soil suitability assessment the *Guide for Selection of Topdressing Material for Rehabilitation of Disturbed Areas* (Elliot & Reynolds, 2007) was applied to determine which soils on the site are suitable for conserving and utilising in the mine rehabilitation program.

## 2.3 Relevant Project Environmental Assessment Reports

This report should be read in conjunction with the *Agricultural Impact Statement: Cobbora Coal Project* (GSSE, 2012), which provides detailed information on the socio-economic value of the Project's agricultural land resources and quantifies the Project's socio-economic impacts from changed land use.

# 3.0 EXISTING ENVIRONMENT

## 3.1 Climate

The PAA is located in the north-western region of NSW, which typically has a cool temperate climate with moderately dry winters and wetter summers. The annual average rainfall is 619 mm with the majority of this rainfall falling in the summer months of December to January (BOM, 2012). Temperatures within the Project region range from an average monthly maximum of 32º C in January to an average monthly minimum of 2º C in July. The average annual evaporation within the PAA ranges between 1,800 and 2,000 mm (BOM, 2008).

## 3.2 Hydrology and Topography

The PAA is situated in the Macquarie-Bogan Catchment and lies within the Sandy Creek Catchment. The Macquarie-Bogan Catchment extends from the central tablelands of Oberon, Bathurst and Rylstone to the western plains of Nyngan and Coonamble, and includes the Castlereagh, Bogan and Macquarie river valleys.

Regional rivers in the wider region include the Talbragar River, Cudgegong River, Castlereagh River and the Macquarie River. The Talbragar and Cudgegong rivers are proximal to the PAA, situated on its northern edge and traversing the PAA in the south respectively. The Talbragar River flows in a south-westerly direction, joining the Macquarie River north of Dubbo. It is an ephemeral waterway; that is, it ceases to flow during dry periods. The Cudgegong River rises in the Great Dividing Range above Rylstone and is a major tributary of the Macquarie River.

Within the PAA, the main watercourses are the ephemeral Laheys Creek and Sandy Creek. Laheys Creek begins in the PAA's central area and flows north to drain into Talbragar River. Sandy Creek begins in the south-western section of Yarrobil National Park and flows in a northerly direction external to the PAA until its confluence with Laheys Creek in the PAA's central north (**Figure 3.1**).

The PAA exhibits three prominent topographic landforms: alluvial plains, undulating/rolling low hills and steep hills. The elevation ranges between 280 m above sea level around Sandy Creek to 600 m above sea level in the south of the PAA (**Figure 3.1**).

## 3.3 Geology

The majority of the PAA is underpinned by the Nappery and Dunedoo formations, ancient fractured igneous and sedimentary rocks. Basic geologic structures include undifferentiated Permian sandstones and shale and alluvium. Parent rocks include conglomerate; sandstone; siltstone; shale; quartz sandstone; lithic sandstone; ferruginous sandstone and siltstone; carbonaceous shale and coal (Colquhoun et al., 1999).

## 3.4 Soil Landscape Units

The PAA contains six main geomorphic units: (1) Quaternary alluvium; (2) Permian – Triassic sedimentary sandstone and conglomerate; (3) Silurian – Early Devonian marine sandstone; (4) Early Devonian andesite; (5) Tertiary basalt; and (6) Devonian – Carboniferous siliceous granites.

Within these six broad geomorphic units, there are 16 soil landscapes as described by *Soil Landscapes of the Dubbo 1:250,000 Sheet* (Murphy & Lawrie, 1998). These landscapes are listed in **Table 3.1** and are described below.

**Table 3.1: Soil Landscapes**

| Geomorphic Unit | | Dominant Parent Rocks | Soil Landscape Unit | PAA | |
|---|---|---|---|---|---|
| | | | | ha | % |
| 1 | Quaternary alluvium | Alluvium | Cudgegong (Cd) | 128 | <1 |
| | | | Mitchell Creek (Mi) | 507 | 1.9 |
| | | | Talbragar (Tb) | 116 | <1 |
| Subtotal | | | | 751 | 2.7 |
| 2 | Permian – Triassic sedimentary sandstone/ conglomerate | Permian sandstone and shales | Laheys Creek (Lc) | 8,378 | 30.6 |
| | | Triassic and Jurassic conglomerate, sandstone, shale and coal | Dapper Hill (Dh) | 6,639 | 24.2 |
| | | | Spring Ridge (Sr) | 1,683 | 6.1 |
| | | Triassic Sandstone, conglomerate, ferruginous limestone, shale and coal | Ballimore (Bm) | 4,680 | 17.1 |
| Subtotal | | | | 21,380 | 78 |
| 3 | Silurian – early Devonian marine sandstone | Quartz-rich greywacke and slates | Mullion Creek (Mu) | 618 | 2.3 |
| | | | Mookerawa (Mk) | 309 | 1.1 |
| | | Sediments and metasediments mainly of marine origin | Burrendong (Bd) | 291 | 1.1 |
| Subtotal | | | | 1,218 | 4.5 |
| 4 | Early Devonian andesite | Andesite and tuff | Tucklan (Tk) | 2,027 | 7.4 |
| | | | Surface Hill (Su) | 184 | <1 |
| Subtotal | | | | 2,211 | 8.1 |
| 5 | Tertiary basalt | Olivine basalt | Mebul (Me) | 452 | 1.7 |
| | | | Bald Hill (Bh) | 320 | 1.2 |
| Subtotal | | | | 772 | 2.9 |
| 6 | Devonian – Carboniferous siliceous granite | Granite | Rouse (Rs) | 5 | <1 |
| | | | Home Rule (Hr) | 1,049 | 3.8 |
| Subtotal | | | | 1,054 | 3.8 |
| **Total** | | | | **27,386** | **100** |

*Geomorphic unit 1: Quaternary alluvium*

The Quaternary alluvium geomorphic unit covers approximately 3% of the PAA and includes the Mitchell Creek, Talbragar and Cudgegong Soil Landscapes. The Mitchell Creek and Talbragar Soil Landscapes consist predominately of alluvial plains and low terraces of minor streams, levees and basins and are located in the PAA's north-west where Laheys Creek joins with Sandy Creek. The Cudgegong Soil Landscape is located along the Cudgegong River in the south. The dominant underlying parent rock is Quaternary alluvium (sand, silt, clay), which has been derived from various rock types within the catchment.

*Geomorphic unit 2: Permian – Triassic Sedimentary sandstone /conglomerate*

The Permian – Triassic sedimentary sandstone/conglomerate geomorphic unit covers approximately 78% of the PAA and includes the Laheys Creek, Dapper Hill, Ballimore and Spring Ridge Soil Landscapes. These landscapes cover the centre of the PAA and are characterised by undulating low hills to rolling low hills.

The dominant underlying geology is sedimentary sequences of sandstone and conglomerate. The Laheys Creek Soil Landscape is underlain by Permian sandstone and shales, the Dapper Hill and Spring Ridge

Soil Landscapes by Triassic and Jurassic conglomerates and sandstones, and the Ballimore Soil Landscape by Triassic sandstone and conglomerate as well as ferruginous limestone, shale and coal.

*Geomorphic unit 3: Silurian – early Devonian marine sandstone*

The Silurian – early Devonian marine sandstone geomorphic unit covers approximately 4% of the PAA and includes the Mullion Creek, Mookerawa and Burrendong Soil Landscapes. The Mullion Creek Soil Landscape is located in the most southern extent of the PAA and is characterised by undulating low hills. The Mookerawa Soil Landscape occurs along the lower south-east edge of the PAA and is characterised by undulating to rolling low hills, while the Burrendong Soil Landscape occurs in the central-eastern part and is characterised by rolling to steep hills.

The underlying geology is Silurian to early Devonian greywacke, slate, shale, and acidic/siliceous volcanics. The Burrendong Soil Landscape is also underlain by sediments and metamorphic metasediments, mainly of marine origin, which are composed of schist, phylite and additionally some gneiss and rhyolite.

*Geomorphic unit 4: early Devonian andesite*

The early Devonian andesite geomorphic unit covers approximately 8% of the PAA and includes the Tucklan and Surface Hill Soil Landscapes. These landscapes occur in the east of the PAA and are characterised by low undulating hills and rolling low hills. Slopes are generally level to gently inclined (0–3%), with some minor areas having steeper slopes of 3–18%. The underlying parent rocks within this geomorphic unit are andesite, tuff, arkose and shale.

*Geomorphic unit 5: Tertiary basalt*

The Tertiary basalt geomorphic unit covers approximately 3% of the PAA and consists of the Bald Hill and Mebel Soil Landscapes. These landscapes are located in discreet patches in the PAA's southern parts and are characterised by undulating to rolling hills. Slopes are very gentle to gently inclined (3–10%). The underlying rock is predominately composed of Tertiary olivine basalt and dolerite. Rock outcrops are common in the Bald Hill Soil Landscape.

*Geomorphic unit 6: Devonian – Carboniferous siliceous granite*

The Devonian – Carboniferous siliceous granite geomorphic unit covers approximately 4% of the PAA and includes the Home Rule and Rouse Soil Landscapes. These landscapes are located in the most eastern extent of the PAA and cover undulating low rises. The underlying parent rock consists of siliceous granite. The Rouse Soil Landscape also exhibits granite outcropping as tors.

## 3.5 Soil Types

The PAA contains twenty-five soil types. There will be four disturbance levels based on the impacts to soil and land resources (high, medium, low and nil) . Approximately 83.4% of the PAA is categorised as nil disturbance and 15.1% of the PAA will be subject to high disturbance project activities (refer **Table 1.1**).

The soil types within each disturbance category are summarised within **Table 3.2**. The key points are listed below:

- The high disturbance footprint (4,140 ha), which consists of Domains 1 and 5, contains 13 soil types.
- The major soil type in the high disturbance footprint is L1 – Yellow Sodosol; Type 1 (29.1%).There is also L1 – Yellow Sodosol: Type 2 (3.5%).
- Other major soil types in the high disturbance footprint are DS3 - Red Chromosol (20.8%), DS1 – Tenosol; very shallow (15.5%) and DS2 – Rudosol; very shallow (8.8%).
- Eight different Chromosols are in the remainder (22.3%) of the high disturbance footprint.
- The medium disturbance footprint (132 ha) contains only Domain 2, contains 4 soil types. Although 97.7% is L1 – Yellow Sodosol: Type 1.
- The low disturbance footprint (264 ha) contains Domains 3 and 4, contains 12 soil types.
- The major soil type in the low disturbance footprint is L1 – Yellow Sodosol: Type 1 (54.2%), with a phase of this soil type, Yellow Sodosol: type 2, also representing 9.8%.
- Other major soil types in the low disturbance footprint are B1 – Reddish-brown Chromosol (12%), and TK1 – Red Ferrosol (8.7%).
- The nil disturbance footprint (22,850 ha) is covered by Domain 6, and is represented by 21 soil types. The two major soil types are L1 – Yellow Sodosol: Type 1 (28.5%) and DS3 - Red Chromosol (22.8%).

**Table 3.2: Soil Types Overview**

| Soil Type | Soil Type | Land Area | |
|---|---|---|---|
| | | ha | % |
| **High Disturbance Footprint: Domains 1 & 5** | | | |
| B1 | Reddish-brown Chromosol | 149 | 3.6 |
| B1 - Phase 1 | Reddish-brown Chromosol; very shallow | 12 | <1 |
| B2 | Brown Chromosol: Type 1 | 134 | 3.2 |
| B3 | Yellowish-red Chromosol | 202 | 4.9 |
| B4 | Brown Chromosol: Type 2 | 165 | 4 |
| B4 - Phase 1 | Brown Chromosol; shallow | 9 | <1 |
| DS1 | Tenosol; very shallow | 641 | 15.5 |
| DS2 | Rudosol; very shallow | 364 | 8.8 |
| DS3 | Red Chromosol; very shallow | 860 | 20.8 |
| L1 | Yellow Sodosol: Type 1 | 1,204 | 29.1 |
| L1 – Phase 1 | Yellow Sodosol: Type 2 | 145 | 3.5 |
| L2 | Yellowish-brown Chromosol | 161 | 3.9 |
| L3 | Yellowish-red Chromosol | 94 | 2.3 |
| **Sub-total** | | **4,140** | **100** |

| Soil Type | Soil Type | Land Area | |
|---|---|---|---|
| | | ha | % |
| **Medium Disturbance Footprint: Domain 2** | | | |
| DS3 | Red Chromosol; very shallow | <1 | <1 |
| L1 | Yellow Sodosol: Type 1 | 128 | 97.7 |
| L1 – Phase 1 | Yellow Sodosol: Type 2 | <1 | <1 |
| MI1 | Alluvial Soil | 2 | 1.5 |
| **Sub-total** | | **132** | **100** |
| **Low Disturbance Footprint: Domains 3 & 4** | | | |
| B1 | Reddish-brown Chromosol | 32 | 12 |
| BH1 | Red Dermosol | <1 | <1 |
| CD1 | Yellow Chromosol | <1 | <1 |
| DS3 | Red Chromosol; very shallow | 16 | 6 |
| HR1 | Yellow Sodosol | 4 | 1.5 |
| L1 | Yellow Sodosol: Type 1 | 143 | 54.2 |
| L1 – Phase 1 | Yellow Sodosol: Type 2 | 26 | 9.8 |
| ME1 | Red Dermosol | 13 | 4.9 |
| MI1 | Alluvial Soil | 1 | <1 |
| MK1 | Yellow Sodosol | 5 | 1.9 |
| MU1 | Yellow Sodosol | <1 | <1 |
| TK1 | Red Ferrosol | 23 | 8.7 |
| **Sub-total** | | **264** | **100** |
| **Total Low to High Disturbance Footprint** | | **4,536** | **100** |
| **Nil Disturbance Footprint: Domain 6** | | | |
| B1 | Reddish-brown Chromosol | <1 | <1 |
| B4 | Brown Chromosol: Type 2 | 2,309 | 10.1 |
| BD1 | Leptic Rudosol | 291 | 1.3 |
| BH1 | Red Dermosol | 319 | 1.4 |
| CD1 | Yellow Chromosol | 127 | <1 |
| DS1 | Tenosol; very shallow | <1 | <1 |
| DS2 | Rudosol; very shallow | 1,195 | 5.2 |
| DS3 | Red Chromosol; very shallow | 5,216 | 22.8 |
| HR1 | Yellow Sodosol | 1,045 | 4.6 |
| L1 | Yellow Sodosol: Type 1 | 6,512 | 28.5 |
| L1-Phase1 | Yellow Sodosol: Type 2 | 1,634 | 7.2 |
| L2 | Yellowish-brown Chromosol | <1 | <1 |
| L3 | Yellowish-red Chromosol | <1 | <1 |
| ME1 | Red Dermosol | 439 | 1.9 |
| MI1 | Alluvial Soil | 503 | 2.2 |
| MK1 | Yellow Sodosol | 303 | 1.3 |
| MU1 | Yellow Sodosol | 648 | 2.8 |
| RS1 | Yellow Sodosol | 5 | <1 |
| SH1 | Red Chromosol | 184 | <1 |
| TB1 | Red Chromosol | 116 | <1 |
| TK1 | Red Ferrosol | 2,004 | 8.8 |
| **Total Nil Disturbance Footprint** | | **22,850** | **100** |
| **Total Project Application Area** | | **27,386** | **100** |

The land that will be disturbed by the Project and that will be subject to soil salvaging activities is located in the high and medium disturbance domains (Domains 1, 2 and 5). A summary of these major soil types are provided below with detail on all other soil types contained in **Appendix 1**.

*Soil Type L1: Yellow Sodosol: Type 1*

Soil Unit L1 is a Sodosol. Sodosols are soils that have significant texture contrast between the A and B horizons, which are sodic. This soil unit is comprised of four distinct soil horizons and the profile is characterised by a sandy loam trending into light clay. Soil pH trends from moderately acidic to moderately alkaline and to neutral at depth; salinity is very low to low throughout; and the profile shifts from non-sodic to strongly sodic. **Table 3.3** provides a summary of this soil unit.

**Table 3.3 – Overview: Soil Unit L1**

| **Site Description** | |
|---|---|
| <br><br>*Plate 3.1– Profile (Core 1)* | <br>*Plate 3.2 – Landscape (Core )* |
| **Associated Soil Landscape** | Lahey's Creek |
| **Dominant Slope Association** | Lower to mid slopes; 1-3% |
| **Rural Land Capability** | Class IV; main limitation – soil acidification |

*Soil Type L1 – Phase 1: Yellow Sodosol: Type 2*

Soil Unit L1 – Phase 1 is a Sodosol. This soil unit is comprised of four distinct soil horizons and the profile is characterised by a loam transitioning into a medium clay. Soil pH trends from moderately acidic to strongly alkaline; salinity is very low at the surface increasing to medium salinity; and the profile shifts from non-sodic to strongly sodic at depth. **Table 3.4** provides a summary of this soil unit.

**Table 3.4 – Overview: Soil Unit L1 – Phase 1**

| Site Description | |
|---|---|
|   *Plate 3.3– Profile (Core 14)* |  *Plate 3.4 – Landscape (Core 14)* |
| **Associated Soil Landscape** | Lahey's Creek and Ballimore |
| **Dominant Slope Association** | Lower to Mid slope; 1-3% |
| **Rural Land Capability** | Class IV; main limitation – soil structure decline hazard; soil acidification |

*Soil Type DS1: Tenosol: very shallow*

Soil Unit DS1 is a Rudosol. Rudosols are soils that have negligible pedologic organisation. This soil unit is comprised of two distinct soil horizons and the profile is characterised as a sandy loam. Soil pH trends from very strongly acidic to strongly acidic; salinity is very low throughout; and the profile is non-sodic. **Table 3.5** provides a summary of this soil unit. Depth in localised areas can reach 0.5 m.

**Table 3.5 – Overview: Soil Unit DS1**

| Site Description | |
|---|---|
|   *Plate 3.5– Profile (Obs 18)* |  *Plate 3.6 – Landscape (Obs 18)* |
| **Associated Soil Landscape** | Dapper Hill and Spring Ridge |
| **Dominant Slope Association** | Broad crests; 5-18% |
| **Rural Land Capability** | Class VI; main limitation – slope, soil depth |

*Soil Type DS2: Rudosol; very shallow*

Soil Unit DS2 is a Rudosol. This soil unit is comprised of one distinct soil horizon and is characterised as a loam. Soil pH is very strongly acidic; has medium salinity; and the profile is strongly sodic. **Table 3.6** provides a summary of this soil unit. Depth in localised areas can reach 0.5 m.

**Table 3.6 – Overview: Soil Unit DS2**

| Site Description | |
|---|---|
|  *Plate 3.7– Profile (Obs 47)* |  *Plate 3.8 – Landscape (Obs 47)* |
| **Associated Soil Landscape** | Spring Ridge |
| **Dominant Slope Association** | Steep slopes, ridges; 5-33% |
| **Rural Land Capability** | Class VII; main limitation – slope, soil depth |

*Soil Type DS3: Red Chromosol; very shallow*

Soil Unit DS3 is a Chromosol. This soil unit is comprised of one distinct soil horizon and the profile is characterised as a sandy loam. Soil pH trends from very strongly acidic to strongly acidic; salinity is very low throughout; and the profile is non-sodic. **Table 3.7** provides a summary of this soil unit. Depth in localised areas can reach 0.5 m.

**Table 3.7 – Overview: Soil Unit DS3**

| **Site Description** | |
|---|---|
|  *Plate 3.9– Profile (Obs 23)* |  *Plate 3.10 – Landscape (Obs 23)* |
| **Associated Soil Landscape** | Spring Ridge |
| **Dominant Slope Association** | Upper slopes; 5-10% |
| **Rural Land Capability** | Class VI; main limitation – slope, soil depth |

*Soil Type B3: Yellowish-red Chromosol*

Soil Unit B3 is a Chromosol. This soil unit is comprised of five distinct soil horizons and the profile is characterised by a loam transitioning into a clay loam and medium clay at depth. Soil pH trends from neutral to moderately alkaline; salinity is very low or low throughout; and the entire profile is non-sodic. **Table 3.8** provides a summary of this soil unit.

**Table 3.8 – Overview: Soil Unit B3**

| **Site Description** | |
|---|---|
| <br>*Plate 3.11– Profile (Core 13)* | <br>*Plate 3.12 – Landscape (Core 13)* |
| **Associated Soil Landscape** | Ballimore |
| **Dominant Slope Association** | Lower to Mid slope; 1-3% |
| **Rural Land Capability** | Class III; main limitations – slope, soil structure decline hazard |

## 3.6 Vegetation and Land Use

The PAA has been highly modified by agricultural practices. More than half the site has been cleared and is covered by pasture grasses. The remaining areas are in various stages of natural regeneration post-grazing (<10% of the site) or contain mature remnant woodland communities (EMM, 2012). Remnant vegetation occurs in large patches across the PAA and includes parts of Tuckland State Forest, Goodiman State Conservation Area and a small section of the Yarrobil National Park, with smaller discrete patches along the watercourses, road reserves and on hill tops.

Remnant vegetation typically consists of five broad vegetation communities. These are Box Gum Woodlands, Ironbark/Stringybark Woodlands, Red Gum Woodlands, Cypress Woodlands and regrowth communities. Box Gum Woodlands occur on the lower-lying parts of the PAA, usually in association with the floodplain. Ironbark/Stringybark Woodlands occur on gentle midslopes to steep upper slopes. Stringybark Woodlands usually contain large rocky sandstone or granite outcrops, while those dominated by Ironbark contain sandstone or lateritic outcropping. Red Gum Woodlands occur on flat topography at the foot of gentle and steep slopes, whereas Cypress Woodlands occur on gentle midslopes to steep upper slopes and crests. Regrowth communities occur between the floodplain and the lower slopes of the PAA and have been cleared previously for pastoral purposes.

## 3.7 Agricultural Land Classification

The quality of rural land in NSW has been historically mapped according to two different land classification systems. The first of these is known as the Rural Land Capability system. The system identifies eight possible land classes, with Rural Land Capability decreasing progressively from Class I to Class VIII. Class I is the most productive and Class VIII the least productive. The second system is known as the Agricultural

Suitability system and provides a ranking of lands according to their relative productivity for a range of agricultural activities. Class 1 is the most productive and Class 5 the least productive.

The aim of the Rural Land Capability classification system is to delineate the various classes of rural lands on the basis of their capability to remain stable under particular land uses. This system classifies the land in terms of its inherent physical characteristics or physical constraints and denotes measures needed to protect the land from soil erosion and other forms of land degradation. It therefore considers the optimum use of land rather than the maximum use. The Rural Land Capability classification system does not imply any aspect of agricultural suitability, which can involve connection to markets, availability of water and other facilities. The Agricultural Suitability classification system aims to satisfy these agricultural suitability aspects.

The Agricultural Suitability system uses the Rural Land Capability assessment as a basis and then incorporates other specific factors such as closeness to markets, cultural factors, land location and adverse market demand to determine the appropriate Agricultural Suitability class. Consequently, a site's Agricultural Suitability classification may change over time due to market forces and changes to site-specific infrastructure. In contrast, the Rural Land Capability of a site generally will not change; however, some change may occur in conjunction with improvements in agricultural farming methodology that reduce erosion risk.

### 3.7.1 Rural Land Capability Classification

The relevant guideline used to classify the agricultural capability of land in NSW is the S*ystems Used to Classify Rural Lands in New South Wales* (Cunningham et al., 1988). This system classifies the land on its potential for sustainable agricultural use if developed, rather than its current land use, and includes land:

- suitable for cultivation;
- suitable for grazing; and
- not suitable for rural production.

The Rural Land Capacity classes classify the land based on the severity of long-term limitations. Limitations are the result of the interaction between physical resources and a specific land use. A range of factors are used to assess this interaction. These factors include climate, soils, geology, geomorphology, soil erosion, topography and the effects of past land uses. The principal limitation recognised by the classifications is the stability of the soil mantle. The classes are ranked on their increasing soil erosion hazard and decreasing versatility of use. A description of each of these classes is provided in **Table 3.3**.

**Table 3.3: Rural Land Capability Classification**

| Class | Land Use | Management Options |
|---|---|---|
| I | Regular cultivation | No erosion control requirements |
| II | Regular cultivation | Simple requirements, such as crop rotation and minor strategic works |
| III | Regular cultivation | Intensive soil conservation measures required, such as contour banks and waterways |
| IV | Grazing, occasional cultivation | Simple practices, such as stock control and fertiliser application |
| V | Grazing, occasional cultivation | Intensive soil conservation measures required, such as contour ripping and banks |
| VI | Grazing only | Managed to ensure groundcover is maintained |
| VII | Unsuitable for rural production | Green timber maintained to control erosion |
| VIII | Unsuitable for rural production | Should not be cleared, logged or grazed |

Source: Cunningham et al., 1988

The pre-mining Rural Land Capability for the PAA and disturbance footprint ranges from Class II to Class VII (**Table 3.4**; **Figure 3.3**). The key points include:

- The land is capable of both cropping (Class II and III) and grazing (Classes IV to VI) enterprises as well containing some land that is best vegetated with trees and shrubs for erosion control (Class VII).
- The dominant Rural Land Capability classification is Class IV (35.3% of PAA, 46.5% of disturbance footprint).
- Other major classes include Class III (20.8% of PAA, 9.7% of disturbance footprint) and Class VI (17.1% of PAA, 32.7% of disturbance footprint).

**Table 3.4: Pre-mining Rural Land Capability Classes**

| Rural Land Capability | Project Application Area | | Disturbance Footprint | |
|---|---|---|---|---|
| Class | ha | % | ha | % |
| II | 572 | 2.1 | 3 | <1.0 |
| III | 5,691 | 20.8 | 439 | 9.7 |
| IV | 9,785 | 35.7 | 2,109 | 46.5 |
| V | 4,474 | 16.3 | 132 | 2.9 |
| VI | 5,311 | 19.4 | 1,484 | 32.7 |
| VII | 1,553 | 5.7 | 369 | 8.1 |
| **Total** | **27,386** | **100** | **4,536** | **100** |

### 3.7.2 Agricultural Suitability Classification

The relevant guideline used to classify the agricultural suitability of land in NSW is the *Agricultural Suitability Maps: Uses and Limitations* (NSW Agricultural & Fisheries, 1990). Class 1 ranks the land as most suitable for agricultural activities and Class 5 as the least suitable. Classes 1 to 3 are generally considered suitable for a wide variety of agricultural production whereas Classes 4 and 5 are unsuitable for cropping; however, they are suitable for some grazing activities. A description of each of the Agricultural Suitability classes is provided in **Table 3.5**.

**Table 3.5: Agricultural Suitability Classification**

| Class | Land Use | Management Options |
|---|---|---|
| 1 | Highly productive land suited to both row and field crops | Arable land suitable for intensive cultivation where constraints to sustained high levels of agricultural production are minor or absent |
| 2 | Highly productive land suited to both row and field crops | Arable land suitable for regular cultivation for crops but not suited to continuous cultivation |
| 3 | Moderately productive lands suited to improved pasture and to cropping within a pasture rotation | Grazing land or land well suited to pasture improvement. It may be cultivated or cropped in rotation with pasture |
| 4 | Marginal lands not suitable for cultivation and with a low to very low productivity for grazing | Land suitable for grazing but not for cultivation. Agriculture is based on native or improved pastures established using minimum tillage |
| 5 | Marginal lands not suitable for cultivation and with a low to very low productivity for grazing | Land unsuitable for agriculture or at best suited only to light grazing |

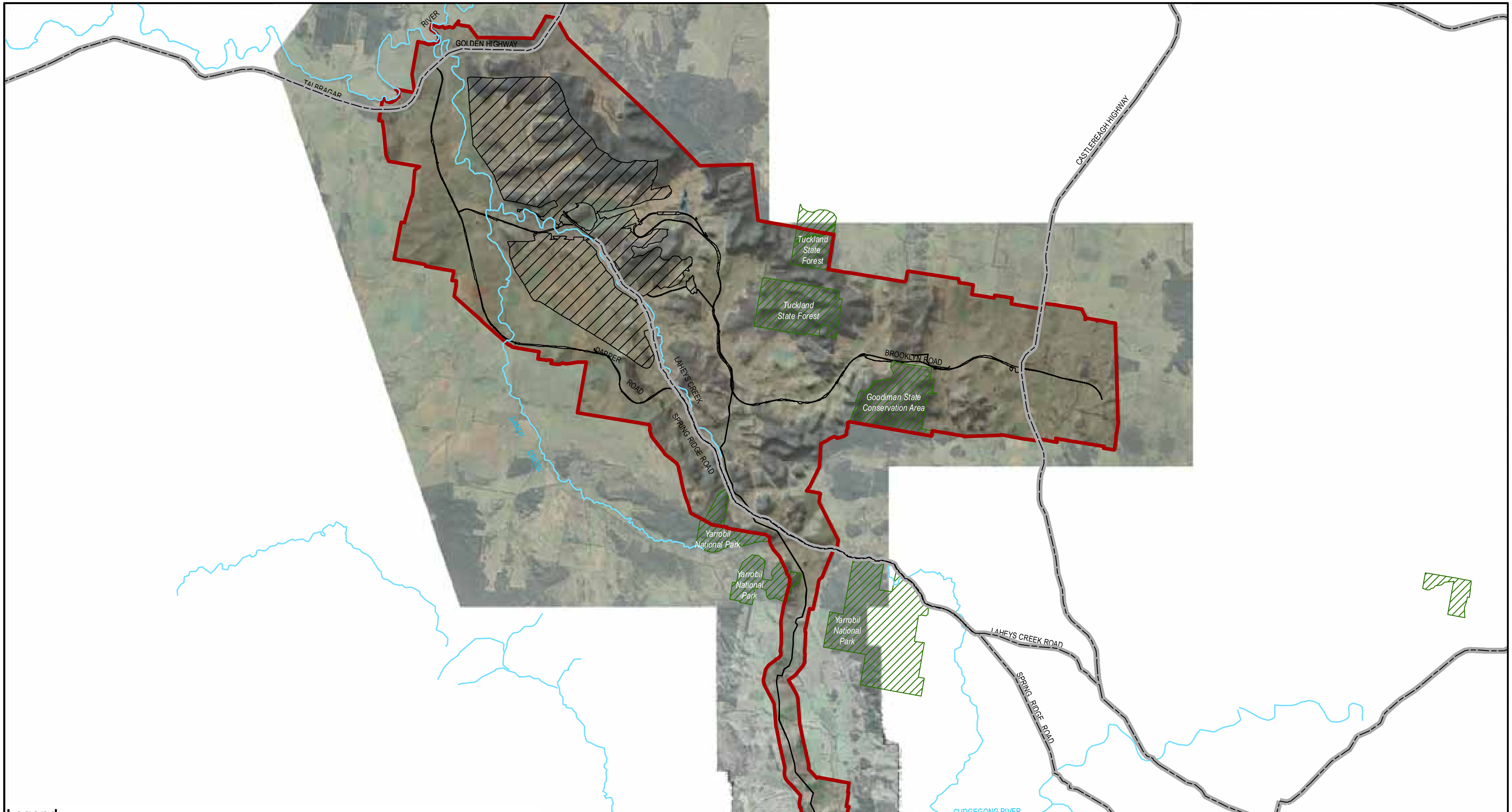
Source: NSW Agriculture & Fisheries (1990).

The pre-mining Agricultural Suitability classification for the PAA and disturbance footprint ranges from Class 1 to Class 5 (**Table 3.5**; **Figure 3.4**). The key points include:

- The land is suitable for both cropping (Classes 2 and 3) and grazing (Class 3 and 4) enterprises as well containing some land that is best used only for light grazing (Class 5).
- The dominant Agricultural Suitability classification is Class 3 (50.6% of PAA, 49.4% of disturbance footprint) and Class 4 (17.1% of PAA, 32.7% of disturbance footprint).
- Other major classes include Class 2 (20.8% of PAA, 9.7% of disturbance footprint) and Class 5 (5.4% of PAA, 8.1% of disturbance footprint).

**Table 3.5: Pre-mining Agricultural Suitability Classes**

| **Agricultural Suitability** | **Project Application Area** | | **Disturbance Footprint** | |
|---|---|---|---|---|
| Class | ha | % | ha | % |
| 1 | 572 | 2.1 | 3 | <1.0 |
| 2 | 5,691 | 20.8 | 439 | 9.7 |
| 3 | 14,259 | 52.0 | 2,241 | 49.4 |
| 4 | 5,311 | 19.4 | 1,484 | 32.7 |
| 5 | 1,553 | 5.7 | 369 | 8.1 |
| **Total** | **27,386** | **100** | **4,536** | **100** |




**Legend**

- Project Application Area
- Roads
- Waterways
- State Forest / National Park / Conservation Area
- Disturbance Footprint

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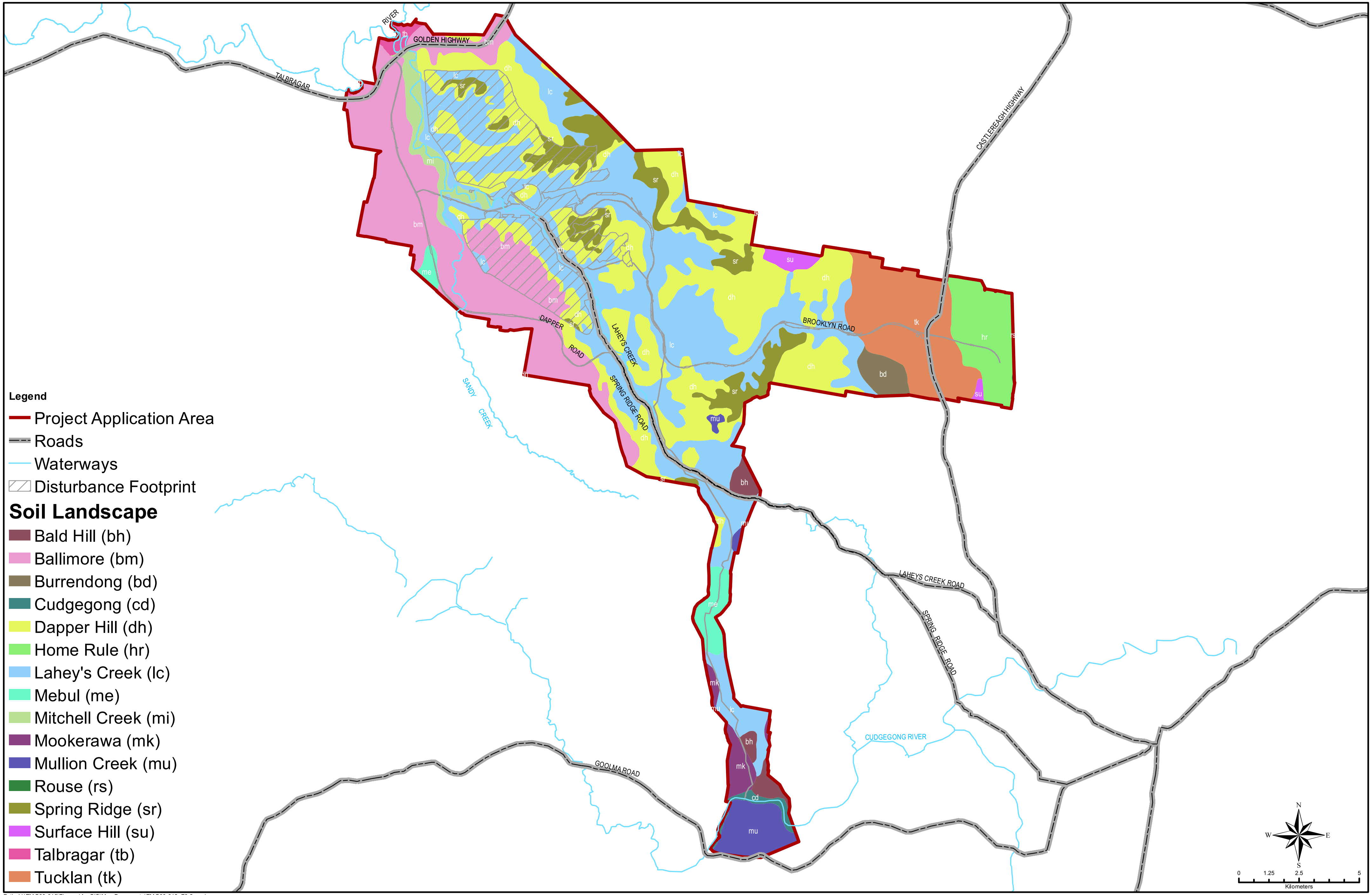
Biophysical Environment
Cobbora Coal Project
**Figure 3.1**

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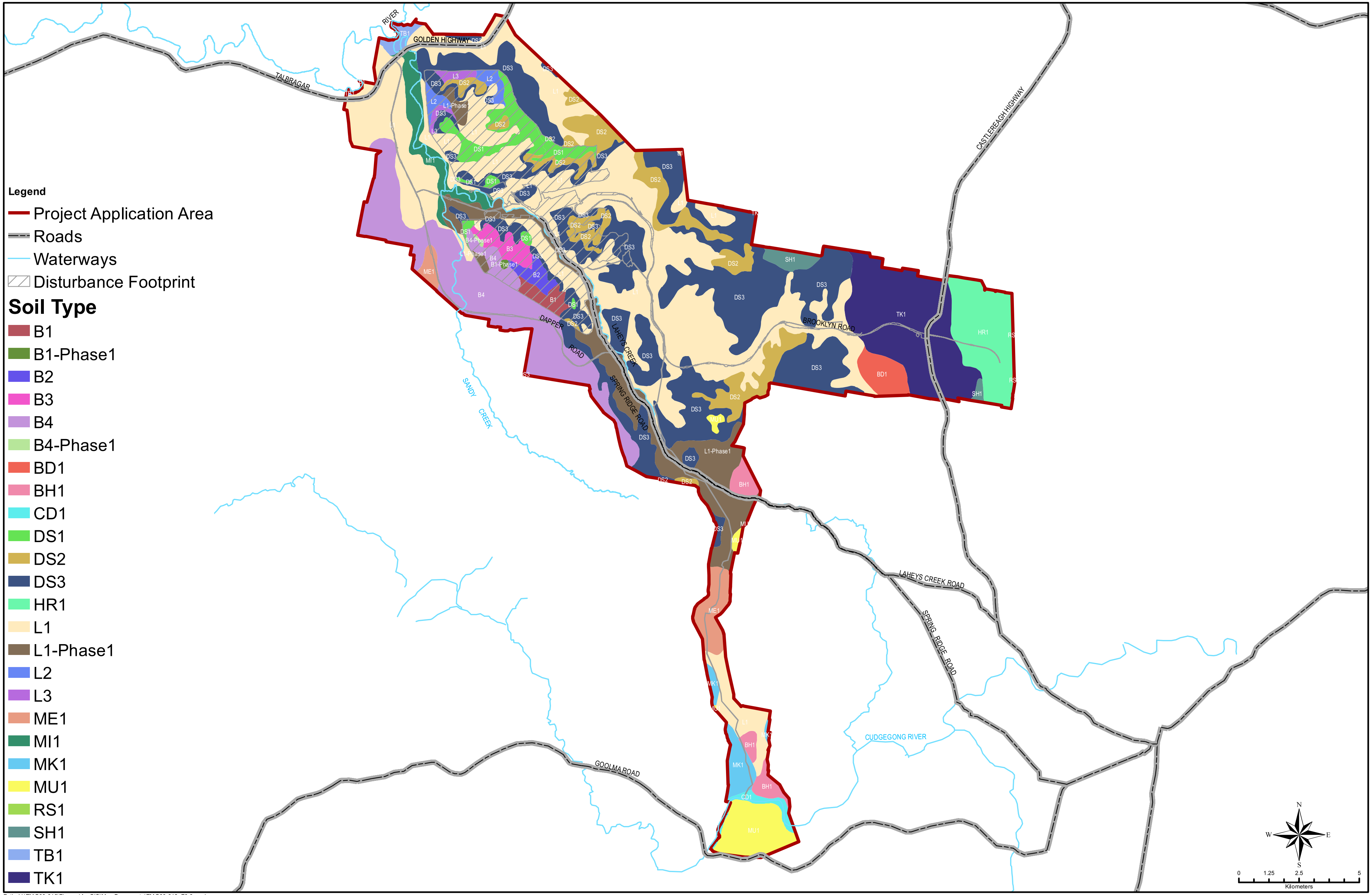
Soil Landscape Units
Cobbora Coal Project
**Figure 3.2**

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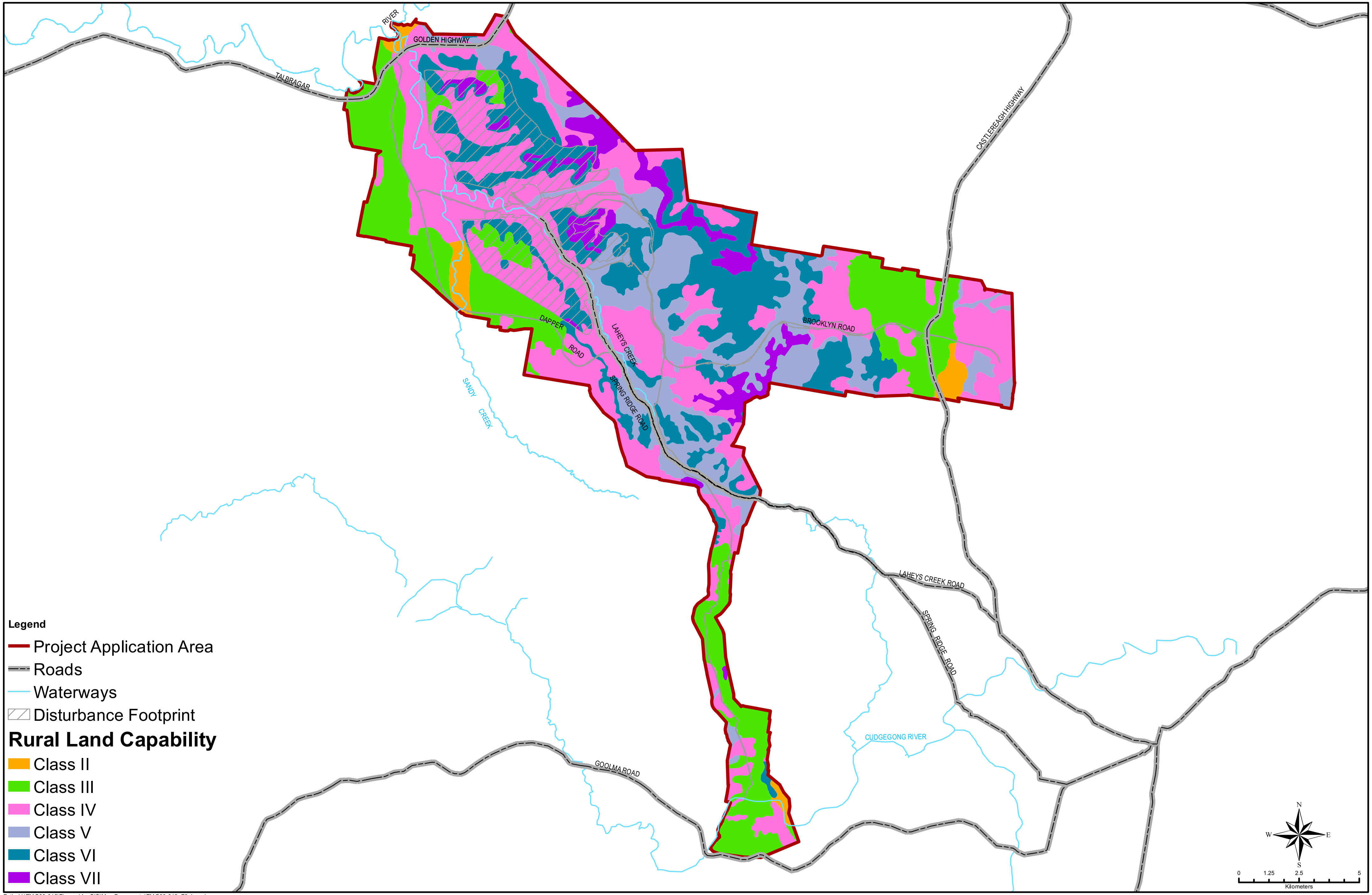
Soil Types

Cobbora Coal Project

**Figure 3.3**

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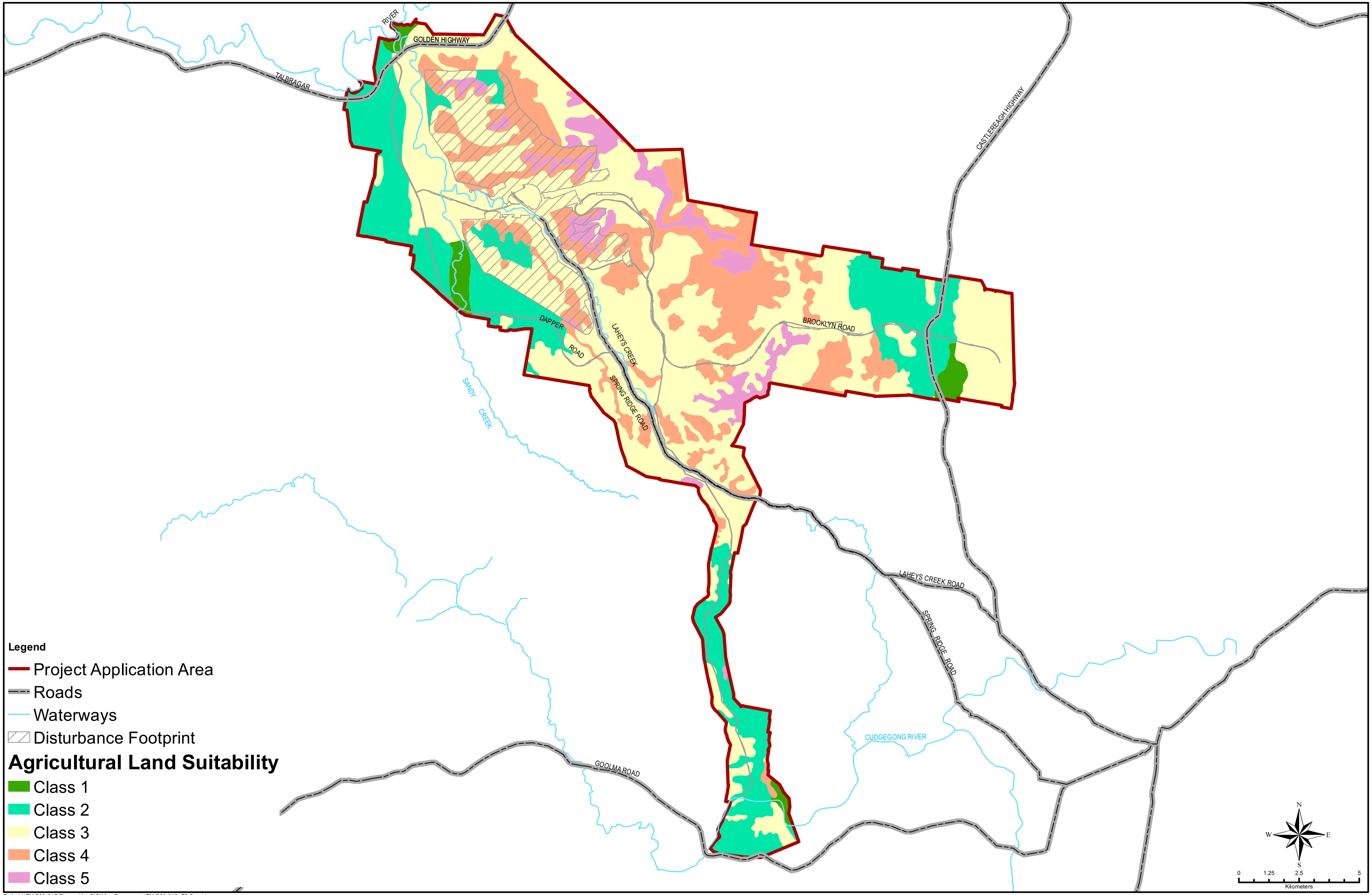
Pre-mining Rural Land Capability Classification

Cobbora Coal Project

**Figure 3.4**

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Pre-mining Agricultural Land Suitability Classification

Cobbora Coal Project

**Figure 3.5**

# 4.0 POST-MINING LANDFORM AND LAND USE

This section provides a summary of the Project's conceptual final landform design, decommissioning strategy, post-mining landform's Rural Land Capability classification, Agricultural Suitability classification, and the proposed post-mining land use.

## 4.1 Conceptual Landform Design and Planning

Landform design and planning takes into account three main components:

- landform stability;
- erosion minimisation; and
- landform compatibility with the surrounding environment.

Rehabilitation will be designed to achieve a stable final landform compatible with the surrounding environment. This will involve shaping the completed overburden emplacement areas, where practical, to achieve slopes of 10º or less. Where slopes exceed 10º, additional drainage and revegetation works will be carried out to aid groundcover establishment and enhance erosion and sediment control.

The final landform will incorporate contour-graded banks installed during the rehabilitation process. The spacing and ultimate dimensions of these banks will be a function of the final slope and catchment area. On the slopes exceeding 10º, linear contour bank spacing will generally range between 50 and 80 m.

Mine planning will limit the total area of disturbance at any one time, considering both clearance in advance of operations and rehabilitation of areas disturbed. This will reduce the potential for wind-blown dust, visual impact and sediment-laden run-off. Treed vegetation along the toe of rehabilitation areas will not be cleared unless an unacceptable safety or erosion risk remains.

Rehabilitation planning seeks to maximise opportunities for a diverse post-mining landscape and land use. It is presently proposed that the final landscape will include a mixture of cropping land, pastoral land and native vegetation (woodland).

## 4.2 Project Decommissioning Strategy

The Project will employ a range of decommissioning strategies at closure to achieve a stable and compatible landform. These strategies are listed in **Table 4.1** and described below.

**Table 4.1: Closure Decommissioning Strategy by Domain**

| Domain | Mine Element | Decommissioning Strategy |
|---|---|---|
| 1 | Mining Operations Domain | Shape overburden to provide a stable landform consistent with the surrounding environment and proposed post-mining land use and minimise final void areas<br>The final tailings emplacement will be allowed to dry to provide a stable landform consistent with the surrounding environment and proposed post-mining land use. |
| 2 | Mine Infrastructure Domain | Remove all infrastructure, regrade embankments and cuttings, and reshape landform to be similar to pre-mining landform |
| 3 | Auxiliary Infrastructure Domain: water supply pipeline – raw water and pipelines | Remove all aboveground infrastructure and cap and cover underground infrastructure. Regrade embankments and cuttings where required and reshape landform to be similar to pre-mining landform<br>(Note: it is likely that it will be agreed with the landholders to leave the pipeline in place, which will be operated by a third party to provide additional water to local industries) |

| Domain | Mine Element | Decommissioning Strategy |
|---|---|---|
| | Auxiliary Infrastructure Domain: Rail spur and rail siding | Remove all rail, sleepers and ballast, and 'below rail' infrastructure as required in consultation with regulators. Embankments and cuttings to remain post-closure. Remove road over rail bridge at Castlereagh Highway |
| | Auxiliary Infrastructure Domain: power easement | Remove all infrastructure |
| 4 | Road Network Domain | Upgraded and realigned roads will be retained at closure |
| | | Haul roads will be reshaped to blend with the surrounding landform and revegetated with appropriate species |
| 5 | Raw Water Dam Domain | The dam will be left in place |

The Mining Operations Domain will be reshaped and progressively rehabilitated to be compatible with the proposed post-mining land use. The components of the Mine Infrastructure Domain and Auxiliary Infrastructure Domain (with the exception of the rail spur) will be decommissioned by removing all infrastructure, reducing slope angles of embankments and cuttings to blend with the surrounding landform, and revegetating with endemic species. The rail spur will have its infrastructure elements removed; however, the embankments and cuttings will be left. The upgraded and realigned roads will remain in place as an active network, whilst the haul roads will be rehabilitated. The raw water dam will also be left as it will provide water storage for post-mining agricultural activities.

## 4.3 Conceptual Final Landform Shape

It is proposed that all the upgraded and realigned roads, as well as the raw water dam, will be retained at closure. All land covered by main and auxiliary infrastructure components, with the exception of the rail spur formation, will be returned to the pre-mining landform and will be capable of supporting pre-mining land uses. The three mining areas will be largely backfilled with overburden and reshaped in accordance with the landform design. Reshaping will ensure that final slopes around the margin of the elevated landform, while generally 10º or less, will not exceed 18º. This landform will differ from its pre-mining state. **Figure 4.1** shows the slopes of the major rehabilitation domain, Mining Operations Domain; further description is provided below.

The reshaped Northern Mining Operations area, which encompasses open-cut Mining Areas A and C and the out-of-pit waste rock emplacement AC-OOP, will be an elevated landform largely composed of flat to gently inclined land with some steeper fringing slopes on the northern and western perimeter. The maximum design height for the elevated landform will be approximately 60 m above the pre-mining landform. It will contain two rehabilitated void areas located in the north and north-east of the final landform. The base of the original void area will be infilled with overburden material to more than 3 m above the water table. The infilled area is referred to as a 'rehabilitated depression'. The remaining non-rehabilitated void area will be associated with the very steeply inclined high wall.

The reshaped Southern Mining Operations area, which encompasses Mining Area B and out-of-pit waste rock emplacement B-OOPW, will be largely composed of flat to gently inclined land with some steeper fringing slopes on the perimeter. The maximum design height for the elevated landform will be approximately 30 m above the pre-mining landform. It will contain one void in the south with a maximum depth of approximately 34 m that is predicted to become a lake on closure. The northern part of the original void area will be infilled to more than 3 m above the water to form a rehabilitated depression.

The reshaped Eastern Mining Operations area, which covers the out-of-pit waste rock emplacement area B-OOPE, will be an elevated landform with no voids. This landform will be largely composed of flat to gently inclined land with some steeper fringing slopes on the western slopes. The eastern slopes abut steeper land to the east. The maximum design height for the elevated landform will be approximately 40 m above the pre-mining landform.

Other mine-related features forming part of the final landform within the PAA will be rock-drop structures, water storage dams and sediment basins used for surface-water management and erosion and sediment control.

## 4.4 Post-mining Rural Land Capability Classification

The Rural Land Capability classification for the rehabilitated disturbance footprint will range from Class III to Class VIII (**Figure 4.2**). This will provide a post-mining landform capable of both cropping (Class III) and grazing (Class IV) enterprises along with some land that is best revegetated with trees and shrubs for erosion control (Class VI) The post-mining landform will also contain areas not suitable for any agricultural enterprise (Class VIII).

Rural Land Capability Class VIII land has been designated for the final void and for the non-rehabilitated high walls associated with the rehabilitated depressions as they will be unsuitable for agricultural use. This classification has also been assigned to all other land that will be taken out of agricultural production and includes land associated with the raw water dam and upgraded and realigned roads.

The post-mining landform's Rural Land Capability Classes differ from the pre-mining landform as follows:

- The land associated with road networks, including upgraded road and realignments, will remain as an active road network at closure (Class VIII land).
- The raw water dam will be retained as an agricultural water resource (Class VIII land).
- The rail spur will have the embankments and cuttings retained (Class VI land).
- All other infrastructure elements contained within the Mine Infrastructure Domain and Auxiliary Infrastructure Domain will be removed and the pre-mining landform and Rural Land Capability class reinstated.
- The land within the Mining Operations Domain will contain a similar mix of Rural Land Capability classes; however, the land use will change due to the commitment to reinstate some native woodland communities. This domain will also contain some Class VIII land, which is associated with the final void and remaining high walls. Further information is contained in Section 4.6.

**Table 4.2** provides the quantity of each Rural Land Capability class in the disturbance footprint for both the pre-mining and post-mining landform. Overall, there will be limited impacts on the overall quantity of Rural Land Capability classes across the PAA (**Table 4.3**). The key points are listed below:

- The primary changes to the Rural Land Capability Class areas will be a 236 ha increase of Class IV land (5.2% of disturbance footprint, 0.9% of PAA), and a 236 ha increase of Class VIII land (5.2% of disturbance footprint, <1.0% of PAA).
- Increases in the area of Rural Land Capability Class IV and VIII will be accompanied by a 349 ha decrease of Class VII land (7.7% of disturbance footprint, 1.3% of PAA), and a 104 ha decrease of Class V land (2.3% of disturbance footprint, 0.4% of PAA).
- There will be minor changes to the areas of Class II and VI land.
- There will be no change to the area of Class III land.

**Table 4.2: Post-mining Rural Land Capability – Disturbance Footprint**

| Rural Land Capability | Pre-mining | | Post-mining | | Change | |
|---|---|---|---|---|---|---|
| Class | ha | % | ha | % | ha | % |
| II | 3 | <1.0 | Nil | Nil | - 3 | - <1.0 |
| III | 439 | 9.7 | 439 | 9.7 | Nil | Nil |
| IV | 2,109 | 46.5 | 2,345 | 51.7 | 236 | 5.2 |
| V | 132 | 2.9 | 28 | 0.6 | - 104 | - 2.3 |
| VI | 1,484 | 32.7 | 1,468 | 32.4 | - 16 | - 0.3 |
| VII | 369 | 8.1 | 20 | 0.4 | - 349 | - 7.7 |
| VIII | Nil | Nil | 236 | 5.2 | 236 | 5.2 |
| **Total** | **4,536** | **100** | **4,536** | **100** | | |

**Table 4.3: Post-mining Rural Land Capability – PAA**

| Rural Land Capability | Pre-mining | | Post-mining | | Change | |
|---|---|---|---|---|---|---|
| Class | ha | % | ha | % | ha | % |
| II | 572 | 2.1 | 569 | 2.1 | -3 | <1.0 |
| III | 5,691 | 20.8 | 5,691 | 20.8 | Nil | Nil |
| IV | 9,785 | 35.7 | 10,021 | 36.6 | 236 | 0.9 |
| V | 4,474 | 16.3 | 4,370 | 15.9 | -104 | -0.4 |
| VI | 5,311 | 19.4 | 5,295 | 19.4 | -16 | <1.0 |
| VII | 1,553 | 5.7 | 1,204 | 4.4 | -349 | -1.3 |
| VIII | Nil | Nil | 236 | <1.0 | 236 | <1.0 |
| **Total** | **27,386** | **100** | **27,386** | **100** | | |

## 4.5 Post-mining Agricultural Suitability

The Agricultural Suitability classification for the post-mining landform will range from Class 2 through to Class 5 (**Figure 4.3**). This means that the post-mining landform will contain arable land that is well suited to regular cultivation (Class 2), good grazing land that is well suited to pasture improvement (Class 3) and land that is suitable for grazing using native or unimproved pastures only (Class 4). It will also contain land that is considered unsuitable for agricultural enterprises but may allow for light grazing (Class 5). Overall there have been limited impacts on the overall quantity of Agricultural Suitability classes across the PAA (**Table 4.5**). The key points are listed below:

- The primary change to the Agricultural Suitability Class areas will be will be a 132 ha increase of Class 3 land (2.9% of disturbance footprint, 0.5% of PAA).
- This increase will be accompanied by a 113 ha decrease of Class 5 land (2.5% of disturbance footprint, 0.5% of PAA).
- There will be minor changes to Class 1 (decrease of 3 ha) and 4 land (decrease of 16 ha) and no impact on State Forest.
- There will be no change to the amount of Class 2 land.

**Table 4.4: Post-mining Agricultural Suitability – Disturbance Footprint**

| Agricultural Suitability | Pre-mining | | Post-mining | | Change | |
|---|---|---|---|---|---|---|
| Class | ha | % | ha | % | ha | % |
| 1 | 3 | <1.0 | Nil | Nil | - 3 | - <1.0 |
| 2 | 439 | 9.7 | 439 | 9.7 | Nil | Nil |
| 3 | 2,241 | 49.4 | 2,373 | 52.3 | 132 | 2.9 |
| 4 | 1,484 | 32.7 | 1,468 | 32.4 | - 16 | - 0.3 |
| 5 | 369 | 8.1 | 256 | 5.6 | - 113 | - 2.5 |
| **Total** | **4,536** | **100** | **4,536** | **100** | | |

**Table 4.5: Post-mining Agricultural Suitability – PAA**

| Agricultural Suitability | Pre-mining | | Post-mining | | Change | |
|---|---|---|---|---|---|---|
| Class | ha | % | ha | % | ha | % |
| 1 | 572 | 2.1 | 569 | 2.1 | -3 | <1.0 |
| 2 | 5,691 | 20.8 | 5,691 | 20.8 | Nil | Nil |
| 3 | 14,259 | 52.0 | 14,391 | 52.5 | 132 | 0.5 |
| 4 | 5,311 | 19.4 | 5,295 | 19.4 | -16 | <1.0 |
| 5 | 1,553 | 5.7 | 1,440 | 5.2 | -113 | -0.5 |
| **Total** | **27,386** | **100** | **27,386** | **100** | | |

## 4.6 Post-mining Land Use

The land that will be predominately subject to an altered land use at mine closure is in the Mining Operations Domain (refer **Section 4.3**). This domain's post-mining land use is shown in **Figure 4.4** and described below.

*Cropping Land*

Rural Land Capability Class III land will be established on the flat to gently sloping land on the central part of the Southern Mining Operations area. This land is proximal to the existing Rural Land Capability Class III land that is present outside of the proposed disturbance footprint. The proponent, CHC, will reinstate the same amount of Rural Land Capability Class III cropping land over the area directly impacted by the Project (**Table 4.2**). The proposed final land use for this class of land is dryland cropping.

*Pastoral Land and Native Vegetation Land (Woodland)*

Rural Land Capability Class IV and Class VI land will be established on the flat to gently sloping land and the moderately steep to steep land, respectively. The proposed final land use will be a combination of pastoral farming and woodland.

CHC will reinstate the same quantity of woodland in the Mining Operations Domain to that directly impacted by the Project. Woodland will be reinstated on all of the Eastern Mining Operations area and on Class IV land located on the western side of the Northern Mining Operations area. These locations were selected as they are proximal to existing tracts of remnant vegetation. Woodland will also be reinstated on the three rehabilitated void depressions and on the moderately steep to steep land across the remaining land in the Mining Operations Domain as this land is best suited to tree and shrub cover. Pasture for pastoral farming activities will be reinstated on the remaining Class IV land.

*Non-Agricultural Land*

Rural Land Capability Class VIII land has been designated for the final void located in the Southern Mining Operations area and for the remaining high walls associated with the rehabilitated depressions. This class designates that the land will be unsuitable for agricultural use. This classification has also been assigned to all other land that will be taken out of agricultural production and includes land associated with the raw water dam and upgraded and realigned roads.

In summary, the post-mining land use in the Mining Operations Domain will be approximately 46% woodland (Class IV, VI and VII), 10% cropping (Class III) and 40% pastoral land (Classes IV). Land associated with sediment basins (<1%) will also be returned to pre-mining land use. The remaining 3% of land will be associated with the final void and remaining high walls (**Table 4.6**).

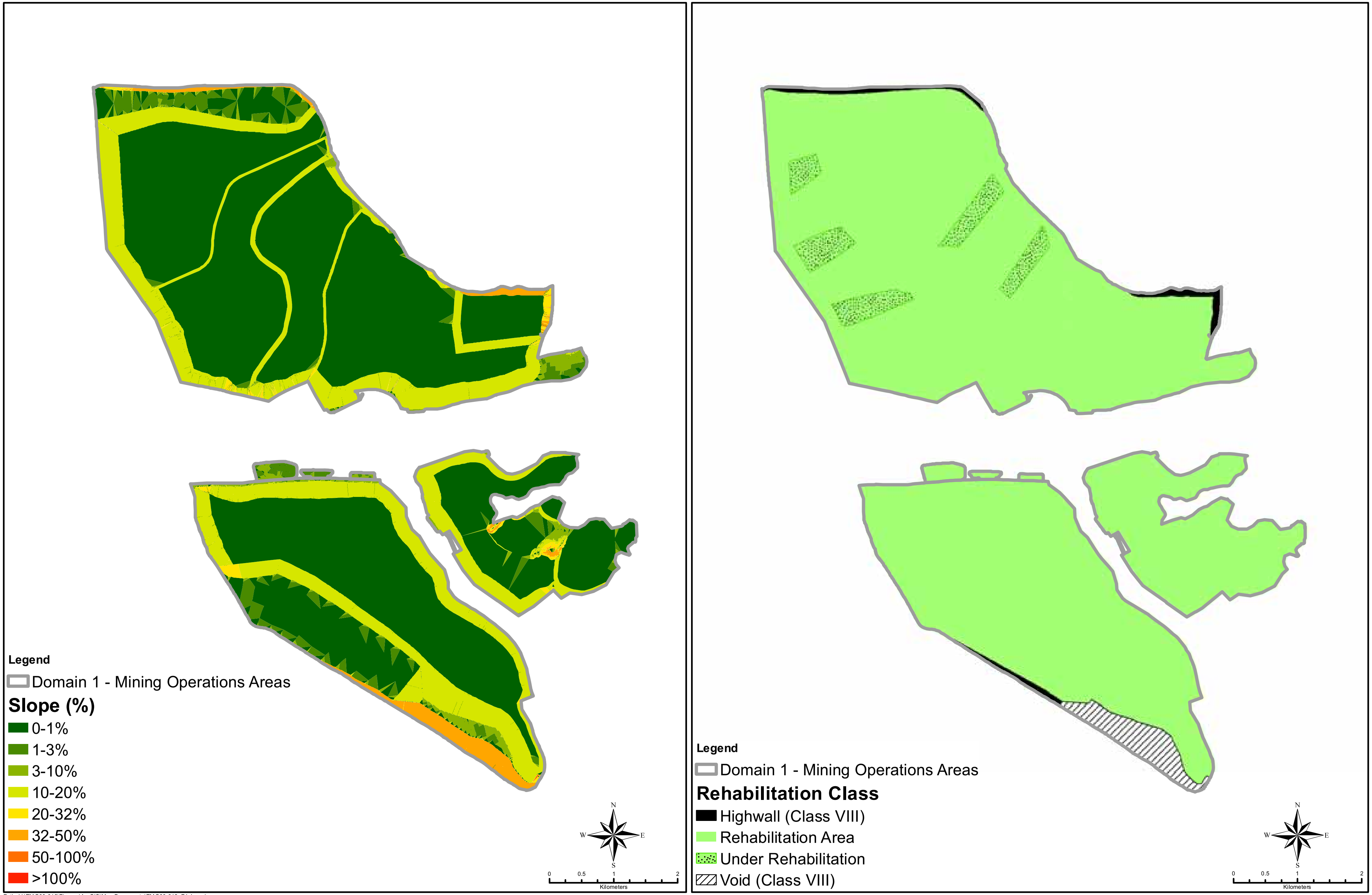
**Table 4.6: Post-mining Land Use – Mining Operations Domain**

| Land Use | Associated Rural Land Capability Class | Associated Landform | Area (ha) | Area (%) |
|---|---|---|---|---|
| Cropping | III | Flat to gently sloping land | 418 | 10.1 |
| Pastoral | IV | Flat to gently sloping land | 1,634 | 39.6 |
| Woodland | IV, VI, VII | Flat to steeply inclined land | 1,901 | 46.1 |
| Subtotal | | | 3,953 | 95.8 |
| Pre-mining | Sediment basins returned to pre-mining land use | | 27 | <1 |
| Subtotal | | | 27 | <1 |
| Void | VIII | Void | 89 | 2.1 |
| High wall | VIII | Highwall | 54 | 1.3 |
| Subtotal | | | 143 | 3.4 |
| **Total** | | | **4,123** | **100** |

## 4.7 Integration of Post-mining Rural Land Use and Surrounding Environment

The woodland areas will where possible link remnant native vegetation and aim to maximise conservation values. The reinstatement of woodland has been designed so that it enhances the treed corridor between the Cobbora Conservation Area in the north, Tuckland State Forest towards the central-east and Yarrobil National Park in the South. The reinstatement of cropping land has been located proximal to the existing Rural Land Capability Class III land external to the west of the disturbance footprint.

The Project's Land Management Plan will ensure the best agricultural use of adjacent non-mine lands and provide opportunities for private farmers to use these through long-term leases.

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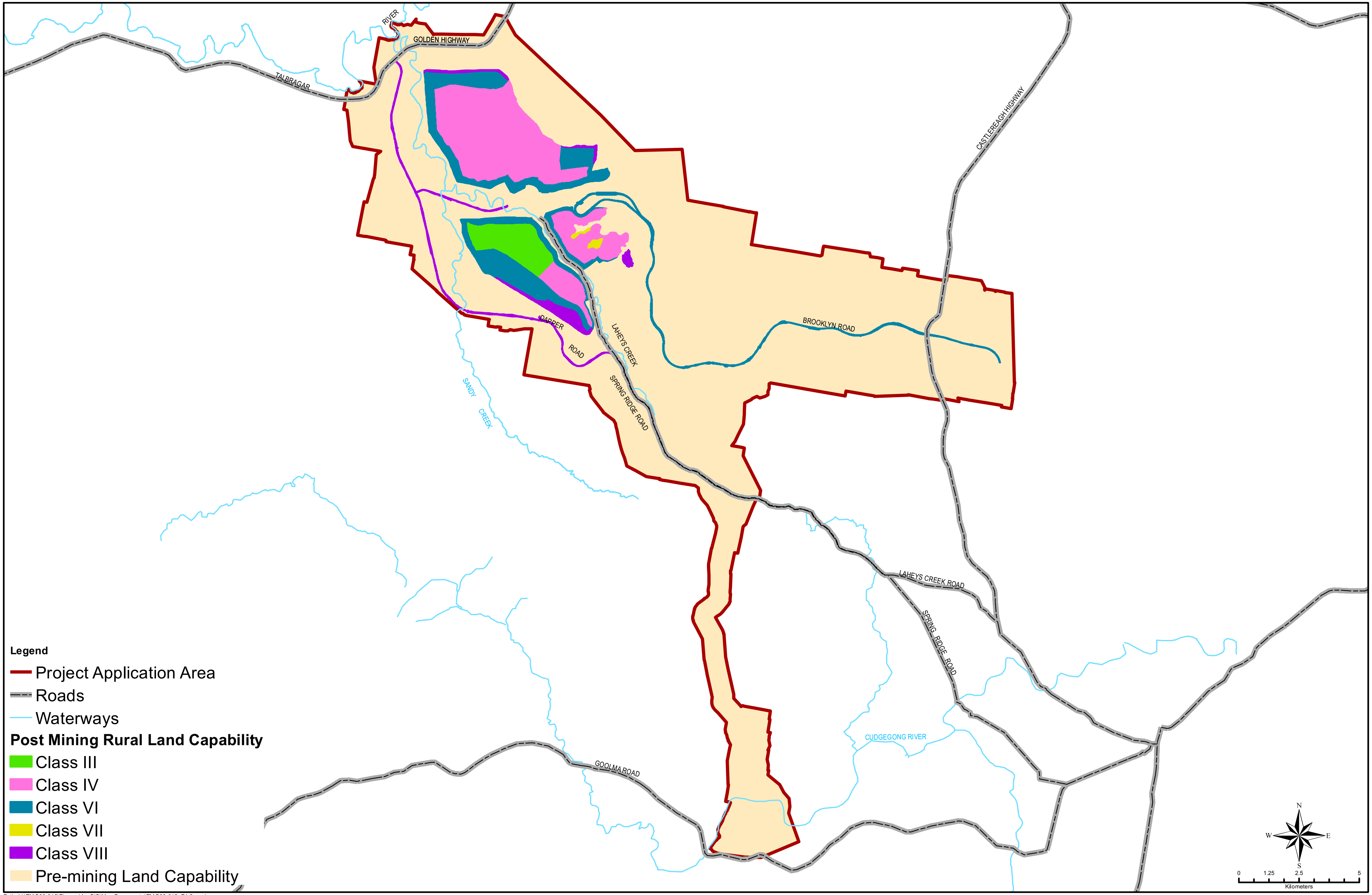
Domain 1: Rehabilitated Landform (Closure)

Cobbora Coal Project

**Figure 4.1**

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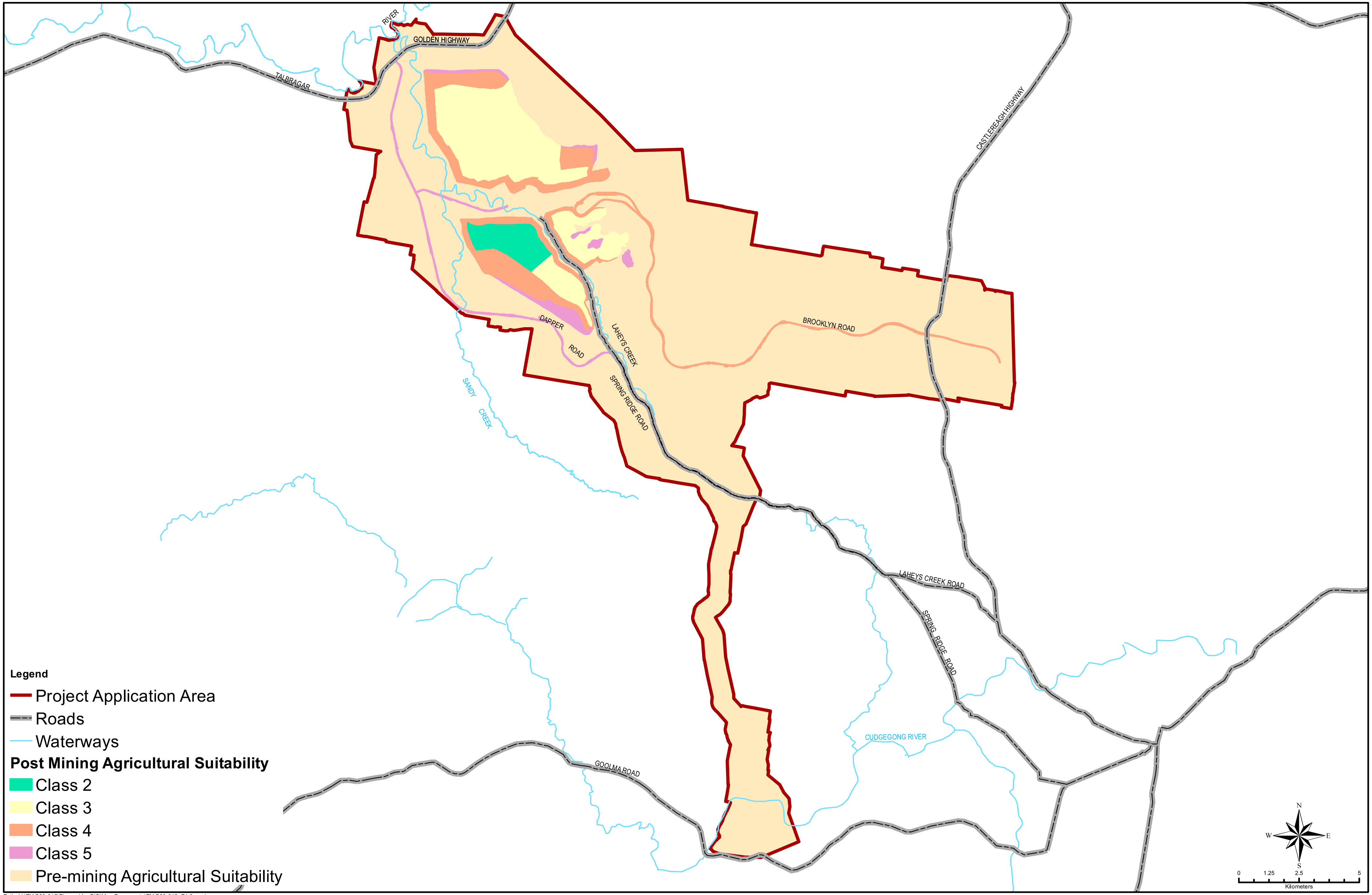
Post-mining Rural Land Capability Classification

Cobbora Coal Project

**Figure 4.2**

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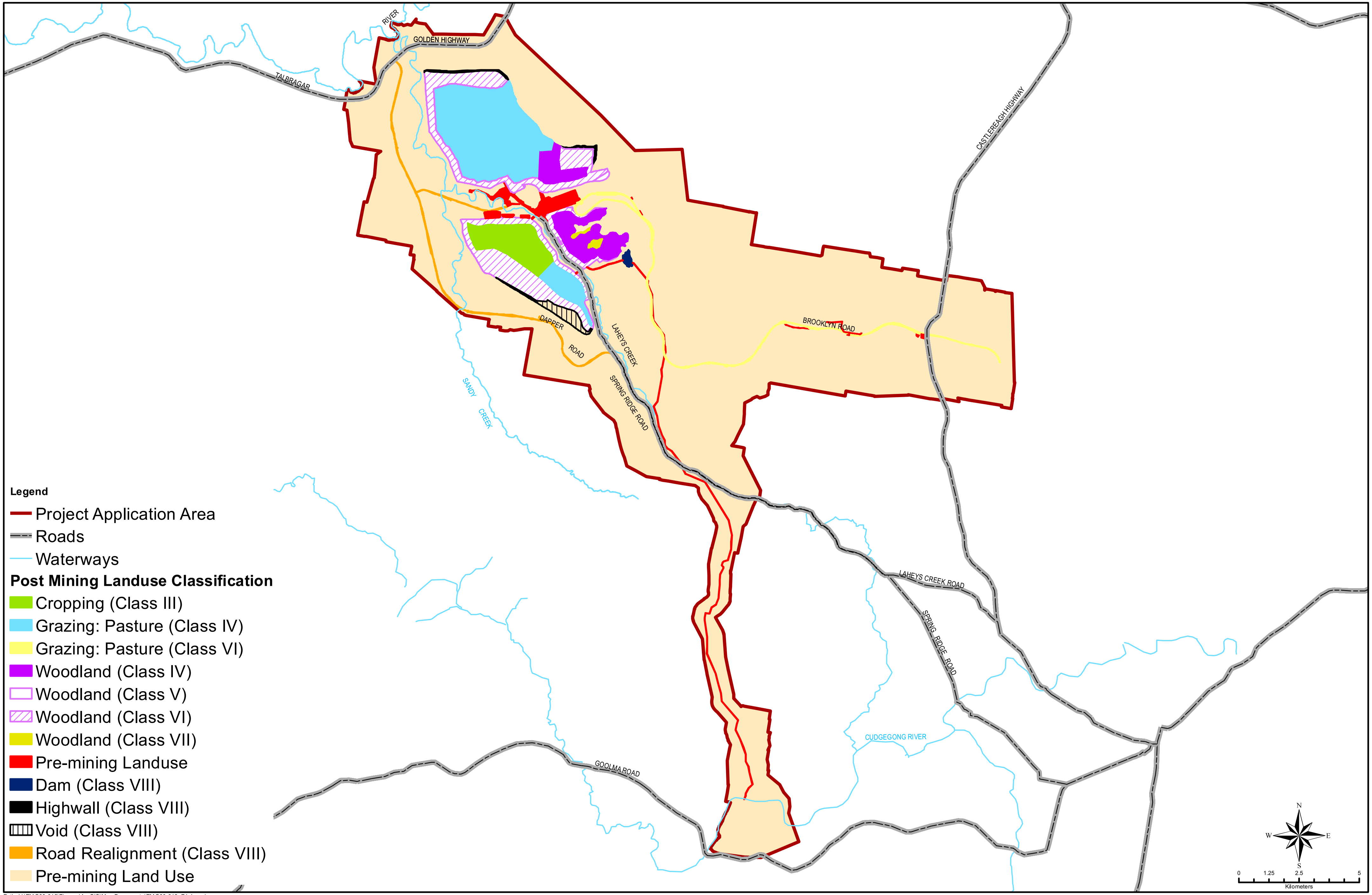
Post-mining Agricultural Suitability Classification

Cobbora Coal Project

**Figure 4.3**

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Post-mining Landuse of Disturbance Footprint
Cobbora Coal Project
**Figure 4.4**

# 5.0 REHABILITATION MANAGEMENT STRATEGY

## 5.1 Short-term and Long-term Objectives

All land disturbed by mining activities will be rehabilitated to form a stable landform with a self-sustaining vegetation cover. This will be achieved by the early establishment of groundcover species and appropriately positioned tree and shrub plantings/sowings immediately following the spreading of topsoil.

Short-term rehabilitation objectives include:

- the minimisation of clearing and/or vegetation disturbance (consistent with operational requirements);
- scheduling of operations, including overburden/ interburden emplacement shaping and revegetation;
- timely rehabilitation of the disturbed areas no longer required for mining-related operations;
- application of topdressing material (topsoil/subsoil) to the final landform based on soil availability and post-mining Rural Land Capability classification targets;
- stabilisation of all earthworks, drainage lines and disturbed areas in order to minimise erosion and sedimentation; and
- control of vermin, feral animals and noxious weeds.

Overall long-term mine rehabilitation objectives are to provide a landform that is safe, low maintenance, and geotechnically stable that blends in with the surrounding topography. Land use will be generally consistent with pre-mining conditions and provide for a mixture of rehabilitated woodland, pastoral land and cropping areas. Specific long-term objectives include:

- the re-establishment to cropping land, pastoral land or woodland in the areas disturbed by the mine;
- the long-term conservation of remnant and degraded native vegetation and/or habitat corridors on the mine site;
- the provision of habitat for fauna and corridors for fauna movement within the final landform;
- ensuring that the quality of run-off water from rehabilitation areas that is released from the site will not cause environmental harm;
- ensuring that the water quality of any residual water bodies is suitable for the nominated use and does not have the potential to cause environmental harm;
- development and implementation of a long-term and regionally integrated biodiversity offset strategy; and
- monitoring of rehabilitation success in terms of physical, chemical and biological parameters.

## 5.2 Progressive Rehabilitation Schedule

The Mining Operations Domain will be progressively rehabilitated and, excluding the final voids, this domain contains 3,785 ha that will require rehabilitation works. The other domains will be rehabilitated at closure with the exception of the Raw Water Dam Domain as it is intended that this area will be retained for post-mining agricultural activities.

The proponent, CHC, will adopt a progressive approach to the rehabilitation of disturbed areas within the Mining Operations Domain. It is proposed that disturbed areas be reshaped within one year of the final overburden placement and then rehabilitated to the target Rural Land Capability classes. This will ensure that areas where mining or overburden placement is completed are promptly shaped, topsoiled and vegetated to provide a stable landform. The progressive formation of the post-mining landform and the establishment of a vegetative cover will reduce the amount of disturbed land at any one time and also reduce the visibility of mine-related activities from surrounding properties and roads. Early reprofiling and revegetation of the external embankments and cutting slopes of the emplacement areas is particularly important and will be targeted as a priority.

The progressive site rehabilitation schedule for the life of the mine is listed in **Table 5.1** and described below. **Figures 5.1a** and **5.1b** illustrate the progressive rehabilitation of the site for years 4, 8, 16 and closure (year 21).

**Table 5.1: Progressive Rehabilitation – Mining Operations Domain**

| **Rehabilitation** | **Land Use** | **Rural Land Capability** | **Area** | |
|---|---|---|---|---|
| Year | Type | Class | ha | % |
| 2–4 | Cropping | III | 0 | 0.0 |
| | Pastoral | IV | 0 | 0.0 |
| | Woodland | IV, VI, VII | 357 | 9.0 |
| Subtotal | | | 357 | 9.0 |
| 4–8 | Cropping | III | 5 | 0.1 |
| | Pastoral | IV | 148 | 3.7 |
| | Woodland | IV, VI, VII | 103 | 2.6 |
| Subtotal | | | 256 | 6.4 |
| 8–16 | Cropping | III | 184 | 4.7 |
| | Pastoral | IV | 564 | 14.3 |
| | Woodland | IV, VI, VII | 156 | 4.0 |
| Subtotal | | | 904 | 23.0 |
| 16–21 (end of mine life) | Cropping | III | 229 | 5.8 |
| | Pastoral | IV | 767 | 19.4 |
| | Woodland | IV, VI, VII | 1,201 | 30.4 |
| Subtotal | | | 2,197 | 55.6 |
| 21-29 | Cropping | III | 0 | 0 |
| | Pastoral | IV | 155 | 3.9 |
| | Woodland | IV, VI, VII | 84 | 2.1 |
| Subtotal | | | 239 | 6.0 |
| **Total** | | | **3,953** | **100.0** |

In total, 3,953 ha will be rehabilitated and 143 ha will be left as void or high wall areas (**Table 4.6**) in the Mining Operations Domain. The following is a brief description of the annual rehabilitation sequencing:

Year 1 No rehabilitation.

Years 2–4 Rehabilitation of 357 ha of land, which includes a large portion of the Eastern Mining Operations area.

Years 4–8 Rehabilitation of 256 ha of land, which is located within the Northern Mining Operations area.

Years 8–16 Rehabilitation of 904 ha of land, which includes large portions of the Northern and Southern Mining Operations area.

Years 16–21 Rehabilitation of 2,197 ha of land, which includes all remaining land in the Mining Operations Domain with the exception of the tailings emplacement areas.

Years 21-29 Rehabilitation of 239 ha of land, which includes the stabilised and revegetated tailings emplacement areas.

## 5.3 Soil Resources

### 5.3.1 Recommended Soil-stripping Depths

The suitability of soil for conservation and use in the rehabilitation of land disturbed associated with mining construction and operations has been determined using the *Guide for Selection of Topdressing Material for Rehabilitation of Disturbed Areas* (Elliot & Reynolds, 2007). This selection procedure determines the appropriate stripping depths of soil material to be removed, and is based on soil physical and chemical parameters, these parameters include soil texture, soil structure, pH and salinity. Full details of this assessment are contained in **Appendix 1**.

The assessment shows that soil in the disturbance footprint has a recommended stripping depth that ranges from 0.0 m to 0.55 m. Most of the unimproved topsoil is limited by physical characteristics such as weak soil structure. However, these physical limitations are generally minor and can be overcome by appropriate management actions. All subsoils are undesirable for use due to physical (e.g. strong consistence) and/or chemical limitations (e.g. sodicity).

**Figure 5.2** provides the spatial distribution of the recommended stripping depths. **Table 5.2** details the maximum recommended stripping depths for each soil type and the key points are listed below:

- There are a total of 14 different soil types within Domains 1, 2 and 5. Thirteen are suitable for use during rehabilitation.
- The major soil limitations are high clay content and strong consistence, or shallow soil depth.
- A number of soil types are limited by poor surface soil structure and/or acidity; however, these can be used with appropriate use of ameliorants.
- One soil type is not suitable for use in rehabilitation (Rudosol; very shallow) was limited by very strong sodicity and acidity, as well as shallow soil depth.
- The Rural Land Capability Class III soil (Soil Type B3) contains no chemical limitations. The physical limitation of high clay content can be managed using soil management practices to facilitate its use in Class III profile re-instatement works.

### 5.3.2 Soil Volume Available for Conservation

The quantity of soil that can be salvaged from the disturbance footprint is based on the recommended soil stripping depths and the area of land that will be disturbed. The land covered by the Auxiliary Infrastructure and Road Network Domains has been excluded as these domains include construction and operational elements that may not disturb the soil profile at depth (e.g. overland power easement, overland pipeline).

The estimated total volume of soil available from areas to be disturbed is approximately 10.1 million cubic metres (MCM). When a handling loss of 5% is allowed, this volume is reduced to approximately 9.6 MCM (**Table 5.2**). It is recommended that the detailed Topsoil Management Plan (which is to be developed prior to the commencement of construction works) provides strategies on how to minimise topsoil losses during stripping to ensure that topsoil resources are preserved.

**Table 5.2: Available Soil Volume: Domain 1, 2 & 5**

| Soil Type | | Stripping Area | Stripping Depth | Quantity of Soil |
|---|---|---|---|---|
| # | Name | ha | m | MCM |
| B1 | Reddish Brown Chromosol | 149 | 0.2 | 0.30 |
| B1 – Phase 1 | Reddish Brown Chromosol; very shallow | 12 | 0.2 | 0.02 |
| B2 | Brown Chromosol: Type 1 | 134 | 0.2 | 0.27 |
| B3 | Yellowish-red Chromosol | 202 | 0.5 | 1.01 |
| B4 | Brown Chromosol: Type 2 | 165 | 0.3 | 0.50 |
| B4 – Phase 1 | Brown Chromosol; shallow | 9 | 0.3 | 0.03 |
| DS1 | Tenosol; very shallow | 641 | 0.2 | 1.28 |
| DS2 | Rudosol; very shallow | 364 | Nil | 0.00 |
| DS3 | Red Chromosol; very shallow | 861 | 0.25 | 2.15 |
| L1 | Yellow Sodosol: Type 1 | 1,332 | 0.2 | 2.66 |
| L1 – Phase 1 | Yellow Sodosol: Type 2 | 146 | 0.45 | 0.66 |
| L2 | Yellowish-brown Chromosol | 161 | 0.55 | 0.89 |
| L3 | Yellowish-red Chromosol | 94 | 0.4 | 0.38 |
| MI1 | Alluvial Soil | 2 | 0.2 | <0.01 |
| **Total** | | | | **10.14** |
| **Total minus 5% handling loss** | | | | **9.64** |

### 5.3.3 Soil Stripping and Handling Management Measures

The following soil-handling techniques are recommended to prevent excessive soil deterioration.

- Strip material to the depths stated in **Table 5.3**, subject to ongoing inspections.
- Maintain soil in a slightly moist condition during stripping. Material will not be stripped in either an excessively dry or wet condition.
- Place stripped material directly onto reshaped overburden and spread immediately (if mining sequences, equipment scheduling and weather conditions permit) to avoid the requirement for stockpiling.
- Less aggressive soil-handling equipment will be used during the salvage and transport of the stripped soil. Examples of this equipment include the use of graders or dozers to form the soil into wind-rows and the subsequent collection of this soil by open-bowl scrapers or dump trucks that have been loaded using front-end loaders.
- Soil transported by dump trucks may be placed directly into storage. Soil transported by scrapers is best pushed to form stockpiles by other equipment (e.g. dozers) to avoid tracking over previously laid soil.
- The surface of soil stockpiles will be left in a coarsely textured condition. This will promote infiltration and minimise erosion until vegetation is established, as well as preventing anaerobic zones forming.
- The maximum topsoil stockpile height will be 3 m. Clayey soils will be stored in lower stockpiles for shorter periods of time compared to sandier soils.

- If long-term stockpiling is planned (i.e. greater than 12 months), the stockpile will be seeded and fertilised as soon as possible as a healthy annual pasture sward provides sufficient competition to minimise the emergence of undesirable weed species. An annual cover crop species that produces sterile florets or seeds will be sown.

- Prior to spreading stockpiled topsoil onto reshaped overburden (particularly onto designated tree seeding areas), a weed assessment of stockpiles will be undertaken to determine if individual stockpiles require herbicide application and / or 'scalping' of weed species prior to topsoil spreading.

- An inventory of available soil will be maintained to ensure adequate topsoil materials continue to be available for rehabilitation activities.

- Topsoil will be spread to the depths as specified in Section 5.4.

## 5.4 Revegetation

The following subsections outline the rehabilitation procedures that will be adopted for each component area within the PAA. CHC will liaise with the relevant government agencies when planning rehabilitation activities.

### 5.4.1 Landform Shaping

*Domain 1*

Placement and shaping of overburden on the Mining Operations Domain will be undertaken to create slopes in general with gradients of up to 10º. Wherever practicable, weathered material will be placed below the subsoil and topsoil layers as this will provide a cover of competent material and avoid the exposure of large rocks on the final surface. Any coarse rejects placed in the mine void will be covered with sufficient overburden to allow successful rehabilitation.

An initial assessment of interburden materials has not identified any risk of acid generation or soluble salt formation; hence, no specific handling or storage requirements are considered necessary.

*Domains 2–4*

The operational landforms associated with the Mine Infrastructure Domain and haul roads (contained within the Road Network Domain) will consist of flat to gently inclined surfaces with steeper perimeter embankments. Post-mining, these landforms will be shaped to create slopes consistent with the surrounding landform.

The operational landforms associated with the Auxiliary Infrastructure Domain, specifically the pipeline and power easement, will be predominantly the same as the pre-mining landform. This is because the pipeline follows the land's surface topography or is buried and the power lines will be on of spaced poles that will not change surface topography. At closure, power poles will be removed and only limited shaping will be required to return this land to its pre-mining landform. The pipeline may be retained to enhance post-mining agricultural activities.

The operational landforms associated with the rail spur will consist of a raised flat surface for the tracks, and steep perimeter embankments and/or adjacent cuttings. At closure, the embankments and cuttings will be retained while the infrastructure components removed. No reshaping of this domain element will be undertaken.

### 5.4.2 Soil Replacement Protocol

*Rehabilitation of Land to Rural Land Capability Class III (cropping land)*

CHC will include a layer of subsoil between the overburden material and the topsoil on land that will be re-established as Rural Land Capability Class III. This will improve the water-holding capacity of the rehabilitated landform and reinstate a more natural soil profile. Subsoil will be spread on overburden to a nominal depth of 500 mm prior to spreading a final cover of topsoil. The depth of topsoil will be a minimum of 300 mm. The ripping of the overburden material will form a deeper subsoil layer providing for a total soil profile of 1.1 m (**Figure 5.2**).

*Rehabilitation of Land to Rural Land Capability Classes IV–VII (pastoral land and woodland)*

CHC will include a layer of subsoil between the overburden material and the topsoil on land to be re-established as Rural Land Capability Class IV to VII. This will improve the water-holding capacity of the rehabilitated landform and reinstate a more natural soil profile. CHC may reduce or eliminate subsoil replacement in targeted areas of woodland rehabilitation as a means of investigating the effects of differing soil profiles on woodland development.

Topsoil and subsoil will each be spread to a minimum depth of 100–150 mm. This will give a combined depth of soil material on the rehabilitated landform of 200–300 mm. The subsoil layer will be spread on an even but roughened surface that has been ripped on the contour to break any compacted and/or smooth surfaces. Ripping will also assist the keying of subsoil into the overburden, which will in turn assist in the prevention of land slip, assist vegetation penetrate deep into the soil profile, encourage water infiltration and percolation, and minimise erosion.

Tree trunks and branches less than 300 mm in diameter and other smaller vegetative debris removed during clearing activities, where available, will be spread over those areas to be restored as rehabilitated woodland.

*Rehabilitation of Tailings Dams*

Decommissioned tailings dam areas will be allowed to dry to form a geotechnically stable surface. This process is expected to take about 5 years. Once the surface is geotechnically stable CHC will rehabilitate the area by:

- capping the area with a minimum of 1 m of low permeability material (e.g. course reject);
- adding a minimum of 1.2 m of material with wide interstitial spacing over the cap. This will form a ‘capillary break’ preventing water from moving upwards from the cap to the soil layer; and
- covering with topsoil and subsoil in accordance with the relevant post-mining Rural Land Capability classification.

*Quantity of Soil Required for the Rehabilitation Program*

The domains that require soil replacement works are Domains 1, 2, 3 and 4. The raw water dam (Domain 5) will remain in place and not require soil replacement works (refer **Section 4.4**). Domains 3 and 4 contain mine elements that may not disturb the soil profile at depth across the entire domain; however, this assessment has assumed that all of Domains 3 and 4 may need rehabilitation to provide a conservative estimate of the maximum required soil resources.

The rehabilitation of the disturbance footprint, using the soil spreading depths specified above, will require approximately 8.6 MCM of soil (**Table 5.5**). Sufficient soil resources are available to achieve the rehabilitation objectives (refer **Table 5.2**)

**Table 5.5: Volume of Soil Material Required**

| Rural Land Capability | Nominal Soil Depth (m) | | | Area[1] | Total Volume of Soil Required |
|---|---|---|---|---|---|
| Class | Topsoil | Subsoil | Total | ha | MCM |
| III | 0.3 | 0.5 | 0.8 | 439 | 3.51 |
| IV and VI | 0.15 | 0.0 | 0.15 | 2,373 | 3.56 |
| VI and VII | 0.1 | 0.0 | 0.1 | 1,488 | 1.49 |
| **Total** | | | | **4,300** | **8.56** |

1 Total disturbance area is 4,536 ha; however, not all land will be rehabilitated, e.g. raw water dam, final voids and roads.

### 5.4.3 Soil Respreading and Seedbed Preparation

The following techniques are recommended to ensure optimum establishment and growth of vegetation:

- Ameliorate soils to minimise limitations, as identified in **Section 5.3.1**. The main limitation for the PAA's soil is weak soil structure. This limitation can be managed by the addition of organic matter as organic matter increases soil aggregate stability and improves soil structure.
- Soil will be ameliorated to improve any inherent limiting factors identified in Section **5.3.1**.
- Topsoil will be spread, treated with fertiliser and seeded in one consecutive operation in order to reduce the potential for topsoil loss from wind and water erosion.
- Where practical, soil will be respread directly onto reshaped areas to the depths specified in **Table 5.5**.
- All topsoiled areas will be lightly contour ripped (after topsoil spreading) to create a 'key' between the soil and the underlying material (e.g. spoil). Ripping will be undertaken on the contour. Best results will be obtained by ripping when soil is moist and when undertaken immediately prior to sowing.
- All topsoiled areas will be scarified prior to or during seeding to reduce run-off and increase infiltration. This can be undertaken by contour tilling with a fine-tined plough or disc harrow.
- The spreading of soil, addition of soil ameliorants, and application of seed will be carried out in consecutive operations to reduce the potential for soil loss to wind and water erosion. Revegetation will be performed immediately following application of the growth medium to avoid erosion.
- Fertiliser additions will be undertaken upon routine receipt of soil test results during a proposed progressive soil-testing program.

### 5.4.4 Surface Management Structures

Surface-water management structures will be progressively installed on the rehabilitated landform. The heights (effective depths) and cross-sectional areas of the individual banks, drains and drop structures will be determined on the basis of individual subcatchment areas. Rock-lined drains will be used, where required, to convey water safely from the rehabilitated landform into the surface-water management system that conveys run-off from the site.

### 5.4.5 Vegetation Establishment

#### *5.4.5.1 Agricultural Land Pasture Sowing*

Following application of topsoil, the areas designated for a post-mining agricultural use (pastoral and cropping) will be sown with a mixture of pasture species. The seed mixture will include fast-growing, short-lived species and perennial grasses and legumes. Example pasture mixes for cool and warm seasons are presented in **Table 5.6**. The pasture mix will be sown simultaneously with an appropriate fertiliser; for example, 250 kg/ha di-ammonium phosphate. Following establishment of these areas, it is anticipated that rotational cropping of pasture and suitable crops will be undertaken.

**Table 5.6: Example Pasture Species Seed Mix**

| Pasture Species | Rate (kg/ha) |
|---|---|
| Warm Season Grasses | |
| Bombatsi Panic | 1–2 |
| Green Panic[1] | 2–4 |
| Rhodes Grass[1] | 1–2 |
| Purple Pigeon Grass | 1–2 |
| Annual Legumes | |
| Subterranean Clover | 4–5 |
| Cool Season Legumes | |
| Barrel (Sephi) Medic | 2–4 |
| Snail (Sava) Medic[1] | 3–5 |
| Woolly Pod Vetch | 4–6 |
| Serradella (Elgara) | 1–2 |
| Lucerne | 0.5 |
| Cool Season Grasses | |
| Phalaris (Sirolan or Holdfast) | 1–2 |
| Wallaby Grass | 0.3–1 |

1 Inoculated with appropriate rhizobia

#### *5.4.5.2 Native Vegetation (Woodland) Establishment*

Following the application of topsoil, the areas designated to be restored as rehabilitated woodland will be initially stabilised with a non-persistent cover crop followed by planting and sowing of a selection of locally occurring trees, shrubs and groundcovers.

A combination of native pasture species will be used on the woodland sites to ensure the rapid establishment of a continuous groundcover, thereby reducing the risk of erosion. Legumes may also be selected to assist in the supply of bio-available nitrogen to the soil. If the use of introduced grasses and/or legumes is deemed necessary for erosion control in the woodland areas, pasture seed and fertiliser will be applied at a lower rate than for pastoral land to reduce competition with tree seed and/or seedlings. Native and exotic pasture species (warm season perennial, cool season perennial, year-long green perennial and annual) will be sown where the risk of erosion is less and on the more protected aspects of landforms.

Tree species will be selected in accordance with the Project's biodiversity offset strategy (**Table 5.7**). The species selection will encourage the re-establishment of the pre-agricultural vegetation communities and, in the medium to longer term, create habitat and corridors for native fauna.

It is anticipated that tube stock will be propagated from locally collected seed though CHC's seed collection program. Tube stock will be used in strategic landscape plantings around the site to mitigate visual impacts. Large areas will be sown by direct seeding methods where site conditions allow.

All areas identified for woodland and pasture re-establishment will be fenced and stock will be excluded until it can be demonstrated that the vegetation is stable and self-sustaining and that grazing will not adversely impact on vegetation establishment and erosion will be minimised.

**Table 5.7: Target Tree Species Mix**

| Land Use | Rural Land Capability Class | Dominant Landform | Target Tree Species |
|---|---|---|---|
| Woodland | IV | Flat to gentle slopes | Blakely's Red Gum (*Eucalyptus blakeyi*), Yellow Box (*E. Mellidor*), White Box (*E. albens*), Grey Box (*E. microcarpa),* Rough-barked Apple (*Angophora floribunda*) and Kurrajong (*Brachychiton populneus*) |
| Pastoral | VI | Moderately to steep slopes | Black Cypress Pine (*Callitris endlicheri*), Red Ironbark (*E. sideroxylon*), Broad-leaved Red Ironbark (*E. fibrosa*) and Red Stringybark (*E. macrrorhyncha*) |

### 5.4.6 Rehabilitation Maintenance

Effective rehabilitation requires an ongoing monitoring and maintenance program throughout and beyond the operational life of the mine. Areas being rehabilitated will be regularly inspected and assessed against the long-term and short-term rehabilitation objectives outlined in **Section 5.1**.

Maintenance activities will be initiated if rehabilitation efforts do not meet success criteria. These may include reseeding and, where necessary, applying additional topsoil and/or applying specialised treatments (such as composted mulch) to areas with insufficient vegetation establishment. Tree guards will be placed around tube stock if grazing by native animals is found to be excessive.

If drainage controls are found to be inadequate or are compromised by grazing stock or wildlife they will be repaired and/or temporary fences installed to exclude animals. Should areas of excessive erosion or sedimentation be identified, remedial works – such as the importation of additional fill, subsoil or topsoil material or the redesigning of water management structures to address erosion – will be implemented.

No time limit has been placed on post-mining rehabilitation maintenance. Rather, maintenance will continue until such time as the success criteria (**Section 5**) are met, although it is generally accepted that is will be at least five years beyond closure.

## 5.5 Weed Management

The presence of weed species has the potential to have a major impact on the success of revegetation and regeneration outcomes. In addition to this, weed species in the surrounding area have the potential to significantly impact on the biodiversity value of rehabilitated areas. Weed management will be a critical component of mine rehabilitation and landscaping activities.

CHC will take the necessary precautions to prevent the excessive occurrence of weeds within the rehabilitated areas. The following weed management measures will be implemented during soil stripping and rehabilitation works.

- The PAA induction program will be used to promote awareness of weed management measures.
- Specific training in weed identification and eradication measures will be provided to relevant site personnel and contractors.
- Contracted equipment involved with rehabilitation operations will be hosed down in an approved wash-down area before entry to site.
- When necessary, spraying herbicide or removing the top layer ('scalping'), including weeds, of topsoil stockpiles will take place prior to respreading.
- Rehabilitation inspections will be carried out to identify potential weed infestations.
- Details of all weed management and eradication programs and follow-up inspections will be entered into the site's environmental management database.
- Existing weed populations on site will be identified and sprayed, together with ongoing weed spraying over the life of the mine.

- Vegetation and topsoil stripped from the weed risk areas with known infestations will be stripped and stockpiled separately. These stockpiles will be marked and recorded in the site's environmental management database.
- Topsoil stripped from weed risk areas with known infestations will either be buried (if treatment is not practicable) or treated (several times if necessary). The decision to bury or treat topsoil from weed risk areas will involve an assessment of the volume of material involved, the dormancy of the particular weed species, the likely number of treatments required, the likely success in eradicating the weed species from the stripped soil and whether the treatment will significantly affect the viability of native seeds and / or the fertility of the soil.
- Soils from weed risk areas that are used in the rehabilitation program will be closely monitored after rehabilitation and any residual weeds that germinate will be treated as appropriate.

Weed control will be undertaken in a manner that will minimise soil disturbance. Any use of herbicides will be carried out in accordance with NSW Government Department of Trade and Investment, Regional Infrastructure and Services (DTIRIS) and Office of Environment and Heritage (OEH) requirements. Records of weed infestations will be maintained and control programs implemented according to best management practice for the weed species concerned.

## 5.6 Water Management in Rehabilitation Areas

Where practicable, water management structures (such as contour banks and drains) will be constructed with longitudinal gradients that permit the transfer of water at non-erosive velocities (e.g. 1:100 (V:H)). Consequently, specialised rehabilitation treatments will generally not be required. Similarly, rock-lined drop structures constructed on the slopes of the emplacements and final void will be retained and allowed to revegetate naturally.

The planting of trees and other vegetation around the various water management structures will enhance the filtration ability of these structures and surrounding areas and minimise the potential for erosion, as well as encouraging their use by native fauna.

In the event that unacceptable levels of erosion are observed, specific fast-growing species and/or specialised treatments such as bitumen/jute meshing or rock lining are recommended.

## 5.7 Erosion and Sediment Control

### 5.7.1 Principle Objectives

A detailed Erosion and Sediment Control Plan will be developed prior to the commencement of rehabilitation works. The principle objectives of the Erosion and Sediment Control Plan will be to:

- minimise erosion and sedimentation from all active and rehabilitated areas, thereby minimising sediment ingress into surrounding surface waters;
- segregate contact water (surface run-off from disturbed catchments; e.g., active areas of disturbance, stockpiles and rehabilitated areas until stabilised), from clean water (surface run-off from catchments that are undisturbed or relatively undisturbed by project-related activities and rehabilitated catchments) and maximise the retention time of contact water so that any discharge from the PAA meets the relevant water quality limits;
- prevent water from being discharged from the PAA but, should water be displaced from the site, enable sufficient settlement/treatment time prior to discharge so that suspended sediment within the water meets the objectives;
- manage surface flows upstream of the PAA so that rehabilitation activities are not affected by flooding;
- prevent erosion of the ephemeral watercourses that traverse the site;

- establish sustainable long-term surface water management features following rehabilitation of the site, including implementation of an effective revegetation and maintenance program; and
- monitor the effectiveness of surface water and sediment controls in order to meet all relevant surface water quality criteria.

### 5.7.2 Principle Design Aspects

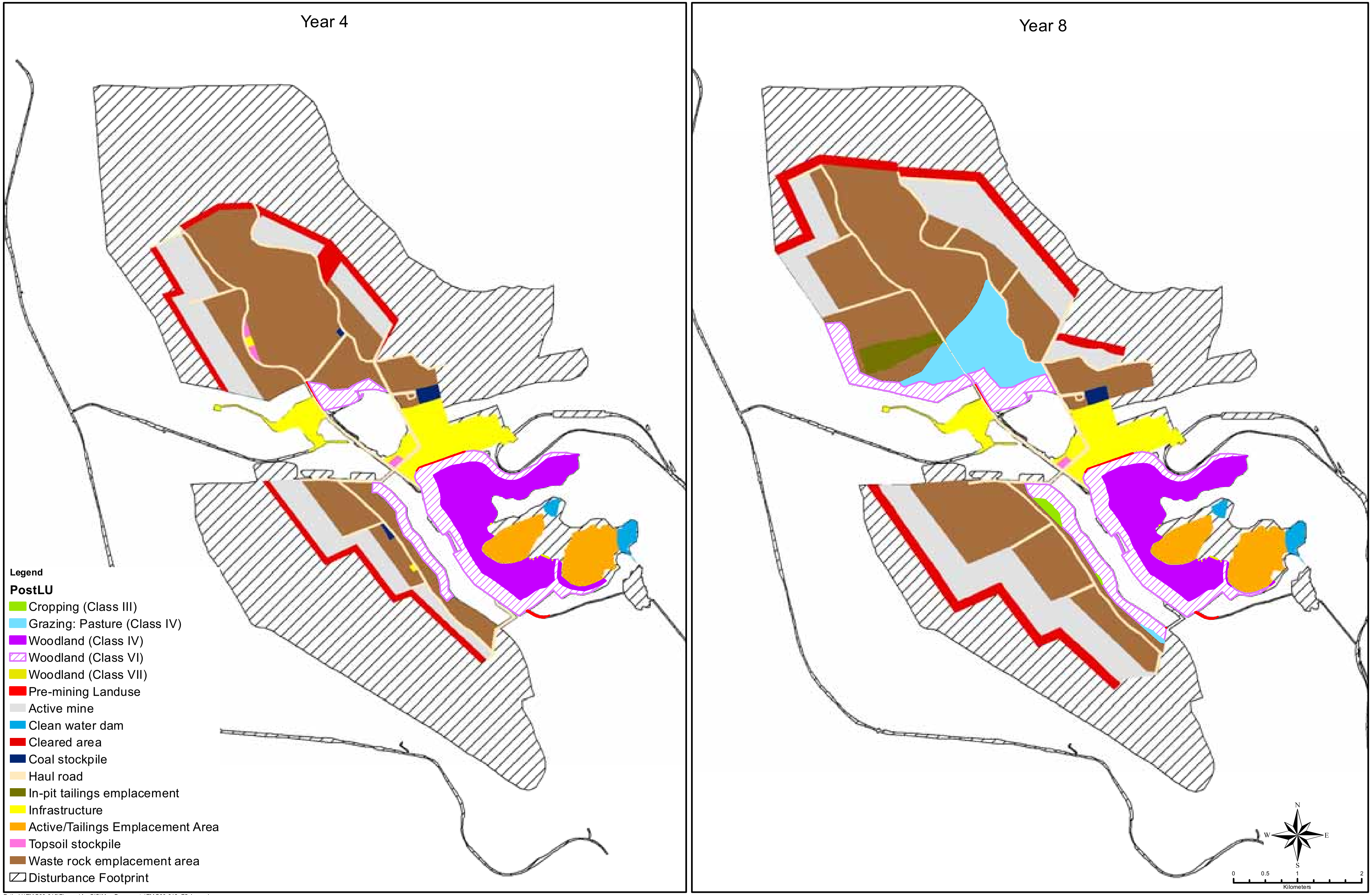
The primary design aspect of the Project is the prevention of clean water in ephemeral drainage channels entering the active disturbance footprint. This will be achieved through the use of diversionary structures such as drains, berms and banks, as well as the containment of contact water in sediment control structures within the active areas of the PAA to eliminate uncontrolled run-off.

Effective erosion and sediment control for the PAA will require appropriate activities to be carried out over the life of the Project including during construction, mine operations and rehabilitation and mine closure.

### 5.7.3 Planning and Design Strategies

The effectiveness of erosion and sediment controls for rehabilitated areas will be optimised through effective planning and design. Suitable strategies will include:

- designing and operating drainage systems for the life of the Project so that they do not cause erosion;
- designing the final Project geometry to create a landform that allows free drainage of surface run-off while minimising erosion (this includes designing an appropriate drainage system that avoids erosion); and
- re-using water as part of the overall water management strategy for the site.

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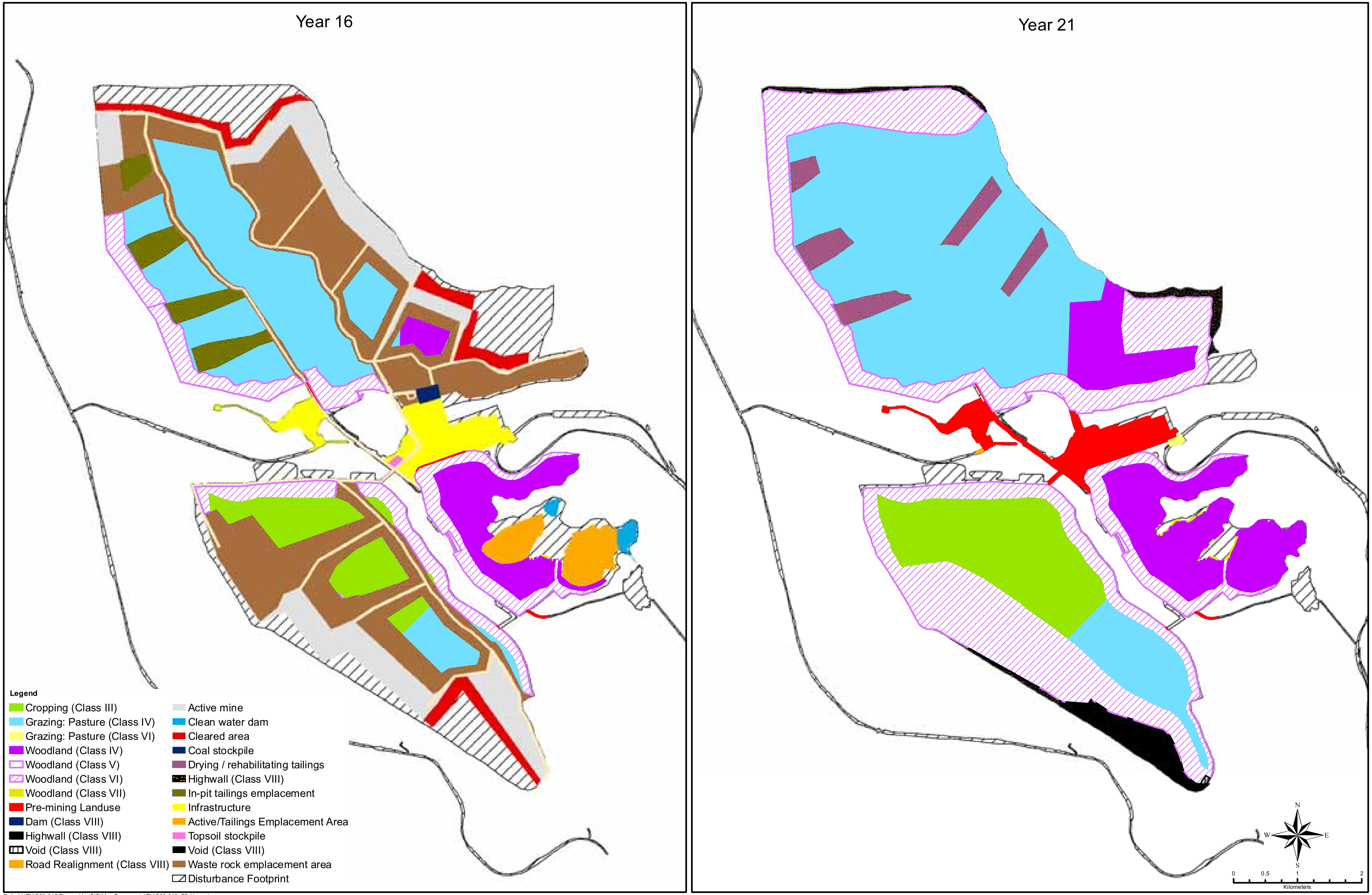
Mine Rehabilitation Strategy: Staged Rehabilitation Year 4 & 8

Cobbora Coal Project

**Figure 5.1a**

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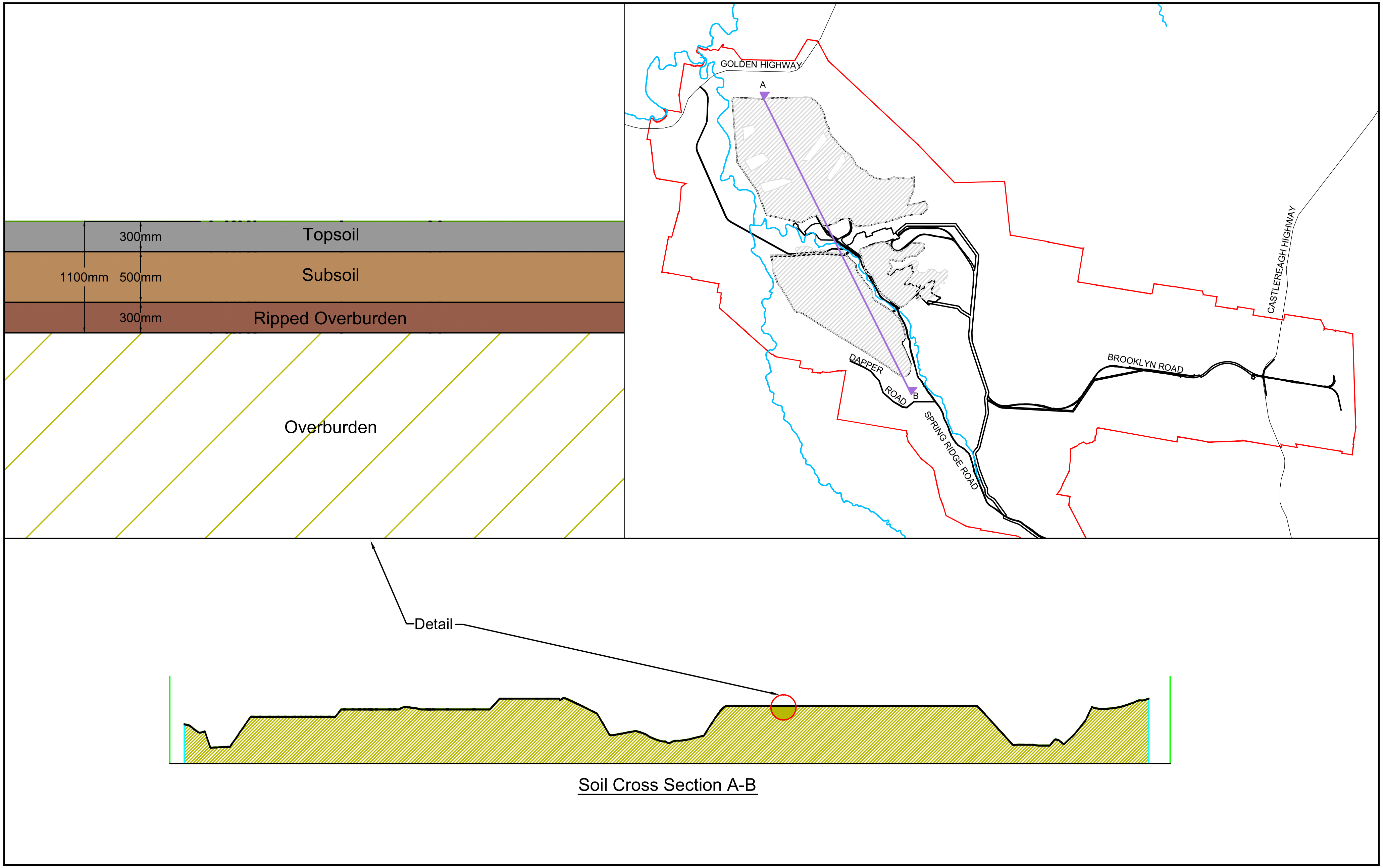
Mine Rehabilitation Strategy: Staged Rehabilitation Year 16 & 21

Cobbora Coal Project

**Figure 5.1b**

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Re-instated Soil Profile
Cobbora Coal Project

**FIGURE 5.2**

# 6.0 REHABILITATION MONITORING AND PERFORMANCE

This section provides information on recommended rehabilitation success criteria and monitoring requirements. The monitoring program will be finalised during the development of the Rehabilitation Management Plan, which will form part of the Mining Operations Plan (MOP).

## 6.1 Preliminary Rehabilitation Success Criteria

Rehabilitation planning criteria presented in this section have been taken from *Strategic Framework for Mine Closure* (ANZMEC, 2000) to ensure the most appropriate and efficient rehabilitation techniques are applied. CHC will seek advice from representatives of the DTIRIS, DP&I and OEH regarding any additional actions that may need to be adopted.

Key performance outcomes that are built into the preliminary rehabilitation success criteria include:

- clearing and/or vegetation disturbance and rehabilitation progress consistent with the MOP;
- successful establishment of vegetation on the final landform consistent with the MOP;
- progressive achievement of landform and land use objectives;
- achievement of the committed objectives with respect to flora and fauna, soil resources, Rural Land Capability class, erosion and sediment control and air quality;
- verification of achievements through monitoring;
- a legally binding arrangement to secure the long-term security of the biodiversity offset areas; and
- performance reporting in the annual environmental management report (AEMR).

The success criteria (often referred to as ‘closure criteria’) are performance objectives or standards against which rehabilitation success (i.e. achieving a sustainable system for the proposed post-mine land use) is measured. Satisfaction and maintenance of the success criteria (as indicated by monitoring results) will demonstrate that the rehabilitated landscape is ready to be relinquished from the mine’s financial assurance and handed back to stakeholders in a productive and sustainable condition. The preliminary success criteria for the rehabilitation areas are identified in **Tables 6.1** and **6.2**.

The success criteria comprise indicators for vegetation, fauna, soil, stability, land use and safety on a landform-type basis that reflects the nominated post-mine land use of a mosaic of native woodland, open grasslands with selective grazing opportunities and dryland cropping.

Criteria that define rehabilitation success at mine closure are provided for each rehabilitation element. Based on the generic indicators provided, each criterion will be further developed to be specific, measurable, achievable, realistic and outcome based, and to reflect the principle of sustainable development. This will be based on results of further research and ongoing monitoring of the progressive rehabilitation areas. The success criteria will be reviewed every three to five years with stakeholder participation to ensure the nominated success criteria remain realistic and achievable.

### 6.1.1 Rural Land Capability Class III Land

Proposed success criteria have been developed based on the PAA’s Rural Land Capability Class III land characteristics compared to a reference site (**Table 6.1**). The reference site will be selected prior to the commencement of the initial rehabilitation campaign.

**Table 6.1: Success Criteria: Rural Land Capability Class III Land**

| Reinstatement Element | Indicator | Criteria |
|---|---|---|
| Landform stability | Slope gradient | Less than 3% |
| | Erosion control | Erosion control structures are installed commensurate with the slope of the landform |
| | Surface-water drainage | Use of contour banks and diversion drains to direct water into stable areas or sediment control basins |
| Soil | Soil depth | Minimum of 300 mm subsoil and 200 mm topsoil |
| | Soil structure | Structural attributes to be on par or better relative to the control site. The target attribute is pedality and it is predicted that optimal structure will be represented by 'moderate structure', evidenced by presence of moderate peds |
| | Salinity (electrical conductivity) | Soil salinity is <0.5 dS/m |
| | pH | Soil pH is between 5.5 and 8.5 |
| | Sodicity | Soil exchange sodium percentage (ESP) is <6% |
| | Nutrient cycling | Macro- and micro-nutrients similar to a reference site. These include nitrogen, phosphorous and cation exchange capacity and sulphur |
| | | Nutrient accumulation and recycling processes are occurring as evidenced by the presence of a litter layer, mycorrhizae and/or other microsymbionts |
| Vegetation | Land use | Land is useable as a functioning agricultural system as per the Class III Rural Land Capability parameters |
| Soil fauna | Species composition | Representation of a range of soil species such as earthworms, springtails and fungi relative to the control site |

### 6.1.2 Rural Land Capability Class IV–VIII Land

The success criteria for all other parts of the disturbance footprint are provided in **Table 6.2**.

**Table 6.2: Preliminary Rehabilitation Success Criteria: General**

| Item | Rehabilitation Element | Indicator | Criteria |
|---|---|---|---|
| 1 | Domain 1: In-pit Overburden | | |
| 1.1 | Landform stability | Slope gradient | At least 75% of the area has overall slopes ≤3H:1V<br>Where the slopes are steeper, additional water management structures will be utilised as required |
| | | Erosion control | Erosion control structures are installed at intervals commensurate with the slope of the landform |
| | | | Average soil loss per annum is <40 t/ha/yr (sheet erosion) |
| | | | Dimensions and frequency of erosion rills and gullies are generally no greater than that in reference sites that exhibit similar landform characteristics |
| | | Surface water drainage | Contour banks and diversion drains are used to direct water into stable areas or sediment control basins |
| | | | All landforms are free-draining except where specific structures (i.e. dams) have been constructed for the storage of water as required for sediment and erosion control or some post-mining land use |
| 1.2 | Water quality | Water quality | Run-off from rehabilitation areas has water quality limits within an acceptable range |
| 1.3 | Soil | Soil depth | Class IV land: minimum of 300 mm<br>Class VI land: minimum of 200 mm |

| Item | Rehabilitation Element | Indicator | Criteria |
|---|---|---|---|
| | | Salinity (electrical conductivity) | Soil salinity content is <0.6 dS/m |
| | | pH | Soil pH is between 5.5 and 8.5 |
| | | Sodium content | Soil ESP is <15% |
| | | Nutrient cycling | Nutrient accumulation and recycling processes are occurring, as evidenced by the presence of a litter layer, mycorrhizae and/or other microsymbionts |
| | | | Adequate macro- and micro-nutrients are present |
| 1.4 | Vegetation: woodland | Land use: woodland | Area accomplishes and remains as a healthy stand of shrubs, trees and grass species |
| | | | The site can be managed for its designated land use without any greater management inputs than other land in the area being for a similar purpose |
| | | Surface cover | Minimum of 70% vegetative cover is present (or 50% if rocks, logs or other features of cover are present) |
| | | | No bare surfaces >20 $m^2$ in area or >10 m in length down slope |
| | | Species composition | A mixture of native trees, shrubs and grasses representative of regionally occurring vegetation are present subject to proposed land use |
| | | | Vegetation communities are developed to attract and support recolonisation by native flora and fauna species found in the area |
| | | Resilience to disturbance | Established species survive and/or regenerate after disturbance |
| | | | Weeds do not dominate native species after disturbance or after rain |
| | | | Pests do not occur in substantial numbers or visibly affect the development of native plant species |
| | | Sustainability | Species are capable of setting viable seed, flowering or otherwise reproducing; evidence of second generation of shrub and understorey species |
| | | | Vegetation develops and maintains a litter layer evidenced by a consistent mass and depth of litter over subsequent seasons |
| | | | More than 75% of shrubs and/or trees are healthy when ranked healthy, sick or dead |
| 1.5 | Vegetation: pastoral agricultural land | Land use | Land is useable as functioning agricultural system as per the Rural Land Capability Class IV parameters |
| | | | The site can be managed for its designated land use without any greater management inputs than for land in the area being used for a similar purpose |
| | | Surface cover | Minimum of 70% vegetative cover is present (or 50% if rocks, logs or other features of cover are present) |
| | | | No bare surfaces >20 $m^2$ in area or >10 m in length down slope |
| | | Species composition | Subject to proposed land use, comprise a mixture of native trees, shrubs and grasses representative of regionally occurring vegetation where possible |
| | | | Pastoral lands are developed to attract and support the recolonisation of target pastures grasses |
| | | Resilience to disturbance | Established species survive and/or regenerate after disturbance |
| | | | Weeds do not dominate native species after disturbance or after rain |
| | | | Pests do not occur in substantial numbers or visibly affect the development of native plant species |
| | | Sustainability | Grass species are capable of setting viable seed, |

| Item | Rehabilitation Element | Indicator | Criteria |
|---|---|---|---|
| | | | flowering or otherwise reproducing; evidence of second generation of shrub and understorey species |
| | | | All surfaces are regraded to the agreed landform and revegetated to a self-sustaining condition similar to vegetation in comparable local areas and to a standard consistent with data obtained from pre-mining baseline environmental studies |
| 1.6 | Fauna: woodland | Vertebrate species | A range of representative species characteristics from each faunal assemblage group (e.g. reptiles, birds and mammals) are present, based on pre-mine fauna lists and fauna sighted within the three-year period preceding mine closure<br>The number of vertebrate species does not show a decrease over a number of successive seasons prior to mine closure |
| | | Invertebrate species | Presence of representatives of a broad range of functional indicator groups involved in different ecological processes |
| | | Habitat structure | Typical food, shelter and water sources required by the majority of vertebrate and invertebrate inhabitants of that ecosystem type are present, including: a variety of food plants<br>Evidence of active use of habitat provided during rehabilitation such as nest boxes and logs, and signs of natural generation of shelter sources including leaf litter |
| 1.7 | Visual | Visual amenity | Long-term visual impact is minimised by creating acceptable landforms, preferably compatible with adjacent landscape |
| 1.8 | Safety | Physical | Excavations are rendered safe |
| | | | All drill holes, pits, open cuts and other openings are securely capped, filled or otherwise made safe |
| | | | Access by members of the public and livestock is restricted as appropriate to site conditions |
| | | | No rubbish remains at the surface, or is at risk of being exposed through erosion |
| 2 | Mining Operations Domain: Final Void (including ramps and highwalls) | | |
| 2.1 | Landform stability | Stability | Inspection undertaken by a qualified geotechnical engineer to ensure that there is no subsidence or slipping of the pit walls present or that is a threat to the long-term stability of the pit abandonment bunds |
| 2.2 | Safety | Risk assessment | Risk assessment undertaken in accordance with relevant guidelines and Australian Standards and risks at levels agreed with the stakeholders |
| | | Physical | As per Item 1.8 |
| 3 | Mine Infrastructure Domain and Auxiliary Infrastructure Domain | | |
| 3.1 | Landform stability | Slope gradient | Regraded batters consistent with surrounding area |
| | | Erosion control | Erosion mitigation measures have been applied<br>Average soil loss per annum per domain unit is <40 t/ha/yr (sheet erosion) |
| | | Surface water drainage | Use of contour banks and diversion drains to direct water into stable areas or sediment control basins |
| 3.2 | Water quality | Water Quality | As per Item 1.2 |
| 3.3 | Soil | Soil Depth | As per Item 1.3 |
| | | Salinity (electrical conductivity) | |
| | | pH | |
| | | Sodium content | |

| Item | Rehabilitation Element | Indicator | Criteria |
|---|---|---|---|
| | | Nutrient cycling | |
| 3.4 | Vegetation:<br>agricultural land use | Land use | As per Item 1.5 |
| | | Surface cover | |
| | | Species composition | |
| | | Resilience to disturbance | |
| | | Sustainability | |
| 3.5 | Visual | Visual amenity | As per Item 1.7 |
| 3.6 | Safety | Physical | As per Item 1.8 |

## 6.2 Rehabilitation Monitoring Design

Regular monitoring of the rehabilitated areas will be required during and after the initial vegetation establishment to determine whether the objectives of the rehabilitation strategy are being achieved. **Table 6.3** presents the elements of the recommended monitoring program, including monitoring frequencies.

Monitoring will be conducted periodically by suitably skilled and qualified persons at locations that are representative of the range of conditions in the rehabilitating areas. Annual reviews will be conducted of monitoring data to assess trends and monitoring program effectiveness. The outcome of these reviews will be reported in each AEMR.

In developing the rehabilitation monitoring program, the following aspects will be taken into consideration:

- Replicated monitoring sites will be established in representative rehabilitation areas of different ages. One monitoring site per 20–40 ha is recommended for each major age class of the rehabilitation areas.
- Sites will be monitored 12 months after establishment and then every two years.
- A standard monitoring plot design for areas rehabilitated with trees will use:
  - 2 m x 2 m quadrants – these will provide some estimate of statistical variance so that, if required, statistical analyses can be undertaken to objectively compare different rehabilitation treatments and changes over time;
  - a 20 m x 10 m plot overlying the 2 m quadrants and located 5 m either side of the centerline, for ease of monitoring; and
  - a 50 m erosion monitoring transect on contour, running through the centre of the plot.

For the areas rehabilitated as pasture, it is proposed that a 100 m transect be established across a ‘typical’ section of rehabilitation at the site and monitored for:

- grass cover in 2 m x 2 m (4 $m^2$) plots every 20 m;
- pasture species present;
- weed species present and percentage of area covered;
- percentage of bare ground; and

- extent and type of erosion.

Along the 100 m transect, general comments (such as rocks present, presence/absence of topsoil and other factors likely to influence rehabilitation development) will be noted.

Site-specific rehabilitation methods will be improved as additional knowledge develops from monitoring data collected through these programs.

**Table 6.3: Recommended Rehabilitation Monitoring Program**

| Item | Aspect of Rehabilitation | Elements to be Monitored | Monitoring Frequency |
|---|---|---|---|
| 1 | Ecosystem Establishment | | |
| 1.1 | General description | Describe the vegetation in general terms; for example:<br>for woodland land use, mixed eucalypt woodland with grass understory and scattered shrubs, dense acacia scrub, etc.<br>for pastoral grazing – density of pasture grass and species.<br>for cropping – crop type | Twelve months after establishment and then every two years |
| 1.2 | 2 m x 2 m quadrants | Count the number of plants of all species, excluding grass<br>Measure live vegetation cover for understorey and grasses (separately) using a line intercept method<br>Record details of ground cover (litter, logs, rocks, etc.) | Twelve months after establishment and then every two years |
| 1.3 | 20 m x 10 m plots | *Woodland*<br>Count all trees >1.6 m tall by species<br>Tag and measure depth, breadth and height (DBH) of trees >1.6 m tall, to a maximum of 10 for any one species<br>Record canopy cover over the whole 20 m centreline when trees are tall enough<br>Subjectively describe tree and/or grass health as relevant, by species if relevant, noting signs of drought stress, nutrient deficiencies, disease and severe insect attack. Where health problems are noted, record the percentage of unhealthy trees/grasses<br>Record any problem and declared noxious weeds<br>Take five surface soil samples (e.g. at approx. 5 m intervals along the centreline) and bulk these for analyses of: pH, electrical conductivity, chloride and sulfate; exchangeable Ca/Mg/K/Na; cation exchange capacity; particle size analysis and R1 dispersion index; 15 bar and field capacity moisture content; organic carbon; total and nitrate nitrogen; total and extractable phosphorus; and copper, manganese and zinc concentrations | Twelve months after establishment and then every two years |
| 1.4 | 100 m transect | *Pastoral land*<br>Measure live vegetation grass cover in 2 m x 2 m (4 $m^2$) plots every 20 m<br>Record pasture species present<br>Record weed species present and percentage of area covered<br>Record percentage of bare ground and extent and type of erosion<br>Subjectively describe pasture health as relevant by species; if relevant, noting signs of drought stress, nutrient deficiencies, disease and severe insect attack. Where health problems are noted, | Twelve months after establishment and then every two years |

| Item | Aspect of Rehabilitation | Elements to be Monitored | Monitoring Frequency |
|---|---|---|---|
| | | record the percentage of unhealthy trees/grasses<br>Record any problem and declared noxious weeds<br>Take five surface soil samples (e.g. at approx. 5 m intervals along the centreline) and bulk these for analyses as per Item 1.3 | |
| 1.5 | 20 m x 10 m plots | *Cropping land*<br>Record annual average crop production and compare with district average<br>Record pasture species present<br>Record weed species present and percentage of area covered<br>Record extent and type of erosion<br>Take five surface soil samples (e.g. at approx. 5 m intervals along the centreline) and bulk these for analyses as per Item 1.3 | Annually |
| 1.6 | 50 m transect | Along the 50 m erosion monitoring transect, record the location, number and dimension of all gullies >30 cm wide and/or 30 cm deep<br>Erosion pins should be established in plots located in newer rehabilitation to record sheet erosion if present | Twelve months after establishment and then every two years |
| 1.7 | Rehabilitation in general | When traversing between monitoring plots, note the presence of species of interest not previously recorded (e.g. key functional or structural species, protected species, and noxious weeds), as well as obvious problems including any extensive bare areas (e.g. those greater than 0.1 ha) | Twelve months after establishment and then every two years |
| 1.8 | Photographic record | For each 20 m x 10 m plot, a photograph should be taken at each end of the plot, along the centreline, looking in | Twelve months after establishment and then every two years |
| 1.9 | Habitat | When traversing between monitoring plots, note general observations relating to the availability and variety of food sources (e.g. flowering/fruiting trees, presence of invertebrates, etc.)<br>Availability and variety of shelter (e.g. depth of leaf litter, presence of logs and hollows)<br>Presence/absence of free water in the rehabilitated areas | Twelve months after establishment and then every two years |
| 1.10 | Fauna | When traversing between monitoring plots, note general observations of vertebrate species (including species of conservation significance)<br>Detailed fauna surveys including presence and approximate abundance and distribution of vertebrate species (focusing on species of conservation significance) | After rehabilitation is three years old, undertake monitoring in autumn and spring and then every two years |
| 1.11 | Weeds and pests | When traversing between monitoring plots, note species identity, the approximate numbers / level of infestation and observations of impact on rehabilitation (if any) | Quarterly during the first two years and every two years after that<br>Inspections should be opportunistic after significant rainfall events |
| 2 | Geotechnical Stability | | |
| 2.1 | Stability | Assessment of the stability of embankments and cuttings and also looking at surface settlements (sink holes). In particular where these features could impact on the performance of any surface water management system<br>Surface integrity of landform cover/capping | Annually |

| Item | Aspect of Rehabilitation | Elements to be Monitored | Monitoring Frequency |
|---|---|---|---|
| | | (measurement of extent of integrity failure)<br>Presence/absence of landform slumping | |
| 3 | Surface and Groundwater | | |
| 3.1 | As described in the groundwater and surface water monitoring programs | | N/A |

# 7.0 FINAL VOID MANAGEMENT

Open-cut mining commonly leaves an open pit (final void) at the end of operations. These pits must be left a condition that is stable, safe and does not cause contamination.

It is envisaged that a single void will remain at mine closure that will cover approximately 110 ha and have a maximum depth of 34 m (**Figure 5.1b**). However, given that groundwater monitoring during operations will provide valuable data for final void design, the final void configuration and depths will be detailed in the mine closure plan that will be prepared in year 15, five years before closure.

## 7.1 Objectives

The primary objectives of the final void management section of this mine rehabilitation strategy are to:

- present options for the final land use of the void following the completion of mining;
- propose rehabilitation measures to minimise potential off-site impacts associated with the final void; and
- propose measures to be incorporated in the final landform to ensure the voids are safe.

## 7.2 Final Land Use Options (Final Void)

The options available for post-mining land use(s) of the final void are generally determined by the location and nature of the void, and although the options presented at this time are considered appropriate, there may be more appropriate options at the time of mine closure.

Waste rock and backloaded coal rejects will be placed into the mined-out areas to the greatest extent practicable during the mine life. It is proposed to backfill three of the mined-out areas to 3 m above the final water table, with the exception of approximately 50% of the void associated with Mining Area B. This will minimise the overall size of the remaining void. As described in Parsons Brinkerhoff (2012), it is anticipated that the remaining final void will contain a lake.

## 7.3 Final Void Rehabilitation

### 7.3.1 Void Slope Stability

*Low Walls*

The low wall is the side of the pit containing waste rock. For the purposes of this assessment, it is assumed that the low walls of the final void will comprise of disturbed and fragmented waste rock. Stability of the low wall will be achieved in the following manner.

- The low wall will be battered back from the angle of repose to ensure the long-term geotechnical stability of the face. Determination of the geotechnical stability of the low wall and recommendations on the final slope will be undertaken by a qualified geotechnical engineer. This will be on the basis of an assessment of the material forming the low wall of the void, the likely degree of settlement, and the degree of weathering expected in the long term. However, it is expected that the low wall sides of the final void will be battered back to 10° where practical or a maximum of 18°.
- Surface-water drainage on and over the low wall will be minimised through the construction of drainage control structures aimed at diverting as much of the catchment as possible away from the final void and back into the surface-water system.
- Erosion of the low wall will be controlled by limiting the length of slope through the use of contour and graded drains, minimising the slope, and by the establishment of suitable vegetation in accordance with the requirements described in **Section 5**.

All low wall areas will be revegetated in accordance with **Section 5**.

*High Wall*

The high wall is the actively mined side of the pit. For the purposes of this assessment, it is assumed that the high wall will be comprised of undisturbed materials generally occurring above the economically lower-most limits of the mineable seam. The high wall material may comprise a range of naturally occurring soil or rock of varying strengths or states of weathering.

To ensure the safety of the final void, the surrounding final slopes will be left in a condition where the risk of slope failure is minimised. It is anticipated that the high wall of the final void will be left at approximately 45° to ensure long-term geotechnical stability, as determined by a suitably qualified geotechnical engineer.

Any assessment of the geotechnical stability of the high wall will consider the:

- long-term final void water level;
- height and inclination of slope and number and spacing of intermediate benches (as may be required to achieve the final slope);
- shear strength of the high wall soils and rocks;
- density and orientation of fractures, faults, bedding planes, and any other discontinuities, and the strength along them; and
- effects of the external factors, such as surface run-off.

### 7.3.2 Public Safety

At mine closure, the final void will be made safe to humans, livestock and wildlife. Key activities to be considered include:

- the battering back of low walls to ensure they are stable;
- where high walls are to be retained post-closure, an appropriately qualified geotechnical engineer will be consulted on final high wall design to ensure that the high wall remains stable;
- the covering of exposed coal seams with inert material to prevent ignition either from spontaneous combustion, bushfires or human interference;
- the construction of a physical barrier, if necessary, at a safe distance from the perimeter of the void to prevent human access. The high wall areas will be secured by the construction of trenches or safety berms. Addition security measures will be installed as required by DTIRIS. The trenches and berms will be constructed in such a way that will prevent access by vehicles;
- signs, clearly stating the risk to public safety and prohibiting public access, will be erected at 50 m intervals along the entire length of any fence;
- surface run-off from land surrounding the void will be diverted so as to prevent any potential development of instability of the void walls; and
- where practicable, grasses and shrubs/trees selected to conform to the agreed post-mining rehabilitation criteria and land use will be planted along the outside edge of the bund wall to lessen any visual impact of the wall.

# 8.0 REVIEW OF REHABILITIATION STRATEGY

This rehabilitation strategy is to be a dynamic document. While it has initially been prepared for this environmental assessment, it will be continually reviewed and updated throughout the life of the Project. Five years prior to mine closure, a more detailed mine closure plan will be prepared. Throughout the life of the Project, the key triggers for a review of this strategy will include, but not be limited to:

- issue of the Project Approval (i.e. amendments to reflect any additional requirements that might be included in the approval);
- changes in legislation or policy that applies to the operation; and
- progressive review throughout the life of the Project (in particular, if there are significant changes to the Project for which this rehabilitation strategy has been prepared).

# 9.0 CONCLUSION

This mine rehabilitation strategy has been prepared in accordance with the *Strategic Framework for Mine Closure*. The key findings of this strategy are listed below.

- The dominant Rural Land Capability is Class IV (46.5% of disturbance footprint, 35.7% of PAA). This land is mainly used for cattle and sheep grazing.
- Other major Rural Land Capability classifications include; Class III land (9.7% of disturbance footprint, 20.8% of PAA) that can be used for the production of crops and Class VI land (32.7% of disturbance footprint, 19.4% of PAA) which, where timber has been removed, can be is used for low intensity cattle grazing along with some merino wool production. The PAA also contains a small quantity of Class II land (2.1%), which is good quality cropping land.
- Post-mining, and following rehabilitation, the Project will reinstate the same quantity of Rural Land Capability Class III land as was present pre-mining. There will also be a 236 ha increases in Class IV land.
- The post-mining landform has been designed to be compatible with the surrounding environment.
- The proposed post-mining land use will integrate with the existing surrounding rural land use, consisting of a diverse mix of pastoral land, cropping land and woodland.
- The reinstatement of cropping land has been located proximal to the existing Rural Land Capability Class III.
- The reinstatement of woodland has been designed so that it enhances the treed corridor between the Cobbora Conservation Area in the north, Tuckland State Forest towards the central-east and Yarrobil National Park in the South.
- The Project's Land Management Plan will ensure the best agricultural use of adjacent non-mine lands and provide opportunities for private farmers to use these through long-term leases.
- Sufficient topsoil resources are available to facilitate the successful achievement of the proposed post-mining land use.
- Rehabilitation will be progressive and disturbed areas will be reshaped within one year of the final overburden placement and then rehabilitated to the target Rural Land Capability Classes.
- A series of rehabilitation objectives and success criteria have been set for the PAA; these relate to its target post-mining land use classification.
- At mine closure, the final void will be made safe to humans, livestock and wildlife.
- This rehabilitation strategy will be continually reviewed and updated throughout the life of the Project. Five years prior to mine closure, a more detailed mine closure plan will be prepared.

# 10.0 REFERENCES

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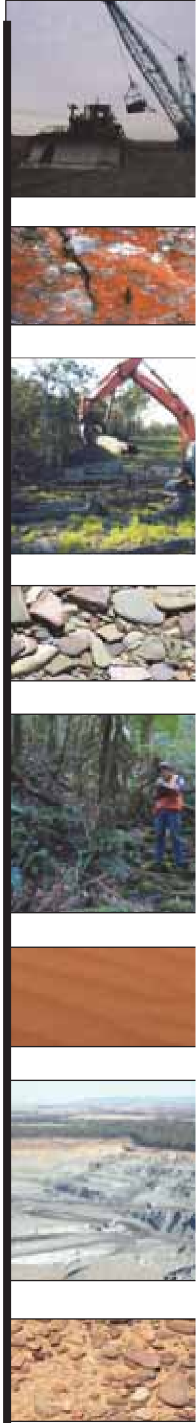

# Soil Survey and Soil Resource Assessment

APPENDIX 1

Our Ref: Lt_EMG00-012_Soil Survey_Final

1st February 2013

Phil Towler
Associate Director
EMGA Mitchell McLennan
Ground Floor, Suite 01, 20 Chandos Street
St Leonards NSW 2065

*Sent via: Email Transmission*

Dear Phil,

# RE: COBBORA COAL PROJECT: SOIL SURVEY AND SOIL RESOURCE ASSESSMENT

## 1.0 INTRODUCTION

EMGA Mitchell McLennan Pty Limited (EMM), on behalf of the proponent, Cobbora Holding Company Pty Limited (CHC), previously engaged GSS Environmental (GSSE) to undertake a Soil and Land Capability Assessment to support an Environmental Assessment (EA) to accompany a major Project Application under Part 3A of the *Environmental Planning and Assessment Act 1979* (NSW) (the EP&A Act) for the proposed Cobbora Coal Project (the Project).

The EA was placed on public exhibition for six weeks between 5 October 2012 and 16 November 2012. In response, Department of Planning and Infrastructure (DP&I) received 229 submissions on the Project. The range of issues raised in the submissions is summarised in Chapter 2 of the Preferred Project Report and Response to Submissions (PPR&RTS). GSSE, on behalf, of the proponent consulted with DP&I in October 2012 and the key outcome was that a higher intensity soil survey was required for the main disturbance area, the Mining Operations Domain. GSSE undertook the agreed fieldwork in November, 2012. The intent of this letter is to provide:

- Soil survey results, which includes a previous soil survey (2009) and the November 2012 survey; and
- Revised topsoil stripping suitability.



| | | | |
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# 2.0 SOIL SURVEY ASSESSMENT: METHODOLOGY

The Project's disturbance footprint is approximately 4,536 ha. The footprint has been divided into six domains for the purposes of rehabilitation planning and this division is based on the level of disturbance (**Table 1**; **Figure 1**). The high disturbance footprint has been assessed at a scale of 1:50,000 with the remainder assessed through a broad intensity survey to ground-truth major soil landscape units.

**Table 1 – Project Application Area: Disturbance Overview**

| Domain | Disturbance Impact | Land Area | |
|---|---|---|---|
| | | ha | % |
| 1 | High | 4,123 | 15 |
| 2 | Medium | 132 | <1 |
| 3 | Low | 164 | <1 |
| 4 | Low | 100 | <1 |
| 5 | High | 17 | <1 |
| Subtotal | | 4,536 | ~15 |
| 6 | Nil | 22,850 | 83.4 |
| **Total** | | **27,386** | **100** |

## 2.1 Reference Map

An initial soil map (reference map) was developed using the following resources and techniques.

*Aerial photographs and topographic maps*

Aerial photo and topographic map interpretation was used as a remote sensing technique allowing detailed analysis of the landscape, and mapping of features expected to be related to the distribution of soils.

*Reference information*

Source materials were used to obtain correlations between pattern elements and soil properties that may be observable in the field. These materials included Cadastral data, prior and current physiographic, geological, vegetation, water resources studies, and the *Soil Landscapes of the Dubbo 1:250 000 Sheet* (Murphy and Lawrie, 1998).

## 2.2 Field Survey Plan

The field survey was an integrated qualitative survey conducted in accordance with the *Guidelines for Surveying Soil and Land Resources* (NCST, 2008) and comprised of the following three survey observation types:

- Detailed profile descriptions (Class I observations);
- Laboratory assessed profiles (Class II observations); and
- Mapping observations (Class IV observations).

The type and density of survey observations across the Project Application Area (PAA) that were utilised in this assessment are listed are shown in **Figure 2** and summarised in **Table 2**.

**Table 2 – Soil Survey Observation Type and Density**

| Area | Survey Scale | Number and Types of Observation | | | |
|---|---|---|---|---|---|
| **Description** | | **Class I (cores)** | **Class II (laboratory)** | **Class IV (mapping)** | **Total** |
| 2009 Soil Survey | 1:250, 000 | 11 | 11 | 20 | **42** |
| 2012 Soil Survey | 1:50, 000 | 22 | 22 | 50 | **94** |
| **Total** | | 33 | 33 | 70 | **136** |

*Detailed Profile Description (Class I Observations)*

Soil profiles were assessed in accordance with the *Australian Soil and Land Survey Field Handbook* (NCST, 2009). Each soil-profile exposure will be excavated by a soil corer to approximately 1.2 m, or to bedrock. After assessment, soil cores will be backfilled with the remaining soil. Detailed soil profile morphological descriptions recorded information that covered the parameters specified in **Table 3**.

**Table 3 – Detailed Soil Profile Description Parameters**

| Descriptor | Application |
|---|---|
| Horizon depth | Weathering characteristics, soil development |
| Field colour | Permeability, susceptibility to dispersion/erosion |
| Field texture grade | Erodibility, hydraulic conductivity, moisture retention, root penetration |
| Boundary distinctness and shape | Erosional/dispositional status, textural grade |
| Consistence force | Structural stability, dispersion, ped formation |
| Structure pedality grade | Soil structure, root penetration, permeability, aeration |
| Structure ped and size | Soil structure, root penetration, permeability, aeration |
| Stones – amount and size | Water holding capacity, weathering status, erosional/depositional character |
| Roots – amount and size | Effective rooting depth, vegetative sustainability |
| Ants, termites, worms, etc. | Biological mixing depth |

*Soil Laboratory Assessment (Class II Observations)*

Soil samples from representative sites were included in the laboratory testing program. Samples were analysed to:

- Assist in the classification of soil taxonomic classes; and
- Assist in the assessment of soil suitability for re-use in the rehabilitation program.

Soil samples were collected from each major soil horizon and analysed for the standard suite of parameters as listed in **Table 4**. Samples were collected at the following standard sampling depths: 0-10 cm, 25-35 cm, 55-65 cm and 90-100 cm, to ensure each soil horizon is sampled. Samples were sent to the Scone Research Centre (NSW) for analysis; this laboratory is National Association of Testing Authority (NATA) accredited; certificates of Analysis are in **Attachment 1.**

**Table 4 – Detailed Soil Profile Description Parameters**

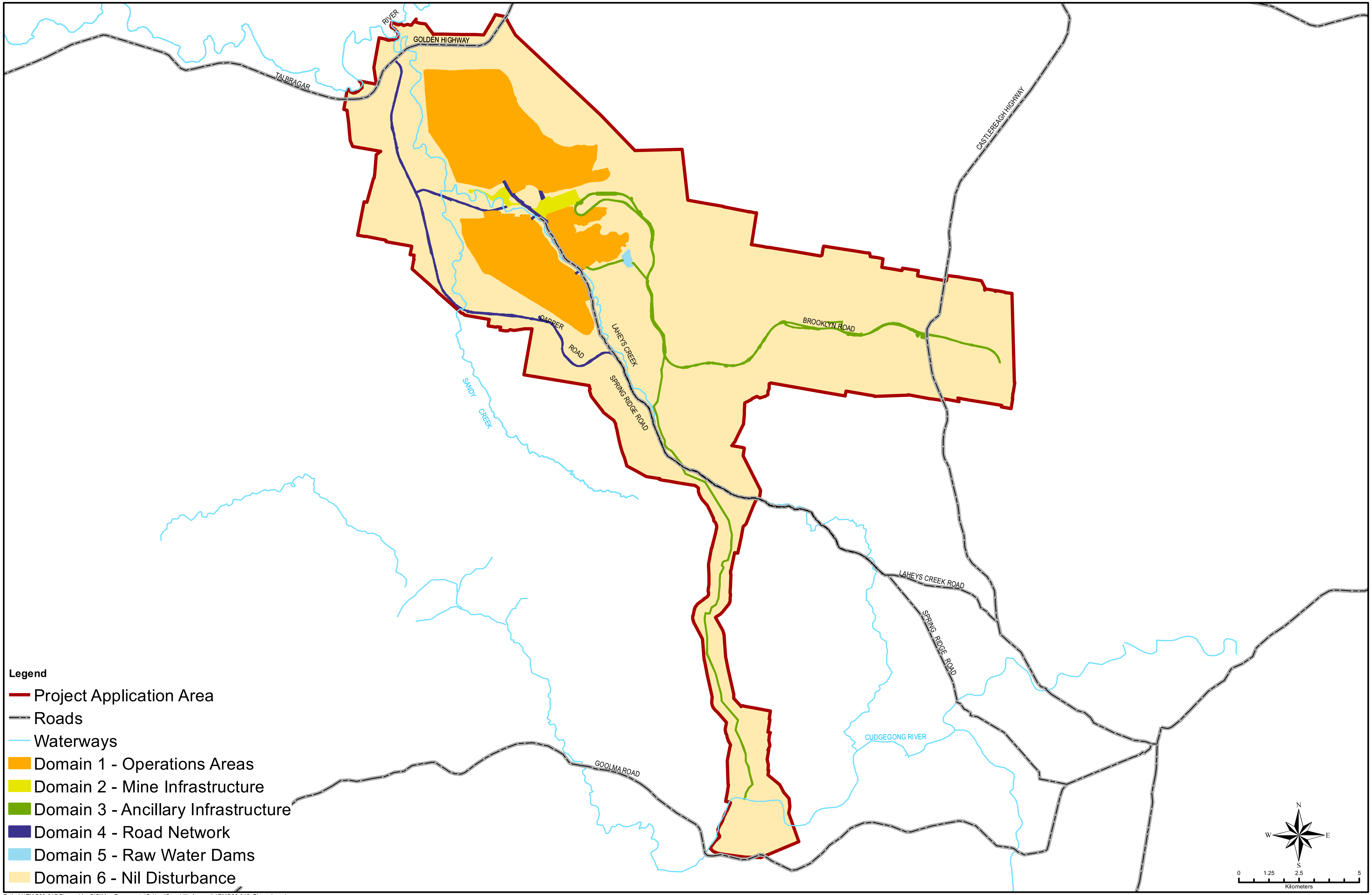
| Laboratory Suite | Sampling Frequency | Laboratory Analysis |
|---|---|---|
| Standard suite | Major soil horizon and/or standard sampling depth | • Electrical conductivity (EC)<br>• pH<br>• Exchangeable cations<br>• Exchangeable Sodium Percent (ESP)<br>• Cation exchange capacity (CEC)<br>• Colour<br>• Emerson Aggregate Test (EAT)<br>• Particle size analysis |

*Mapping Observations (Class IV Observations)*

Mapping observations consisted of exposed cuttings (such as cut slopes), topsoil exposure of up to 0.3 m using a spade, vegetation cover associations, and rock outcrops. These were utilised to confirm mapping boundaries, soil type distributions and any other characteristics being mapped in the survey.

## 2.3 Soil Classification Nomenclature

The applicable technical standard for naming the types of soil identified is the *Australian Soil Classification* (ASC) system (Isbell, 1996).

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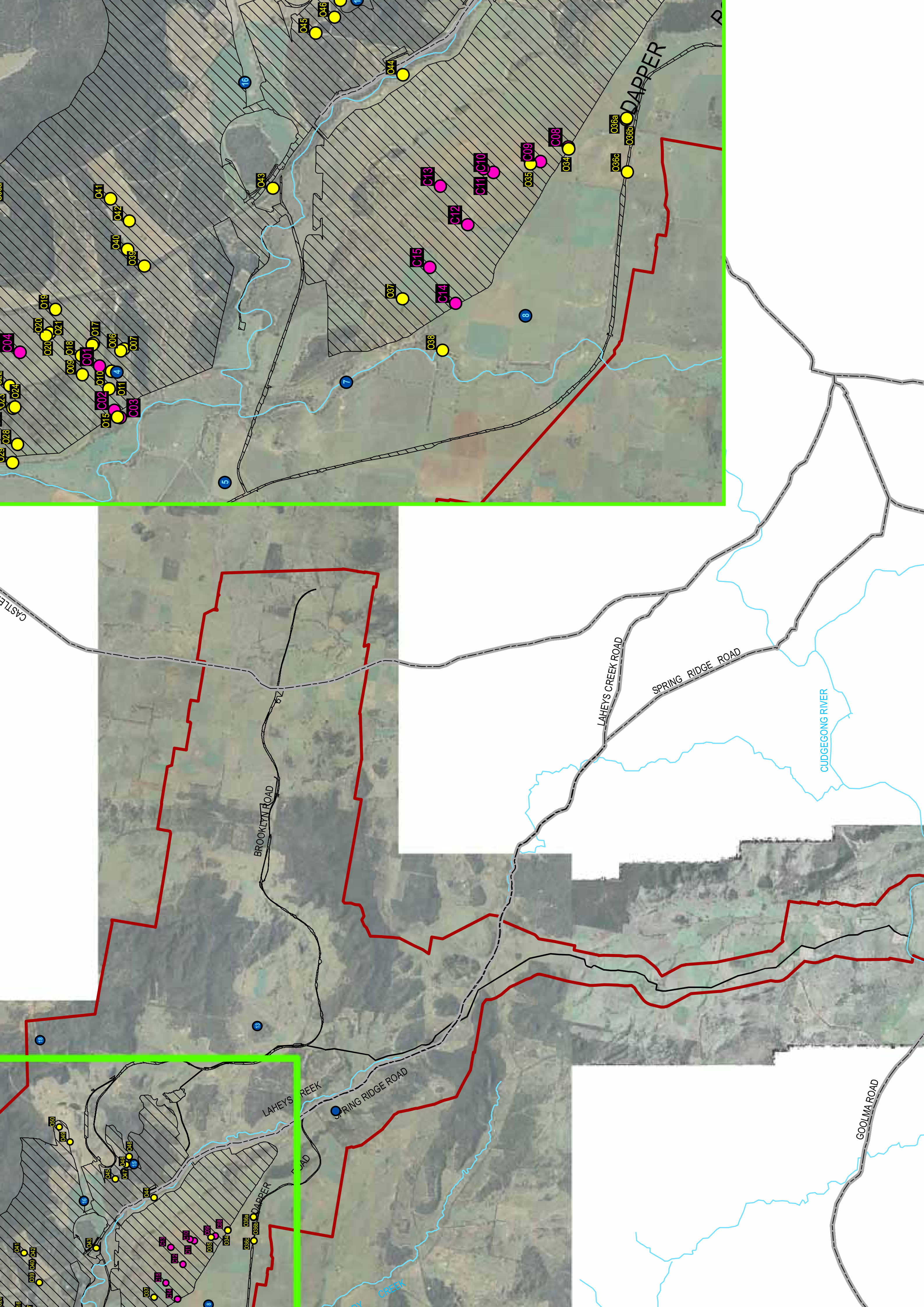
GSS ENVIRONMENTAL
Environmental, Land and Project Management Consultants

Domain Plan
Cobbora Coal Project
**Figure 1**



DAPPER
LAHEYS CREEK ROAD
SPRING RIDGE ROAD
CUDGEGONG RIVER
BROOKLYN ROAD
GOOLMA ROAD
C01
C02
C03
C04
C08
C09
C10
C11
C12
C13
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## 3.0 SOIL SURVEY RESULTS

A total of 16 soil landscape units and 25 soil types were identified within the PAA (**Figure 3**). Soil types within Domain 1 are shown at a greater scale in **Figure 3.1** and **Figure 3.2**. There will be four disturbance levels based on the impacts to soil and land resources (high, medium, low and nil). Approximately 83% of the PAA is categorised as nil disturbance (**Table 1**) and 15% of the PAA will be subject to high disturbance project activities. The soil types within each disturbance category of the PAA have been summarised within **Table 5**.

**Table 5 – Project Application Area: Soil Types Overview**

| Soil Type | Soil Type | Land Area | |
|---|---|---|---|
| | | ha | % |
| **High Disturbance Footprint: Domains 1 & 5** | | | |
| B1 | Reddish-brown Chromosol | 149 | 3.6 |
| B1 - Phase 1 | Reddish-brown Chromosol; very shallow | 12 | <1 |
| B2 | Brown Chromosol: Type 1 | 134 | 3.2 |
| B3 | Yellowish-red Chromosol | 202 | 4.9 |
| B4 | Brown Chromosol: Type 2 | 165 | 4 |
| B4 - Phase 1 | Brown Chromosol; shallow | 9 | <1 |
| DS1 | Tenosol; very shallow | 641 | 15.5 |
| DS2 | Rudosol; very shallow | 364 | 8.8 |
| DS3 | Red Chromosol; very shallow | 860 | 20.8 |
| L1 | Yellow Sodosol: Type 1 | 1,204 | 29.1 |
| L1 – Phase 1 | Yellow Sodosol: Type 2 | 145 | 3.5 |
| L2 | Yellowish-brown Chromosol | 161 | 3.9 |
| L3 | Yellowish-red Chromosol | 94 | 2.3 |
| **Sub-total** | | **4,140** | **100** |
| **Medium Disturbance Footprint: Domain 2** | | | |
| DS3 | Red Chromosol; very shallow | <1 | <1 |
| L1 | Yellow Sodosol: Type 1 | 128 | 97.7 |
| L1 – Phase 1 | Yellow Sodosol: Type 2 | <1 | <1 |
| MI1 | Alluvial Soil | 2 | 1.5 |
| **Sub-total** | | **132** | **100** |
| **Low Disturbance Footprint: Domains 3 & 4** | | | |
| B1 | Reddish-brown Chromosol | 32 | 12 |
| BH1 | Red Dermosol | <1 | <1 |
| CD1 | Yellow Chromosol | <1 | <1 |
| DS3 | Red Chromosol; very shallow | 16 | 6 |
| HR1 | Yellow Sodosol | 4 | 1.5 |
| L1 | Yellow Sodosol: Type 1 | 143 | 54.2 |
| L1 – Phase 1 | Yellow Sodosol: Type 2 | 26 | 9.8 |
| ME1 | Red Dermosol | 13 | 4.9 |
| MI1 | Alluvial Soil | 1 | <1 |
| MK1 | Yellow Sodosol | 5 | 1.9 |

| Soil Type | Soil Type | Land Area | |
|---|---|---|---|
| | | ha | % |
| MU1 | Yellow Sodosol | <1 | <1 |
| TK1 | Red Ferrosol | 23 | 8.7 |
| **Sub-total** | | **264** | **100** |
| **Total Low to High Disturbance Footprint** | | **4,536** | **100** |
| **Nil Disturbance Footprint: Domain 6** | | | |
| B1 | Reddish-brown Chromosol | <1 | <1 |
| B4 | Brown Chromosol: Type 2 | 2,309 | 10.1 |
| BD1 | Leptic Rudosol | 291 | 1.3 |
| BH1 | Red Dermosol | 319 | 1.4 |
| CD1 | Yellow Chromosol | 127 | <1 |
| DS1 | Tenosol; very shallow | <1 | <1 |
| DS2 | Rudosol; very shallow | 1,195 | 5.2 |
| DS3 | Red Chromosol; very shallow | 5,216 | 22.8 |
| HR1 | Yellow Sodosol | 1,045 | 4.6 |
| L1 | Yellow Sodosol: Type 1 | 6,512 | 28.5 |
| L1 - Phase1 | Yellow Sodosol: Type 2 | 1,634 | 7.2 |
| L2 | Yellowish-brown Chromosol | <1 | <1 |
| L3 | Yellowish-red Chromosol | <1 | <1 |
| ME1 | Red Dermosol | 439 | 1.9 |
| MI1 | Alluvial Soil | 503 | 2.2 |
| MK1 | Yellow Sodosol | 303 | 1.3 |
| MU1 | Yellow Sodosol | 648 | 2.8 |
| RS1 | Yellow Sodosol | 5 | <1 |
| SH1 | Red Chromosol | 184 | <1 |
| TB1 | Red Chromosol | 116 | <1 |
| TK1 | Red Ferrosol | 2,004 | 8.8 |
| **Total Nil Disturbance Footprint** | | **22,850** | **100** |
| **Total Project Application Area** | | **27,386** | **100** |

Land within medium to high disturbance areas has been assessed through a detailed soil survey and detailed descriptions of each soil type are provided in **Section 3.1**. Land that is proposed to be subject to low or nil disturbance has been assessed through desktop analysis and a summary of the major soil types is provided in **Section 3.2** and **Section 3.3**.

## 3.1 Medium to High Disturbance Area

The high and medium disturbance area includes Domains 1, 2 & 5, which covers the Mining Operations Area, Mine Infrastructure Area and Raw Water Dam. This area is covered by five soil landscape units including Ballimore, Lahey's Creek, Dapper Hill, Spring Ridge, and Mitchell Creek.

### 3.1.1 Ballimore Soil Landscape

The Ballimore soil landscape unit covers undulating low hills and is underlain by Triassic and Jurassic Sedimentary Sandstone. Slopes are generally 1-5% with lengths between 2000-3000 m and drainage lines are well spaced with 500-1500 m intervals. Areas of moderate to severe sheet and gully erosion have occurred in localised areas.

This field survey found that this soil landscape unit primarily consists of:

- Soil Type B1: Reddish-brown Chromosol. This soil type generally occurs on upper slopes with slope inclines of 3-5% and covers small sections of Domains 1 & 4.
- Soil Type B1 – Phase 1: Reddish-brown Chromosol; very shallow. This soil type generally occurs on crests and covers a very minor section of land in Domain 1.
- Soil Type B2: Brown Chromosol Type 1. This soil type generally occurs on mid and upper slopes with slope inclines of 1-3% and covers a small section of land in Domain 1. Type 1 Brown Chromosol contains high silt content in the topsoil.
- Soil Type B3: Yellowish-red Chromosol. This soil type generally occurs on lower and mid slopes with slope inclines of 1-3% and covers a small section of land in Domain 1.
- Soil Type B4: Brown Chromosol Type 2. This soil type generally occurs on mid to upper slopes with slope inclines of 1-3% and covers a small section of land in Domain 1. Type 2 Brown Chromosol contains a higher sand content in the topsoil, as compared to Type 1.
- Soil Type B4 – Phase 1: Brown Chromosol; shallow. This soil type generally occurs on upper slopes with slope inclines of 1-3% and covers a very minor section of land in Domain 1.

This soil landscape unit has a varied Rural Land Capability of Class III and VI. Most of the area is suitable for grazing (Class IV and VI) with some areas suitable for cropping with appropriate erosion controls (Class III).

**Plate 1** – Ballimore Landscape (Core 13)

*Soil Type B1 – Reddish-brown Chromosol*

Soil Type B1 is a Chromosol. Chromosols are soils that have significant texture contrast between the A and B horizons. This soil type covers 149 ha (3.6%) of the high disturbance area (refer **Figure 3**). This soil type is comprised of four distinct soil horizons and the profile is characterised by clay loam overlying medium clay. Soil pH trends neutral to moderately alkaline; medium salinity is present in the topsoil, salinity is very low throughout the subsoil; and the entire profile is non-sodic. **Table 6** provides a summary of this soil type.

**Table 6 – Overview: Soil Type B1**

| **Site Description** | |
|---|---|
|  **Plate 2** – Profile (Core 8) |  **Plate 3** – Landscape (Core 8) |
| **ASC Name** | Brown Chromosol (representative site – Core 8) |
| **Dominant Slope Association** | Upper slope; 3-5% slope |
| **Rural Land Capability** | Class IV; main limitation - slope |
| **Soil Stripping Depth** | 0.2 m; main limitation - high subsoil clay content and strong consistence. |

| **Physical Characteristics** | | |
|---|---|---|
| **Horizon** | **Depth (m)** | **Description** |
| A1 | 0.0–0.05 | Dark brown (10YR3/3) clay loam; moderate structure grade of 25 – 50 mm platy peds with a weak consistence. Nil mottling and nil stone content. Well drained with a clear and even boundary. |
| A2 | 0.05–0.20 | Dark brown (7.5YR3/4) clay loam; moderate structure grade of 20 – 50 mm platy peds with weak consistence. Nil mottling and nil stone content. Well drained with a clear and even boundary. |
| B2 | 0.20–0.60 | Brown (7.5YR4/5)* medium clay; strong structure grade sub angular blocky peds with strong consistence. Nil mottling and nil stone content. Well drained with a gradual boundary. |
| B22 | 0.60–0.85+ | Dark yellowish-brown (10YR4/5) silty clay; strong structure grade sub angular blocky peds with strong consistence. Some (20%) yellow mottling and nil stone content. |

| Analytical Description | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Horizon** | **Depth** | **Colour** | **pH** | **EC** | **CEC** | **ESP** | **EAT** |
| No. | m | Munsell | - | dS/cm | meq/100g | % | Class |
| A1 | 0.0–0.05 | 10YR3/3 | 6.8 | 0.2 | 12 | 0.8 | 8 |
| | | Dark brown | Neutral | Medium | Moderate | Non-sodic | Negligible |
| A2 | 0.05–0.20 | 7.5YR3/4 | 6.8 | 0.04 | 8 | 1.2 | 2(1) |
| | | Dark brown | Neutral | Very low | Low | Non-sodic | High to moderate |
| B2 | 0.20–0.60 | 7.5YR4/5 | 7.7 | 0.03 | 13 | 0.7 | 2(1) |
| | | Brown | Mildly alkaline | Very low | Moderate | Non-sodic | High to moderate |
| B22 | 0.60–0.85+ | 10YR4/5 | 8.2 | 0.05 | 14 | 0.7 | 3(1) |
| | | Dark yellowish-brown | Moderately alkaline | Very low | Moderate | Non-sodic | Slight |

* Colour is classified as 'brown' using ASC nomenclature

*Soil Type B1 – Phase 1: Reddish-Brown Chromosol; very shallow*

Soil Type B1 – Phase 1 is a Chromosol. This soil has a high coarse fragment presence. This soil type covers 12 ha (<1%) of the high disturbance area (refer **Figure 3**). This soil type is comprised of a shallow soil profile characterised by a loam overlying medium clay. Soil pH is neutral; salinity is low to very low; and the profile is non-sodic. **Table 7** provides a summary of this soil type.

**Table 7 – Overview: Soil Type B1 – Phase 1**

| Site Description | |
|---|---|
|  **Plate 4** – Profile (Core 12) |  **Plate 5** – Landscape (Core 12) |
| **ASC Name** | Brown Chromosol; very shallow (representative site – Core 12) |
| **Dominant Slope Association** | Crest; 3-5% |
| **Rural Land Capability** | Class IV; main limitations - slope and soil depth |
| **Soil Stripping Depth** | 0.2 m; main limitation - shallow depth |

*Soil Type B2 – Brown Chromosol: Type 1*

Soil Type B2 is a Chromosol. This soil type covers 134 ha (3.2%) of the high disturbance area (refer **Figure 3**). This soil type is comprised of three distinct soil horizons and the profile is characterised by a silty loam overlying heavy clay. Soil pH trends from slightly acidic to mildly alkaline; salinity is very low throughout; and the entire profile is non-sodic. **Table 8** provides a summary of this soil type.

**Table 8 – Overview: Soil Type B2**

**Site Description**


**Plate 6** – Profile (Core 10)

**Plate 7** – Landscape (Core 10)

| | |
|---|---|
| **ASC Name** | Brown Chromosol; silty (representative site – Core 10) |
| **Dominant Slope Association** | Mid to Upper slope; 1-3% slope |
| **Rural Land Capability** | Class IV; main limitation – soil structure decline hazard, silt & fine sand fraction |
| **Soil Stripping Depth** | 0.2 m; main limitation - high clay content with strong consistence |

**Physical Characteristics**

| Horizon | Depth (m) | Description |
|---|---|---|
| A1 | 0.0–0.10 | Dark yellowish-brown (10YR3/6) silty loam; moderate structure grade of 10 mm sub angular blocky peds with a moderate consistence. Nil mottling and nil stone content. Moderately drained with a clear and even boundary. |
| B21 | 0.10–0.30 | Strong brown (7.5YR4/6)* heavy clay; strong structure grade of sub angular blocky peds with strong consistence. Nil mottling and nil stone content. Moderately drained with a gradual and even boundary. |
| B22 | 0.30–0.80 | Dark yellowish-brown (10YR4/6) heavy clay; strong structure grade of sub angular blocky peds with strong consistence. Nil mottling and nil stone content. Moderately drained with a gradual and even boundary. |

**Analytical Description**

| Horizon | Depth | Colour | pH | EC | CEC | ESP | EAT |
|---|---|---|---|---|---|---|---|
| No. | m | Munsell | - | dS/cm | meq/100g | % | Class |
| A1 | 0.0–0.10 | 10YR3/6 | 6.5 | 0.08 | 11 | 1.7 | 3(1) |
| | | Dark yellowish-brown | Slightly acidic | Very low | Low | Non-sodic | Slight |
| B21 | 0.10–0.30 | 7.5YR4/6 | 6.8 | 0.02 | 14 | 2.1 | 3(2) |
| | | Brown | Neutral | Very low | Moderate | Non-sodic | Slight |
| B22 | 0.30–0.80 | 10YR4/6 | 7.6 | 0.13 | 17 | 2.3 | 5 |
| | | Dark yellowish-brown | Mildly alkaline | Very low | Moderate | Non-sodic | Slight |

* Colour is classified as 'brown' using ASC nomenclature

*Soil Type B3 – Yellowish-red Chromosol*

Soil Type B3 is a Chromosol. This soil type covers 202 ha (4.9%) of the high disturbance area (refer **Figure 3**). This soil type is comprised of five distinct soil horizons and the profile is characterised by a loam/clay loam overlying medium clay. Soil pH trends from neutral to moderately alkaline; salinity is very low or low throughout; and the entire profile is non-sodic. **Table 9** provides a summary of this soil type.

**Table 9 – Overview: Soil Type B3**

**Site Description**

**Plate 8** – Profile (Core 13)

**Plate 9** – Landscape (Core 13)

| | |
|---|---|
| **ASC Name** | Red Chromosol (representative site – Core 13) |
| **Dominant Slope Association** | Lower to Mid slope; 1-3% |
| **Rural Land Capability** | Class III; main limitations – slope, soil structure decline hazard |
| **Soil Stripping Depth** | 0.5 m; main limitation - high clay content with strong consistence. Subsoil salvage recommended for reinstatement of Class III land (**Section 5**). |

**Physical Characteristics**

| Horizon | Depth (m) | Description |
|---|---|---|
| A11 | 0.0–0.10 | Dark brown (7.5YR3/4) loam; strong structure grade of 0 – 10 mm spheroidal peds with a weak to moderate consistence. Nil mottling and nil stone content. Well drained with a grained and even boundary. |
| A12 | 0.10–0.20 | Dark brown (7.5YR3/4) clay loam; strong structure grade of 10 – 20 mm smooth angular blocky peds with strong consistence. Nil mottling and nil stone content. Well drained with a gradual and even boundary. |
| A13 | 0.20–0.50 | Strong brown (7.5YR4/6) clay loam; moderate structure grade of 5 – 20 mm sub angular blocky peds with moderate consistence. Nil mottling and nil stone content. Well drained with a gradual and wavy boundary. |
| B21 | 0.50-0.80 | Yellowish-red (5YR4/6)* medium clay; strong structure grade of 20 – 50 mm sub angular blocky peds with strong consistence. Nil mottling and nil stone content. Moderately drained with a clear and wavy boundary. |
| B22 | 0.80-1.00+ | Strong brown (7.5YR5/6) medium clay; strong structure grade of 20 – 50 mm sub angular blocky peds with strong consistence. Some (20%) yellow mottling and nil stone content. |

| Analytical Description | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Horizon** | **Depth** | **Colour** | **pH** | **EC** | **CEC** | **ESP** | **EAT** |
| No. | m | Munsell | - | dS/cm | meq/100g | % | Class |
| A1 | 0.0–0.10 | 7.5YR3/4 | 6.7 | 0.04 | 10 | 3.0 | 7 |
| | | Dark Brown | Neutral | Very low | Low | Non-sodic | Negligible |
| A2 | 0.10–0.20 | 7.5YR3/4 | 7 | 0.11 | 10 | 4.2 | 5 |
| | | Dark Brown | Neutral | Low | Low | Non-sodic | Slight |
| B1 | 0.20–0.50 | 7.5YR4/6 | 7.2 | <0.01 | 8 | 3.8 | 3(3) |
| | | Strong brown | Neutral | Very low | Low | Non-sodic | Moderate |
| B21 | 0.50-0.80 | 5YR4/6 | 7.8 | 0.02 | 16 | 3.1 | 3(2) |
| | | Yellowish-red | Mildly alkaline | Very low | Moderate | Non-sodic | Slight |
| B22 | 0.80-1.00+ | 7.5YR5/6 | 8.3 | 0.07 | 19 | 3.7 | 3(2) |
| | | Strong brown | Moderately alkaline | Very low | Moderate | Non-sodic | Slight |

*Colour is classified as 'red' using ASC nomenclature

*Soil Type B4 – Brown Chromosol: Type 2*

Soil Type B4 is a Chromosol. This soil type covers 165 ha (4%) of the high disturbance area (refer **Figure 3**). This soil type is comprised of four distinct soil horizons and the profile is characterised by a loam overlying a medium clay and sandy clay. Soil pH trends from moderately acidic in the topsoil to neutral in the remaining profile; salinity is very low to low throughout; and sodicity is present at depth. **Table 10** provides a summary of this soil type.

**Table 10 – Overview: Soil Type B4**

**Site Description**

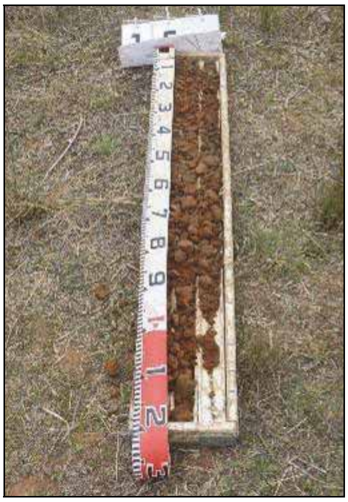


**Plate 10** – Profile (Core 15)

**Plate 11** – Landscape (Core 15)

| | |
|---|---|
| **ASC Name** | Brown Chromosol (representative site – Core 15) |
| **Dominant Slope Association** | Mid slope; 1-3% slope |
| **Rural Land Capability** | Class IV; main limitation – soil structure decline hazard; silt & fine sand fraction |
| **Soil Stripping Depth** | 0.3 m; main limitations - high subsoil clay and subsoil sodicity. Ameliorants required to improve soil structure in topsoil. |

| Physical Characteristics | | |
|---|---|---|
| **Horizon** | **Depth (m)** | **Description** |
| A | 0.0–0.10 | Dark yellowish-brown (10YR3/4) loam; weak structure grade of 10-20 mm sub angular blocky peds with a weak consistence. Nil mottling and nil stone content. Moderately drained with a gradual and even boundary. |
| B1 | 0.10–0.30 | Strong brown (7.5YR4/6) sandy clay loam; moderate structure grade of 15-30 mm sub angular blocky peds with moderate consistence. Nil mottling and nil stone content. Well drained with a clear and wavy boundary. |
| B21 | 0.30–0.80 | Strong brown (7.5YR5/6)* light medium clay; strong structure grade of 20-50 mm angular blocky peds with moderate consistence. Nil mottling and nil stone content. Moderately drained with a gradual and even boundary. |
| B22 | 0.80+ | Strong brown (7.5YR4/6) sandy clay; moderate structure grade of 20-100 mm sub angular blocky peds with moderate consistence. Some (20%) red mottling and nil stone content. |

| Analytical Description | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Horizon** | **Depth** | **Colour** | **pH** | **EC** | **CEC** | **ESP** | **EAT** |
| No. | m | Munsell | - | dS/cm | meq/100g | % | Class |
| A | 0.0–0.10 | 10YR3/4 | 6 | 0.03 | 5 | 2.0 | 8 |
| | | Dark yellowish-brown | Moderately acidic | Very low | Very low | Non sodic | Negligible |
| B21 | 0.10–0.30 | 7.5YR4/6 | 6.8 | 0.01 | 5 | 2.1 | 3(2) |
| | | Strong brown | Neutral | Very low | Very low | Non sodic | Slight |
| B21 | 0.30–0.80 | 7.5YR5/6 | 7.3 | 0.04 | 7 | 6.2 | 5 |
| | | Strong brown | Neutral | Very low | Low | Marginally sodic | Slight |
| B22 | 0.80+ | 7.5YR4/6 | 6.8 | 0.12 | 8 | 11.4 | 6 |
| | | Strong brown | Neutral | Low | Low | Sodic | Negligible |

* Colour is classified as 'brown' using ASC nomenclature

*Soil Type B4 – Phase 1 – Brown Chromosol; shallow*

Soil Type B4 – Phase 1 is a Chromosol. This soil type is a shallow phase of Soil Type B2 and covers 9 ha (<1%) of the high disturbance area (refer **Figure 3**). **Table 11** provides a summary of this soil type.

**Table 11 – Overview: Soil Type B4 – Phase 1**

| **Site Description** | |
|---|---|
|   **Plate 12** – Site (Obs 37) |  **Plate 13** – Landscape (Obs 37) |
| **ASC Name** | Brown Chromosol; shallow (representative site – Obs 37) |
| **Dominant Slope Association** | Upper slope to crest; 1-3% |
| **Rural Land Capability** | Class IV; main limitations – soil structure decline hazard, soil depth |
| **Soil Stripping Depth** | 0.3 m; main limitation - shallow soil depth |

## 3.1.2 Lahey's Creek Soil Landscape

The Lahey's Creek soil landscape unit covers undulating low hills, mainly on lower slopes and valley floors and is underlain by Triassic and Jurassic Sedimentary Sandstone. Slopes are 3-10% with lengths between 500-1500 m and drainage lines are spaced 400-1200 m apart. Moderate sheet and gully erosion is common, with some areas of severe gully erosion.

This field survey found that this soil landscape unit primarily consists of:

- Soil Type L1: Yellow Sodosol: Type 1. This soil type generally occurs on the lower to mid slopes with slope inclines of 1-3% and covers a significant portion of land in Domain 1 and the majority of Domain 2. It also covers a large section of land within Domains 3 & 4 (low disturbance footprint). Type 1 Yellow Sodosol contains a high sand content in the topsoil.

- Soil Type L1 – Phase 1: Yellow Sodosol: Type 2. This soil type generally occurs on the lower to mid slopes with slope inclines of 1-3% and covers a minor section of land in Domains 1 & 2, as well as Domains 3 & 4 (low disturbance footprint). Type 2 Yellow Sodosol contains a lower sand content in the topsoil, as compared to Type 1, and has a loamy texture.

- Soil Type L2: Yellowish-brown Chromosol. This soil type generally occurs on lower slopes with slope inclines of 1-3% and covers a small section of land within Domain 1.

- Soil Type L3: Yellowish-red Chromosol. This soil type generally occurs on straight slopes with slope inclines of 3-5% and covers a small section of land within Domain 1. This type grades in to the Dapper Hill soil landscape unit.

This soil landscape predominantly has a Rural Land Capability of Class IV, only suitable for grazing. Some remaining land is Class III on the lower slopes, suitable for cropping with appropriate erosion controls.

**Plate 14** – Lahey's Creek Landscape

*Soil Type L1 – Yellow Sodosol: Type 1*

Soil Type L1 is a Sodosol. Sodosols are soils that have significant texture contrast between the A and B horizons and contain a sodic B horizon. This soil type covers 1,203 ha (29.1%) of the high disturbance area (refer **Figure 3**). It is comprised of four distinct soil horizons and the profile is characterised by a sandy loam overlying light clay. Soil pH trends from moderately acidic to neutral at depth; salinity is very low to low throughout; and the profile is non-sodic in the topsoil and strongly sodic at depth. **Table 12** provides a summary of this soil type.

**Table 12 – Overview: Soil Type L1**

| Site Description | |
|---|---|
| <br>**Plate 15** – Profile (Core 1) | <br>**Plate 16** – Landscape (Core 1) |
| **ASC Name** | Brown Sodosol (representative site – Core 1) |
| **Dominant Slope Association** | Lower to mid slopes; 1-3% |
| **Rural Land Capability** | Class IV; main limitation – soil acidification hazard |
| **Soil Stripping Depth** | 0.2 m; main limitations - poor soil structure and sodicity at depth. Ameliorants required to improve soil structure in topsoil. |

**Physical Characteristics**

| Horizon | Depth (m) | Description |
|---|---|---|
| A1 | 0.0–0.10 | Very dark brown (7.5YR2.5/2) sandy loam; very weak structure grade of <5 mm subangular blocky peds with very weak consistence. Nil mottling and nil stone content. Well drained with a clear and even boundary. |
| A2 | 0.10–0.20 | Very dark grayish-brown (10YR3/2) loamy sand; apedal structure. Nil mottling and nil stone content. Well drained with a clear and even boundary. |
| B21 | 0.20–0.60 | Light olive brown (2.5Y5/4)* light clay; strong structure grade of 20 – 40 mm sub angular blocky peds with strong consistence. Orange mottles (20%) with 10% secondary grey mottles. Gradual boundary. |
| B22 | 0.60–1.20 | Light olive brown (2.5Y5/4) light clay; strong structure grade of 20 – 40 mm sub angular blocky peds with strong consistence. Orange mottles (40%) with 20% secondary grey mottles. |

| Analytical Description | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Horizon** | **Depth** | **Colour** | **pH** | **EC** | **CEC** | **ESP** | **EAT** |
| No. | m | Munsell | - | dS/cm | meq/100g | % | Class |
| A1 | 0.0–0.10 | 7.5YR2.5/2 | 5.8 | 0.04 | 6 | 2.0 | 8 |
| | | Very dark brown | Moderately acidic | Very low | Low | Non-sodic | Negligibl e |
| A2 | 0.10–0.20 | 10YR3/2 | 5.9 | 0.01 | 3 | 8.0 | 3(1) |
| | | Very dark grayish-brown | Moderately acidic | Very low | Very low | Marginally sodic | Slight |
| B21 | 0.20–0.60 | 2.5Y5/4 | 7.5 | 0.11 | 8 | 22.2 | 2(2) |
| | | Light olive brown | Mildly alkaline | Low | Low | Strongly sodic | High |
| B22 | 0.60-1.2 | 2.5Y5/4 | 6.7 | 0.18 | 8 | 28.6 | 2(2) |
| | | Light olive brown | Neutral | Low | Low | Strongly sodic | High |

*Colour is classified as 'brown' using ASC nomenclature

*Soil Type L1 – Phase 1*

Soil Type L1 – Phase 1 is a Sodosol. This soil type covers 146 ha (3.5%) of the high disturbance area (refer **Figure 3**). This soil type is comprised of four distinct soil horizons and the profile is characterised by a loam overlying a medium clay. Soil pH trends from moderately acidic to strongly alkaline; salinity is very low at the surface increasing to medium salinity with depth; and profile is non-sodic in the topsoil and strongly sodic at depth. **Table 13** provides a summary of this soil type.

**Table 13 – Overview: Soil Type L1 – Phase 1**

| Site Description | |
|---|---|
|  **Plate 17** – Profile (Core 14) |  **Plate 18** – Landscape (Core 14) |
| **ASC Name** | Brown Sodosol (representative site – Core 14) |
| **Dominant Slope Association** | Lower to mid slope; 1-3% |
| **Rural Land Capability** | Class IV; main limitation – soil structure decline hazard; soil acidification |
| **Soil Stripping Depth** | 0.45 m; main limitations - high clay content and sodicity at depth. Ameliorants required to improve soil structure in topsoil. |

| Physical Characteristics | | |
|---|---|---|
| **Horizon** | **Depth (m)** | **Description** |
| A1 | 0.0–0.15 | Dark brown (10YR3/3) loam; very weak structure grade of 5 mm blocky peds with a weak consistence. Nil mottling and nil stone content. Well drained with an abrupt and even boundary. |
| B1 | 0.15–0.45 | Strong brown (7.5YR4/6) clay loam; moderate structure grade of 10 – 20 mm sub angular blocky peds with moderate consistence. Nil mottling and nil stone content. Well drained with a clear and even boundary. |
| B21 | 0.45–0.90 | Yellowish-brown (10YR5/6)* medium clay; strong structure grade of 50 – 100 mm sub angular blocky peds with strong consistence. Some (10%) red mottling and nil stone content. Poorly drained with a gradual and even boundary. |
| B22 | 0.90–1.20 | Dark yellowish-brown (10YR4/6) medium clay; strong structure grade of 50 mm sub angular blocky peds with weak consistence. Nil mottling and nil stone content. |

| Analytical Description | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Horizon** | **Depth** | **Colour** | **pH** | **EC** | **CEC** | **ESP** | **EAT** |
| No. | m | Munsell | - | dS/cm | meq/100g | % | Class |
| A1 | 0.0–0.15 | 10YR3/3 | 5.6 | 0.02 | 5 | 2.0 | 8 |
| | | Dark brown | Moderately acidic | Very low | Very low | Non-sodic | Negligible |
| B1 | 0.15–0.45 | 7.5YR4/6 | 7.3 | 0.02 | 7 | 2.8 | 3(2) |
| | | Strong brown | Neutral | Very low | Low | Non-sodic | Slight |
| B21 | 0.45–0.90 | 10YR5/6 | 8.4 | 0.21 | 15 | 11.8 | 5 |
| | | Yellowish-brown | Moderately alkaline | Low | Moderate | Sodic | Slight |
| B22 | 0.90–1.20 | 10YR4/6 | 8.6 | 0.28 | 15 | 15.8 | 2(2) |
| | | Dark yellowish-brown | Strongly alkaline | Medium | Moderate | Strongly sodic | High |

*Colour is classified as 'brown' using ASC nomenclature

*Soil Type L2 – Yellowish-brown Chromosol*

Soil Type L2 is a Chromosol. This soil type covers 161 ha (3.9%) of the high disturbance area (refer **Figure 3**). This soil type is comprised of four distinct soil horizons and the profile is characterised by a sandy loam overlying light- medium clay. Soil pH trends from strongly acidic to mildly alkaline; salinity is very low throughout; and the profile is generally non-sodic. **Table 14** provides a summary of this soil type.

**Table 14 – Overview: Soil Type L2**

<table>
<tr><th colspan="3">Site Description</th></tr>
<tr><td colspan="2">

Plate 19 – Profile (Core 6)</td><td>
Plate 20 – Landscape (Core 6)</td></tr>
<tr><td colspan="2">ASC Name</td><td>Brown Chromosol (representative site – Core 6)</td></tr>
<tr><td colspan="2">Dominant Slope Association</td><td>Lower slope; 1-3%</td></tr>
<tr><td colspan="2">Land Capability</td><td>Class III; main limitations – slope, soil structure decline hazard</td></tr>
<tr><td colspan="2">Soil Stripping Depth</td><td>0.55 m; main limitations - high clay content. Ameliorants required to improve structure of topsoil.</td></tr>
<tr><th colspan="3">Physical Characteristics</th></tr>
<tr><th>Horizon</th><th>Depth (m)</th><th>Description</th></tr>
<tr><td>A1</td><td>0.0–0.10</td><td>Dark yellowish-brown (10YR3/4) sandy loam; very weak structure grade with a weak consistence. Nil mottling and nil stone content. Well drained with a gradual and even boundary.</td></tr>
<tr><td>A21</td><td>0.10–0.55</td><td>Brown (7.5YR4/4) sandy loam; very weak structure grade with weak consistence. Nil mottling and nil stone content. Well drained with a clear and even boundary.</td></tr>
<tr><td>B1</td><td>0.55–0.70</td><td>Dark yellowish-brown (10YR4/5) light medium clay; weak structure grade with weak consistence. Nil mottling and nil stone content. Moderately drained with a gradual and even boundary.</td></tr>
<tr><td>B2</td><td>0.70+</td><td>Yellowish-brown (10YR5/6)* heavy clay; strong structure grade with moderate consistence. Some (20%) grey mottling and nil stone content.</td></tr>
</table>

| Analytical Description | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Horizon** | **Depth** | **Colour** | **pH** | **EC** | **CEC** | **ESP** | **EAT** |
| No. | m | Munsell | - | dS/cm | meq/100g | % | Class |
| A1 | 0.0–0.10 | 10YR3/4 | 5.5 | 0.01 | 3 | 5.9 | 3(1) |
| | | Dark yellowish-brown | Strongly acidic | Very low | Very low | Non-sodic | Slight |
| A21 | 0.10–0.55 | 7.5YR4/4 | 6.9 | 0.01 | 5 | 6.4 | 3(1) |
| | | Brown | Neutral | Very low | Very low | Marginally sodic | Slight |
| B1 | 0.55–0.70 | 10YR4/5 | 7.4 | 0.05 | 10 | 5.3 | 3(2) |
| | | Dark yellowish-brown | Mildly alkaline | Very low | Low | Non-sodic | Slight |
| B2 | 0.70–1.2 | 10YR5/6 | 7.6 | 0.01 | 17 | 5.2 | 2(1) |
| | | Yellowish-brown | Mildly alkaline | Very low | Moderate | Non-sodic | High to Moderate |

*Colour is classified as 'brown' using ASC nomenclature

*Soil Type L3 – Yellowish-red Chromosol*

Soil Type L3 is a Chromosol. This soil type covers 94 ha (2.3%) of the high disturbance area (refer **Figure 3**). This soil type is comprised of four distinct soil horizons and the profile is characterised by a sandy loam overlying heavy clay. Soil pH trends from moderately acidic through to moderately alkaline; salinity is very low throughout; and the profile is marginally sodic to non-sodic. **Table 15** provides a summary of this soil type.

**Table 15 – Overview: Soil Type L3**

**Site Description**


**Plate 21**– Profile (Core 5)

**Plate 22** – Landscape (Core 5)

| | |
|---|---|
| **ASC Name** | Red Chromosol (representative site – Core 5) |
| **Dominant Slope Association** | Slope; 3-5% |
| **Rural Land Capability** | Class IV; main limitations - slope |
| **Soil Stripping Depth** | 0.40 m; main limitation - high clay content. Ameliorants required to improve topsoil structure. |

| Physical Characteristics | | |
|---|---|---|
| **Horizon** | **Depth (m)** | **Description** |
| A1 | 0.0–0.15 | Dark Brown (10YR3/3) sandy loam; weak structure grade of 1 – 5 mm sub angular blocky peds with a weak consistence. Nil mottling and nil stone content. Rapidly drained with a clear and even boundary. |
| A2 | 0.15–0.40 | Dark yellowish-brown (10YR4/4) sandy loam; apedal structure grade with weak consistence. Nil mottling and nil stone content. Rapidly drained with a clear and wavy boundary. |
| B21 | 0.40–0.60 | Yellowish-red (5YR5/6)* heavy clay; moderate structure grade of sub angular blocky peds with moderate consistence. Nil mottling and nil stone content. Poorly drained with a gradual and wavy boundary. |
| B22 | 0.60–1.2 | Yellowish-red (5YR5/6)* heavy clay; moderate structure grade of mm sub angular blocky peds with moderate consistence. Nil mottling and nil stone content. |

| Analytical Description | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Horizon** | **Depth** | **Colour** | **pH** | **EC** | **CEC** | **ESP** | **EAT** |
| No. | m | Munsell | - | dS/cm | meq/100g | % | Class |
| A1 | 0.0–0.15 | 10YR3/3 | 5.6 | 0.03 | 3 | 7.0 | 3(1) |
| | | Dark Brown | Moderately acidic | Very low | Very low | Marginally sodic | Slight |
| A2 | 0.15–0.40 | 10YR4/4 | 6.4 | <0.01 | 3 | 7.4 | 3(1) |
| | | Dark yellowish-brown | Slightly acidic | Very low | Very low | Marginally sodic | Slight |
| B21 | 0.40–0.60 | 5YR5/6 | 7.8 | 0.02 | 16 | 1.9 | 3(1) |
| | | Yellowish-red | Mildly alkaline | Very low | Moderate | Non-sodic | Slight |
| B21 | 0.60–1.2 | 5YR5/6 | 8.1 | 0.03 | 20 | 1.5 | 5 |
| | | Yellowish-red | Moderately alkaline | Very low | Moderate | Non-sodic | Slight |

*Colour is classified as 'red' using ASC nomenclature

### 3.1.3 Dapper Hill & Spring Ridge Soil Landscapes

The Dapper Hill and Spring Ridge soil landscapes units are underlain by Triassic and Jurassic Sedimentary Sandstone. Dapper Hill Slopes are generally 5-18% with lengths between 500-1000 m and drainage lines are well spaced with 500-1500 m intervals. Spring Ridge slopes. Slopes are generally between 10-33% with lengths between 300-800 m and drainage lines are spaced 300-500 m apart. Abundant rock outcrop and surface stone is present in the Spring Ridge soil landscape. Moderate sheet and minor gully erosion has occurred.

This field survey found that this soil landscape unit primarily consists of:

- Soil Type DS1: Tenosol; very shallow. This soil type generally occurs on broad crests; however it also includes some slope inclines of up to 10% and covers a significant portion of Domain 1.

- Soil Type DS2: Rudosol; very shallow. This soil type generally occurs on steep slopes and elevated ridges with rock outcrop and covers a large portion of Domain 1.

- Soil Type DS3: Red Chromosol; very shallow. This soil type generally occurs on upper slopes with slope inclines of 5-10% and covers a significant portion of Domain 1, the entire Domain 5 and a minor section of Domain 2. It also covers small sections of land within Domains 3 & 4 (low disturbance footprint).

This soil landscape unit has a Rural Land Capability between Class VI and VII, indicating the most suitable only for grazing or timber/forestry.

**Plate 23** – *Dapper Hill & Spring Ridge Landscape*

*Soil Type DS1 – Tenosol; very shallow*

Soil Type DS1 is a Tenosol. Tenosols are soils that have only weak pedologic organisation apart from the A horizons. This soil type covers 641 ha (15.5%) of the high disturbance area (refer **Figure 3**). This soil type is comprised of two soil horizons and the profile is characterised as a weakly structured sandy loam. Soil pH trends from very strongly acidic to strongly acidic; salinity is very low throughout; and the profile is non-sodic. **Table 16** provides a summary of this soil type. Depth in localised and in some areas can reach 0.5 m.

**Table 16 – Overview: Soil Type DS1**

**Site Description**


**Plate 24** – Profile (Obs 18)

**Plate 25** – Landscape (Obs 18)

| | |
|---|---|
| **ASC Name** | Tenosol; very shallow (representative site – Obs 18) |
| **Dominant Slope Association** | Broad crests; 5-18% |
| **Rural Land Capability** | Class VI; main limitations – slope, shallow soil depth |
| **Soil Stripping Depth** | 0.2 m; marginal for stripping. Ameliorants required to improve structure of topsoil and neutralise acidity. |

**Physical Characteristics**

| Horizon | Depth (m) | Description |
|---|---|---|
| A1 | 0.0–0.10 | Very dark brown (7.5YR2.5/3) sandy loam; weak structure grade of 5 mm sub angular peds with a weak consistence. Nil mottling and 10% stone content. Well drained with a clear and even boundary. |
| B2w | 0.10–0.20 | Dark brown (7.5YR3/4) sandy loam; very weak structure grade of 10 mm sub angular blocky peds with weak consistence. Nil mottling and 10% stone content. Well drained with a clear and even boundary. |
| C | 0.20+ | Bedrock |

**Analytical Description**

| Horizon | Depth | Colour | pH | EC | CEC | ESP | EAT |
|---|---|---|---|---|---|---|---|
| No. | m | Munsell | - | dS/cm | meq/100g | % | Class |
| A1 | 0.0–0.10 | 7.5YR2.5/3 | 5.0 | 0.01 | 3 | 3.7 | 3(1) |
| | | Very dark brown | Very strongly acidic | Very low | Very low | Non-sodic | Slight |
| B2w | 0.10–0.20 | 7.5YR3/4 | 5.3 | 0.02 | 3 | 3.8 | 5 |
| | | Dark brown | Strongly acidic | Very low | Very low | Non-sodic | Slight |

*Soil Type DS2 – Rudosol; very shallow*

Soil Type DS2 is a Rudosol. Rudosols are soils that have negligible pedologic organization. This soil type covers 364 ha (8.8%) of the high disturbance area (refer **Figure 3**) and is comprised of one distinct soil horizon. This horizon is characterised as a loam; soil pH is very strongly acidic; salinity is medium; and is strongly sodic. **Table 17** provides a summary of this soil type. Depth in localised areas can reach 0.5 m.

**Table 17 – Overview: Soil Type DS2**

<table>
<tr><th colspan="2">Site Description</th></tr>
<tr><td><br>**Plate 26** – Profile (Obs 47)</td><td><br>**Plate 27** – Landscape (Obs 47)</td></tr>
<tr><td>**ASC Name**</td><td>Rudosol (representative site – Obs 47)</td></tr>
<tr><td>**Dominant Slope Association**</td><td>Steep slopes, ridges; 10-33%</td></tr>
<tr><td>**Rural Land Capability**</td><td>Class VII; main limitation – slope, shallow soil depth</td></tr>
<tr><td>**Soil Stripping Depth**</td><td>Not recommended for stripping due to poor chemical and physical attributes.</td></tr>
</table>

| Physical Characteristics | | |
|---|---|---|
| **Horizon** | **Depth (m)** | **Description** |
| A1 | 0.0–0.15 | Very dark grayish-brown (10YR3/2) loam; weak structure grade with weak consistence. Nil mottling and high stone content. Well drained with a clear and even boundary. |
| R | 0.15+ | Bedrock |

| Analytical Description | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Horizon** | **Depth** | **Colour** | **pH** | **EC** | **CEC** | **ESP** | **EAT** |
| No. | m | Munsell | - | dS/cm | meq/100g | % | Class |
| A1 | 0.0–0.15 | 10YR3/2 | 4.5 | 0.22 | 3 | 32.0 | 8 |
| | | Very dark grayish-brown | Very strongly acidic | Medium | Very low | Strongly sodic | Negligible |

*Soil Type DS3 – Red Chromosol; very shallow*

Soil Type DS3 is a Chromosol. This soil type covers 860 ha (20.8%) of the high disturbance area (refer **Figure 3**). This soil type is comprised of one distinct soil horizon and the profile is characterised as a sandy loam. Soil pH trends from very strongly acidic to strongly acidic; salinity is very low throughout; and the profile is non-sodic. **Table 18** provides a summary of this soil type. Depth in localised areas can reach 0.5 m.

**Table 18 – Overview: Soil Type DS3**

**Site Description**

**Plate 28** – Profile (Obs 23)

**Plate 29** – Landscape (Obs 23)

| | |
|---|---|
| **ASC Name** | Red Chromosol; very shallow (representative site – Obs 47) |
| **Dominant Slope Association** | Upper slopes; 5-10% |
| **Land Capability** | Class VI; main limitation – slope, shallow soil depth |
| **Soil Stripping Depth** | 0.25 m; main limitation - shallow soil depth |

**Physical Characteristics**

| Horizon | Depth (m) | Description |
|---|---|---|
| A1 | 0.0–0.25 | Very dark brown (7.5YR2.5/3) sandy loam; moderate structure grade of 5 – 10 mm blocky peds with a weak to moderate consistence. Nil mottling and nil stone content. Well drained with a clear and even boundary. |
| C | 0.25+ | Bedrock |

**Analytical Description**

| Horizon | Depth | Colour | pH | EC | CEC | ESP | EAT |
|---|---|---|---|---|---|---|---|
| No. | m | Munsell | - | dS/cm | meq/100g | % | Class |
| A1 | 0.0–0.25 | 7.5YR2.5/3 | 5.8 | 0.03 | 3 | 3.4 | 8 |
| | | Very dark brown | Moderately acidic | Very low | Very low | Non-sodic | Negligible |

### 3.1.4 Mitchell Creek Soil Landscape

The Mitchell Creek soil landscape unit covers alluvial plains and terraces of minor streams. It is located on Quaternary alluvium. Slopes are up to 4% with lengths between 50-500 m. Active streambank and gully erosion is present along most creeks.

This soil landscape covers 2 ha (1.5%) of the medium disturbance area (refer **Figure 3**). Soils are highly variable and relate to the adjacent or upstream soil landscapes. Soils vary from alluvial deposits of Rudosols and Dermosols, with Chromosols, Sodosols and Vertosols on terraces. **Table 19** provides a summary of this soil type.

**Table 19 – Overview: Mitchell Creek Dominant Soil Type**

| Site Description | |
|---|---|
| **ASC Name** | Rudosol, Dermosol, Chromosol, Sodosol, Vertosol |
| **Dominant Slope Association** | Alluvial plains and terraces; 0-4% |
| **Rural Land Capability** | Class IV; Main limitations - soil structure, flood hazard |
| **Soil Stripping Depth** | On-site testing required prior to removal; expect minimum soil depth of 0.2 m suitable for stripping. |

## 3.2 Low Disturbance Area

The low disturbance area includes Domains 3 and 4 (**Figure 1**), which covers the Auxiliary Infrastructure Area and the Road Network. This area is covered by 12 soil landscape units including Ballimore, Bald Hill, Cudgegong, Dapper Hill, Spring Ridge, Home Rule, Lahey's Creek, Mebul, Mitchell Creek, Mookerawa, Mullion Creek and Tucklan.

The Balllimore, Dapper Hill and Spring Ridge, and Lahey's Creek soil landscape units were described in detail previously, the remaining are briefly described below.

### 3.2.1 Bald Hill Soil Landscape

The dominant soil type in the Bald Hill soil landscape is a Red Dermosol and covers <1 ha (<1%) of the low disturbance area (refer **Figure 3**). This soil profile is characterised by a fine sandy loam overlaying light clay. Soil pH is neutral to mildly alkaline and salinity is low. **Table 20** provides a summary of this soil type.

**Table 20 – Overview: Bald Hill Dominant Soil Type**

| Site Description | |
|---|---|
| **ASC Name** | Red Dermosol |
| **Dominant Slope Association** | Crests, Mid to upper slopes; 10-35% slope |
| **Rural Land Capability** | Class IV with minor coverage of V, VII; main limitations – slope, rockiness |
| **Physical Characteristics** | |
| **Horizon** | **Description** |
| Topsoil (A1) | Dark reddish-brown fine sandy loam and loam; weak crumb structure and neutral (pH 7.0). Well drained with moderate soil permeability. |
| Subsoil (B2) | Reddish-brown light clay; strong structure of polyhedral peds and mildly alkaline (pH 7.5). |

### 3.2.2 Cudgegong Soil Landscape

The dominant soil type in the Cudgegong soil landscape is a Yellow Chromosol, although alluvial soils on the lowest terraces are also common. The Cudgegong unit covers <1 ha (<1%) of the low disturbance area (refer **Figure 3**). The Yellow Chromosol soil profile is characterised by a sandy loam overlaying fine sandy clay loam. Soil pH is generally slightly acidic throughout and salinity is low. **Table 21** provides a summary of this soil type.

**Table 21 – Overview: Cudgegong Dominant Soil Type**

| Site Description | | |
|---|---|---|
| **ASC Name** | | Yellow Chromosol |
| **Dominant Slope Association** | | Low terraces; 0-2% |
| **Rural Land Capability** | | Class III; however, class II also common. Main limitation – soil decline hazard, flood hazard |
| **Physical Characteristics** | | |
| **Horizon** | **Description** | |
| Topsoil (A1) | Brown to Bright brown fine sandy loam; massive to weak structure and slightly acidic (pH 6 – 6.5). Rapidly drained with permeable soil. | |
| Subsoil (B2) | Bright yellowish-brown fine sandy clay loam; moderately structure and slightly acidic (pH 6.0). Some orange mottling. | |

### 3.2.3 Home Rule Soil Landscape

The dominant soil type in the Home Rule soil landscape unit is a Yellow Sodosol. This soil type covers 4 ha (1.5%) of the low disturbance area (refer **Figure 3**). This soil profile is characterised by a sandy loam overlaying sandy clay. Soil pH varies from moderately acidic to strongly alkaline throughout the profile and salinity is low to moderate. **Table 22** provides a summary of this soil type.

**Table 22 – Overview: Home Rule Dominant Soil Type**

| Site Description | | |
|---|---|---|
| **ASC Name** | | Yellow Sodosol |
| **Dominant Slope Association** | | Lower slopes; 4-8% slope |
| **Rural Land Capability** | | Class IV; however, class V and VI also common. Main limitations – high erosion hazard, sodicity |
| **Physical Characteristics** | | |
| **Horizon** | **Depth (m)** | **Description** |
| Topsoil (A1) | 0.0–0.40 | Brown to dull yellowish-orange to dull yellowish-brown sandy loam to fine sandy loam; massive structure and moderately acidic to strongly alkaline (pH 6.0-8.5). Imperfectly drained with slow soil permeability. |
| Subsoil (B2) | 0.40–1.50 | Dull yellowish-orange to bright yellowish-brown sandy clay; moderate structure and moderately acidic to strongly alkaline (pH 6.0-8.5). Some mottling. |

### 3.2.4 Mebul Soil Landscape

The dominant soil type in the Mebul soil landscape is a Red Dermosol and covers 13 ha (4.9%) of the low disturbance area (refer **Figure 1**). This soil profile is characterised by a loam to clay loam, overlaying clay. Soil pH is generally moderately alkaline throughout and salinity is low. **Table 23** provides a summary of this soil type.

**Table 23 – Overview: Mebul Dominant Soil Type**

| Site Description | | |
|---|---|---|
| **ASC Name** | Red Dermosol | |
| **Dominant Slope Association** | Crests; 2-15% slope | |
| **Rural Land Capability** | Class III; however, Class IV also common. Main limitations – slope, rock outcrop | |
| **Physical Characteristics** | | |
| **Horizon** | **Depth (m)** | **Description** |
| Topsoil (A1) | 0.0–0.10 | Brown loam to clay loam; strong structure and moderately alkaline (pH 8.0). Well drained with moderate soil permeability. |
| Subsoil (B2) | 0.05–0.90 | Brown to Reddish-brown clay; structure of sub angular blocky peds and moderately alkaline (pH 8.0 – 8.5). |

### 3.2.5 Mookerawa Soil Landscape

The dominant soil type in the Mookerawa soil landscape unit is Yellow Sodosol. This soil type covers 5 ha (1.9%) of the low disturbance area (refer **Figure 3**). This soil profile is characterised by a loam overlaying light clay. Soil pH is moderately acidic to slightly acidic; low to moderate salinity is present. **Table 24** provides a summary of this soil type.

**Table 24 – Overview: Mookerawa Dominant Soil Type**

| Site Description | |
|---|---|
| **ASC Name** | Yellow Sodosol |
| **Dominant Slope Association** | Lower slopes to depressions; 8-30% slope |
| **Rural Land Capability** | Class IV; however, Class III and VI also common. Main limitations – slope, waterlogging, sodicity |
| **Physical Characteristics** | |
| **Horizon** | **Description** |
| Topsoil (A1) | Dark brown loam; massive structure and moderately acidic (pH 6.0). Imperfectly drained with very low to low soil permeability. Some quartz stone and ironstone fragments. |
| Topsoil (A2) | Loam; slightly acidic (pH 6.5). Bleached layer. |
| Subsoil | Dull yellowish-brown to bright reddish-brown light to medium clay; moderate structure and moderately alkaline (pH 6.0-6.5). |

### 3.2.6 Mullion Creek Soil Landscape

The dominant soil type in the Mullion Creek soil landscape unit is Yellow Sodosol. This soil type covers <1 ha (<1%) of the low disturbance area (refer **Figure 3**). This soil profile is characterised by a fine sandy loam overlaying light - medium clay. Soil pH is moderately acidic to slightly acidic and low to high salinity is present. **Table 25** provides a summary of this soil type.

**Table 25 – Overview: Mullion Creek Dominant Soil Type**

| Site Description | |
|---|---|
| **ASC Name** | Yellow Sodosol |
| **Dominant Slope Association** | Lower slopes and depressions; 3-12% slope |
| **Rural Land Capability** | Class III; however, Class IV also common. Main limitations – slope, very high erosion hazard, rock outcrop, sodicity |
| **Physical Characteristics** | |
| **Horizon** | **Description** |
| Topsoil (A1) | Dark brown fine sandy loam; massive structure and moderately acidic (pH 6.0). Imperfectly drained with very low to low soil permeability. Some quartz stone and ironstone fragments. |
| Topsoil (A2) | Fine sandy loam; slightly acidic (pH 6.5). Bleached layer with 10-15% stones. |
| Subsoil (B2) | Dull yellowish-brown to bright reddish-brown light to medium clay; moderate structure and moderately alkaline (pH 6.0-6.5). |

### 3.2.7 Tucklan Soil Landscape

The dominant soil type in the Tucklan soil landscape unit is a Red Ferrosol and it covers 23 ha (8.7%) of the low disturbance area (refer **Figure 3**). This soil profile is characterised by a gravelly sandy clay loam grading into a gravelly clay loam overlying light - medium clay. Soil pH is slightly acidic to neutral and moderate salinity is present. **Table 26** provides a summary of this soil type.

**Table 26 – Overview: Tucklan Dominant Soil Type**

| Site Description | | |
|---|---|---|
| **ASC Name** | | Red Ferrosol |
| **Dominant Slope Association** | | Lower to mid slopes; 3-15% slope |
| **Rural Land Capability** | | Class III; however, Class II, IV and VI also common. Main limitation - erosion hazard |
| **Physical Characteristics** | | |
| **Horizon** | **Depth (m)** | **Description** |
| Topsoil (A1) | 0.0–0.10 | Dark reddish-brown gravelly sandy clay loam; slightly acidic (pH 6.5). Well drained with moderate soil permeability. |
| Topsoil (A12) | 0.10–0.20 | Gravelly clay loam. Well drained with moderate soil permeability. |
| Subsoil (B) | 0.20–0.60 | Dark reddish-brown light medium clay; strong structure and neutral (pH 7.0). Well drained with moderate soil permeability. |

## 3.3 Nil Disturbance Area: Domain 6

The nil disturbance area is designated Domain 6. This area is covered by a total of 16 soil landscape units, including the 12 within the low disturbance area as well as Burrendong, Rouse, Surface Hill and Talbragar, which are described below.

### 3.3.1 Burrendong Soil Landscape

The dominant soil type in the Burrendong soil landscape unit is Leptic Rudosol. This soil type covers 291 ha (1.3%) of the nil disturbance area (refer **Figure 3**). This soil profile is characterised by a fine sandy loam, fine sandy clay loam or loam, overlaying rock with some sandy clay loam. Soil pH is strongly acidic to moderately acidic; low salinity is present. **Table 27** provides a summary of this soil type.

**Table 27 – Overview: Burrendong Dominant Soil Type**

| Site Description | | |
|---|---|---|
| **ASC Name** | Leptic Rudosol | |
| **Dominant Slope Association** | Hillcrests, Upper slopes; 20-50% slope | |
| **Rural Land Capability** | Class VII; however, Class IV also common. Main limitations – shallow soil depth, rock outcrop, slope | |
| **Physical Characteristics** | | |
| **Horizon** | **Depth (m)** | **Description** |
| Topsoil (A1) | 0.0–0.15 | Dark brown fine sandy loam to fine sandy clay loam; massive to weak structure and moderately acidic (pH 5.5). Or a dark brown or Yellowish-brown fine sandy loam to loam, massive to weak structure and moderately to slightly acidic (pH 5.5-6.0). Well drained with high soil permeability. |
| CB | 0.15+ | Rock outcrop with some bright brown sandy clay loam; weak structure and moderately to slightly acidic (pH 5.5-6.0). |

### 3.3.2 Rouse Soil Landscape

The dominant soil type in the Rouse soil landscape is a Yellow Sodosol. This soil type covers 5 ha (<1%) of the nil disturbance area (refer **Figure 3**). Soil pH varies from moderately acidic to strongly alkaline throughout the profile and low salinity is present. **Table 28** provides a summary of this soil type.

**Table 28 – Overview: Rouse Dominant Soil Type**

| Site Description | |
|---|---|
| **ASC Name** | Yellow Sodosol |
| **Dominant Slope Association** | Lower slopes and depressions; 5-15% slope |
| **Rural Land Capability** | Class IV; Main limitations – slope, sodicity |
| **Physical Characteristics** | |
| **Horizon** | **Description** |
| Topsoil (A1) | Brown to Dull yellowish-orange to Yellowish-brown sandy loam; weak structure and moderately acidic to strongly alkaline (pH 6.0-8.5). Imperfectly drained with slow soil permeability. |
| Topsoil (A2) | Dull yellowish-brown sandy loam; massive structure. |
| Subsoil (B2) | Yellowish-brown to Dull yellowish-orange to Bright yellowish-brown sandy clay loam; moderate structure and moderately acidic to strongly alkaline (pH 6.0-8.5). |

### 3.3.3 Surface Hill Soil Landscape

The dominant soil type in the Surface Hill soil landscape is a Red Chromosol. This soil type covers 184 ha (<1%) of the nil disturbance area (refer **Figure 3**). This soil profile is characterised by a fine sandy loam overlaying light - medium clay. Soil pH is slightly acidic in the topsoil; low salinity is present. **Table 29** provides a summary of this soil type.

**Table 29 – Overview: Bald Hill Dominant Soil Type**

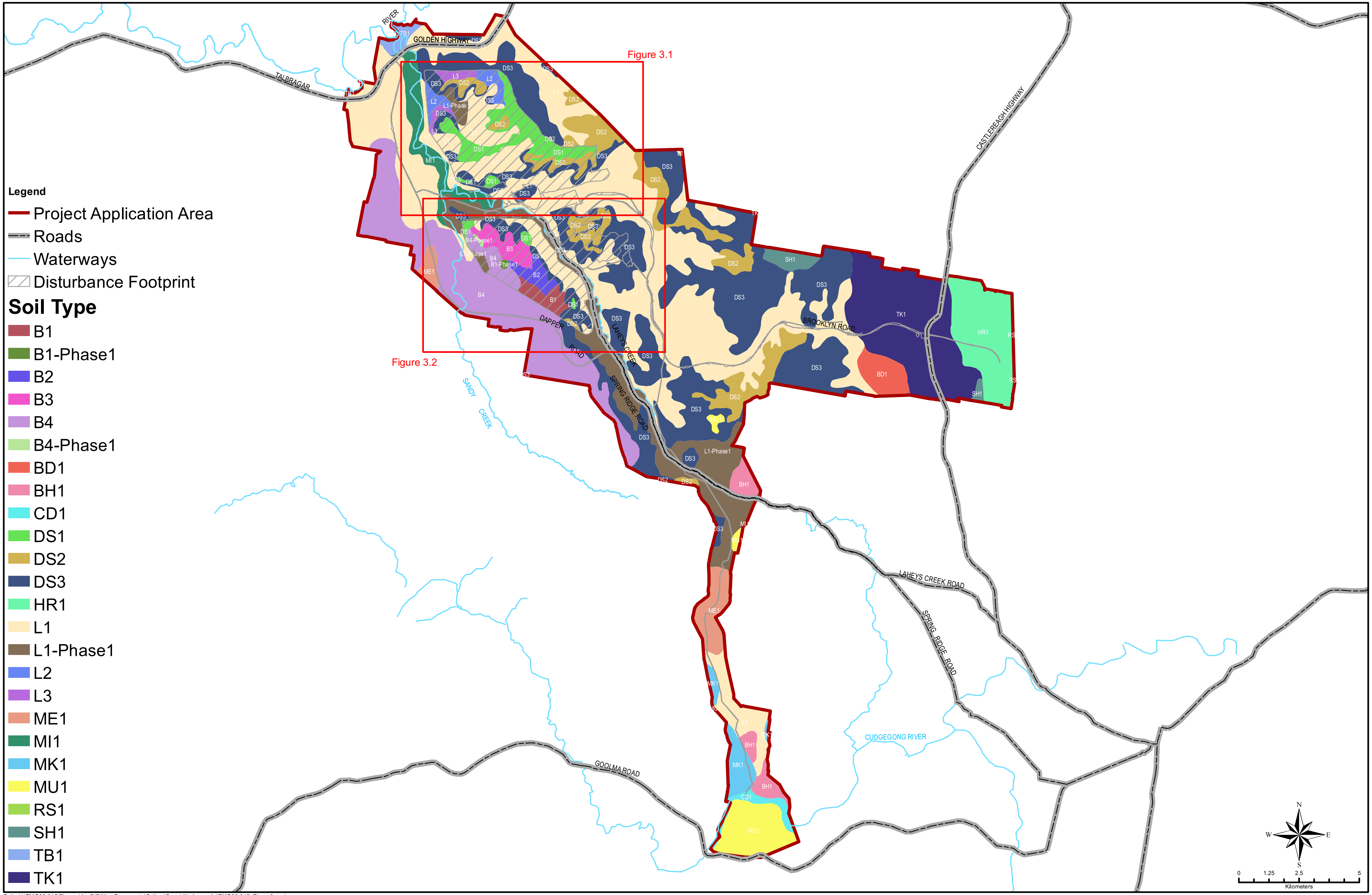
| Site Description | |
|---|---|
| **ASC Name** | Red Chromosol |
| **Dominant Slope Association** | Crests, Upper slopes; 10-15% slope |
| **Rural Land Capability** | Class V; however, Class IV and VI also common. Main limitations - slope, rock outcrop. |
| **Physical Characteristics** | |
| **Horizon** | **Description** |
| Topsoil (A1) | Dark reddish-brown fine sandy loam; weak structure. Well drained with moderate soil permeability. |
| Topsoil (A2) | Dark reddish-brown fine sandy loam; weak structure. Well drained with moderate soil permeability and clear boundary. |
| Subsoil (B2) | Reddish-brown light to medium clay; moderate to strong structure. |

### 3.3.4 Talbragar Soil Landscape

The dominant soil type in the Talbragar soil landscape unit is a Red Chromosol and covers 116 ha (<1%) of the nil disturbance area (refer **Figure 3**). This soil profile is characterised by a fine sand overlaying medium clay. Soil pH is slightly acidic throughout; low salinity is present. **Table 30** provides a summary of this soil type.

**Table 30 – Overview: Talbragar Dominant Soil Type**

| Site Description | | |
|---|---|---|
| **ASC Name** | Red Chromosol | |
| **Dominant Slope Association** | Higher terraces; 0-3% slope | |
| **Rural Land Capability** | Class II; Main limitation - some erosion hazard along stream banks | |
| **Physical Characteristics** | | |
| **Horizon** | **Depth (m)** | **Description** |
| Topsoil (A1) | 0.0–0.40 | Dark reddish-brown fine sand; Weak structure and slightly acidic. Well drained with low to moderate soil permeability. Bleached A2 horizon is commonly present. |
| Subsoil (B21) | 0.40–1.00 | Reddish-brown medium clay; well-structured and slightly acidic. Well drained with low to moderate soil permeability. |
| Subsoil (B22) | 1.00+ | Yellowish-brown medium clay; well-structured and slightly acidic. Some grey mottling. |

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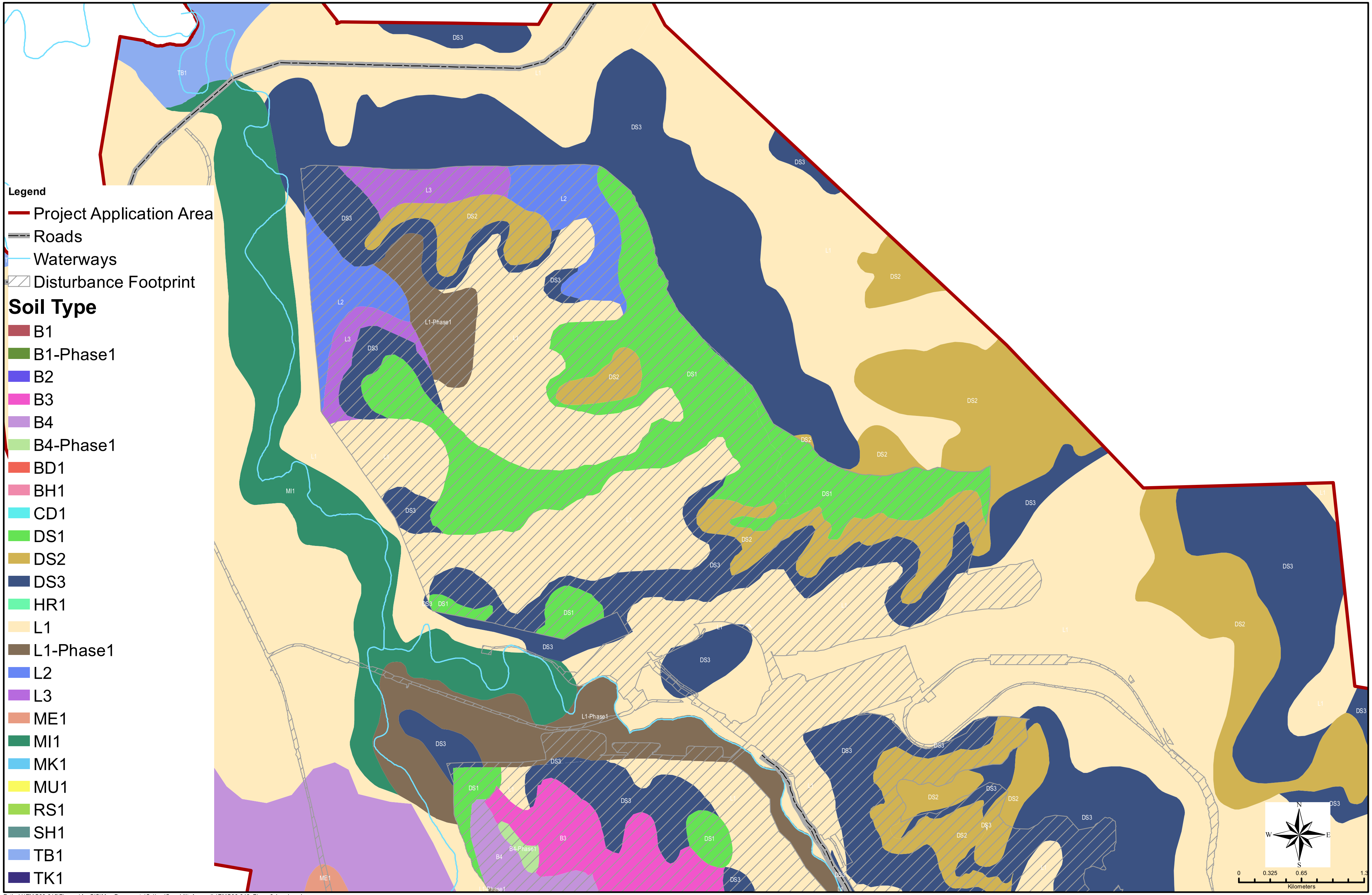
Soil Types
Cobbora Coal Project
**Figure 3**

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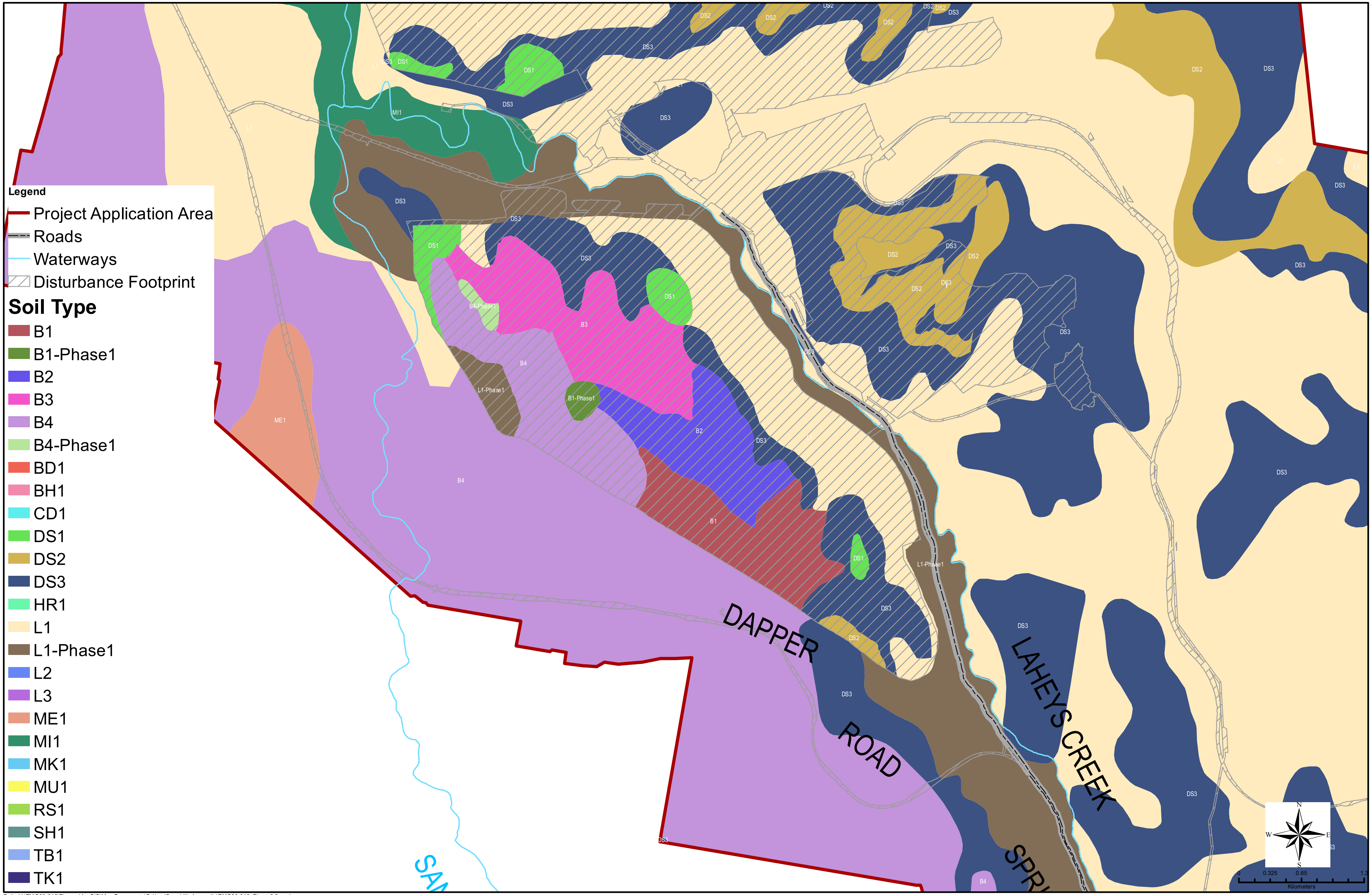
Environmental, Land and Project Management Consultants

Soil Types
Cobbora Coal Project
**Figure 3.1**




Path: V:\EMG00-012\Figures\ArcGIS\Map Documents\SoilandCapabilityAppendix\EMG00-012_Figure3.2.mxd

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Environmental, Land and Project Management Consultants

Soil Types

Cobbora Coal Project

**Figure 3.2**

# 4.0 SOIL RESOURCE ASSESSMENT

In accordance with the adequacy response approved by the NSW DPI, this section includes an updated soil stripping assessment. This assessment includes determination of soil suitability and volumes for salvage and re-use for rehabilitation.

Determination of suitable soil to conserve for later use in rehabilitation works has been conducted in accordance with Elliot & Reynolds (2000). The procedure involves assessing soils based on a range of physical and chemical parameter. These are summarised in **Table 31.**

**Table 31 - Topsoil Stripping Suitability Criteria**

| Parameter | Desirable Criteria |
|---|---|
| Structure grade | >30% peds |
| Coherence | Coherent (wet and dry) |
| Mottling | Absent |
| Macrostructure | >10 cm |
| Force to disrupt peds | ≤ 3 force |
| Texture | Finer than a Fine Sandy Loam |
| Gravel and sand content | <60% |
| pH | 4.5 to 8.4 |
| Salt content | <1.5 dS/m |

## 4.1 Soil Stripping Suitability

The assessment shows that soil in the disturbance footprint has a recommended stripping depth that ranges from 0.0 m to 0.55 m. The recommended depths are the depth of soil that could be salvaged via the stripping process and re-used in progressive and post-construction rehabilitation works. Most of the unimproved topsoil is limited by physical characteristics such as weak soil structure. However, these physical limitations are generally minor and can be overcome by appropriate management actions. All subsoils are undesirable for use due to physical (e.g. strong consistence) and/or chemical limitations (e.g. sodicity).

**Table 32** details the maximum recommended stripping depths for each soil type and their major limitations. **Figure 4** provides the spatial distribution of the recommended stripping depths.

The key points are listed below:

- There are a total of 14 different soil types within Domains 1, 2 and 5. Thirteen are suitable for use during rehabilitation.
- The major soil limitations are high clay content and strong consistence, or shallow soil depth.
- A number of soil types are limited by poor surface soil structure and/or acidity; however, these can be used with appropriate use of ameliorants.
- One soil type is not suitable for use in rehabilitation (Soil Type DS 2) was limited by very strong sodicity and acidity, as well as shallow soil depth.

- The Rural Land Capability Class III soil (Soil Type B3) contains no chemical limitations. The physical limitation of high clay content can be managed using soil management practices to facilitate its use in Class III profile re-instatement works.

**Table 32 - Soil Resources: Salvage Assessment**

| Soil Type | | Stripping Depth (m) | | Limitations |
|---|---|---|---|---|
| # | Name | Topsoil | Subsoil | |
| B1 | Reddish-brown Chromosol | 0.2 | Nil | High subsoil clay content and strong consistence of subsoil. |
| B1 – Phase 1 | Reddish-brown Chromosol; very shallow | 0.2 | Nil | Shallow soil depth. |
| B2 | Brown Chromosol: Type 1 | 0.2 | Nil | High subsoil clay content and strong consistence of subsoil. |
| B3 | Yellowish-red Chromosol | 0.5 | 0.5 | High subsoil clay content and strong consistence of subsoil.<br>Subsoil salvage recommended for reinstatement of Class III land. Amelioration required[1]. |
| B4 | Brown Chromosol: Type 2 | 0.3 | Nil | High subsoil clay content and subsoil sodicity Amelioration[2] required to improve topsoil structure. |
| B4 – Phase 1 | Brown Chromosol; shallow | 0.3 | Nil | Shallow soil depth. |
| L1 | Yellow Sodosol: Type 1 | 0.2 | Nil | High subsoil clay content subsoil sodicity. Amelioration[2] required to improve topsoil soil structure. |
| L1 – Phase 1 | Yellow Sodosol: Type 2 | 0.45 | Nil | High subsoil clay content subsoil sodicity. Amelioration[2] required to improve topsoil soil structure. |
| L2 | Yellowish-brown Chromosol | 0.55 | Nil | High clay content. Ameliorantion[2] required to improve structure of topsoil. |
| L3 | Yellowish-red Chromosol | 0.4 | Nil | High clay content. Ameliorantion[2] required to improve structure of topsoil. |
| DS1 | Tenosol; very shallow | 0.2 | Nil | Topsoil marginal for stripping. Ameliorants[2] required to improve structure of topsoil and neutralise acidity[3]. |
| DS2 | Rudosol; very shallow | Nil | Nil | Not recommended for stripping due to poor chemical and physical attributes. |
| DS3 | Red Chromosol; very shallow | 0.25 | Nil | Shallow soil depth. |
| MI1 | Alluvial Soil | 0.2 | Nil | Further testing required. |

1 Ameliorate with gypsum reduce 'cloddiness' of soil

2 Ameliorate with organic amendments to improve weakly structured soils

3 Ameliorate with lime to improve soil pH

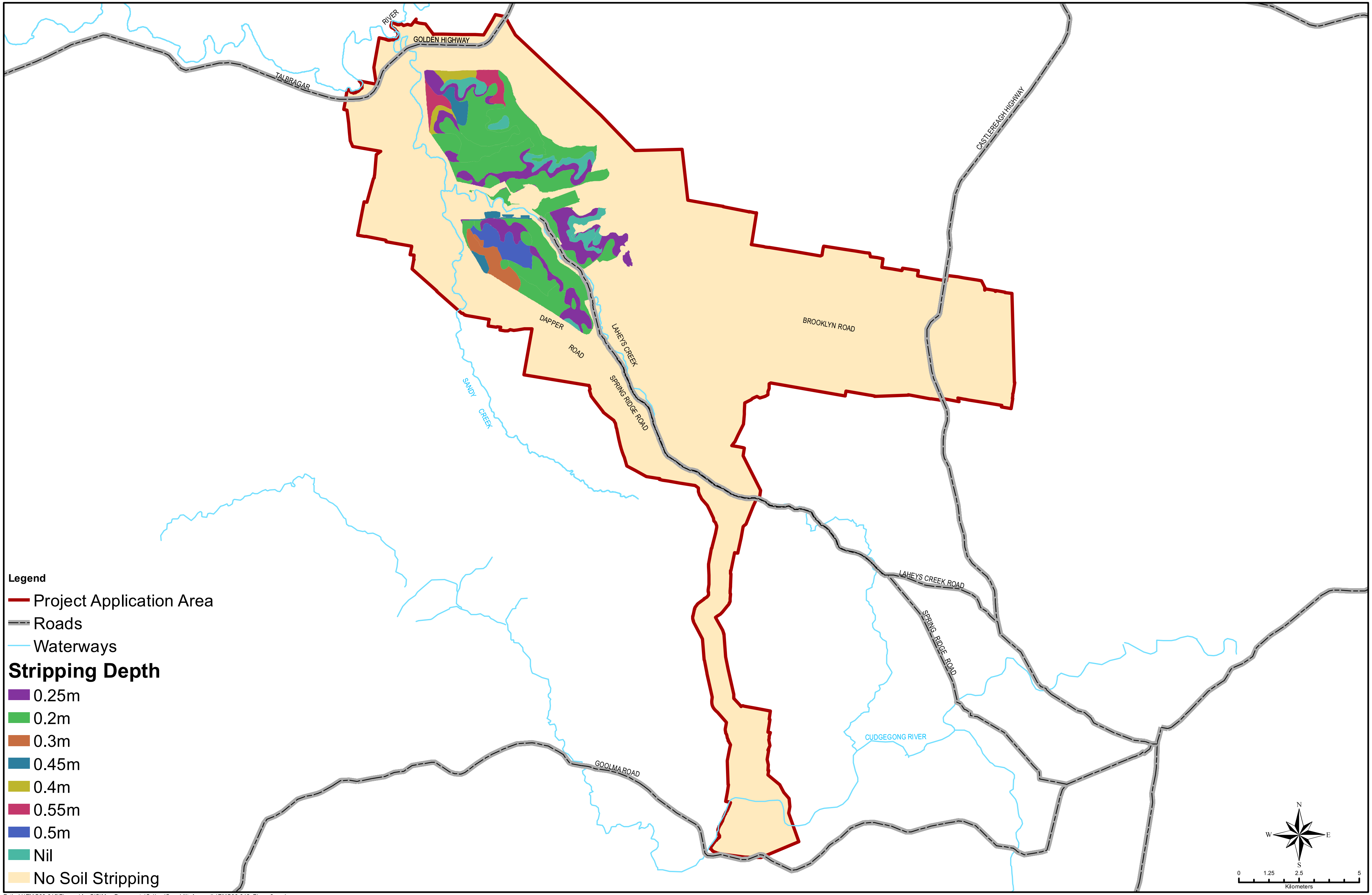
## 4.2 Soil Stripping Volume

The quantity of soil that can be salvaged from the disturbance footprint is based on the recommended soil stripping depths and the area of land that will be disturbed. The land covered by the Auxiliary Infrastructure and Road Network Domains has been excluded as these domains include construction and operational elements that may not disturb the soil profile at depth (e.g. overland power easement, overland pipeline).

The estimated total volume of soil available from areas to be disturbed is 10.1 million cubic metres (MCM). When a handling loss of 5% is allowed, this volume is reduced to approximately 9.6 MCM (**Table 33**). It is recommended that the detailed Topsoil Management Plan (which is to be developed prior to the commencement of construction works) provides strategies on how to minimise topsoil losses during stripping to ensure that topsoil resources are preserved.

**Table 33 - Available Soil Volume: Domain 1, 2 & 5**

| Soil Type | | Stripping Area | Stripping Depth | Quantity of Soil |
|---|---|---|---|---|
| # | Name | ha | m | MCM |
| B1 | Reddish-brown Chromosol | 149 | 0.2 | 0.30 |
| B1 – Phase 1 | Reddish-brown Chromosol; very shallow | 12 | 0.2 | 0.02 |
| B2 | Brown Chromosol: Type 1 | 134 | 0.2 | 0.27 |
| B3 | Yellowish-red Chromosol | 202 | 0.5 | 1.01 |
| B4 | Brown Chromosol: Type 2 | 165 | 0.3 | 0.50 |
| B4 – Phase 1 | Brown Chromosol; shallow | 9 | 0.3 | 0.03 |
| DS1 | Tenosol; very shallow | 641 | 0.2 | 1.28 |
| DS2 | Rudosol; very shallow | 364 | Nil | 0.00 |
| DS3 | Red Chromosol; very shallow | 861 | 0.25 | 2.15 |
| L1 | Yellow Sodosol: Type 1 | 1,332 | 0.2 | 2.66 |
| L1 – Phase 1 | Yellow Sodosol: Type 2 | 146 | 0.45 | 0.66 |
| L2 | Yellowish-brown Chromosol | 161 | 0.55 | 0.89 |
| L3 | Yellowish-red Chromosol | 94 | 0.4 | 0.38 |
| MI1 | Alluvial Soil | 2 | 0.2 | <0.01 |
| **Total** | | | | **10.14** |
| **Total minus 5% handling loss** | | | | **9.64** |

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Soil Stripping Depths
Cobbora Coal Project
**Figure 4**

## 5.0 SUMMARY

This Soils and Rural Land Capability Assessment has been prepared in accordance with the *Guidelines for Surveying Soil and Land Resources* (NCST, 2008) and consultation with the DPI in October, 2012. The key findings of this assessment are listed below.

- The PAA is 27,386 ha and has a disturbance footprint that covers approximately 4,536 ha. The footprint was divided into six domains: (1) Mining Operations Domain, (2) Mine Infrastructure Domain, (3) Auxiliary Infrastructure Domain, (4) Road Network Domain, (5) the Raw Water Dam Domain, and (6) Nil Disturbance Domain.

- The PAA is covered by 25 different soil types. Within the disturbance footprint a total of 21 soil types were identified. The majority of soil types are texture contrast soils (Chromosols), some with sodic sub-soils (Sodosols) as well some Tenosols and Rudosols.

- Within the high and medium disturbance footprint Yellow Sodosols (Type 1 and 2) are the most dominant soil type, followed by very shallow Red Chromosols, Tenosols and Rudosols. Other soil types are minor and represented less than 5% of the area.

- Within the low disturbance footprint Yellow Sodosols (Type 1 and 2) were also the most dominant soil type.

- Within the high and medium disturbance areas, there are a total of 14 different soil types, of which 13 are suitable for use during rehabilitation.

- The major soil limitations for soil stripping suitability are high clay content and strong consistence, or shallow soil depth.

- The estimated total volume of soil available from areas to be disturbed is 10.1 million cubic metres (MCM). When a handling loss of 5% is allowed, this volume is reduced to approximately 9.6 MCM

Yours Faithfully,
**GSS ENVIRONMENTAL**

Adele Calandra
*Senior Environmental Scientist*

## REFERENCES


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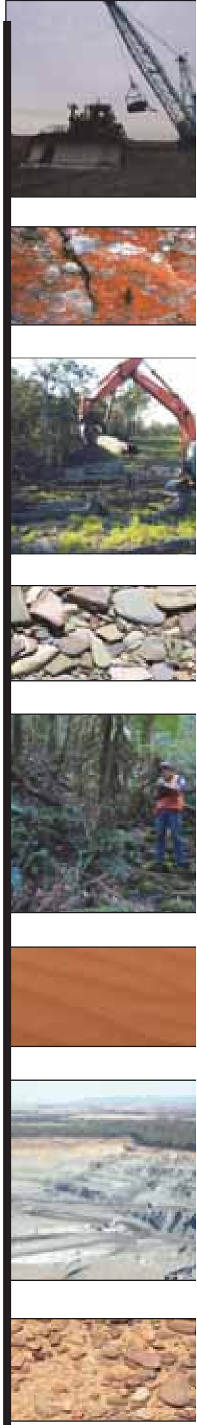

# Soil Laboratory Test Results

# Certificate of Analysis

ATTACHMENT 1

Soil Conservation Service

**SOIL TEST REPORT**



**Scone Research Centre**

---

| | |
|---|---|
| REPORT NO: | SCO09/310R1 |
| REPORT TO: | Clayton Richards<br>GSS Environmental<br>PO Box 907<br>Hamilton NSW 2303 |
| REPORT ON: | Thirty one soil samples<br>Cobbara<br>ERM02-001 |
| PRELIMINARY RESULTS ISSUED: | Not issued |
| REPORT STATUS: | Final |
| DATE REPORTED: | 1 December 2009 |
| METHODS: | Information on test procedures can be obtained from Scone Research Centre |

TESTING CARRIED OUT ON SAMPLE AS RECEIVED
THIS DOCUMENT MAY NOT BE REPRODUCED EXCEPT IN FULL

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SR Young

SR Young
(Laboratory Manager)

**SOIL AND WATER TESTING LABORATORY**
**Scone Research Service Centre**



Report No: SCO09/310R1
Client Reference: Clayton Richards
GSS Environmental
PO Box 907
Hamilton NSW 2303

| Lab No | Method | P7B/1 Particle Size Analysis (%) | | | | | P9B/2 | C1A/4 | C2A/3 | C5A/3 CEC & ex cation (me/100g) | | | Colour | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sample Id | clay | silt | f sand | c sand | gravel | EAT | EC (dS/m) | pH | CEC | Na | ESP | Dry | Moist |
| 1 | Cobbora 1-1 | 21 | 16 | 38 | 23 | 2 | 3(2) | 0.02 | 5.3 | 7.1 | 0.1 | 1 | 7.5YR5/4 | 7.5YR3/3 |
| 2 | Cobbora 1-2 | 16 | 9 | 31 | 39 | 5 | 5 | <0.01 | 5.9 | 6.9 | 0.3 | 4 | 7.5YR6/6 | 7.5YR7/6 |
| 3 | Cobbora 2-1 | 16 | 21 | 32 | 30 | 1 | 8/3(2) | 0.03 | 5.7 | 8.2 | 0.2 | 2 | 10YR6/4 | 10YR4/3 |
| 4 | Cobbora 2-2 | 14 | 21 | 34 | 30 | 1 | 8/3(3) | 0.01 | 6.1 | 8.0 | 0.3 | 4 | 7.5YR6/4 | 7.5YR4/6 |
| 5 | Cobbora 2-3 | 52 | 6 | 16 | 23 | 3 | 3(2) | 0.01 | 6.3 | 18.7 | 0.9 | 5 | 10YR6/6 | 10YR5/6 |
| 6 | Cobbora 4-1 | 15 | 12 | 28 | 43 | 2 | 8/3(1) | 0.07 | 5.5 | 12.1 | 0.3 | 2 | 7.5YR5/4 | 7.5YR3/3 |
| 7 | Cobbora 4-2 | 35 | 9 | 16 | 32 | 8 | 5 | 0.02 | 5.8 | 9.3 | 0.6 | 6 | 7.5YR6/6 | 7.5YR5/8 |
| 8 | Cobbora 4-3 | 41 | 7 | 12 | 28 | 12 | 3(1) | 0.03 | 6.0 | 12.0 | 0.7 | 6 | 7.5YR6/6 | 7.5YR5/8 |
| 9 | Cobbora 5-1 | 20 | 19 | 39 | 21 | 1 | 3(3) | 0.05 | 5.6 | 9.7 | 0.3 | 3 | 10YR5/3 | 10YR3/3 |
| 10 | Cobbora 5-2 | 22 | 20 | 38 | 20 | <1 | 3(3) | 0.01 | 5.8 | 6.9 | 0.3 | 4 | 10YR6/4 | 10YR4/4 |
| 11 | Cobbora 7-1 | 19 | 12 | 37 | 30 | 2 | 8/3(2) | 0.01 | 5.5 | 8.0 | 0.3 | 4 | 7.5YR6/4 | 7.5YR3/4 |
| 12 | Cobbora 7-2 | 21 | 13 | 33 | 28 | 5 | 5 | <0.01 | 5.5 | 9.0 | 0.4 | 4 | 7.5YR6/4 | 7.5YR4/4 |
| 13 | Cobbora 7-3 | 79 | 8 | 10 | 3 | <1 | 5 | 0.02 | 6.0 | 17.3 | 1.0 | 6 | 10YR7/6 | 10YR5/6 |

# SOIL AND WATER TESTING LABORATORY
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Report No: SCO09/310R1
Client Reference: Clayton Richards
GSS Environmental
PO Box 907
Hamilton NSW 2303

| Lab No | Method | P7B/1 Particle Size Analysis (%) | | | | | P9B/2 | C1A/4 | C2A/3 | C5A/3 CEC & ex cation (me/100g) | | | Colour | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sample Id | clay | silt | f sand | c sand | gravel | EAT | EC (dS/m) | pH | CEC | Na | ESP | Dry | Moist |
| 14 | Cobbora 8-1 | 22 | 12 | 34 | 26 | 6 | 8/3(1) | 0.05 | 5.4 | 12.8 | 0.4 | 3 | 7.5YR4/4 | 7.5YR3/3 |
| 15 | Cobbora 8-2 | 30 | 8 | 29 | 21 | 12 | 3(1) | 0.02 | 6.2 | 14.5 | 0.4 | 3 | 5YR5/6 | 5YR3/4 |
| 16 | Cobbora 8-3 | 59 | 9 | 28 | 4 | <1 | 5 | 0.03 | 7.1 | 18.4 | 1.2 | 7 | 7.5YR6/8 | 7.5YR5/8 |
| 17 | Cobbora 11-1 | 17 | 17 | 31 | 31 | 4 | 3(1) | 0.03 | 6.0 | 8.1 | 0.2 | 2 | 7.5YR5/4 | 7.5YR3/4 |
| 18 | Cobbora 11-2 | 17 | 14 | 35 | 32 | 2 | 3(2) | 0.01 | 6.2 | 5.3 | 0.2 | 4 | 7.5YR6/4 | 7.5YR4/4 |
| 19 | Cobbora 11-3 | 61 | 10 | 10 | 11 | 8 | 1 | 0.30 | 7.0 | 22.6 | 4.1 | 18 | 10YR6/6 | 10YR5/6 |
| 20 | Cobbora 13-1 | 9 | 10 | 33 | 28 | 20 | 3(1) | 0.02 | 6.5 | 11.6 | 0.2 | 2 | 7.5YR5/4 | 7.5YR3/3 |
| 21 | Cobbora 13-2 | 8 | 12 | 26 | 32 | 22 | 3(1) | 0.01 | 7.5 | 10.2 | 0.4 | 4 | 7.5YR6/4 | 7.5YR3/4 |
| 22 | Cobbora 13-3 | 47 | 10 | 18 | 17 | 8 | 2(1) | 0.13 | 8.4 | 19.7 | 1.4 | 7 | 7.5YR6/6 | 7.5YR5/6 |
| 23 | Cobbora 15-1 | 23 | 12 | 32 | 30 | 3 | 8/3(1) | 0.09 | 5.1 | 12.4 | 0.5 | 4 | 10YR5/2 | 10YR3/2 |
| 24 | Cobbora 15-2 | 32 | 15 | 26 | 24 | 3 | 6 | 0.22 | 4.4 | 10.5 | 1.2 | 11 | 10YR5/3 | 10YR3/2 |

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# SOIL AND WATER TESTING LABORATORY
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Report No: SCO09/310R1
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GSS Environmental
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Hamilton NSW 2303

| Lab No | Method | P7B/1 Particle Size Analysis (%) | | | | | P9B/2 | C1A/4 | C2A/3 | C5A/3 CEC & ex cation (me/100g) | | | Colour | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sample Id | clay | silt | f sand | c sand | gravel | EAT | EC (dS/m) | pH | CEC | Na | ESP | Dry | Moist |
| 25 | Cobbora 16-1 | 19 | 18 | 33 | 29 | 1 | 3(1) | 0.05 | 6.3 | 10.8 | 0.2 | 2 | 10YR5/4 | 10YR3/2 |
| 26 | Cobbora 16-2 | 20 | 21 | 30 | 28 | 1 | 5 | 0.01 | 6.7 | 10.3 | 0.2 | 2 | 10YR6/4 | 10YR4/4 |
| 27 | Cobbora 16-3 | 37 | 15 | 27 | 21 | <1 | 5 | 0.05 | 6.9 | 13.0 | 0.7 | 5 | 7.5YR6/4 | 7.5YR4/4 |
| 28 | Cobbora 18-1 | 13 | 15 | 36 | 32 | 4 | 8/3(1) | 0.04 | 5.4 | 7.1 | 0.3 | 4 | 7.5YR5/4 | 7.5YR3/3 |
| 29 | Cobbora 18-2 | 7 | 11 | 32 | 29 | 21 | 3(1) | 0.03 | 5.7 | 3.3 | 0.3 | 9 | 7.5YR6/3 | 7.5YR4/4 |
| 30 | Cobbora 18-3 | 37 | 11 | 25 | 20 | 7 | 2(3) | 0.55 | 9.0 | 14.9 | 4.8 | 32 | 10YR6/4 | 10YR4/6 |
| 31 | Cobbora 5-3 | 62 | 13 | 15 | 10 | <1 | 4 | 0.17 | 8.8 | 26.1 | 1.3 | 5 | 10YR6/6 | 10YR4/6 |

SR Young

END OF TEST REPORT

**SOIL TEST REPORT**



**Scone Research Centre**

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| | |
|---|---|
| REPORT NO: | SCO12/413R1 |
| REPORT TO: | Adele Calandra<br>GSS Environmental<br>PO Box 907<br>Hamilton NSW 2303 |
| REPORT ON: | Seventy five soil samples<br>Ref: EMG00-012 |
| PRELIMINARY RESULTS ISSUED: | Not issued |
| REPORT STATUS: | Final |
| DATE REPORTED: | |
| METHODS: | Information on test procedures can be obtained from Scone Research Centre |

TESTING CARRIED OUT ON SAMPLE AS RECEIVED
THIS DOCUMENT MAY NOT BE REPRODUCED EXCEPT IN FULL

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(Laboratory Manager)

# SOIL CONSERVATION SERVICE
## Scone Research Centre



Report No: SCO12/413R1

Client Reference: Adele Calandra
GSS Environmental
PO Box 907
Hamilton NSW 2303

| Lab No | Method | C1A/4 | C2A/3 | C2B/3 | C5A/4 CEC & exchangeable cations (me/100g) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Sample Id | EC (dS/m) | pH | pH ($CaCl_2$) | CEC | Na | K | Ca | Mg | Al |
| 1 | Obs 7 0-15cm | 0.14 | 5.5 | 5.1 | 11.8 | 0.2 | 0.6 | 6.8 | 3.4 | <0.3 |
| 2 | Obs 7 15-30cm | 0.13 | 5.5 | 5.0 | 3.8 | 0.2 | 0.2 | 2.5 | 0.9 | <0.3 |
| 3 | Obs 7 40-50cm | 0.13 | 4.9 | 4.5 | 5.0 | 0.1 | 0.2 | 2.1 | 1.3 | 0.9 |
| 4 | Core 1 0-10cm | 0.04 | 5.8 | 5.0 | 6.3 | 0.1 | 0.1 | 3.3 | 1.9 | <0.3 |
| 5 | Core 1 10-20cm | 0.01 | 5.9 | 5.0 | 2.5 | 0.2 | 0.2 | 1.0 | 1.3 | <0.3 |
| 6 | Core 1 45-55cm | 0.11 | 7.5 | 6.1 | 8.1 | 1.8 | 0.1 | 0.7 | 5.4 | nt |
| 7 | Core 1 70-80cm | 0.18 | 6.7 | 5.8 | 8.4 | 2.4 | 0.1 | 0.7 | 5.2 | <0.3 |
| 8 | Obs 9 0-10cm | 0.05 | 5.6 | 4.7 | 8.7 | <0.1 | 1.0 | 4.3 | 2.8 | 0.4 |
| 9 | Obs 9 10-30cm | 0.03 | 5.6 | 4.6 | 5.0 | 0.2 | 0.6 | 2.1 | 2.2 | 0.7 |
| 10 | Obs 9 30-50cm | 0.05 | 5.7 | 4.5 | 11.6 | 0.8 | 0.5 | 1.4 | 7.2 | 1.3 |

**SOIL CONSERVATION SERVICE**
**Scone Research Centre**

Report No: SCO12/413R1
Client Reference: Adele Calandra
GSS Environmental
PO Box 907
Hamilton NSW 2303

| Lab No | Method | C1A/4 | C2A/3 | C2B/3 | C5A/4 CEC & exchangeable cations (me/100g) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Sample Id | EC (dS/m) | pH | pH ($CaCl_2$) | CEC | Na | K | Ca | Mg | Al |
| 11 | Core 2 0-10cm | 0.02 | 5.6 | 4.7 | 4.4 | 0.1 | 0.3 | 2.3 | 1.6 | 0.5 |
| 12 | Core 2 20-30cm | 0.01 | 6.0 | 4.9 | 3.1 | 0.1 | 0.2 | 1.6 | 1.3 | 0.7 |
| 13 | Core 2 40-50cm | <0.01 | 7.0 | 5.4 | 2.3 | 0.1 | 0.1 | 1.3 | 1.2 | 0.9 |
| 14 | Core 2 65-75cm | 0.05 | 8.2 | 6.4 | 4.8 | 0.7 | 0.1 | 1.8 | 2.5 | nt |
| 15 | Core 3 0-10cm | 0.03 | 5.7 | 4.9 | 8.2 | 0.2 | 0.7 | 3.1 | 3.7 | <0.3 |
| 16 | Core 3 25-35cm | 0.25 | 5.3 | 5.0 | 2.5 | 0.6 | 0.2 | 1.3 | 1.8 | <0.3 |
| 17 | Core 3 55-65cm | 1.22 | 6.7 | 6.2 | 20.7 | 3.3 | 0.2 | 5.3 | 11.2 | 0.5 |
| 18 | Obs 17 0-10cm | 0.09 | 4.9 | 4.2 | 3.1 | 0.3 | 0.4 | 1.1 | 1.1 | 0.9 |
| 19 | Obs 17 15-30cm | 0.22 | 5.0 | 4.2 | 3.0 | 1.1 | 0.1 | 0.6 | 1.8 | 0.9 |
| 20 | Obs 17 30-50cm | 0.06 | 5.9 | 4.4 | 6.8 | 1.1 | 0.1 | 0.4 | 4.8 | 1.1 |
| 21 | Obs 18 0-10cm | 0.01 | 5.0 | 4.1 | 2.7 | <0.1 | 0.2 | 0.8 | 0.5 | 1.5 |
| 22 | Obs 18 20-30cm | 0.02 | 5.3 | 4.3 | 2.6 | <0.1 | 0.1 | 0.9 | 0.7 | 1.2 |

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Report No: SCO12/413R1
Client Reference: Adele Calandra
GSS Environmental
PO Box 907
Hamilton NSW 2303

| Lab No | Method | C1A/4 | C2A/3 | C2B/3 | C5A/4 CEC & exchangeable cations (me/100g) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Sample Id | EC (dS/m) | pH | pH ($CaCl_2$) | CEC | Na | K | Ca | Mg | Al |
| 23 | Core 04 0-10cm | 0.05 | 5.9 | 5.0 | 12.7 | 0.1 | 0.7 | 6.4 | 3.9 | 0.3 |
| 24 | Core 04 25-35cm | 0.02 | 6.5 | 5.2 | 8.0 | 0.2 | 0.7 | 3.4 | 3.2 | 0.4 |
| 25 | Core 04 55-65cm | 0.04 | 6.5 | 5.1 | 5.8 | 0.7 | 0.2 | 1.7 | 3.4 | 0.5 |
| 26 | Core 04 95-100cm | 0.05 | 6.3 | 4.8 | 8.9 | 1.0 | 0.3 | 1.4 | 5.7 | 0.5 |
| 27 | Core 05 0-10cm | 0.03 | 5.6 | 4.6 | 3.0 | 0.2 | 0.3 | 1.2 | 0.5 | <0.3 |
| 28 | Core 05 25-35cm | <0.01 | 6.4 | 5.1 | 2.7 | 0.2 | 0.1 | 1.1 | 0.6 | <0.3 |
| 29 | Core 05 55-65cm | 0.02 | 7.8 | 6.6 | 16.2 | 0.3 | 1.1 | 6.9 | 5.1 | nt |
| 30 | Core 05 75-85cm | 0.03 | 8.1 | 7.0 | 19.8 | 0.3 | 1.4 | 8.3 | 7.2 | nt |
| 31 | Core 06 0-10cm | 0.01 | 5.5 | 4.5 | 3.4 | 0.2 | 0.3 | 0.6 | 0.7 | <0.3 |
| 32 | Core 06 25-35cm | 0.01 | 6.9 | 5.4 | 4.7 | 0.3 | 0.2 | 1.2 | 1.2 | <0.3 |
| 33 | Core 06 55-65cm | 0.05 | 7.4 | 6.4 | 9.5 | 0.5 | 0.7 | 2.5 | 4.3 | nt |
| 34 | Core 06 75-85cm | 0.10 | 7.6 | 6.6 | 17.3 | 0.9 | 1.4 | 4.1 | 8.1 | nt |

**SOIL CONSERVATION SERVICE**
**Scone Research Centre**



Report No: SCO12/413R1
Client Reference: Adele Calandra
GSS Environmental
PO Box 907
Hamilton NSW 2303

| Lab No | Method | C1A/4 | C2A/3 | C2B/3 | C5A/4 CEC & exchangeable cations (me/100g) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Sample Id | EC (dS/m) | pH | pH ($CaCl_2$) | CEC | Na | K | Ca | Mg | Al |
| 35 | Core 07 0-10cm | 0.01 | 6.0 | 5.0 | 3.5 | 0.3 | 0.1 | 1.1 | 1.0 | <0.3 |
| 36 | Core 07 25-35cm | <0.01 | 6.2 | 4.8 | <0.5 | 0.1 | 0.2 | 0.5 | 0.8 | <0.3 |
| 37 | Core 07 65-75cm | 0.03 | 7.6 | 6.0 | 3.7 | 0.7 | 0.2 | 0.2 | 3.4 | nt |
| 38 | Core 08 0-5cm | 0.20 | 6.8 | 6.4 | 12.1 | 0.1 | 2.0 | 7.5 | 2.6 | <0.3 |
| 39 | Core 08 10-20cm | 0.04 | 6.8 | 5.9 | 8.0 | <0.1 | 1.6 | 4.8 | 1.3 | 0.3 |
| 40 | Core 08 25-35cm | 0.03 | 7.7 | 6.6 | 13.8 | <0.1 | 2.2 | 7.9 | 3.3 | nt |
| 41 | Core 08 50-60cm | 0.04 | 8.3 | 7.2 | 15.1 | 0.1 | 1.6 | 8.9 | 4.4 | nt |
| 42 | Core 08 70-80cm | 0.05 | 8.2 | 7.4 | 14.1 | 0.1 | 1.5 | 7.4 | 4.5 | nt |
| 43 | Core 09 0-10cm | 0.04 | 7.1 | 6.5 | 13.2 | 0.1 | 1.7 | 8.2 | 2.4 | nt |
| 44 | Core 09 20-30cm | 0.02 | 7.4 | 6.5 | 13.4 | 0.2 | 1.5 | 8.0 | 4.3 | nt |
| 45 | Core 09 50-60cm | 0.03 | 7.9 | 6.9 | 15.7 | 0.4 | 1.5 | 7.9 | 6.7 | nt |
| 46 | Core 09 70-80cm | 0.05 | 8.0 | 7.1 | 16.1 | 0.5 | 1.5 | 7.4 | 7.1 | nt |

# SOIL CONSERVATION SERVICE
## Scone Research Centre



Report No: SCO12/413R1

Client Reference: Adele Calandra
GSS Environmental
PO Box 907
Hamilton NSW 2303

| Lab No | Method | C1A/4 | C2A/3 | C2B/3 | C5A/4 CEC & exchangeable cations (me/100g) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Sample Id | EC (dS/m) | pH | pH ($CaCl_2$) | CEC | Na | K | Ca | Mg | Al |
| 47 | Core 10 0-10cm | 0.08 | 6.5 | 5.7 | 11.5 | 0.2 | 1.9 | 6.8 | 2.5 | <0.3 |
| 48 | Core 10 20-30cm | 0.02 | 6.8 | 5.7 | 14.4 | 0.3 | 1.5 | 7.1 | 5.8 | <0.3 |
| 49 | Core 10 55-65cm | 0.13 | 7.6 | 7.1 | 17.1 | 0.4 | 1.2 | 7.7 | 8.7 | nt |
| 50 | Core 10 80-90cm | 0.19 | 8.4 | 7.9 | 17.8 | 0.6 | 1.1 | 13.0 | 7.8 | nt |
| 51 | Core 11 0-10cm | 0.08 | 6.3 | 5.5 | 9.5 | 0.3 | 2.1 | 5.9 | 2.4 | <0.3 |
| 52 | Core 11 25-35cm | 0.01 | 6.6 | 5.4 | 9.5 | 0.4 | 0.6 | 5.2 | 3.8 | <0.3 |
| 53 | Core 11 55-65cm | 0.09 | 8.2 | 7.2 | 19.4 | 1.4 | 0.7 | 6.4 | 11.3 | nt |
| 54 | Core 11 80-90cm | 0.28 | 9.1 | 8.3 | 27.6 | 2.2 | 0.9 | 19.1 | 12.4 | nt |
| 55 | Core 11 110cm | 0.31 | 9.3 | 8.5 | 27.1 | 2.4 | 0.9 | 20.7 | 11.7 | nt |
| 56 | Core 12 0-10cm | 0.11 | 6.8 | 6.3 | 12.6 | 0.3 | 1.5 | 9.7 | 3.2 | nt |
| 57 | Core 12 10-20cm | 0.04 | 7.0 | 6.1 | 10.9 | 0.2 | 2.2 | 6.1 | 3.1 | nt |

# SOIL CONSERVATION SERVICE
## Scone Research Centre



Report No: SCO12/413R1
Client Reference: Adele Calandra
GSS Environmental
PO Box 907
Hamilton NSW 2303

| Lab No | Method | C1A/4 | C2A/3 | C2B/3 | C5A/4 CEC & exchangeable cations (me/100g) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Sample Id | EC (dS/m) | pH | pH ($CaCl_2$) | CEC | Na | K | Ca | Mg | Al |
| 58 | Core 13 0-10cm | 0.04 | 6.7 | 5.8 | 9.9 | 0.3 | 1.8 | 6.3 | 1.8 | <0.3 |
| 59 | Core 13 10-20cm | 0.11 | 7.0 | 6.6 | 9.5 | 0.4 | 1.2 | 6.5 | 2.4 | nt |
| 60 | Core 13 25-35cm | <0.01 | 7.2 | 6.1 | 7.8 | 0.3 | 0.9 | 5.2 | 2.3 | nt |
| 61 | Core 13 55-65cm | 0.02 | 7.8 | 6.9 | 16.1 | 0.5 | 1.3 | 8.6 | 6.3 | nt |
| 62 | Core 13 80-90cm | 0.07 | 8.3 | 7.6 | 18.7 | 0.7 | 1.3 | 9.2 | 8.3 | nt |
| 63 | Core 14 0-10cm | 0.02 | 5.6 | 4.6 | 5.1 | 0.1 | 0.8 | 3.1 | 1.1 | 0.5 |
| 64 | Core 14 25-35cm | 0.02 | 7.3 | 6.3 | 7.1 | 0.2 | 0.4 | 4.7 | 2.2 | nt |
| 65 | Core 14 55-65cm | 0.15 | 8.1 | 7.4 | 12.6 | 1.1 | 0.3 | 6.9 | 5.7 | nt |
| 66 | Core 14 70-80cm | 0.21 | 8.4 | 7.7 | 15.3 | 1.8 | 0.4 | 7.6 | 7.1 | nt |
| 67 | Core 14 90cm | 0.28 | 8.6 | 7.8 | 15.2 | 2.4 | 0.6 | 6.2 | 8.1 | nt |

**SOIL CONSERVATION SERVICE**
**Scone Research Centre**



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Hamilton NSW 2303

| Lab No | Method | C1A/4 | C2A/3 | C2B/3 | C5A/4 CEC & exchangeable cations (me/100g) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Sample Id | EC (dS/m) | pH | pH ($CaCl_2$) | CEC | Na | K | Ca | Mg | Al |
| 68 | Core 15 0-10cm | 0.03 | 6.0 | 4.9 | 4.6 | 0.1 | 1.3 | 3.0 | 1.1 | 0.6 |
| 69 | Core 15 20-30cm | 0.01 | 6.8 | 5.8 | 4.7 | 0.1 | 0.5 | 3.8 | 1.5 | 0.5 |
| 70 | Core 15 55-65cm | 0.04 | 7.3 | 6.5 | 6.5 | 0.4 | 0.3 | 3.6 | 3.6 | nt |
| 71 | Core 15 90-100cm | 0.12 | 6.8 | 6.2 | 7.9 | 0.9 | 0.3 | 2.5 | 4.5 | nt |
| 72 | Obs 33 0-10cm | 0.01 | 5.0 | 4.0 | 2.2 | 0.1 | 0.2 | 0.7 | 0.8 | 1.9 |
| 73 | Obs 33 20-30cm | 0.01 | 5.4 | 4.2 | 2.5 | 0.2 | 0.1 | 0.7 | 1.9 | 1.7 |
| 74 | Obs 47 0-15cm | 0.22 | 4.5 | 3.9 | 2.5 | 0.8 | 0.6 | 0.8 | 1.4 | 1.4 |
| 75 | Obs 23 0-10cm | 0.03 | 5.8 | 4.6 | 2.9 | 0.1 | 0.8 | 1.8 | 1.4 | 1.4 |

**SOIL CONSERVATION SERVICE**
**Scone Research Centre**



Report No: SCO12/413R1
Client Reference: Adele Calandra
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PO Box 907
Hamilton NSW 2303

| Lab No | Method | P7B/2 Particle Size Analysis (%) | | | | | P9B/2 | Colour | |
|---|---|---|---|---|---|---|---|---|---|
| | Sample Id | clay | silt | f sand | c sand | gravel | EAT | Dry | Moist |
| 1 | Obs 7 0-15cm | 13 | 8 | 28 | 39 | 12 | 8 | 10YR 4/3 | 10YR 2/2 |
| 2 | Obs 7 15-30cm | 9 | 6 | 11 | 22 | 52 | 5 | 10YR 5/4 | 7.5YR 3/4 |
| 3 | Obs 7 40-50cm | 12 | 8 | 20 | 27 | 33 | 5 | 7.5YR 5/4 | 7.5YR 3/2 |
| 4 | Core 1 0-10cm | 10 | 7 | 36 | 44 | 3 | 8 | 7.5YR 5/3 | 7.5YR 2.5/2 |
| 5 | Core 1 10-20cm | 7 | 10 | 30 | 50 | 3 | 3(1) | 10YR 5/3 | 10YR 3/2 |
| 6 | Core 1 45-55cm | 33 | 8 | 23 | 26 | 10 | 2(2) | 2.5Y 6/4 | 2.5Y 5/4 |
| 7 | Core 1 70-80cm | 35 | 8 | 26 | 27 | 4 | 2(2) | 2.5Y 6/4 | 2.5Y 5/4 |
| 8 | Obs 9 0-10cm | 15 | 12 | 30 | 26 | 17 | 7 | 10YR 5/3 | 10YR 3/2 |
| 9 | Obs 9 10-30cm | 18 | 11 | 29 | 25 | 17 | 3(3) | 10YR 5/4 | 10YR 3/4 |
| 10 | Obs 9 30-50cm | 51 | 5 | 19 | 20 | 5 | 2(1) | 10YR 5/5 | 10YR 4/5 |

# SOIL CONSERVATION SERVICE
## Scone Research Centre



Report No: SCO12/413R1
Client Reference: Adele Calandra
GSS Environmental
PO Box 907
Hamilton NSW 2303

| Lab No | Method | P7B/2 Particle Size Analysis (%) | | | | | P9B/2 | Colour | |
|---|---|---|---|---|---|---|---|---|---|
| | Sample Id | clay | silt | f sand | c sand | gravel | EAT | Dry | Moist |
| 11 | Core 2 0-10cm | 14 | 7 | 23 | 52 | 4 | 7 | 10YR 5/3 | 10YR 3/3 |
| 12 | Core 2 20-30cm | 8 | 8 | 23 | 56 | 5 | 3(1) | 10YR 5/4 | 10YR 3/4 |
| 13 | Core 2 40-50cm | 10 | 7 | 25 | 51 | 7 | 3(2) | 10YR 6/3 | 10YR 4/5 |
| 14 | Core 2 65-75cm | 20 | 7 | 22 | 47 | 4 | 2(1) | 10YR 6/4 | 10YR 5/5 |
| 15 | Core 3 0-10cm | 26 | 14 | 24 | 32 | 4 | 7 | 10YR 6/4 | 10YR 4/5 |
| 16 | Core 3 25-35cm | 17 | 20 | 35 | 25 | 3 | 3(1) | 10YR 7/2 | 10YR 5/3 |
| 17 | Core 3 55-65cm | 59 | 13 | 20 | 7 | 1 | 2(3) | 2.5YR 6/4 | 2.5YR 5/6 |
| 18 | Obs 17 0-10cm | 8 | 6 | 23 | 19 | 44 | 3(1) | 10YR 5/3 | 10YR 3/3 |
| 19 | Obs 17 15-30cm | 18 | 12 | 31 | 23 | 16 | 3(2) | 10YR 6/3 | 10YR 4/6 |
| 20 | Obs 17 30-50cm | 39 | 14 | 41 | 5 | 1 | 2(2) | 10YR 7/4 | 10YR 5/8 |
| 21 | Obs 18 0-10cm | 11 | 6 | 29 | 31 | 23 | 3(1) | 10YR 3/4 | 7.5YR 2.5/3 |
| 22 | Obs 18 20-30cm | 7 | 3 | 15 | 14 | 61 | 5 | 10YR 5/4 | 7.5YR 3/4 |

**SOIL CONSERVATION SERVICE**
**Scone Research Centre**



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GSS Environmental
PO Box 907
Hamilton NSW 2303

| Lab No | Method | P7B/2 Particle Size Analysis (%) | | | | | P9B/2 | Colour | |
|---|---|---|---|---|---|---|---|---|---|
| | Sample Id | clay | silt | f sand | c sand | gravel | EAT | Dry | Moist |
| 23 | Core 04 0-10cm | 25 | 20 | 30 | 24 | 1 | 3(1) | 10YR 5/3 | 10YR 3/2 |
| 24 | Core 04 25-35cm | 28 | 19 | 25 | 26 | 2 | 3(3) | 10YR 5/3 | 10YR 3/4 |
| 25 | Core 04 55-65cm | 26 | 17 | 30 | 25 | 2 | 2(1) | 10YR 6/3 | 10YR 4/4 |
| 26 | Core 04 95-100cm | 35 | 12 | 28 | 22 | 3 | 2(1) | 10YR 6/4 | 10YR 5/6 |
| 27 | Core 05 0-10cm | 9 | 5 | 41 | 42 | 3 | 3(1) | 10YR 5/4 | 10YR 3/3 |
| 28 | Core 05 25-35cm | 8 | 4 | 36 | 34 | 18 | 3(1) | 10YR 6/3 | 10YR 4/4 |
| 29 | Core 05 55-65cm | 54 | 2 | 17 | 16 | 11 | 3(1) | 7.5YR 5/8 | 5YR 5/6 |
| 30 | Core 05 75-85cm | 55 | 4 | 15 | 12 | 14 | 5 | 7.5YR 5/8 | 5YR 5/6 |
| 31 | Core 06 0-10cm | 11 | 8 | 39 | 40 | 2 | 3(1) | 10YR 5/4 | 10YR 3/4 |
| 32 | Core 06 25-35cm | 12 | 6 | 31 | 43 | 8 | 3(1) | 7.5YR 5/4 | 7.5YR 4/4 |
| 33 | Core 06 55-65cm | 34 | 5 | 22 | 24 | 15 | 3(2) | 10YR 5/5 | 10YR 4/5 |
| 34 | Core 06 75-85cm | 58 | 6 | 19 | 16 | 1 | 2(1) | 10YR 6/5 | 10YR 5/6 |

**SOIL CONSERVATION SERVICE**
**Scone Research Centre**



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Hamilton NSW 2303

| Lab No | Method | P7B/2 Particle Size Analysis (%) | | | | | P9B/2 | Colour | |
|---|---|---|---|---|---|---|---|---|---|
| | Sample Id | clay | silt | f sand | c sand | gravel | EAT | Dry | Moist |
| 35 | Core 07 0-10cm | 11 | 9 | 33 | 44 | 3 | 8 | 10YR 5/4 | 10YR 3/3 |
| 36 | Core 07 25-35cm | 9 | 8 | 35 | 43 | 5 | 3(1) | 7.5YR 6/4 | 7.5YR 4/4 |
| 37 | Core 07 65-75cm | 18 | 6 | 25 | 31 | 20 | 2(1) | 7.5YR 6/5 | 7.5YR 4/5 |
| 38 | Core 08 0-5cm | 24 | 12 | 47 | 13 | 4 | 8 | 10YR 5/3 | 10YR 3/3 |
| 39 | Core 08 10-20cm | 34 | 22 | 34 | 6 | 4 | 2(1) | 7.5YR 5/4 | 7.5YR 3/4 |
| 40 | Core 08 25-35cm | 46 | 20 | 29 | 3 | 2 | 2(1) | 7.5YR 5/5 | 7.5YR 4/5 |
| 41 | Core 08 50-60cm | 47 | 24 | 22 | 5 | 2 | 3(2) | 7.5YR 5/5 | 7.5YR 4/5 |
| 42 | Core 08 70-80cm | 39 | 25 | 22 | 4 | 10 | 3(1) | 10YR 6/4 | 10YR 4/5 |
| 43 | Core 09 0-10cm | 22 | 14 | 37 | 17 | 10 | 7 | 7.4YR 4/5 | 7.5YR 3/4 |
| 44 | Core 09 20-30cm | 55 | 12 | 16 | 7 | 10 | 3(2) | 5YR 4/5 | 5YR 3/4 |
| 45 | Core 09 50-60cm | 73 | 10 | 10 | 4 | 3 | 3(2) | 5YR 5/5 | 5YR 4/5 |
| 46 | Core 09 70-80cm | 65 | 13 | 13 | 5 | 4 | 3(1) | 7.5YR 5/6 | 10YR 4/6 |

**SOIL CONSERVATION SERVICE**
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| Lab No | Method | P7B/2 Particle Size Analysis (%) | | | | | P9B/2 | Colour | |
|---|---|---|---|---|---|---|---|---|---|
| | Sample Id | clay | silt | f sand | c sand | gravel | EAT | Dry | Moist |
| 47 | Core 10 0-10cm | 24 | 27 | 33 | 13 | 3 | 3(1) | 10YR 4/6 | 10YR 3/6 |
| 48 | Core 10 20-30cm | 57 | 17 | 16 | 7 | 3 | 3(2) | 7.5YR 5/6 | 7.5YR 4/6 |
| 49 | Core 10 55-65cm | 53 | 16 | 11 | 6 | 14 | 5 | 10YR 5/6 | 10YR 4/6 |
| 50 | Core 10 80-90cm | 29 | 16 | 12 | 13 | 30 | 4 | 10YR 5/6 | 10YR 4/6 |
| 51 | Core 11 0-10cm | 22 | 23 | 29 | 18 | 8 | 3(2) | 10YR 4/6 | 10YR 3/4 |
| 52 | Core 11 25-35cm | 27 | 18 | 28 | 16 | 11 | 3(2) | 7.5YR 4/6 | 7.5YR 3/4 |
| 53 | Core 11 55-65cm | 59 | 12 | 16 | 11 | 2 | 2(2) | 7.5YR 5/6 | 7.5YR 4/6 |
| 54 | Core 11 80-90cm | 57 | 25 | 10 | 7 | 1 | 4 | 10YR 6/4 | 10YR 5/6 |
| 55 | Core 11 110cm | 52 | 31 | 9 | 7 | 1 | 4 | 2.5Y 6/4 | 2.5Y 5/6 |
| 56 | Core 12 0-10cm | 15 | 14 | 61 | 7 | 3 | 3(1) | 10YR 4/4 | 10YR 3/4 |
| 57 | Core 12 10-20cm | 42 | 19 | 36 | 3 | 0 | 2(1) | 7.5YR 6/4 | 7.5YR 5/6 |

**SOIL CONSERVATION SERVICE**
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| Lab No | Method | P7B/2 Particle Size Analysis (%) | | | | | P9B/2 | Colour | |
|---|---|---|---|---|---|---|---|---|---|
| | Sample Id | clay | silt | f sand | c sand | gravel | EAT | Dry | Moist |
| 58 | Core 13 0-10cm | 19 | 11 | 37 | 26 | 7 | 7 | 7.5YR 4/6 | 7.5YR 3/4 |
| 59 | Core 13 10-20cm | 23 | 14 | 32 | 21 | 10 | 5 | 7.5YR 4/6 | 7.5YR 3/4 |
| 60 | Core 13 25-35cm | 23 | 12 | 33 | 19 | 13 | 3(3) | 7.5YR 5/6 | 7.5YR 4/6 |
| 61 | Core 13 55-65cm | 48 | 8 | 22 | 19 | 3 | 3(2) | 7.5YR 5/6 | 5YR 4/6 |
| 62 | Core 13 80-90cm | 46 | 9 | 32 | 13 | <1 | 3(2) | 7.5YR 6/6 | 7.5YR 5/6 |
| 63 | Core 14 0-10cm | 15 | 20 | 48 | 11 | 6 | 8 | 10YR 5/4 | 10YR 3/3 |
| 64 | Core 14 25-35cm | 23 | 15 | 37 | 22 | 3 | 3(2) | 7.5YR 5/6 | 7.5YR 4/6 |
| 65 | Core 14 55-65cm | 45 | 7 | 20 | 25 | 3 | 3(1) | 10YR 6/6 | 10YR 5/6 |
| 66 | Core 14 70-80cm | 44 | 8 | 21 | 23 | 4 | 5 | 10YR 5/6 | 10YR 4/6 |
| 67 | Core 14 90cm | 47 | 15 | 25 | 13 | 0 | 2(2) | 10YR 5/6 | 10YR 4/6 |

**SOIL CONSERVATION SERVICE**
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| Lab No | Method | P7B/2 Particle Size Analysis (%) | | | | | P9B/2 | Colour | |
|---|---|---|---|---|---|---|---|---|---|
| | Sample Id | clay | silt | f sand | c sand | gravel | EAT | Dry | Moist |
| 68 | Core 15 0-10cm | 15 | 13 | 43 | 22 | 7 | 8 | 10YR 4/4 | 10YR 3/4 |
| 69 | Core 15 20-30cm | 22 | 7 | 36 | 25 | 10 | 3(2) | 7.5YR 5/6 | 7.5YR 4/6 |
| 70 | Core 15 55-65cm | 35 | 5 | 38 | 18 | 4 | 5 | 7.5YR 6/6 | 7.5YR 5/6 |
| 71 | Core 15 90-100cm | 35 | 3 | 32 | 24 | 6 | 6 | 7.5YR 5/8 | 7.5YR 4/6 |
| 72 | Obs 33 0-10cm | 12 | 8 | 32 | 39 | 9 | 8 | 10YR 4/4 | 10YR 3/3 |
| 73 | Obs 33 20-30cm | 18 | 9 | 32 | 36 | 5 | 3(1) | 10YR 4/4 | 10YR 3/4 |
| 74 | Obs 47 0-15cm | 12 | 12 | 37 | 33 | 6 | 8 | 10YR 5/2 | 10YR 3/2 |
| 75 | Obs 23 0-10cm | 10 | 3 | 32 | 46 | 9 | 8 | 10YR 3/6 | 7.5YR 2.5/3 |

END OF TEST REPORT